Final Program

ORTHOPAEDIC TRAUMA ASSOCIATION

OTA 37th Annual Meeting

Wednesday-Saturday

October 20 - 23, 2021

Fort Worth Convention Center
Fort Worth, Texas

FORT WORTH TEXAS

Program Committee

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ORTHOPAEDIC TRAUMA ASSOCIATION

PRE-MEETING EVENTS:

- Basic Science Focus Forum
- Orthopaedic Trauma Boot Camp
- Orthopaedic Trauma for NP's and PA's
- International Trauma Care Forum
- E/M and Surgical Coding Course
- Young Practitioners Forum
- Pelvis and Acetabulum Course
- Soft Tissue Coverage Skills Course
- OTA Member Fireside
- Residents Comprehensive Fracture Course

19+
CME

2022 ANNUAL MEETING

TAMPA, FLORIDA
OCTOBER 12 – 15, 2022

ORTHOPAEDIC TRAUMA ASSOCIATION

9400 West Higgins Road, Suite 305
Rosemont, IL 60018-4975
Phone: (847) 698-1631
FAX: (847) 430-5140
E-mail: ota@ota.org

Heather A. Vallier, MD

President's Welcome 2021

Dear OTA Members, Guests and Associates:

I am excited to welcome you to the 37th OTA Annual Meeting! Following more than a year of very few chances to meet in person, this year's meeting will be a very welcome chance to re-engage with colleagues and friends, and take advantage of an outstanding educational program developed by the OTA Annual Meeting Program Committee under the leadership of Stephen Kottmeier, MD, Program Committee Chair, and Gerard Slobogean, MD, Co-Chair.

The 2021 Annual Meeting offers an outstanding array of opportunities to engage in cutting edge orthopaedic trauma education and research, with offerings tailored to every learner. Whether your career in orthopaedic trauma is just beginning, or you are a seasoned practitioner, this year's long-awaited reunion of the orthopaedic trauma community is at last here!

Finally, I want to extend sincere appreciation to the OTA Annual Meeting Program Committee and the many OTA members, presenters, committee members and other volunteers contributing to making this year's meeting one of the best and most memorable ever.

Respectfully,

Heather A. Vallier, MD
OTA President

Welcome

Find a Surgeon

OTA Membership Directory available at www.ota.org.
Search by name or location.
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Orthopaedic Trauma Association
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Home Page: www.ota.org

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Schedule and presenters subject to change. Online version on the OTA website will have updates.

NOTE: Cameras (including cell phone cameras) may NOT be used in any portion of the meeting.

GENERAL INFORMATION

SCIENTIFIC POSTERS *Exhibit Hall A*
and **TECHNICAL EXHIBITS**
(See Scientific Posters on pages 199 - 404; Exhibitor Listing on pages 538 - 540)

Open: Thursday 2:30 PM – 5:00 PM *(Unopposed time: 2:55 - 3:35 PM)*
5:15 PM – 6:15 PM
(Happy Hour Exhibitor Reception *(Exhibit Hall A)*
Sponsored by **OsteoCentric Technologies**)

Friday 9:00 AM – 5:00 PM
(Unopposed times: 9:00 AM - 9:40 AM; 12:21 PM - 1:21 PM; 3:27 PM - 3:57 PM)
12:34 PM - 1:14 PM and 5:30 PM - 6:10 PM
Poster and Video Tours

Saturday 9:00 AM – 12:45 PM
(Unopposed times: 9:00 AM - 9:30 AM; 11:42 AM - 12:42 PM)
11:57 AM - 12:37 PM
Poster and Video Tours

SPEAKER READY ROOM *Room 104*
Open: Tuesday 4:00 PM – 6:00 PM
Open: Wed. thru Fri. 6:00 AM – 6:00 PM
Open: Saturday 6:00 AM – 4:30 PM

INTERNATIONAL RECEPTION *Ballroom Lobby, Level 2*
Wednesday 4:50 PM – 6:00 PM

WELCOME RECEPTION *The Water Garden*
Thursday 6:20 PM – 8:20 PM

WOMEN IN ORTHOPAEDIC TRAUMA KATHY CRAMER MEMORIAL LUNCHEON *Room 121 B*
Friday 12:21 PM – 1:21 PM

NEW MEMBER LUNCHEON *Room 121 C*
Friday 12:21 PM – 1:21 PM

RESEARCH MENTOR LUNCHEON *Room 121 E*
Friday 12:21 PM – 1:21 PM

MILITARY RECEPTION *Belt Buckle Lobby, Level 1*
Friday 5:30 PM – 6:30 PM

VINYASA YOGA Sponsored by **SurgeonMasters** *Room 101*
Friday 6:00 PM – 7:00 PM

MEDITATION Sponsored by **SurgeonMasters** *Room 101*
Daily (Wed. - Fri.) 7:00 AM – 7:30 AM

TAI CHI Sponsored by **SurgeonMasters** *Room 101*
Wednesday 5:00 PM – 6:00 PM

WELLNESS ROOM Sponsored by **SurgeonMasters** *Room 101*
Daily (Wed. - Fri.) 7:30 AM – 4:00 PM *The Wellness Room will serve as a quiet room during the meeting. We request that this space be a technology-free zone.*

ACKNOWLEDGMENTS

The Orthopaedic Trauma Association gratefully acknowledges the following foundations, companies, and individuals for their generous financial support received through OTA and through OREF to fund OTA reviewed research grants.

2021 OTA RESEARCH & EDUCATION DONORS
(as of August 26, 2021)

Platinum Award ($150,000 - $249,999)

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OTA Legacy Society

OTA acknowledges and thanks the many generous donors who give not only of their time, but of their financial resources to ensure the OTA mission thrives.

ICON Award ($50,000 or greater)

Kathryn E. Cramer, MD†
Dr. Todd W. and Mrs. Jennifer Mailly
Dr. Thomas (Toney) A. and Mrs. Gina Russell
Roy Sanders, MD

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Bruce H. Ziran, MD, FACS

†=Deceased

OTA Legacy Society, continued

The OTA is pleased to honor the following individuals and organizations who have reached a lifetime giving level of $10,000 or greater.

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Michael J. Prayson, MD
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David C. Templeman, MD
Paul Tornetta III, MD
Dr. Peter & Mrs. Frances Trafton
USCF/SFGH Orthopaedic Trauma Institute
J. Tracy Watson, MD
John Charles Weinlein, MD
Edward C. Yang, MD

ORTHOPAEDIC TRAUMA ASSOCIATION

OTA extends sincere gratitude to

Roy Sanders, MD

for his ongoing leadership and his generous endowment of the Roy Sanders OTA Traveling Fellowship. The program will enrich the lives of the selected fellows and help build the next generation of OTA leaders.

Complete details regarding the program are available on the OTA website: https://ota.org/fellowship/traveling-fellowship

ACKNOWLEDGMENTS *(as of October 14, 2021)*

The Orthopaedic Trauma Association gratefully acknowledges the following individuals for their generous financial support received through OTA and through OREF to fund OTA Research and Education.

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Roy Sanders

2021 Sponsors Award ($5,000 - $25,000)
Michael Archdeacon
Brendan Patterson
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A Herbert Alexander, Paul Appleton, Kathleen Caswell, Brett Duane Crist, Azad Dadgar-Dehkordi, James M. Glen, Melissa A. Gorman, Kevin P. Haddix, Todd M. Hall, Joseph Hoegler, Michael S. Kain, Mark A. Leberte, James F. Mautner, Toni McLaurin, Eric L. Pagenkopf, Rachel Reilly, Edward K. Rodriguez, Carla Smith, Jason W. Stoneback, J. Tracy Watson, David B. Weiss, Ryan E. Will, John J. Wixted, David Zuelzer

2021 Associates Award (up to $249)
Stuart Aiken, Jeffrey O. Anglen, Abar A. Ansari, Scott Bassuener, James A. Blair, Garrett Cavanaugh, Milind M. Chaudhary, Daniel J. Coll, Alexander M. Crespo, Brian J. Cross, Mario Cuadra, Aaron Dickens, David M. Dromsky, James P. Elmes, Carol C. Forsyth, Warren E. Gardner, Adam Gitlin, Meganne Gourley, Andrew W. Grose, Jonathan M. Gross, Robert Guinderson, Kevin Haddix, William Hakeos, Susan P. Harding, Armodios Hatzidakis, Giselle M. Hernandez, Sherri Keith, Mark A. Kelley, Dirk W. Kiner, Anton M. Kurtz, Gerald Lang, Thomas M. Large, Ross K. Leighton, Geoffrey Marecek, Jessie C. McBeth, Toni M. McLaurin, Brian Miller, Peter Montbach, Michele A. Prevost, J. Spence Reid, Coleen S. Sabatini, Augustine Saiz, Neil Sardesai, Joseph P. Scheschuk, Prism Schneider, Sheila Sprague, David M. Tainter, Laura L. Tosi, Andrew Trenholm, Eric G. Verwiebe, John C. Wheeler, Lu Zhang

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2020 Associates Award (up to $249)

Samuel G. Agnew, Jaimo Ahn, Stuart A. Aitken, Eliza Anderson*, Jeffrey O. Anglen, Elhadi Babikir*, Chelsea Bahney*, Benjamin Best*, James A. Blair, Robert H. Blotter, J. Stephen Brecht, CPT Benjamin Childs, Alec Cikes, Carol E. Copeland, Kory Cornum, Alexander M. Crespo*, Nicholas Danford, Graham J. DeKeyser*, Glenn R. Diekmann, Andrew R. Fras*, Bethany Gallagher*, Steven Gammon*, Matthew R. Garner, Jacqueline Geissler, Adam Gitlin, Christopher Grimsrud, Andrew W. Grose, Jonathan M. Gross, Robert Gunderson*, Susan Palmer Harding, Edward J. Harvey, Giselle M. Hernandez, Mike Hogervorst, Chad Ishmael*, Victor T. Jando, James F. Kellam, Mark A. Kelley, Paul K. Kosmatka, Hans J. Kreder, Michael Krosin, Thomas Large, Patrick B. Leach, Adam Lee, Carol A. Lin*, Michael Linn*, Frank Liporace, Frank Lyons, Geoffrey Marecek, Jessie C. Mcbeth*, Richard P. Meinig, Michael E. Miller, Charles N. Moon*, Vidushan Nadarajah*, Mark C. Olson, James Ostrander, Michele A. Prevost, Thomas Revak*, John Riehl*, Jason W. Roberts, David M. Romano, Augustine M. Saiz Jr.*, Joseph P. Scheschuk, Cary C. Schwartzbach, Kyle Schweser*, Babar Shafiq, Jon R. Shereck, Carla S. Smith, Jeffrey M. Smith, David Swanson, Eric Swart, Todd A. Swenning, Alex Telis, Herbert J. Thomas III, Laura Lowe Tosi, Rahul Vaidya*, Pieter Jan van Huijstee*, Corey V. Zandschulp*, Cai Wadden, David T. Watson, Lawrence X. Webb, John Weston*, John C. Wheeler, Patrick Yoon, Terri A. Zachos, Lu Zhang, David Zuelzer*

Thanks

* Sincere gratitude is extended to OTA 1st time donors

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT
ACKNOWLEDGMENTS

COTA acknowledges the generous 2021 financial support
for the 2021-2022 Fellowship Year from the following Industry Partners:

DePuy Synthes	**$250,000**
Smith and Nephew	**$200,000**
Stryker	**$200,000**
Medtronic	**$75,000**

website: https://ota.org/education/fellowship/cota-grants-program

Thank you, **Dr. Finnegan**, for your many years of service
serving as both secretary and treasurer.

COTA congratulates **Dr. Bogdan** in her new role as secretary/treasurer.

ORTHOPAEDIC TRAUMA ASSOCIATION

2021 Basic Science Focus Forum

October 20-21, 2021

Room 201 AB

Basic Science Committee

Aaron Nauth, MD, Chair
Andrew Evans, MD, FACS
Justin Haller, MD
Michael Hast, PhD
Christopher Lee, MD
Saam Morshed, MD, PhD
Emil Schemitsch, MD
Andrew Trenholm, MD
John Wixted, MD

Learning Objectives

Upon successful completion of this course, participants will be able to:

- Update knowledge in the basic science of orthopaedic trauma
- Demonstrate an improved understanding of the biomechanics of fracture fixation
- Understand the basic science and clinical implications of orthopaedic infections
- Explore the latest research on polytrauma from a basic science and clinical perspective
- Understand the basic science and clinical aspects of post-traumatic osteoarthritis
- Explore the latest basic and clinical research on enhancing fracture healing
- Understand the concepts around design and analysis in clinical research.

ORTHOPAEDIC TRAUMA ASSOCIATION

2021 Basic Science Focus Forum

WEDNESDAY, October 20, 2021

Room 201 AB

6:00 AM **Speaker Ready Room**
(Room 104)

6:15 AM **Registration**
(13th Street Lobby)

6:45 AM **Continental Breakfast**
(Room 201 AB)

7:30 AM **Introduction**
***Aaron Nauth, MD**, Program Chair*

7:35 – 9:05 AM

SYMPOSIUM I:
GREAT DEBATES IN TRAUMA BIOMECHANICS

Moderators: *Michael Hast, PhD*
Emil H. Schemitsch, MD

7:35 AM **Overview**
Michael Hast, PhD

7:40 AM **Mechanics vs. Biology - Which is "More Important" to Consider?**
(6 minutes per speaker)
Robert O'Toole, MD
Ara Nazarian, PhD

7:58 AM Discussion

8:13 AM **Locked Plate vs. Forward Dynamization vs. Reverse Dynamization - Which Way Should I Go?**
(6 minutes per speaker)
Samir Mehta, MD
Utku Kandemir, MD
Vaida Glatt, PhD

8:25 AM Discussion

Key: Δ = presentation was funded by an OTA administered grant
Names in bold = **Presenter**

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

8:40 AM **Sawbones vs. Cadaver Models - What Should I Believe Most?**
(6 minutes per speaker)
William M. Ricci, MD
Michael Hast, PhD

8:52 AM Discussion

9:05 – 10:00 AM

PAPER SESSION I
BIOMECHANICS

Moderators: *Michael Hast, PhD*
Emil H. Schemitsch, MD

9:05 AM
(p. 61)
PAPER 1
Δ Smart Fracture Plate Monitors Callus Stiffness
Eric H. Ledet, PhD; Madelyn Stout, BS; Sydney M. Caparaso, BS; Keegan Cole MD; Benjamin Liddle, BS; Nathaniel Cady, PhD; Reena Dahle, PhD; ***Michael T. Archdeacon, MD, FAAOS***

9:13 AM
(p. 62)
PAPER 2
A Biomechanical Comparison of Two Fixation Methods for Unstable Lateral Compression Pelvic Ring Injuries
Eric Hempen, MD*; Benjamin Matthew Wheatley, MD; Patrick Schimoler, MS; Alexander Kharlamov, MD, PhD; Patricia Melvin, MD; Mark Carl Miller, PhD; Gregory T. Altman, MD; Daniel T. Altman, MD; Edward Ryan Westrick, MD*

9:21 AM Discussion

9:28 AM
(p. 63)
PAPER 3
The Effect of Screw Fixation on Sacroiliac Joint Stiffness using Vibration Energy Color Doppler Imaging
Caleb Gottlich, MD*; Alex Stephen Drusch, MS; Thomas Githens, DO; Cyrus Theodore Caroom, MD; Phillip Spelman Sizer, PhD, PT*

9:36 AM
(p. 64)
PAPER 4
Orthogonal Plating of Distal Femur Fractures: A Biomechanical Comparison with Plate-Nail and Parallel Plating Constructs
Zoe Beatrice Cheung, MD*; Philip Nasser, MS; James C. Iatridis, PhD; David Forsh, MD*

9:44 AM
(p. 65)
PAPER 5
A Biomechanical Comparison Between TightRope and Suture-Post Fixation: A Novel Technique
Pierce Johnson, MD; ***Paulo Castaneda, MD****; Robert Walker, MD; Tony K. Nguyen, MD; J. Tracy Watson, MD*

9:52 AM Discussion

10:00 AM Morning Break

Δ OTA Grant

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

SYMPOSIUM II: SRI COLLABORATIVE SESSION: SIMPLE DESIGN AND ANALYSIS STRATEGIES FOR SOLVING COMMON PROBLEMS IN ORTHOPAEDIC CLINIC RESEARCH

10:15 – 11:07 AM

Moderators: *Saam Morshed, MD*
Gerard Slobogean, MD

10:15 AM **Overview**
Saam Morshed, MD

10:17 AM **Not a RCT? How Do We Get Causal Inference from Observational Data**
David Shearer, MD

10:27 AM **Confounding Bias and How to Best Adjust for It [Stratification, Matching, Regression, and PSA]**
Saam Morshed, MD

10:37 AM **The Power of Repeated Measures and Longitudinal Data [Longitudinal Regression, etc.]**
Gerard Slobogean, MD

10:47 AM **Handling Missing Data and Loss to Follow-up [Imputation, Time to Event Analysis, etc.]**
Leah Gitajn, MD

10:57 AM Discussion

PAPER SESSION II: QUANTIFYING FRACTURE HEALING

11:07 AM – 12:00 PM

Moderators: *Saam Morshed, MD*
Gerard Slobogean, MD

11:07 AM (p. 66) **PAPER 6**
A Short Course of Dehydroepiadrosterone is Associated with Accelerated Fracture Healing in a Mouse Fracture Model
***David Kirby, MD**; Daniel B. Buchalter, MD; Cyrus Luczkow, BS; John Frederick Dankert, MD; Devan Mehta, MD; Philipp Leucht, MD*

11:15 AM (p. 67) **PAPER 7**
Adult Collagen X Fracture Biomarker Levels Demonstrate Early Peak After Fracture to Match Preclinical Model
***Zachary Mark Working, MD**; Kaitlyn E. Whitney, BS; Justin Hellwinkel, MD; Lauren Pierpoint PhD; Ryan Coghlan MS; Darin M. Friess MD; Theodore Miclau, MD; William Horton, MD; Brian Johnstone, PhD; Chelsea S. Bahney, PhD*

11:23 AM Discussion

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

11:29 AM (p. 68) **PAPER 8**
Δ Novel Profiling Method to Detect Hypoxia Biomarker After Cold Therapy at Bone Injury Site
Matthew Zakaria BS, MSc*; Yazan Honjol BA, MD; Drew Schupbach, MD; Géraldine Merle, PhD; Edward J. Harvey, MD, MSc*

11:37 AM (p. 69) **PAPER 9**
Three-Dimensional Ultrasound Reconstruction of Sonographic Callus: A Novel Imaging Modality for Early Evaluation of Fracture Healing
Jamie A. Nicholson, MBCHB, MRCSED*; William M. Oliver, MBBS, MRCSED; Tom MacGillivray, PhD; Christopher M. Robinson, MD; Hamish Robert Wallace Simpson, ChB, DMed, MA, MB*

11:45 AM (p. 70) **PAPER 10**
Δ Advanced Imaging Evaluation of Distal Radius Fractures Using Finite Element (FE) Analysis of High-Resolution Peripheral Quantitative CT
Phillip John Curtis Spanswick, MSc; Mohammad Salem, PhD; Danielle Whittier, BS; Robert Korley, MD; Steven Boyd, PhD; ***Prism Schneider, MD, PhD***

11:53 AM Discussion

12:00 PM Proceed to Ballroom C

12:05–1:00 PM *(Ballroom C)*
INDUSTRY LUNCH (No CME credits offered)
Zimmer Biomet
Current Topics in Clavicle Fracture Management
Speaker: ***Anil Dutta, MD***
Box lunch provided by OTA.

1:00 PM Return to Meeting Room 201 AB

1:05 – 1:57 PM

SYMPOSIUM III: ORTHOPAEDIC INFECTIONS: WHAT HAVE WE LEARNED?

Moderator: *Christopher Lee, MD*

1:05 PM **Overview**
Christopher Lee, MD

1:07 PM **Host Modulation in Infection Prevention**
Nicholas Bernthal, MD

1:17 PM **Race to the Surface – Orthopaedic Implants and Infection**
Joseph Wenke, PhD

1:27 PM **PO vs. IV Antibiotics in Orthopaedic Infections**
Paul Holtom, MD

1:37 PM **Antibiotic Powder Use in Orthopaedic Infection and Prevention – Current Concepts**
Robert V. O'Toole, MD

1:47 PM Discussion

Δ OTA Grant

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

1:57 – 2:52 PM

PAPER SESSION III: INFECTION, SCAFFOLDS AND OSTEOPOROSIS

Moderator: *Christopher Lee, MD*

1:57 PM (p. 71) **PAPER 11**
A Micro-CT and Biomechanical Analysis of the Effects of Intra-Wound Vancomycin Powder on Infection and Bone Healing in a Rat Model
Ikran Ali, BS*; Charles Godbout, PhD; Hening Sun, BS; Graeme Hoit, MD; Emil H. Schemitsch, MD; Aaron Nauth, MD*

2:05 PM (p. 72) **PAPER 12**
Microgel-Enhanced Delivery of Adenosine to Accelerate Fracture Healing
Shyni Vargheese, PhD; Jiaul Hoque, PhD; ***Mark Gage, MD***

2:13 PM Discussion

2:20 PM (p. 73) **PAPER 13**
Human Mesenchymal Stromal Subcellular Compositions Depends on Bone Mass Density: A Single Cell Level Study by Mass Cytometry
Benjamin Eggerschwiler, PhD; Elisa Anna Casanova, PhD; Daisy Canepa, MSc; Sascha Halvachizadeh, MD; Georg Osterhoff, MD; ***Yannik Kalbas, MD****; Hans-Christoph Pape, MD; Paolo Cinelli, PhD*

2:28 PM (p. 74) **PAPER 14**
Bone Targeting Nanocarrier-Assisted Delivery of Adenosine to Treat Osteoporotic Bone Loss
Shyni Vargheese, PhD; Jiaul Hoque, PhD; ***Mark Gage, MD***

2:36 PM (p. 75) **PAPER 15**
Thrombelastography Platelet Mapping Identifies Platelet-Mediated Hypercoagulability Following a Hip Fracture
Prism Schneider, MD, PhD*; Daniel You, MD; Andrew Dodd, MD; Paul James Duffy, MD; Ryan Martin, MD; Robert Korley, MD*

2:44 PM Discussion

2:52 PM Afternoon Break

3:05– 3:57 PM

SYMPOSIUM IV: POST- TRAUMATIC OA: FROM BASIC SCIENCE TO CLINICAL IMPLICATIONS

Moderators: *Justin Haller, MD*
Zachary Working, MD

3:05 PM **Overview**
Justin Haller, MD

3:07 PM **Role of Bone Remodeling in PTOA Development**
Marjolein van der Meulen, PhD

3:17 PM **Assessing Mechanical Variables that Impact PTOA Development and Outcome**
Donald D. Anderson, PhD

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

3:27 PM **Influence of Inflammatory Cytokines on the Pathogenesis of PTOA**
Steven Olson, MD

3:37 PM **Biologic Enhancements for the Prevention of PTOA**
J. Lawrence Marsh, MD

3:47 PM Discussion

3:57 – 4:52 PM

PAPER SESSION IV
POST-TRAUMATIC OSTEOARTHRITIS

Moderators: *Justin Haller, MD*
Zachary Working, MD

3:57 PM (p. 76) **PAPER 16**
Greater Acute Articular Inflammatory Response in Tibial Plafond Fractures as Compared to Rotational Ankle Fractures
Lucas Scott Marchand, MD*; David Lynn Rothberg, MD; Thomas F. Higgins, MD; Justin Haller, MD*

4:05 PM (p. 77) **PAPER 17**
Articular Fragment Restoration is Critical to Mitigate Post-traumatic Osteoarthritis in a Porcine Pilon Fracture Model
Graham John Dekeyser; Richard Tyler Epperson, PhD; Dustin Williams, PhD; Aaron L. Olsen, DVM, PhD; ***Justin Haller, MD***

4:13 PM Discussion

4:20 PM (p. 78) **PAPER 18**
Articular Fracture Increases Inflammatory Chondrocyte Gene Expression more than Compression with a High Synovitis Co-culture Model
Megan Libke, BS; Daniel Joseph Cunningham, MD; Bridgette D. Furman, BS; Virginia Byers Kraus, PhD; Farshid Guilak, PhD; Amy L. McNulty, BS, PhD; ***Steven A. Olson, MD***

4:28 PM (p. 79) **PAPER 19**
Combination of Lidocaine and IL-1Ra Is Effective at Reducing Degradation of Porcine Cartilage Explants
Michael W. Buchanan, BS; Bridgette D. Furman, BS; Amy L. McNulty, BS, PhD; ***Steven A. Olson, MD***

4:36 PM (p. 80) **PAPER 20**
Systemic Glucose-Insulin-Potassium Reduces Skeletal Muscle Injury, Kidney Injury, and Pain in a Murine Ischemia-Reperfusion Model
Daniel B. Buchalter, MD*; David Kirby, MD; Devan Mehta, MD; John Frederick Dankert, MD; Kenneth A. Egol, MD; Sanjit R. Konda, MD; Philipp Leucht, MD*

4:44 PM Discussion

4:52 PM Adjourn for the Day

Please attend the International Reception
Level 2 - Ballroom Lobby
Join your colleagues for refreshments, 4:50 - 6:00 PM.

With special thanks and support from 3M Health Care.

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

ORTHOPAEDIC TRAUMA ASSOCIATION

2021 Basic Science Focus Forum

THURSDAY, October 21, 2021

Ballroom C and 201 AB

Basic Science Focus Forum and International Trauma Care Forum will have their combined symposium in Ballroom C

6:00 AM **Speaker Ready Room**
(Room 104)

6:45 AM **Continental Breakfast**
(Ballroom C)

7:30 AM **Introduction**
Hans-Christoph Pape, MD

(Ballroom C)
7:35 – 8:35 AM **JOINT SESSION – SYMPOSIUM V: MANAGEMENT OF (ASEPTIC) NON-UNIONS AND SEVERE BONE DEFECTS: LET'S GET THIS THING HEALED!**

Moderators: *Aaron Nauth, MD*
Hans-Christoph Pape, MD

7:35 AM **The Biomechanics of Nonunion Etiology and Treatment**
Brett Crist, MD

7:45 AM **Induced Membrane Technique for Nonunion Management**
Saam Morshed, MD

7:55 AM **Biological Treatments for Nonunions: Bone Graft Types and Bone Graft Substitutes**
J. Tracy Watson, MD

8:05 AM **Outlook for New Research Options: The AO Registry Initiative**
Hans-Christoph Pape, MD

8:15 AM **Putting It All Together: A Comprehensive Approach to Nonunion Management**
Aaron Nauth, MD

8:25 AM Discussion

8:35 AM Break/Proceed to Meeting Room 201 AB

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

8:45 – 9:40 AM PAPER SESSION V: POLYTRAUMA AND COMPARTMENT SYNDROME

Moderator: *Aaron Nauth, MD*

8:45 AM (p. 81) **PAPER 21**
Humanitarian Scholar – Kenya
Post-Traumatic Inflammatory Load: Interleukin-6 and -8 Levels, Associated Potential Surrogate Markers and Regression Analysis for Impact of Various Injury Properties
Dennis K. Rono, MBCHB, MMED

8:53 AM (p. 82) **PAPER 22**
Lipidomic Analysis in a Porcine Polytrauma Model Show Significant Posttraumatic Changes to the Circulating Lipid Profile
Yohei Kumabe, MD*; Yannik Kalbas, MD; Sascha Halvachizadeh, MD; Thorsten Hornemann, PhD; Roman Pfeifer, MD; Paolo Cinelli, PhD; Hans-Christoph Pape, MD*

9:01 AM
Discussion

9:09 AM (p. 83) **PAPER 23**
Protective Effects of New Femoral Reaming Techniques (Reamer Irrigator Aspirator, RIA I and II) on Pulmonary Function and Posttraumatic Contusion (CT Morphology): Results from a Standardized Large Animal Model
Sascha Halvachizadeh, MD*; Michel Paul Johan Teuben, MD, MSc; Yannik Kalbas, MD; Nikola Cesarovic, DVM, PhD; Paolo Cinelli, PhD; Roman Pfeifer, MD; Hans-Christoph Pape, MD*

9:16 AM (p. 84) **PAPER 24**
In Vivo Intramuscular pH in Tibia Fractures Is Acidic But Normalizes After Stabilization and Resuscitation
Loren O. Black, MD, MBA*; Megan Catherine Rushkin, MPH; Emelia Sodders, MS; Jeffrey Samuel Cheesman, MD; James E. W. Meeker, MD; Jung U. Yoo, MD; Darin M. Friess, MD; Zachary Mark Working, MD*

9:24 AM (p. 85) **PAPER 25**
Pre-Clinical Acute Compartment Syndrome with a Porcine Continuous Measurement Model
Yazan Honjol, BA, MD; Rachel Monk, BS; Drew Schupbach, MD; Géraldine Merle, PhD; ***Edward J. Harvey, MD, MSc***

9:32 AM
Discussion

9:40 – 10:32 AM — SYMPOSIUM VI: FRACTURE HEALING - ORTHOBIOLOGICS: FROM BASIC SCIENCE TO CLINICAL APPLICATION

Moderators: *Andrew Evans, MD*
John Wixted, MD

9:40 AM **Overview**
Andrew Evans, MD

9:42 AM **Basic Science Pathways for Pharmacologic Approaches to Enhancing Fracture Repair**
John Wixted, MD

9:52 AM **Translational Challenges in Fracture Repair - What the FDA Needs to See**
Doug Dirschl, MD

10:02 AM **Study Design Tactics that Optimize the Potential for Clinical Translation of Basic Science Research**
Joseph Johnson, MD

10:12 AM **Candidate Basic Science Pathways as Potential Targets for Clinical, Surgical, and Orthobiologics Modification**
Jaimo Ahn, MD, PhD

10:22 AM Discussion

10:32 – 11:15 AM — PAPER SESSION VI: FRACTURE HEALING: CELLS AND BONE GRAFTING

Moderators: *Andrew Evans, MD*
John Wixted, MD

10:32 AM (p. 86) **PAPER 26**
Biomimetic Hematoma: Novel Carrier Delivers Extremely Low Dose rhBMP-2 for Highly Effective Healing of Large Bone Defects in Goats
Vaida Glatt, PhD; *Anna Woloszyk, PhD; Animesh Agarwal, MD*

10:40 AM (p. 87) **PAPER 27**
Short Platelet Rich Plasma Exposure Induces a Priming Effect on the Biophysiological Potency of Bone Marrow Mesenchymal Stem Cells in Human
James Vun, MBChB, MRCSED; *Paul Harwood, FRCS (Ortho), MSc; Jehan Jomaa El-Jawhari, MBChB, MSc, PhD; Elena Jones, PhD; Peter Giannoudis, MD, BS, MBBS*

10:48 AM (p. 88) **PAPER 28**
Bone Graft Composition with RIA from a Native Versus Previously Reamed Long Bone for Bone Graft Harvest?
Stephanie N. Moore-Lotridge, PhD; *Cesar Cereijo, DO; Sam Robert Johnson, BS; Jonathan G. Schoenecker, MD; Cory Alan Collinge, MD; William T. Obremskey, MD, MPH*

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

10:56 AM (p. 89) **PAPER 29**	**Comparison of Reamer-Irrigator-Aspirator to Bone Marrow Aspirate Concentrate for Osteoprogenitor Cell Retention and Osteoinductive Protein Release on Cancellous Bone** ***Brett D. Crist, MD****; Aaron Michael Stoker, MS, PhD; Jane Liu, MD; James P. Stannard, MD; James L. Cook, DVM, PhD*
11:04 AM	Discussion
11:12 AM	Adjourn to **INDUSTRY LUNCH SYMPOSIA** *(On-site Registration Available)* Boxed lunch provided by OTA.

ORTHOPAEDIC TRAUMA ASSOCIATION

2021 International Trauma Care Forum

October 20-21, 2021

(Room 202 CD)

International Program Committee

Theodore Miclau III, MD, Chair
Hans-Christoph Pape, MD, FACS, Co-Chair
Zsolt J. Balogh, MD, PhD
Victor de Ridder, MD, PhD, MBA
Paul S. Whiting, MD

Learning Objectives

Upon successful completion of this course, participants will be able to:

- Assess current techniques of the management of patients with pelvic instability
- Discuss the latest treatments for fracture management in geriatric patients
- Understand the treatment options, planning, and outcomes of patients with distal tibia fractures
- Outline all the latest upper and lower extremity fracture fixation techniques
- Review the latest recommendations for the treatment of patients following multiple injuries.

ORTHOPAEDIC TRAUMA ASSOCIATION

2021 International Trauma Care Forum

WEDNESDAY, October 20, 2021

(Room 202 CD)

6:00 AM **Speaker Ready Room**
(Room 104)

6:15 AM **Registration**
(13th Street Lobby)

6:45 AM **Continental Breakfast**
(Room 202 CD)

7:30 AM **Introduction**
Theodore Miclau III, MD, Program Chair

7:35 – 8:15 AM **SYMPOSIUM I: HUMERUS FRACTURES: SELECTING FIXATION FOR A SUCCESSFUL OUTCOME**

Moderators: *Hans-Christoph Pape, MD*
Michael McKee, MD

7:35 AM **Overview**
Michael D. McKee, MD

7:38 AM **Nonoperative Management: Indications**
Utku Kandemir, MD

7:48 AM **ORIF: Indications and Techniques**
Stefaan J. Nijs, MD

7:58 AM **Humerus Nonunion/Malunion**
Peter A. Cole, MD, FAOA

8:08 AM Discussion

Key: Δ = presentation was funded by an OTA administered grant
Names in bold = **Presenter**

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

8:15 – 8:50 AM

PAPER SESSION I: UPPER EXTREMITY

Moderators: *Hans-Christoph Pape, MD*
Michael McKee, MD

8:15 AM (p. 90) **PAPER 30**
Plate Fixation of Midshaft Clavicle Fractures for Delayed Union and Nonunion Is a Cost-Effective Intervention But Functional Deficits Persist at Long-Term Follow-up
***Benjamin James Fox MBChB**; Nicholas D. Clement; Deborah Jane Macdonald, BA; Christopher M. Robinson, MD; Jamie A. Nicholson, MBChB*

8:21 AM (p. 91) **PAPER 31**
Prospective Study: Functional Results of the Reverse Shoulder Fracture Prosthesis Versus Conservative Treatment and Plate Osteosynthesis in Displaced Multipart Proximal Humerus Fractures
***Leanne Stephanie Blaas, MD**; Charlotte M. Lameijer, MD, PhD; Jian Zhang Yuan, MD; Frank Bloemers, MD, PhD; Robert Jan Derksen, MD, MSc, PhD*

8:27 AM (p. 92) **PAPER 32**
Operatively Managed Distal Radius Fractures: Complications and Re-intervention Rates from a Single Centre
***Katrina Roxanne Bell, MBChB, MRCSED**; James Robert Balfour, MBChB; William M. Oliver, MBBS, MRCSED; Timothy O. White, MD; Samuel Molyneux, FRCS (Ortho), MSc; Nicholas D. Clement, MRCS Ed; Andrew David Duckworth, MBChB, MSc, PhD*

8:33 AM (p. 93) **PAPER 33**
3D Virtual Pre-Operative Planning Lowers the Risk of Dorsal Screw Penetration in Volar Plating of Intra-Articular Distal Radius Fractures
***Jasper Prijs, BS**; Bram Schoolmeesters, MD; Denise Eygendaal, MD; J.P. De Vries MD, PhD; Paul C. Jutte, MD, PhD; Job N. Doornberg, MS; Ruurd Jaarsma, FRACS; Frank Ijpma, MD, PhD*

8:39 AM Discussion

8:50 – 9:05 AM

SPECIAL INTEREST LECTURE:

8:50 AM **General Aspects of a Geriatric Fracture Care - Do We Have Evidence Based Results?**
TBD

9:05 AM Morning Break

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

9:20 – 10:05 AM — SYMPOSIUM II: PELVIC RING INJURIES: RECENT ADVANCES IN DIAGNOSIS AND TREATMENT

Moderators: *Paul S. Whiting, MD*
H. Claude Sagi, MD

9:20 AM **Overview**
H. Claude Sagi, MD

9:23 AM **High-Energy Injuries: Stopping the Bleeding**
Cyril Mauffrey, MD, MRCS

9:33 AM **Which Ring Injuries are Unstable?**
Hassan Mir, MD

9:43 AM **Unstable Injuries: Selecting the Right Approach and Fixation**
Milton Lee (Chip) Routt Jr, MD

9:53 AM Discussion

10:05 – 11:00 AM — PAPER SESSION II: PELVIS AND ACETABULUM

Moderators: *Paul S. Whiting, MD*
H. Claude Sagi, MD

10:05 AM (p. 94) **PAPER 34**
Urinary and Sexual Dysfunction Following Pelvic Fractures: A Retrospective Cross-Sectional Study
Elisa Wyllema, BS*; Oliver Brunckhorst, MBBS, MRCS; Kamran Ahmed, MBBS, PhD; Aswinkumar Vasireddy, MBBS*

10:11 AM (p. 95) **PAPER 35**
Pelvis and Acetabular Fractures - Patterns, Etiology, Management and Early Outcomes at a National Trauma Hospital In Eldoret Kenya
Victor Kipkemei Bargoria, MD

10:17 AM (p. 96) **PAPER 36**
Pelvic and Acetabular Fractures Secondary to Horse Riding: Experience From a Major Trauma Centre in England
Ali Hussain, MBChB*; Marios Ghobrial, MD; Benjamin Michael Davies DPHIL (OXON), FRCS (Ortho), MBBS; Peter Hull, MBChB,FRCS (Ortho); Andrew Douglas Carrothers, FRCS (Ortho), MD; Jaikirty Rawal, FRCS (Ortho), MA, MBBS; Daud Chou, FRCS (Ortho), MBBS, MSc*

10:23 AM Discussion

10:33 AM (p. 97) **PAPER 37**
Outcomes of Surgical Implant Generation Network (SIGN) Intramedullary Nail in Treatment of Lower Limb Implant Failure in Herat Regional Hospital, Herat Afghanistan
Sayed Sharif Hamed, MD; ***Mohammad Jawad Nazari, BA***

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

10:39 AM (p. 98) **PAPER 38**
Preventable Trauma Deaths and Corrective Actions to Prevent Them: A 10-Year Comparative Study at the Komfo Anokye Teaching Hospital, Kumasi, Ghana
Dominic Konadu-Yeboah, MPH

10:45 AM (p. 99) **PAPER 39**
Experience and Outcomes of the SIGN FIN Nail in the Treatment of Fractures of the Femoral Shaft
Kebba Marenah MBBS, MRCS

10:51 AM Discussion

11:00 – 11:53 AM

SYMPOSIUM III: PILON FRACTURES - CONSENSUS AND CONTROVERSY

Moderators: *Theodore Miclau III, MD*
Ross K. Leighton, MD

11:00 AM **Overview**
Theodore Miclau III, MD

11:03 AM **Surgical Approaches in Pilon Fractures**
David Shearer, MD

11:13 AM **Preventing Complications: Pre- and Post-op Strategies**
Stephen Kottmeier, MD

11:23 AM **ORIF vs. Fusion: What are the Indications?**
Boris A. Zelle, MD

11:33 AM **Complex Open Pilon Fractures: Limb Salvage vs. Amputation**
Joseph R. Hsu, MD

11:43 AM Discussion

11:53 AM Proceed to Ballroom C

12:05–1:00 PM *(Ballroom C)*
INDUSTRY LUNCH (No CME credits offered)
Zimmer Biomet
Current Topics in Clavicle Fracture Management
Speaker: ***Anil Dutta, MD***
Box lunch provided by OTA.

1:00 PM Return to Meeting Room 202 CD

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

1:05 – 1:48 PM

SYMPOSIUM IV: TIBIAL NAILING: PUSHING THE LIMITS

Moderators: *Zsolt J. Balogh, MD, PhD*
Mark Lee, MD
Paul Whiting, MD

1:05 PM **Overview**
Mark Lee, MD

1:08 PM **Proximal Fractures: Challenges, Tricks and Outcomes**
Christian Krettek, MD, FRACS

1:18 PM **Midshaft Segmental Fractures: Benefits and Limits**
Sean Nork, MD

1:28 PM **Distal Fractures: Is Nailing Superior?**
Heather A. Vallier, MD

1:38 PM Discussion

1:48 – 2:44 PM

PAPER SESSION III: LOWER EXTREMITY

Moderators: *Zsolt J. Balogh, MD, PhD*
Mark Lee, MD
Paul Whiting, MD

1:48 PM
(p. 100)
PAPER 40
Functional Outcome of Distal Fibula Fractures Comparing Conventional AO-Semitubular Plating to Minimally Invasive Intramedullary "Photodynamic Bone Stabilization"
Michael Wiktor Zyskowski, MD*; Frederik Greve, MD; Markus Wurm, MD; Sebastian Pesch, MD; Patrick Pflüger, MD; Michael Müller, MD; Peter Biberthaler, MD; Chlodwig Kirchhoff, MD*

1:54 PM
(p. 101)
PAPER 41
Humanitarian Scholar – Nepal
Use of Kirschner Wires and Sutures for Anchorage of Partial Avulsion of Heel Pad
Devendra S. Bhat, MS*; Tul Bahadur Pun, MS; Dawa Lama, MS; Abhishek Jirel, MS*

2:00 PM
(p. 102)
PAPER 42
Post-Operative CT Scan Findings and Functional Outcome In Patients Treated by Syndesmotaxis with an Ilizarov External Fixator for Tibial Plateau Fractures
Stamatios A. Papadakis, MD, PhD, MSc*; Dimitris Pallis, MD, MSc; Georgios Gourtzelidis, MD; Margarita-Machaela Ampadiotaki, MD; Konstantinos Kateros, MD; George Anastasios Macheras, MD, PhD*

2:06 PM Discussion

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

2:16 PM (p. 103) **PAPER 43**
Management of Open Tibia Fractures in Cuba
Horacio Tabares Sáez, MD; ***Madeline Mackechnie, MA****;*
Patrick Albright, MD, MS; Horacio Tabares Neyra, MD, PhD; Theodore Miclau, MD

2:22 PM (p. 104) **PAPER 44**
Individualized Determination of Mechanical Fracture Environment and Healing Potential in Tibial Fractures: Clinical Feasibility of a Novel Simulation Workflow
Benedikt J. Braun, MD*; Michael Roland, PhD; Marcel Orth, MD*

2:28 PM (p. 105) **PAPER 45**
Δ **A Pilot, Masked, Randomized Controlled Trial to Evaluate Local Gentamicin Versus Saline in Open Tibia Fractures**
Billy Thomson Haonga, MD; Nae Yeon Won, BA, MPH; Ericka Von Kaeppler, BS; Claire Donnelley, BS; Edmund Ndalama Eliezer, MD, MMed; Mayur Urva, BS; Abigail Cortez, MD; Saam Morshed, MD; ***David Shearer, MD***

2:34 PM Discussion

2:44 PM Afternoon Break

3:00 – 3:43 PM SYMPOSIUM V: HIP FRACTURE MANAGEMENT: OPTIMIZING OUTCOMES

Moderators: *Hans-Christoph Pape, MD*
Emil Schemitsch, MD

3:00 PM **Overview**
Hans-Christoph Pape, MD

3:03 PM **Developing an Orthogeriatric Program: Key Steps**
Meir Marmor, MD

3:13 PM **Multicenter Studies: Is There Enough Evidence to Change Practice?**
Gerard Slobogean, MD, MPH

3:23 PM **Hip Fracture Augmentation: Techniques and Outcomes**
Thomas A. (Toney) Russell, MD

3:33 PM Discussion

Δ OTA Grant

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3:43 – 4:50 PM

PAPER SESSION IV: GERIATRIC

Moderators: *Hans-Christoph Pape, MD*
Emil Schemitsch, MD

3:43 PM (p. 106) **PAPER 46**
Clinical Frailty Score on Admission Predicts 30-Day Survival, Post-operative Complications and Institutionalization in Patients with Fragility Hip Fractures: A Cohort Study of 1255 Patients
***Adeel Ikram, MBBS, MRCS**; Alan Norrish, FRCS (Ortho); Ben Marson, MBBS; Simon John Craxford, MBBS; John Gladman, MD; Benjamin Ollivere, MD, MA, MBBS*

3:49 PM (p. 107) **PAPER 47**
A Novel Mesh-Free Method for Accurately Simulating the Crushing and Cracking Behavior of Trabecular Bone Tissue with a Wide Range of Clinically Relevant Bone Mineral Density Values
***Sloan Austin Kulper, PhD**; Tsui Hin Lin, BA; Xiaodan Ren, PhD; Dana Joseph Coombs, MS; Michael Bushelow, MS; Evan Fang, BS; Ahmed Abbas Alvi, BS; Erica Ueda, PhD; Teng Zhang, PhD; Christian Xinshuo Fang, FRCS (Ortho), MBBS*

3:55 PM (p. 108) **PAPER 48**
Is the Use of Short Cephalomedullary Nails a Risk Factor for Thigh Pain and Re-fractures?
***R. D. Iyer, MBBS, MS**; Siddharth Dubey, MBBS; Bhaskar Sarkar, MS*

4:01 PM (p. 109) **PAPER 49**
Osteotomy and Intramedullary Nailing for Incomplete Diaphyseal Atypical Femoral Fracture with Increased Anterolateral Bowing
*Chang-Wug Oh, MD; **Kyeong Hyeon Park, MD**; Joon-Woo Kim, MD, PhD*

4:07 PM
Discussion

4:17 PM (p. 110) **PAPER 50**
For the Better Outcome for Hip Fracture Patients: The First Orthogeriatric Co-management in Japan
Takahiro Waki, MD

4:23 PM (p. 111) **PAPER 51**
Multidisciplinary Approach to Prevent Secondary Fractures After Geriatric Hip Fractures: What Has Changed After This Approach?
***Etsuo Shoda, MD**; Shimpei Kitada, MD*

4:29 PM (p. 112) **PAPER 52**
Teaching the "HECTOR" Approach to Daily Reviews Results In Sustained Improvements In Medical Management of Elderly Trauma Patients
***Robyn Brown, MBBS, MRCS, MSc**; Lucy Alice Radmore, MBBS, MRCS; Joseph Dow, MBBS; Fatumata Binta Jalloh, BS, PA; Ella Saitch, MBChB; Noel Peter, FRCS (Ortho)*

4:35 PM
(p. 113)
PAPER 53

Excess Death in Fragility Fracture Patients During the First Wave May Be Due to Altered Care Pathways

Adeel Ikram, MBBS, MRCS*; Alan Norrish, FRCS (Ortho); Luke Paul Ollivere, MSc, PhD; Ana M. Valdes, MA, PhD; Benjamin Ollivere, MD, MA, MBBS*

4:41 PM Discussion

4:50 PM Adjourn for the Day

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Level 2 - Ballroom Lobby
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ORTHOPAEDIC TRAUMA ASSOCIATION

2021 International Trauma Care Forum

THURSDAY, October 21, 2021

Ballroom C and Room 202 CD

International Trauma Care Forum and Basic Science Focus Forum will have their combined symposium in Ballroom C

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(Room 104)

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(Ballroom C)

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Hans-Christoph Pape, MD

(Ballroom C)
7:35 – 8:35 AM

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Hans-Christoph Pape, MD

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Hans-Christoph Pape, MD

8:15 AM **Putting It All Together: A Comprehensive Approach to Nonunion Management**
Aaron Nauth, MD

8:25 AM Discussion

8:35 AM Break/Proceed to Meeting Room 202 CD

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8:50 – 9:05 AM **KEY NOTE LECTURE:**

8:50 AM **Digital Health and Orthopaedics**
Edward J. Harvey, MD, MSc

9:05 – 10:00 AM **PAPER SESSION V: GENERAL INTEREST PAPERS**

Moderators: *Theodore Miclau III, MD*
Florian T. Gebhard, MD, PhD

9:05 AM (p. 114) **PAPER 54**
Orthopedic Trauma Research Priorities in Latin America: Developing Consensus through a Modified Delphi Approach
***Heather Roberts, MD**; Madeline Mackechnie, MA; Theodore Miclau, MD; Julio Segovia, MD; Fernando De La Huerta, MD; Marcelo Rio, MD; Carlos Guillermo Sanchez Valenciano, MD; David Shearer, MD*

9:11 AM (p. 115) **PAPER 55**
Prevalence and Sociodemographic Characteristics of Post-traumatic Stress Disorder in Adult Orthopaedic Trauma Patients in a Ugandan Referral Hospital
***Alexis Dun Bo-Ib Buunaaim, MMED (Ortho)**; Catherine Adito Abbo, MBChB, PhD; Patrick Sekimpi, MMED (Ortho)*

9:17 AM (p. 116) **PAPER 56**
Public Patronage and Its Associated Factors Toward Traditional Bonesetting for Musculoskeletal Injury Management: A Cross-Sectional Study
Wubshet Aderaw Workneh, MD

9:23 AM Discussion

9:33 AM (p. 117) **PAPER 57**
Effect of Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) with Hydroxyapatite (HA) Carrier in Induced Membrane Technique (IMT): A Retrospective Propensity Score-matched Study
***Whee Sung Son, MD**; Jae-Woo Cho, PhD; Wonseok Choi, MD; Han-Ju Kim, MD; Eic Ju Lim, MD; Seungyeob Sakong, MD; Jong-Keon Oh, MD, PhD*

9:39 AM (p. 118) **PAPER 58**
CT-Based L1 Bone Mineral Density in Dutch Trauma Patients: Are North American Reference Values Valid in Europe?
***Tim Kobes, MD**; Arthur A.R. Sweet, MD; Sophie Brigitte Helena Verstegen, BS; Marijn Houwert, MD, PhD; Wouter B. Veldhuis, MD, PhD; Luke Leenen, FACS, MD, PhD; Pim De Jong, MD, PhD; Mark Van Baal, MD, PhD*

9:45 AM (p. 119) **PAPER 59**
Humanitarian Scholar – Philippines
Shifting to an App-Based Method of Preoperative Templating in Orthopaedic Surgery
***Chloe Marie Samarita, MD**; Juan Agustin Coruna IV, MD; Jose Maria Coruna, MD*

9:51 AM Discussion

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

10:00 – 11:05 AM

SYMPOSIUM VII: IOTA SYMPOSIUM OPEN FRACTURES: CURRENT TREATMENT PERSPECTIVES

Moderators: *Theodore Miclau III, MD*
Sushrut Babhulkar, MD

10:00 AM **Overview**
Theodore Miclau III, MD

10:03 AM **Antibiotic Administration: Type, Timing, and Route**
Hiroaki Minehara, MD

10:13 AM **Surgical Timing: Which Fractures, What Time?**
Rafael Amadei, MD

10:23 AM **Critical Sized Bone Defects: Current Evidence**
Achille Contini, MD

10:33 AM **Wound Coverage: Vacs to Flaps – When and How**
Michael Kelly, MD

10:43 AM **Open Fractures: What are the Top Research Questions?**
Emil Schemitsch, MD

10:53 AM Discussion
All Faculty

11:05 am Adjourn to
INDUSTRY LUNCH SYMPOSIA *(On-site Registration Available)*
Boxed lunch provided by OTA.

ORTHOPAEDIC TRAUMA ASSOCIATION

2021 Annual Meeting

October 21-23, 2021

Exhibit Hall B & C

Program Committee

Stephen A. Kottmeier, MD, Chair
Gerard P. Slobogean, MD, MPH, FRCSC, Co-Chair
Animesh Agarwal, MD
Andrew M. Choo, MD
Brett D. Crist, MD
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Edward J. Harvey, MD
Kelly A. Lefaivre, MD, FRCSC
Nirmal C. Tejwani, MD, FRCS
Harmeeth S. Uppal, MD, MS, FACS

Learning Objectives

After attending the OTA Annual Meeting, participants will be able to:

- Assess the efficacy of new treatment options through evidence-based data
- Recognize that there is a still a roll for nonoperative treatment of fractures and identify when to abandon nonsurgical treatment plans
- Evaluate various nonsurgical and surgical treatment options in musculoskeletal injury management
- Synthesize the most current research study findings in pelvic fracture management
- Interpret relevant clinical practice guidelines for pain management, augmentation of fracture repair and revision surgery.

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

2021 Annual Meeting

Thursday, October 21, 2021

Exhibit Hall B & C

6:00 AM	**Speaker Ready Room** *(Room 104)*
6:15 AM	**Registration** *(13th Street Lobby)*
7:00 – 7:30 AM	**Meditation** *(Room 101)*
11:15 AM	**INDUSTRY LUNCH SYMPOSIA** *(On-site Registration Available)* Boxed Lunch Included
1:00 1:20 PM	**Welcome and Donor Awards** ***Heather A. Vallier, MD,*** *President* ***Stephen A. Kottmeier, MD,*** *Program Chair*
1:20 1:25 PM	**Local Host Welcome** ***Cory A. Collinge, MD***

Exhibit Hall B & C

1:25 – 2:55 PM

SYMPOSIUM I:
HOW CAN THE OTA SUPPORT YOUR WELL-BEING?
A Panel Discussion and Town Hall on Sustaining Your Career via Advocacy, Leadership and Wellness

Moderator: *Jeffrey M. Smith, MD*

OTA Wellness Task Force Directives
Matthew R. Garner, MD

Why We Should Measure the Wellness and Well-Being of Our Members
Philip R. Wolinsky, MD

Career Satisfaction through Leadership and Professional Development
Heather A. Vallier, MD

How to Collectively Advocate for Wellness
Anna Miller, MD

Keynote - "A Bad Day is Not a Life Sentence - Learning to Process Experience"
Preston B. Cline, EdD

How Can the OTA Support Your Well-Being?
A Panel Discussion and Town Hall on Sustaining Your Career via Advocacy, Leadership and Wellness
Panel Moderator: *Jeffrey M. Smith, MD*
Panelists: *Thomas M. Large, MD; Ben Caesar, MD; Anna Miller, MD; Jeffrey M. Smith, MD; Preston B. Cline, EdD*

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Town Hall Discussion

Strategies for Surgeon Wellness
Jeffrey M. Smith, MD

2:55 – 3:35 PM Refreshment Break
Visit Scientific Posters & Technical Exhibits *(Exhibit Hall A)*

Exhibit Hall B & C

SCIENTIFIC PAPER SESSION I: PROGRAM HIGHLIGHTS

3:35 – 4:45 PM

Moderators - Stephen A. Kottmeier, MD & Gerard Slobogean, MD, MPH

3:35 PM (p. 123) **PAPER 60**
A Randomized Controlled Trial Comparing Operative and Nonoperative Treatment of Humeral Diaphyseal Fractures
Stephane Bergeron, MD; Prism Schneider, MD; Allan Liew, FRCSC; Hans J. Kreder, MD, MPH; ***Gregory Berry, MD***

3:41 PM (p. 124) **PAPER 61**
Is the Use of Bipolar Hemiarthroplasty Over Monopolar Hemiarthroplasty Justified? A Propensity Score-Weighted Analysis of a Multicenter Randomized Controlled Trial
Marianne Comeau-Gauthier, MD*; Sofia Bzovsky, MSc; Mohit Bhandari, MD, PhD; Daniel Axelrod, MD; Rudolf W. Poolman, MD, PhD; Frede Frihagen, MD, PhD; Sheila Sprague, PhD; Emil H. Schemitsch, MD; HEALTH Investigators*

3:47 PM (p. 125) **PAPER 62**
A Prospective Randomized Controlled Trial Comparing Subcutaneous Enoxaparin and Oral Rivaroxaban for Venous Thromboembolism Prophylaxis in Orthopaedic Trauma Patients
Mitchell P. John, MD*; Benjamin D. Streufert, MD; Hassan Riaz Mir, MD, MBA; Katheryne Downes, PhD*

3:53 PM Discussion

3:58 PM (p. 126) **PAPER 63**
Intraoperative Hematoma Block Decreases Postoperative Pain and Narcotic Consumption After Intramedullary Rodding of Femoral Shaft Fractures: A Randomized Control Trial
Alex Yue, MD*; Nihar Samir Shah, MD; Robert Matar, MD; Ramsey Samir Sabbagh, MS; H. Claude Sagi, MD*

4:04 PM (p. 127) **PAPER 64**
Δ Periarticular Multimodal Analgesia Decreases Postoperative Pain in Tibial Plateau Fractures: A Double Blind Randomized Controlled Pilot Study
Patrick Kellam, MD*; Graham J. DeKeyser, MD; Lucas S. Marchand, MD; Thomas F. Higgins, MD; David L. Rothberg, MD; Justin Haller, MD*

Key: Δ = presentation was funded by an OTA administered grant
Names in bold = **Presenter**

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4:10 PM (p. 128) **PAPER 65**

Definitive Flap Coverage Within 48 Hours of Definitive Fixation Reduces Deep Infection Rate in Open Tibial Shaft Fractures Requiring Flap Coverage

***Paul Tornetta III, MD**; Khalid Al-Hourani, MD; Jeff J. Foote, MD, MSc; Andrew D. Duckworth, MBChB, MSc, PhD; Timothy O. White, MD; Michael Kelly MBBS, MD; Michael T. Stoddart, MBBS; Justin J. Koh, MD; Stephen A. Sems, MD; Mhd Tayseer Shamaa, MBBS; Debi Sorg, RN; Hassan Riaz Mir, MD, MBA; Benjamin D. Streufert, MD; Clay A. Spitler, MD; Brian Mullis, MD; John C. Weinlein, MD; Lisa K. Cannada, MD; Emily Wagstrom, MD; Jerald Westberg, BA; Abigail Cortez, MD; Peter C. Krause, MD; Andrew J. Marcantonio, DO; Gillian Soles, MD; Jason Lipof, MD; Ross K. Leighton, MD; Michael J. Bosse, MD; Chad Coles, MD; Jowan G. Penn-Barwell, MB ChB; Joseph R. Hsu, MD; Aleksi Reito, MD, PhD; Heather A. Vallier, MD; Saam Morshed, MD*

4:16 PM Discussion

4:21 PM (p. 129) **PAPER 66**

Operative Versus Non-Operative Treatment of Severely Shortened or Comminuted Clavicle Fractures in Older Adolescent Athletes: Results from a Prospective, Multicenter, Level 2 Cohort Study

***David D. Spence, MD**; Philip L. Wilson, MD; Donald S. Bae, MD; Michael T. Busch, MD; Eric W. Edmonds, MD; Henry B. Ellis, MD; Katelyn A. Hergott, MPH; Mininder S. Kocher, MD, MPH; G. Ying Li, MD; Elizabeth Liotta, MBBS; Jeffrey J. Nepple, MD; Nirav K. Pandya, MD; Andrew T. Pennock, MD; Crystal A. Perkins, MD; Coleen S. Sabatini, MD, MPH; David N. Williams, PhD; Samuel C. Willimon, MD; Benton E. Heyworth, MD*

4:27 PM (p. 130) **PAPER 67**

Risk of Iatrogenic Sciatic Nerve Injury During Posterior Acetabular Fracture Fixation: Does Patient Position Matter?

***Jason Yunti Chen, MD**; Ishani Sharma, BA; Joshua Everhart, MD, MPH; Ramsey S. Sabbagh, MS; Nakul Narendran, BA; Michael T. Archdeacon, MD, FAAOS; H. Claude Sagi, MD; Brian Mullis, MD; Roman Natoli, MD*

4:33 PM (p. 131) **PAPER 68**

The Effect of Anterior Support Screw (AS2) for Unstable Femoral Trochanteric Fractures: A Multicenter Randomized Controlled Trial

***Takashi Maehara, MD, PhD**; Hiroyuki Suzuki, MD; Tomohiko Shimizu, MD; Takahiro Hamada, MD; Masanori Yorimitsu, MD; Hidefumi Teramoto, MD, PhD; Kazushi Mihara, DC; Takao Mae, MD; Takashi Hayakawa, MD; Yasunori Okamoto, MD; Takeshi Doi, MD; Yoshihisa Anraku, MD; Jun Hara, MD*

4:39 PM Discussion

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

4:45 – 5:15 PM

President's Message

(Exhibit Hall B & C)

"The Courage to Heal: Building Resilience and Transforming Recovery"

Heather A. Vallier, MD
OTA President
Professor of Orthopaedic Surgery
Case Western Reserve University
MetroHealth System – Cleveland, Ohio

Introduction: Brendan M. Patterson, MD

5:15 – 6:15 PM **OTA Business Meeting**
(Members Only)

5:15– 6:15 PM **Happy Hour – Exhibitor Reception** *(Exhibit Hall A)*
*(Sponsored by **OsteoCentric Technologies**)*

6:20 – 8:20 PM **WELCOME RECEPTION** *(The Water Gardens)*
Join your colleagues for cocktails and hors d'oeuvres at the Water Gardens.

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ORTHOPAEDIC TRAUMA ASSOCIATION

2021 Annual Meeting

Friday, October 22, 2021

Exhibit Hall B & C

6:00 AM	**Speaker Ready Room** *(Room 104)*
6:15 AM	**Registration** *(13th Street Lobby)*
6:30 – 7:30 AM	**Concurrent Breakout Sessions –** Seating available first come, first-served.
6:30 AM	**Continental Breakfast** *(Outside Breakout Session Rooms)*

6:30 – 7:30 AM — CONCURRENT BREAKOUT SESSIONS

Pelvic and Acetabulum Fractures *(Exhibit Hall B&C)*
Moderator: *Paul Tornetta III, MD*
Faculty: *David C. Templeman, MD; Reza Firoozabadi, MD; Michael S. Kain, MD; Andrew H. Schmidt, MD*

From Fixation to Revision in Periprosthetic and Interprosthetic Hip & Knee Fractures: When, How and Getting it Right *(Room 201 AB)*
Moderator: *Frank A. Liporace, MD*
Faculty: *Richard S. Yoon, MD; Derek J. Donegan, MD, MBA; Mark Gage, MD*

Managing Complex Humerus Fractures: From Proximal to Distal *(Room 203 AB)*
Moderator: *Andrew M. Choo, MD*
Faculty: *Timothy S. Achor, MD; Michael J. Gardner, MD; Eben A. Carroll, MD*

The Traumatized Midfoot: Tips and Tricks for Successful Reconstruction *(Room 203 CD)*
Moderator: *Harmeeth S. Uppal, MD, MS*
Faculty: *Brad J. Yoo, MD; Gregory John Della Rocca, MD, PhD, FAAOS, FACS; Stephen K. Benirschke, MD*

Challenges in Non-union Treatment - A Case-Based Symposium *(Room 204 AB)*
Moderator: *Paul S. Whiting, MD*
Faculty: *J. Spence Reid, MD; Gerald J. Lang, MD; David Goodspeed, MD*

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Exhibit Hall B & C

7:30 – 9:00 AM

SYMPOSIUM II: HOT OFF THE PRESS: LATEST RANDOMIZED CONTROLLED TRIALS THAT CAN CHANGE YOUR PRACTICE IN 2021

Moderator: *Niloofar Dehghan, MD, MSc*

Flail Chest Injuries – Does Surgery Improve Outcomes? Who Benefits from Fixation?
Niloofar Dehghan, MD, MSc

What's the Verdict on Vancomycin Powder? Will It Help Decrease Infections?
Robert V. O'Toole, MD

Should I Recommend Routine Vitamin D Supplementation to my Patients? Will It Improve Fracture Union?
Gerard Slobogean MD, MPH

Negative Pressure Wound Therapy for Open Fractures: We Use It, but Does It Work, and Is It Worth the Cost?
Tim Chesser, FRCS

Syndesmosis Injuries: Should I Use Tightrope Instead of Screws?
Prism Schneider, MD, PhD

Cephalomedullary Nail for Hip Fracture Fixation – Can I Use a Short Nail or Should It Be Long?
Steven F. Shannon, MD

Hip Fracture in Elderly: Does THA have Better Outcomes Compared to Hemiarthroplasty?
Emil H. Schemitsch, MD

9:00 – 9:40 AM Break
Visit Scientific Posters & Technical Exhibits *(Exhibit Hall A)*

9:40 – 11:06 AM **Concurrent Sessions**
(General Session and Breakout Sessions run concurrently.)
Paper Session II: Foot, Ankle, Pilon & Hip and Femur (9:40 – 11:06 AM)
Concurrent Breakout Sessions (10:00 – 11:00 AM)

Exhibit Hall B & C

9:40 – 11:06 AM

SCIENTIFIC PAPER SESSION II: FOOT, ANKLE, PILON & HIP AND FEMUR

Moderators - Gregory Della Rocca, MD, PhD, FACS & Lori Reed, MD

9:40 AM
(p. 132)
PAPER 69

Prospective Randomized Controlled Trial: Early Weight Bearing After Conservative Treatment of Weber B Ankle Fractures
Robert C. Stassen, MD*; Stijn Franssen, MD; Erik De Loos, MD; Berry Meesters, MD; Bert Boonen DMed; Raoul Van Vugt, MD, PhD*

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FRIDAY, OCTOBER 22, 2021

9:46 AM (p. 133) **PAPER 70**
Does Hindfoot Nailing Decrease Unplanned Return to the Operating Room After Geriatric Open Ankle Fracture?
Richard Wawrose, MD*; Mitchell Fourman, MD; Brendan Casey, DO; Joshua N. Adjei, MD; Gele Moloney, MD; Peter A. Siska, MD; Ivan S. Tarkin, MD*

9:52 AM (p. 134) **PAPER 71**
Fractures and Macroscopic Osteochondral Injuries of the Talar Dome Associated with Pilon Fractures
Kevin Tetsworth, MD*; Nicholas Green, BS; Gregory Barlow, MD; Miran Stubican, MD; Frode Vindenes, MD; Vaida Glatt, PhD*

9:58 AM (p. 135) **PAPER 72**
Is the Sinus Tarsi Approach Safer Than the Extended Lateral Approach for Calcaneal Fractures?
Thomas M. Seaver, MD*; Zachary Zeller, MD; Paul Tornetta III, MD; Andrew J. Marcantonio, DO; Alexander J. Ment, BA; Hassan Riaz Mir, MD, MBA; Randi Alexander, MPH; Mitchell K. Messner, MD; Clay A. Spitler, MD; Erin L. Hofer, MD; Anna N. Miller, MD; Jerald Westberg, BA; Jessica M. Downes, MD; Noah Joseph, MD; Heather A. Vallier, MD; Yu Min Suh, MD; Robert F. Ostrum, MD; Benjamin Ollivere, MD, MA, MBBS; Adeel Ikram, MBBS, MRCS; Brian Mullis, MD; Jorge Figueras, BS; Darin M. Friess, MD; Emelia Sodders, MS; Noelle L. Van Rysselberghe, MD; Michael J. Gardner, MD; Amanda Pawlak, MD; Stephen Kottmeier, MD; Saam Morshed, MD; Zachary Lim, MD; Aden Malik, MD; Lawrence H. Goodnough, MD; Eli W. Bunzel, MD; Reza Firoozabadi, MD; Patrick Yoon, MD*

10:04 AM Discussion

10:09 AM (p. 136) **PAPER 73**
Δ Patients with Hip Fractures Treated with Arthroplasty Demonstrate Prolonged Hypercoagulability and Increased Venous Thromboembolism Risk
Daniel You, MD*; Robert Korley, MD; Richard E. Buckley, MD; Paul J. Duffy, MD; Ryan Martin, MD; Andrea Soo, PhD, MSc; Prism Schneider, MD, PhD*

10:15 AM (p. 137) **PAPER 74**
Who, if Anyone, May Benefit from a Total Hip Arthroplasty After a Displaced Femoral Neck Fracture? A Subgroup Analysis of the HEALTH Trial
Frede Frihagen, MD, PhD; Marianne Comeau-Gauthier, MD; Daniel Axelrod, MD; ***Sofia Bzovsky, MSc****; Rudolf W. Poolman, MD, PhD; Diane Heels-Ansdell, MSc; Mohit Bhandari, MD, PhD; Sheila Sprague, PhD; Emil H. Schemitsch, MD; HEALTH Investigators*

10:21 AM (p. 138) **PAPER 75**
Surgical Approach and Dislocation Rate Following Hemiarthroplasty in Geriatric Femoral Neck Fracture Patients with Cognitive Impairment: Is There an Association?
Miles S. Parsons, MD; ***Brian J. Page, MD****; Joshua Ho-Sung Lee, MD; Joel Dennison, MD; Kendall A. Pye Hammonds, MPH; Kindyle L. Brennan, PhD; Michael L. Brennan, MD; Daniel L. Stahl, MD*

10:27 AM Discussion

Δ OTA Grant

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

10:32 AM (p. 139) **PAPER 76**
Peri-Implant Femur Fractures After Intertrochanteric Hip Fractures Occur Late and are More Common in Short Nails in Long-term Follow-up
Patrick Curtin, MD; *Laura Thurber, BA; Gregory Iovanel; Daniel Mandell, MD; Eric F. Swart, MD*

10:38 AM (p. 140) **PAPER 77**
Risk Factors for Non-union of Distal Femur Fractures
Ryan Cone, MD; Kyle Cichos, BS; Yvonne E. Chodaba, MD; ***Alexander Roszman, MD***; *Gerald McGwin, MS, PhD; Clay A. Spitler, MD*

10:44 AM Discussion

10:49 AM (p. 141) **PAPER 78**
Midterm Outcomes After the Surgical Treatment of Atypical Femoral Fractures: Minimum 3-Year Follow up
Kyu-Tae Hwang, PhD; *Soo-Young Jeong, MD; Chang-Wug Oh, MD; Joon-Woo Kim, MD, PhD; Oog Jin Shon, MD, PhD; Ji Wan Kim, MD; Youngho Cho, MD; Ki Chul Park*

10:55 AM (p. 142) **PAPER 79**
Risk Factors for Early Conversion Total Hip Arthroplasty after Pipkin 4 Femoral Head Fracture
Kyle Cichos, BS; Patrick F. Bergin, MD; Parker A. White, MD; Elie S. Ghanem, MD; ***Clay A. Spitler, MD***; *Gerald McGwin, MS, PhD*

11:01 AM Discussion

10:00 – 11:00 AM CONCURRENT BREAKOUT SESSIONS

Navigating Work and Life Stressors as an Orthopaedic Traumatologist *(Room 204 AB)*
Moderator: *Matthew R. Garner, MD*
Faculty: *Derek J. Donegan, MD, MBA; Milton L. Routt, MD; Milton T. M. Little, MD; Jonah Hebert-Davies, MD*

Treatment of Supracondylar Femur Fractures: Plating, Nailing and Nonunions *(Room 202 CD)*
Moderator: *Frank A. Liporace, MD*
Faculty: *Michael A. Maceroli, MD; Richard S. Yoon, MD; John P. Ketz, MD; Marcus F. Sciadini, MD*

Diversity and Inclusion in Orthopaedic Trauma *(Room 203 AB)*
Moderator: *Joseph R. Hsu, MD*
Faculty: *Anna N. Miller, MD; Hassan R. Mir, MD, MBA; Paul B. Gladden, MD; Heather A. Vallier, MD*

Bringing Your Idea to Market-The Innovation Dream *(Room 201 AB)*
Moderator: *Edward J. Harvey, MD*
Faculty: *Charles Allan; Thomas A. Russell, MD; Ross K. Leighton, MD; Dominique Rouleau, MD*

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11:06 AM –
11:51 AM

John Border, MD Memorial Lecturer

(Exhibit Hall B & C)

Noah Galloway
Military veteran who served in Iraq and was severely injured in combat. He shares his struggles and triumphs to help motivate and inspire others to live their best life.

"Living with No Excuses"

11:51 AM –
12:21 PM

Immediate Past President's Message

(Exhibit Hall B & C)

"Orthopaedics in 2021: A View from Both Sides of the 49th Parallel"

Michael D. McKee, MD
OTA Immediate Past President
Professor and Chairman, Department of Orthopaedic Surgery
University of Arizona College of Medicine–Phoenix Banner University Medical Center Phoenix

Introduction: Emil H. Schemitsch, MD

12:21 –
1:21 PM

Lunch in Exhibit Hall
Visit Scientific Posters & Technical Exhibits *(Exhibit Hall A)*

12:21 –
1:21 PM

ORTHOPAEDIC TRAUMA ASSOCIATION

New Member Luncheon
(Room 121 C)

12:21 –
1:21 PM

Women in Orthopaedic Trauma
Kathy Cramer, MD Memorial Luncheon
(Room 121 B)

Chair: *Emily Wagstrom, MD*
Co-Chair: *Mai Nguyen, MD*

With special thanks and support from PFS Med, Inc.

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

12:34 – 1:14 PM — LUNCHTIME GUIDED POSTER AND VIDEO TOURS

(PT1) **Knee/Tibia** *(Exhibit Hall A)*
Guide: *Robert V. O'Toole, MD*

(PT2) **General Interest** *(Exhibit Hall A)*
Guide: *Michael J. Gardner, MD*

(VT) **Video Tours** *(Exhibit Hall A)*
Guide: *James A. Blair, Jr., MD*

1:21 – 3:27 PM **Concurrent Sessions**
(General Session and Breakout Sessions run concurrently.)
Paper Session III: Geriatric Fractures and Peds (1:21 – 2:30 PM)
Concurrent Breakout Sessions (1:50 – 2:50 PM)
Paper Session IV: Pelvis and Acetabulum (2:30 – 3:27 PM)

Exhibit Hall B & C — SCIENTIFIC PAPER SESSION III: GERIATRIC FRACTURES AND PEDS

1:21 – 2:30 PM — **Moderator - Edward J. Harvey, MD**

1:21 PM (p. 143) **PAPER 80**
Hip Fracture with Elevated Troponin: Harbinger of Mortality or Need for Accelerated Surgery?
Jocelyn Wu, BA; Nathan N. O'Hara, MHA; Nicholas Rolle, BS; Flavia K. Borges, PhD; P.J. Devereaux, MD; ***Gerard Slobogean, MD, MPH***

1:27 PM (p. 144) **PAPER 81**
Risk of Conversion to Total Hip Arthroplasty Following Hemiarthroplasty for Hip Fracture
Kanu M. Okike, MD, MPH*; Kathryn E. Royse, MPH, MSPH, PhD; David W. Zeltser, MD; Gurpreet Singh, MD; Liz Paxton, PhD, MA*

1:33 PM (p. 145) **PAPER 82**
Persistent Opioid Usage Following Hip Fracture Surgery in Opioid-Naïve Older Patients
Kanu M. Okike, MD, MPH*; Richard N. Chang, MPH; Priscilla H. Chan, MS; Liz Paxton, PhD, MA; Heather A. Prentice, PhD*

1:39 PM Discussion

1:44 PM (p. 146) **PAPER 83**
The Results: NIHR Feasibility Randomized Controlled Trial: Acetabular Fractures in Older Patients Intervention Trial (AceFIT)
Andrew D. Carrothers, FRCS (Ortho)*; Joseph Alsousou, MD; Daud Chou, FRCS (Ortho); Jaikirty Rawal, FRCS (Ortho); Joseph M. Queally, MD; Peter Hull, MBChB*

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FRIDAY, OCTOBER 22, 2021

1:50 PM (p. 147) **PAPER 84**
Outcomes for Geriatric Proximal Humerus Fractures: A Matched Comparison of Nonoperative Management and Reverse Shoulder Arthroplasty
Steven Samborski, MD; ***Brittany Haws, MD****; Steven Karnyski, MD; Kyle T. Judd, MD; Catherine A. Humphrey, MD, MBA; Gillian Soles, MD; John T. Gorczyca, MD; Ilya Voloshin, MD; Gregg T. Nicandri, MD; John P. Ketz, MD*

1:56 PM (p. 148) **PAPER 85**
Intravenous Tranexamic Acid Given at Femoral Fragility Fracture Surgery Reduces Blood Transfusion Requirements Fourfold
Matilda Powell-Bowns, MBChB, MEd, MRCS; Rhys K. Olley, MBChB; Conor McCann, MBChB; James R. Balfour, MBChB; Caitlin M. Brennan MBChB, MRCS; Jasmine Peh, MBChB; Andrew D. Duckworth, MBChB, MSc, PhD; ***Chloe Scott, FRCS***

2:02 PM Discussion

2:07 PM (p. 149) **PAPER 86**
Long-Leg Versus Short-Leg Cast Immobilization for Displaced Distal Tibial Physeal Fractures
Christopher D. Souder, MD*; James Spearman, MD; Lori A. Thornton, MS, RN, FNP-C; Jessica Treiber, MPH, PA-C; Ainsley K. Bloomer, BA, BS; Brian P. Scannell, MD; Christine A. Ho, MD*

2:13 PM (p. 150) **PAPER 87**
Non-Operative Versus Operative Treatment of Z-Type Comminuted Clavicle Fractures in Adolescents: A Prospective Sub-Stratified Cohort Analysis
Coleen S. Sabatini, MD, MPH*; Eric W. Edmonds, MD; Elizabeth S. Liotta, MBBS; Katelyn A. Hergott, MPH; Donald S. Bae, MD; Michael T. Busch, MD; Henry B. Ellis, MD; Mininder S. Kocher, MD, MPH; G. Ying Li, MD; Jeffrey J. Nepple, MD; Nirav K. Pandya, MD; Andrew T. Pennock, MD; Crystal A. Perkins, MD; David D. Spence, MD; David N. Williams, PhD; Samuel C. Willimon, MD; Philip L. Wilson, MD; Benton E. Heyworth, MD*

2:19 PM (p. 151) **PAPER 88**
Changes in Superior Displacement, Angulation, and Shortening in the Early Phase of Healing for Completely Displaced Midshaft Clavicle Fractures in Adolescents: Results from a Prospective, Multicenter Study
Andrew T. Pennock, MD; ***Benton E. Heyworth, MD****; Tracey Bastrom, MA; Donald S. Bae, MD; Michael T. Busch, MD; Eric W. Edmonds, MD; Henry B. Ellis, MD; Mininder S. Kocher, MD, MPH; G. Ying Li, MD; Elizabeth Liotta, MBBS; Nirav K. Pandya, MD; Crystal A. Perkins, MD; Coleen S. Sabatini, MD, MPH; David D. Spence, MD; Samuel C. Willimon, MD; David N. Williams, PhD; Philip L. Wilson, MD; Jeffrey J. Nepple, MD*

2:25 PM Discussion

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

1:50 – 2:50 PM — CONCURRENT BREAKOUT SESSIONS

Current Strategies and Techniques for Operative Fixation of Complex Ankle Fractures and Fractures of the Tibial Plafond *(Room 201 AB)*
Moderator: *Frank A. Liporace, MD*
Faculty: *Richard S. Yoon, MD; Mark Gage, MD; Marcus F. Sciadini, MD; Jason W. Nascone, MD*

High Energy Proximal Femur Fractures: Avoiding Mistakes to Optimize Success *(Room 204 AB)*
Moderator: *Marschall B. Berkes, MD*
Faculty: *Timothy S. Achor, MD; Christopher McAndrew, MD; Milton T.M. Little, MD*

State of the Art for Operative Management of Femoral Head Fractures *(Room 202 CD)*
Moderator: *Brett D. Crist, MD*
Faculty: *Kyle Schweser, MD; John C. Hagedorn, MD*

Olecranon and Proximal Ulna Fractures and Fracture-Dislocations: Not So Easy! *(Room 203 AB)*
Moderator: *Utku Kandemir, MD*
Faculty: *Milan K. Sen, MD; Bertrand Perey; Michael D. McKee, MD*

Exhibit Hall B & C — 2:30 – 3:27 PM — SCIENTIFIC PAPER SESSION IV: PELVIS AND ACETABULUM

Moderators - Animesh Agarwal, MD & H. Claude Sagi, MD

2:30 PM (p. 152) **PAPER 89**
Is External Beam Radiation Therapy Really Associated with Low Rates of Heterotopic Ossification After Acetabular Surgery?
Adam Boissonneault, MD*; Gerard Slobogean, MD, MPH; Elizabeth Harkin, MD; Jayesh Gupta, BS; Nathan N. O'Hara, MHA; Robert V. O'Toole, MD*

2:36 PM (p. 153) **PAPER 90**
Delayed Fixation of Acetabular Fractures in Polytrauma Patients With and Without Concomitant Lower Extremity Fractures Significantly Increases the Odds of Complications
Lauren Nowak, PhD, MSc*; David Sanders, MD; Abdel-Rahman Lawendy, FRCS; Christopher Del Balso, MSc, MBBS; Emil H. Schemitsch, MD*

2:42 PM (p. 154) **PAPER 91**
Administration of Venous Thromboembolism Chemoprophylaxis Within 12 Hours of Pelvic and Acetabular Surgery Has No Effect on Estimated Blood Loss, Perioperative Change in Hemoglobin, or Need for Transfusion
Lukas Keil, MD*; Sean A. Flannigan, BS; Robert F. Ostrum, MD; Jesse C. Hahn, MD*

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

2:48 PM	Discussion
2:53 PM (p. 155) **PAPER 92**	**Results of Emergency Department Stress of Lateral Compression Type 1 Fracture Correlate with Validated Instability Scoring System** *Graham J. Dekeyser, MD; Patrick Kellam, MD; Thomas F. Higgins, MD; Justin Haller, MD;* ***Lucas S. Marchand, MD****; David L. Rothberg, MD*
2:59 PM (p. 156) **PAPER 93**	**Contralateral Lateral Stress Radiographs to Evaluate Stability of Minimally Displaced Lateral Compression Type 1 Pelvic Ring Injuries Are Equivalent to Ipsilateral Lateral Stress Radiographs** ***Joshua A. Parry, MD****; Michael M. Hadeed, MD; Austin Heare, MD; Stephen Stacey, MD; Cyril Mauffrey, MD, MRCS*
3:05 PM	Discussion
3:10 PM (p. 157) **PAPER 94**	**Percutaneous Posterior Pelvic Stabilization for Spinopelvic Dissociation: A 20-Year Series of Displaced and Nondisplaced Fracture Patterns** ***Justin P. Moo Young, MD****; Jonathan Savakus, MD; Daniel E. Pereira, BA; Jeffrey Hills, MD; Byron F. Stephens, MD; Phillip Mitchell, MD*
3:16 PM (p. 158) **PAPER 95**	**A Comparison of Open versus Percutaneous Approaches to Spinopelvic Dissociation: Presentation, Complications and Outcome** ***Justin P. Moo Young, MD****; Jonathan Savakus, MD; Daniel E. Pereira, BA; Jeffrey Hills, MD; Byron F. Stephens, MD; Phillip Mitchell, MD*
3:22 PM	Discussion
3:27 PM – 3:57 PM	Break Visit Scientific Posters & Technical Exhibits *(Exhibit Hall A)*

Exhibit Hall B & C

SCIENTIFIC PAPER SESSION V: GENERAL INTEREST AND POST-TRAUMATIC GENERAL INTEREST

3:57 – 5:23 PM

Moderators - Andrew M. Choo, MD & Stephen Warner, MD, PhD

3:57 PM (p. 159) **PAPER 96**	**Agricultural Trauma Causing Open Fractures: Is Antibiotic Coverage Against Anaerobic Organisms Indicated?** ***Malynda Wynn, MD****; Kyle K. Kesler, MD; Michael J. Robertson, MD; Robert T. Higginbotham, BA; John Morellato, MBBS; J. Lawrence Marsh, MD; Matthew Hogue, MD*
4:03 PM (p. 160) **PAPER 97**	**Does Cumulative Topical Antibiotic Powder Use Increase the Risk of Nephrotoxicity?** ***Robert V. O'Toole, MD****; Nathan N. O'Hara, PhD; Jessica Carullo, BS; Manjari Joshi, MD; Sheila Sprague, PhD; Gerard Slobogean, MD, MPH*
4:09 PM (p. 161) **PAPER 98**	**What Is Most Important to Patients When Pursuing Limb Salvage Following a Limb-Threatening Injury?** ***Alison L. Wong, FRCSC****; Cynthia Shannon, BS, BSN; Abdulai Bangura, BS; Lily Mundy, MD; Nathan N. O'Hara, MHA; Raymond A. Pensy, MD*

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

4:15 PM Discussion

4:20 PM (p. 162) **PAPER 99**
Effects of the Trauma Collaborative Care Intervention: 12-Month Results from a Prospective Multicenter Cluster Clinical Trial
Stephen Wegener, PhD; ***TCCS METRC Investigators***

4:26 PM (p. 163) **PAPER 100**
Orthopaedic Surgery I-PASS Intervention Leads to Sustained Improvement in Quality of Patient Handoffs
Derek S. Stenquist, MD*; Caleb Yeung, MD; Laura Rossi, PhD, RN; Antonia F. Chen, MD, MBA; Mitchel B. Harris, MD*

4:32 PM (p. 164) **PAPER 101**
How Many Sites Should an Orthopaedic Trauma Prospective Multicenter Trial Have? A Marginal Analysis of Completed Trials
Lauren Allen, MA*; Robert V. O'Toole, MD; Michael J. Bosse, MD; William T. Obremskey, MD, MPH; Kristin Archer, PhD; Lisa K. Cannada, MD; Jaimie T. Shores, MD; Renan C. Castillo, MD; METRC Investigators*

4:38 PM Discussion

4:43 PM (p. 165) **PAPER 102**
Transfusion After Harvesting Bone Graft with RIA: Practice Changes Reduced Transfusion Rate by More than Half
Lucas S. Marchand, MD*; Patrick Kellam, MD; Graham J. DeKeyser, MD; Justin Haller, MD; David L. Rothberg, MD; Thomas F. Higgins, MD*

4:49 PM (p. 166) **PAPER 103**
Primary Closure of External Fixator Pin Sites Does not Increase the Incidence of Surgical Site Infection
Jeffery Shroff, MD; Steven Karnyski, MD; Brittany Haws, MD; ***James D. Brodell, BA****; Sandeep Soin, MD; Kyle T. Judd, MD; Gillian Soles, MD; Catherine A. Humphrey, MD, MBA; John T. Gorczyca MD; John P. Ketz, MD*

4:55 PM (p. 167) **PAPER 104**
Intimate Partner Violence During Recovery from an Orthopaedic Injury: An Observational Cohort Study
Kim Madden, PhD; ***Sheila Sprague, PhD****; Brad Petrisor, MD; Prism Schneider, MD, PhD; Ydo Kleinlugtenbelt, MD, PhD; Elisa A.M. Hackenberg, MD; Maria Villar, MD, PhD; Jeremy Hall, MD, MEd; Sofia Bzovsky, MSc; Lehana Thabane, PhD; Mohit Bhandari, MD, PhD; PRAISE-2 Investigators*

5:01 PM Discussion

5:06 PM (p. 168) **PAPER 105**
Efficacy of a Multimodal Analgesic Protocol at Reducing Opioid Use After Orthopaedic Trauma
Brooke Herndon, PharmD*; Emily Slade, PhD; Svetla Slavova, PhD; Feitong Lei, MPH; Zhengyan Huang, PhD; Shannon Johnson, BSN, RN; Paul E. Matuszewski, MD; Eric S. Moghadamian, MD; Douglas Oyler, PharmD*

5:12 PM (p. 169) **PAPER 106**
Early Pain Self-Efficacy Predicts Chronic Pain and Pain-Related Disability 24 Months After Lower Extremity Fracture
Josh Van Wyngaarden, DPT, PT; Brian Noehren, PT, PhD; Kristin Archer, PhD; ***Lucy C. Bowers, BS****; Paul E. Matuszewski, MD*

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

5:18 PM Discussion

5:30 – 6:30 PM **MILITARY RECEPTION** *(Belt Buckle Lobby - Level 1)*
All Active Duty Military, Retired Military, and Landstuhl Distinguished Visit Scholar participants are welcome to attend.

5:30 – 6:10 PM SUDS N'SCIENCE GUIDED POSTER AND VIDEO TOURS

(PT3) **Hip/Femur** *(Exhibit Hall A)*
Guide: *Kyle J. Jeray, MD*

(PT4) **Foot and Ankle** *(Exhibit Hall A)*
Guide: *Anna N. Miller, MD*

(VT) **Video Tours** *(Exhibit Hall A)*
Guide: *Joseph Hoegler, MD*

ORTHOPAEDIC TRAUMA ASSOCIATION

2021 Annual Meeting

Saturday, October 23, 2021

Exhibit Hall B & C

6:00 AM **Speaker Ready Room** *(Room 104)*

6:15 AM **Registration** *(13th Street Lobby)*

6:30 – 7:30 AM **Concurrent Breakout Sessions –** Seating available first come, first-served.

6:30 AM **Continental Breakfast**
(Outside Breakout Session Rooms)

6:30 – 7:30 AM **CONCURRENT BREAKOUT SESSIONS**

Gray Zone Pelvis': What Do I Do? *(Exhibit Hall B & C)*
Moderator: *Jason W. Nascone, MD*
Faculty: *Milton L. Routt, MD; Adam J. Starr, MD; Robert V. O'Toole, MD; H. Claude Sagi, MD*

Displaced Intra-Articular Calcaneus Fracture Management from "Soup to Nuts": When, How, and Getting it Right *(Room 202 CD)*
Moderator: *John P. Ketz, MD*
Faculty: *Michael A. Maceroli, MD; Roy W. Sanders, MD; Mark Gage, MD*

Shoulder Girdle Injuries: Optimizing Decision Making and Surgical Management *(Room 203 AB)*
Moderator: *Emil H. Schemitsch, MD*
Faculty: *Michael D. McKee, MD; Niloofar Dehghan, MD, MSc; Jeremy Hall, MD, MEd; Aaron Nauth, MD; Peter A. Cole, MD*

Lower Extremity Deformity-How to Evaluate, When to Plate, When to Nail, When to Frame, and When to Give Up *(Room 201 AB)*
Moderator: *Brett D. Crist, MD*
Faculty: *Mitchell Bernstein, MD; Mark A. Lee, MD; Mauricio Kfuri, MD, PhD; Rahul Vaidya, MD*

Exhibit Hall B & C

7:30 – 9:00 AM

SYMPOSIUM III: HOW CAN WE FIX RACIAL, ETHNIC, AND SOCIOECONOMIC HEALTHCARE DISPARITIES IN ORTHOPAEDICS AND DO THESE DISPARITIES EXIST IN ORTHOPAEDIC TRAUMA?

An Introduction and Review from the OTA Diversity Committee

Moderator: *Gilbert R. Ortega MD, MPH*

Introduction to the OTA Diversity Committee, Mission Statement and Goals
Gil R. Ortega, MD, MPH

Current Orthopaedic Training and Statistics
Lisa K. Cannada, MD

General Health Disparities
Milton T.M. Little, MD

Orthopaedic Surgeon Perspective Disparities
Toni M. McLaurin, MD

Hip Fractures Disparities
Nirmal C. Tejwani, MD

Clavicle Fractures Disparities
Gerald J. Lang, MD

Pain Management Disparities
Emily S. Benson, MD

LGBTQ Disparities
Sarah N. Pierrie, MD

Solutions
Jacque J. Krumrey, MD

Panel Questions and Discussion

9:00 – 9:30 AM Break
Visit Scientific Posters & Technical Exhibits *(Exhibit Hall A)*

9:30 – 11:42 AM **Concurrent Sessions**
(General Session and Breakout Sessions run concurrently.)
Paper Session VI: Tibia/Knee and Tibial Plateau (9:30 – 10:39 AM)
Concurrent Breakout Sessions (10:15 –11:15 AM)
Paper Session VII: Post Traumatic Reconstruction (10:39 – 11:42 AM)

Exhibit Hall B & C

9:30 – 10:39 AM

SCIENTIFIC PAPER SESSION VI: TIBIA/KNEE AND TIBIAL PLATEAU

Moderators - Brett D. Crist, MD & Kyle Schweser, MD

9:30 AM
(p. 170)
PAPER 107

Outcomes of Intramedullary Nailing Versus External Fixation in the Treatment of Open Tibial Fractures: 3 to 5-Year Follow-up Study of a Randomized Clinical Trial
Abigail Cortez, MD*; Mayur Urva, BS; Billy T. Haonga, MD; Claire Donnelley, BS; Ericka Von Kaeppler, BS; Heather Roberts, MD; David Shearer, MD; Saam Morshed, MD*

9:36 AM
(p. 171)
PAPER 108

Gentamicin-Coated Nail is Effective Fracture-Related Infection Prophylaxis in Open Tibial Fractures
Alvaro Zamorano, MD*; Pierluca Zecchetto; Carlos Felipe Albarrán, MD; Andrés Sebastián Alberto Oyarzún Martínez, MD; Luis Bahamonde, MD*

9:42 AM
(p. 172)
PAPER 109

How Long Can Debridement Wait in Type IIIB Open Tibia Fractures?
Jeff J. Foote, MD, MSc*; Paul Tornetta III, MD; Khalid Al-Hourani, MD; Aleksi Reito, MD, PhD; Michael J. Bosse, MD; Ross K. Leighton, MD; Chad Coles, MD; Jamal Al-Asiri, MD; David J. Stockton, MD, MSc; Xavier L. Griffin, MBBS, MSc; Stephen A. Sems MD; Heather A. Vallier, MD; Hassan Riaz Mir, MD, MBA; Clay A. Spitler, MD; Brian Mullis, MD; Lisa K. Cannada, MD; Emily Wagstrom, MD; Jerald Westberg, BA; Saam Morshed, MD; Peter C. Krause, MD; Andrew J. Marcantonio, DO; Gillian Soles, MD*

9:48 AM

Discussion

9:53 AM
(p. 173)
PAPER 110

Pace of Recovery of Physical Function After Tibial Plateau Fractures
Patrick Kellam, MD*; Graham J. DeKeyser, MD; Thomas F. Higgins, MD; David L. Rothberg, MD; Justin Haller, MD; Lucas S. Marchand, MD*

9:59 AM
(p. 174)
PAPER 111

An International Comparison of Acute Versus Staged Fixation of Bicondylar Tibial Plateau Fractures
Lazaro Mesa, MD*; Nicholas Birkett, MBChB, MSc; Reuben C. Lufrano, MD; Rutba Chatta, MD; Melihah Hassan, MD; Paul J. Hannon, MD; Joshua Mizels, BA; David Ensor, MBBS; David T. Watson, MD; Anjan R. Shah, MD; Benjamin Maxson, DO; Anthony F. Infante, DO; David Donohue, MD; Peter Bates, FRCS (Ortho); Katheryne Downes, PhD; Pramod Achan, MB, FRCS; Roy W. Sanders, MD, FAAOS; Ishvinder S. Grewal, MBBS, BSc; Hassan Riaz Mir, MD, MBA*

10:05 AM
(p. 175)
PAPER 112

Prepping in the External Fixator to Facilitate Staged Open Reduction and Internal Fixation of Bicondylar Tibial Plateau Fractures Does Not Increase Infection Rates
Derek S. Stenquist, MD*; Caleb Yeung, MD; Theodore Guild, MD; Michael J. Weaver, MD; Mitchel B. Harris, MD; Arvind G. Von Keudell, MD*

10:11 AM

Discussion

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

10:16 AM (p. 176) **PAPER 113**
Rates of Early Revision Surgery in Operatively Treated Patella Fractures: A Retrospective Review of 286 Cases
Rohit Gopinath, BS; Jonathan Howatt, MD; Allan Liew, FRCSC; ***Geoffrey P. Wilkin, MD***

10:22 AM (p. 177) **PAPER 114**
Fasciotomies in Bicondylar Tibial Plateau Fractures Do Not Have Increased Rates of Infection or Nonunion
Kyla Huebner, MD*; Derek S. Stenquist, MD; Michael J. Weaver, MD; Arvind G. Von Keudell, MD*

10:28 AM (p. 178) **PAPER 115**
Tibial Plateau Fractures in the Elderly Have Clinical Outcomes Similar to those in Younger Patients
Meghan Carey Derken, BA*; Cody R. Perskin, BA; Philipp Leucht, MD; Sanjit R. Konda, MD; Abhishek Ganta, MD; Kenneth A. Egol, MD*

10:34 AM Discussion

10:15 – 11:15 AM CONCURRENT BREAKOUT SESSIONS

The Treatment of Peri-prosthetic Fractures in 2021: A Comprehensive Evidence-based Approach! *(Room 203 AB)*
Moderator: *Emil H. Schemitsch, MD*
Faculty: *Aaron Nauth, MD; Adam A. Sassoon, MD; Michael J. Gardner, MD; Andrew H. Schmidt, MD*

Combined Pelvic Ring and Acetabulum Fractures: What I've Learned and What I Wish I Would Have Known Back Then *(Room 204 AB)*
Moderator: *Marcus F. Sciadini, MD*
Faculty: *Michael A. Maceroli, MD; Jason W. Nascone, MD; Conor P. Kleweno, MD; Brent T. Wise, MD*

Rotation, Rotation, Rotation: Why is it Important and How To Get it Right in Lower Extremity IM Nailing *(Room 202 CD)*
Moderator: *James C. Krieg, MD*
Faculty: *Patrick C. Schottel, MD; Michael Blankstein, MD; Mark R. Brinker, MD; Ida L. Gitajn, MD*

Tips and Tricks for Getting the Metaphysis Right With Different Implants! *(Room 201 AB)*
Moderator: *Benjamin Ollivere, MD, MA*
Faculty: *Paul Tornetta III, MD; Reza Firoozabadi, MD; J. Tracy Watson, MD*

Exhibit Hall B & C

10:39 – 11:42 AM

SCIENTIFIC PAPER SESSION VII: POST TRAUMATIC RECONSTRUCTION

Moderators - Nirmal C. Tejwani, MD & Daniel N. Segina, MD

10:39 AM (p. 179) **PAPER 116**
Ten-Year Incidence and Possible Predictors of Conversion to Total Knee Arthroplasty Following Operative Fixation of Distal Femur Fractures: Analysis of 6,086 Patients
Zachary Telgheder, MD*; Jason Strelzow, MD; Jennifer Lewis, BA; Katheryne Downes, PhD; Hassan Riaz Mir, MD, MBA*

10:45 AM (p. 180) **PAPER 117**
Lower Complications in Acute THA for Intertrochanteric Femur Fractures than Delayed Conversion THA After Failed Operative Fixation
Luke Myhre, MD*; Patrick Kellam, MD; Lucas Anderson, MD; Jeremy Gililland, MD; Justin Haller, MD; Lucas S. Marchand, MD*

10:51 AM (p. 181) **PAPER 118**
Outcomes and Survivorship of Vascularized Fibular Grafting for Post-Traumatic Osteonecrosis of the Femoral Head
Keith Whitlock, MD*; Eliseo DiPrinzio, MD; Daniel J. Lorenzana, MD; Rachel Hein, MD; Daniel J. Cunningham, MD; Marc J. Richard, MD; Mark Gage, MD; James R. Urbaniak, MD*

10:57 AM Discussion

11:02 AM (p. 182) **PAPER 119**
Induced Membrane Technique Is Effective for Both Metaphyseal and Diaphyseal Fractures with Acute Bone Loss
Lillia Steffenson, MD*; Stephen Wallace, MD; Alexander Roszman, MD; Clay A. Spitler, MD; Michael Githens, MD; Justin Haller, MD*

11:08 AM (p. 183) **PAPER 120**
Risk Factors and Characteristics of Recalcitrant Osteomyelitis Following Appropriate Initial Surgical and Antibiotic Treatment
Nihar S. Shah, MD*; Arun Kanhere, BS, MSc; Ramsey S. Sabbagh, MS; John Bonamer; Austin Franklin; Matthew D. Doyle; Matthew Frederickson, BS; Drew T. Sanders, MD; H. Claude Sagi, MD*

11:14 AM (p. 184) **PAPER 121**
The Effect of Free versus Local Flaps on Time to Union In Open Tibia Fractures
Nicole Zelenski, MD*; Jennifer Tangtiphaiboontana, MD; Anthony J. Archua, MD; Doga Kuruoglu, MD; Maria Yan, MD; Samyd S. Bustos, MD; Steven L. Moran, MD*

11:20 AM Discussion

11:25 AM (p. 185) **PAPER 122**
Percutaneous Strain Reduction Screws Are a Cost Effective and Reproducible Method to Treat Long Bone Non-Union
Matthew Bence, MA, MB; Alpesh Kothari, MD, MSc; Andrew Riddick, MBBS; Will Eardley, FRCS (Ortho); Robert C. Handley, FRCS; ***Alex Trompeter, FRCS (Ortho)***

11:31 AM (p. 186) **PAPER 123**
Orthoplastic Treatment of Open Lower Limb Fractures Improves Outcome: A 12-Year Review
Estelle M. D'Cunha, MBChB; John M. McMaster, DMed, MBChB; Jowan G. Penn-Barwell, MB, ChB; ***Charles A. Fries, ChB, MA, MB, MSc***

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11:37 AM Discussion

11:42 AM - 12:42 PM Lunch
Visit Scientific Posters & Technical Exhibits *(Exhibit Hall A)*

11:57 AM – 12:37 PM

LUNCHTIME GUIDED POSTER AND VIDEO TOURS

(PT5) **Upper Extremity** *(Exhibit Hall A)*
Guide: *Andrew M. Choo, MD*

(PT6) **International** *(Exhibit Hall A)*
Guide: *Ida Leah Gitajn, MD*

(VT) **Video Tours** *(Exhibit Hall A)*
Guide: *TBD*

Exhibit Hall B & C

12:42 – 2:12 PM

SYMPOSIUM IV: TOLERATE OR RE-OPERATE: WHAT TO DO THE DAY AFTER?

Moderators: *Hans-Christoph Pape, MD*
Miguel Triana, MD

Overview
Hans-Christoph Pape, MD

Proximal Humerus
Guy Putzeys, MD

Pelvis/Acetabulum
Francisco C. Rodríguez, MD, PhD

Proximal Femur
Yoram A. Weil, MD

Proximal Tibia
Bertil Bouillon, MD, PhD

Distal Tibia
Michael Verhofstad, MD, PhD

Discussion
All Faculty

2:12 – 3:39 PM **Concurrent Sessions**
(Breakout Sessions and General Session run concurrently.)
Concurrent Breakout Sessions (2:12 – 3:12 PM)
Paper Session VIII: Upper Extremity, Wrist & Hand (2:12 – 3:39 PM)

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

2:12 – 3:12 PM — CONCURRENT BREAKOUT SESSIONS

From Knee to Ankle: Tips and Strategies for Managing Tibial Shaft Fractures in Proximal, Middle, and Distal Thirds *(Room 202 CD)*
Moderator: *Michael A. Maceroli, MD*
Faculty: *Cory A. Collinge, MD; Sandeep Soin, MD; John P. Ketz, MD; Roberto C. Hernandez-Irizarry, MD*

Rehab to Optimize Outcomes: Getting Our Patients Back on their Feet *(Room 201 AB)*
Moderator: *Daniel J. Stinner, MD, LTC*
Faculty: *William T. Obremskey, MD, MPH; Joseph R. Hsu, MD; Kristin Archer, PhD*

Exhibit Hall B & C — SCIENTIFIC PAPER SESSION VIII: UPPER EXTREMITY & WRIST AND HAND

2:12 – 3:39 PM

Moderators - Harmeeth S. Uppal, MD, MS & John A. Scolaro, MD, MA

2:12 PM (p. 187) **PAPER 124**
Spin in the Abstracts of Meta-analyses and Systematic Reviews: Midshaft Clavicle Fractures
Matthew Gulbrandsen, MD; *R. Casey Rice, MD; Trevor Gulbrandsen, MD; Joseph Liu, MD*

2:18 PM (p. 188) **PAPER 125**
Acute Plate Fixation of Displaced Midshaft Clavicle Fractures Is not Associated with Earlier Return of Normal Shoulder Function When Union Is Achieved
Jamie A. Nicholson, MBChB, MRCSED; *Nicholas D. Clement, MRCS Ed; Andrew D. Clelland, MBChB; Deborah J. MacDonald, BA; Hamish R.W. Simpson, ChB, Dmed; Christopher M. Robinson, MD*

2:24 PM (p. 189) **PAPER 126**
Δ **Multicenter, Prospective, Observational Trial of Non-Operative versus Operative Treatment for High-Energy Midshaft Clavicle Fractures**
Kyle J. Jeray, MD; *Brian Mullis, MD; Joshua Everhart, MD, MPH; John S. Broderick, MD; Stephanie L. Tanner MS; Southeastern Fracture Consortium*

2:30 PM
Discussion

2:35 PM (p. 190) **PAPER 127**
Not All Proximal Humerus Fractures Do Well Without Surgery: Anterior Translation Predicts the Need for Surgery
Amir Shahien, MD; ***Paul Tornetta III, MD***; *Brian Mullis, MD; Elive F. Likine, MD; Gillian Soles, MD; Steven Samborski, MD; Clay A. Spitler, MD; Siddhant K. Mehta, MD, PhD; Scott P. Ryan, MD; Taryn E. Leroy, MD*

Δ OTA Grant

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SATURDAY, OCTOBER 23, 2021

2:41 PM (p. 191) **PAPER 128**	**Long-Term Outcomes of Secondary Implant Removal and Arthrolysis in Patients with a Painful Stiff Shoulder After Open Reduction and Locking Plate Fixation for a Proximal Humeral Fracture** ***Navnit S. Makaram, MBChB, MRCS****; Christopher M. Robinson, MD*
2:47 PM (p. 192) **PAPER 129**	**No Change in Outcome Between 1 and 5 Years after Repair of Displaced Proximal Humerus Fracture** ***Sanjit R. Konda, MD****; Rachel Ranson, MS; Connor P. Littlefield, BA; Rachel Roller, MS; Kenneth A. Egol, MD*
2:53 PM	Discussion
2:58 PM (p. 193) **PAPER 130**	**Surgical Treatment of Dorsally Displaced Distal Radius Fractures with a Volar Locking Plate Versus Conventional Percutaneous Methods: Minimum 10-Year Follow-Up of a Randomized Controlled Trial** ***Sandeep R. Deshmukh, MBChB****; Ben Marson, MBBS; Reuben Ogollah, PhD; Tim Davis, FRCS; Alexia Karantana, FRCS (Ortho)*
3:04 PM (p. 194) **PAPER 131**	**Δ Delayed Fixation of Distal Radius Fractures Past 3 Weeks After Initial Failed Closed Reduction Increases the Odds of Reoperation** ***Lauren Nowak, PhD, MSc****; Melanie Macnevin, BS; Joel-Amir Moktar, MD; Emil H. Schemitsch, MD*
3:10 PM (p. 195) **PAPER 132**	**The Trajectory of Long-Term Recovery Following Open Reduction and Internal Fixation for Distal Radius Fractures** ***Gabriel Larose, MD****; Henry M. Broekhuyse, MD; Pierre Guy, MD; Peter J. O'Brien, MD; Darren Roffey, PhD; Kelly Ann Lefaivre, MD, MS*
3:16 PM	Discussion
3:21 PM (p. 196) **PAPER 133**	**Open Reduction and Internal Fixation of Multifragmentary Fractures of the Radial Head Does Not Lead to Worse Outcomes Compared to Arthroplasty** ***Phillip McKegg, MS****; Genaro Deleon, MS; Nathan N. O'Hara, MHA; Qasim Ghulam, MS; Zachary D. Hannan, BS; Robert V. O'Toole, MD; Christopher Langhammer, MD; Lucas S. Marchand, MD; Gerard Slobogean, MD, MPH; Raymond A. Pensy, MD; W. Andrew Eglseder, MD*
3:27 PM (p. 197) **PAPER 134**	**Percutaneous Fixation of Acute Scaphoid Waist Fractures: Long-Term Patient-Reported Functional Outcomes and Satisfaction at a Mean of 11 Years Following Surgery** *Paul Stirling, MRCSEd; Ryan D. Broll, MBChB; Samuel Molyneux, FRCS (Ortho); Christopher W. Oliver, MD, MBBS; Margaret M. McQueen, MD;* ***Andrew David Duckworth, MBChB, MSc, PhD***
3:33 PM	Discussion
3:39 PM	Closing Remarks and Adjourn
	See you next year in Tampa, Florida, October 12-15, 2022

Δ OTA Grant

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Δ Smart Fracture Plate Monitors Callus Stiffness

Eric H. Ledet, PhD; Madelyn Stout, BS; Sydney M. Caparaso, BS; Keegan Cole, MD; Benjamin Liddle, BS; Nathaniel Cady, PhD; Reena Dahle, PhD;
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Purpose: Nonunion of fractures treated with plate osteosynthesis results in substantial morbidity and return to the operating room. The diagnosis of nonunion is based on qualitative clinical examination and radiographic assessment of callus. These are subjective and often ambiguous. Measurement of callus stiffness provides a quantitative assessment of fracture healing. Biomechanically, a plate is loaded in parallel with the bone. Initially, all loads (ie, during weight bearing) are transmitted through the plate, but as callus stiffness increases, forces through the plate decrease. In this way, a "smart" fracture plate that measures force can serve as an objective indicator of fracture healing. Previously, transducer technology has required bulky electronics and modification to the plates. We have developed a novel wireless sensor technology and technique to measure forces with no modification to the plate. The purpose of this study was to demonstrate the ability to distinguish different phases of fracture healing using a wireless force-sensing smart osteosynthesis plate.

Methods: A 6-mm osteotomy was created in the distal third of three Sawbones biomechanical femurs to simulate an OTA 33A-3 fracture. A novel wireless, batteryless, disk-shaped force sensor of 9-mm diameter and 350-μm thickness was placed on the outside surface of a distal femoral locking bridge plate over an open hole near the fracture. A small "force concentrator" was then placed over the sensor and affixed to the plate by placing screws through it and the plate. In this way, no modifications of the plate are required. Because fracture plates are inherently loaded in eccentric axial compression, the load causes them to bend slightly. During this slight deformation, the force concentrator acts as a mechanical amplifier and loads the sensor transversely. Constructs were placed into a mechanical testing machine with a 6° valgus anatomic axis. Loads were applied in 50-N increments to 700 N. Loading was repeated with the osteotomy defect empty (to simulate the acute postoperative period) and then filled with silicone (early callus formation) then polymethylmethacrylate (hard callus). Data were compared between treatment conditions using an analysis of variance and Games Howell test to determine if the smart plate could detect differences in callus stiffness.

Results: For applied axial force greater than 100 N, there was a statistically significant difference in force measured by the sensor for the acute postoperative phase (empty osteotomy) and the other two stages of healing. For all values of applied axial force greater than 150 N, there were statistically significant differences in measured force between all three stages of healing.

Conclusion: Results from this preliminary study demonstrate that the smart plate is effective at discerning between stages of healing. The technology is promising as an objective assessment of fracture healing.

Δ OTA Grant

A Biomechanical Comparison of Two Fixation Methods for Unstable Lateral Compression Pelvic Ring Injuries

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Purpose: Management of the anterior component of unstable lateral compression (LC) (AO/OTA 61B2) pelvic ring injuries remains controversial. Common internal fixation options include plating and superior pubic ramus screws. These constructs have been evaluated in anterior-posterior compression fracture patterns, but no study has compared the two for unstable LC patterns, which is the purpose of this study.

Methods: A rotationally unstable LC pelvic ring injury was modeled in 10 fresh-frozen cadaver specimens by creating a complete sacral fracture, disruption of posterior ligaments, and ipsilateral superior and inferior ramus fractures. All specimens were repaired posteriorly with fully threaded 7-mm cannulated transiliac transsacral screws through the S1 and S2 corridors. The superior ramus was repaired with either a 3.5-mm pelvic reconstruction plate (n = 5) or a bicortical 5.5-mm cannulated superior ramus screw (n = 5). Specimens were loaded for 1000 cycles at 400 N followed by an additional 3 cycles at 800 N. Displacement and angulation of the superior and inferior ramus fractures were measured with a 3-dimensional motion tracker. The two fixation methods were then compared with Mann-Whitney U tests.

Results: Screw fixation had lower average displacement and angulation than plate fixation in all categories, with the motion at the inferior ramus at 800 N of loading showing a statistically significant difference.

Conclusion: Although management of the anterior ring in unstable LC injuries remains controversial, indications for fixation are becoming more defined over time. In this study, the 5.5-mm cannulated retrograde superior ramus screw significantly outperformed the 3.5-mm reconstruction plate in angulation of the inferior ramus fracture at 800 N. No other significance was found; however, there was a trend toward significance with the ramus screw demonstrating lower average displacements and angulations in all categories for both the inferior and superior ramus fractures.

Table 1: Fracture displacements and angulations. Significant comparisons are noted with a *.

Location		Displacement (mm)				Angulation (°)			
Superior Ramus	Loading	400N		800N		400N		800N	
	Repair	Screw	Plate	Screw	Plate	Screw	Plate	Screw	Plate
	Average	0.043	0.078	0.083	0.158	0.680	1.102	0.629	1.106
	St. Dev	0.036	0.032	0.083	0.063	0.593	0.987	0.495	0.782
	P-Value	0.210		0.144		0.210		0.144	
Inferior Ramus	Loading	400N		800N		400N		800N	
	Repair	Screw	Plate	Screw	Plate	Screw	Plate	Screw	Plate
	Average	0.154	0.341	0.306	0.814	0.345	1.103	0.698	1.840
	St. Dev	0.119	0.183	0.142	0.416	0.281	0.983	0.408	1.104
	P-Value	0.144		0.095		0.210		0.037*	

The Effect of Screw Fixation on Sacroiliac Joint Stiffness using Vibration Energy Color Doppler Imaging

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Purpose: The sacroiliac joints (SIJs) are highly specialized articulations in the pelvis that allow load transfer between the upper and lower body. Traumatic pelvic disruption often results in surgical fixation of one or both of the SIJs. Pain at the SIJ is associated with asymmetries in joint laxity or stiffness. This proof-of-concept study is the first to measure SIJ stiffness, using a novel technique, in patients with intact sacroiliac screw fixation. Our objectives were (1) to establish vibration energy color Doppler imaging (VECDI) SIJ intrarater reliability, (2) to measure SIJ stiffness in subjects following surgical fixation using VECDI, (3) to compare stiffness data in post-surgical subjects and healthy control subjects, and (4) to assess the relationship between stiffness and self-reported pain and disability.

Methods: 13 reliability and 19 experimental subjects between 18 and 65 years of age were tested using VECDI. Experimental subjects were grouped based on SIJ implant fixation: unilateral (n = 3), bilateral (n = 8), or controls (n = 8). Subjects were placed into a side-lying position on top of a shaker apparatus that transmits vibration energy to the pelvic ring, while three color Doppler images were taken from the SIJ. Initially, one investigator performed three unilateral SIJ measurements in reliability subjects over 2 separate testing days. Next, the investigator performed three SIJ measurements, bilaterally, of the experimental subjects at 6 weeks (T1), and 12 weeks (T2). Additionally, control subjects were measured once, bilaterally, for comparison.

Results: Intraclass correlation coefficients (ICCs) suggest good intrarater reliability (ICC = .819; 95% confidence interval [CI] = 0.405-0.945). No significant differences for ΔTU were observed between subjects (P>0.05). Additionally, within the unilateral fixation group at T1, a qualitative trend was observed between the involved (mean = 3.67 ± 4.2 standard deviation [SD]) and uninvolved side (mean = 10.13 ± 2.8 SD). Pearson correlation coefficients associate current pain at T1 and T2 ($P = 0.004$, r = 0.879), and Oswestry Disability Index (ODI) values at T1 and T2 ($P = 0.003$, r = 0.890).

Conclusion: This is the first investigation to utilize VECDI in measuring SIJ stability. Presently, we offer VECDI as an objective, validated, and reliable tool in SIJ stiffness assessments. Following surgical fixation, experimental subjects demonstrated similar stiffness values 6 and 12 weeks post-operation compared to controls. Alternatively, we observed potentially meaningful differences between the involved and uninvolved sides at T1 in unilateral fixation subjects. However, direct inferences cannot be concluded due to a small sample size. Future research should investigate pre- to post-screw removal to determine the time course of healing from SIJ surgical stabilization and removal.

Orthogonal Plating of Distal Femur Fractures: A Biomechanical Comparison with Plate-Nail and Parallel Plating Constructs

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Purpose: Recent studies on supplemental fixation of distal femur fractures have demonstrated superior biomechanical properties of lateral-medial plating and plate-nail constructs compared to lateral locked plating alone. Orthogonal plating through a single lateral approach may provide comparable stability without disrupting the remaining soft-tissue envelope around the knee. The purpose of this study was to compare the biomechanical properties of orthogonal plating with plate-nail and parallel plating constructs for supracondylar distal femur fractures.

Methods: A supracondylar distal femur fracture with medial metaphyseal comminution was simulated using 15 synthetic osteoporotic composite femurs. The specimens were divided into 3 groups: (1) plate-nail construct with a lateral locked distal femoral plate and a retrograde intramedullary nail, (2) parallel plating with a lateral locked distal femoral plate and a medial 4.0-mm compression plate, and (3) orthogonal plating with a lateral locked distal femoral plate and a posterior one-third tubular plate. Each specimen was mounted reversibly on a multiaxial Bionix Testing System (MTS) and underwent nondestructive cyclic loading along the mechanical axis of the femur in torsion to 10 Nm, and then axial compression to 800 N. Gapping at the fracture site was measured using infrared markers and a 3-dimensional motion capture system. Torsional stiffness and axial stiffness were determined and compared using a Kruskal-Wallis one-way analysis of variance. Strain at the fracture site during axial loading was also determined.

Results: The plate-nail, parallel plating, and orthogonal plating constructs had a mean torsional stiffness of 74.5 ± 20.7, 81.2 ± 23.7, and 66.2 ± 31.1 Nm/degree, respectively, with no significant difference among the 3 groups ($P = 0.51$). There was also no difference in axial stiffness among the 3 groups ($P = 0.53$), and strain at the fracture site during axial loading was <1% in all specimens. There was no difference in strain among the 3 groups ($P = 0.20$).

Conclusion: Orthogonal plating of supracondylar distal femur fractures demonstrated comparable torsional and axial stability to plate-nail and parallel plating constructs. All specimens had <1% strain at the fracture site at peak load, suggesting sufficient stabilization for bone healing. These biomechanical results suggest that the benefit of enhanced stability from dual-implant fixation to allow for earlier weight bearing can be achieved through orthogonal plating using a single incision approach. Orthogonal plating warrants further investigation as a novel alternative for fixation of osteoporotic distal femur fractures, particularly for periprosthetic fractures with a preexisting midline incision and a femoral component that is not amenable to nailing.

A Biomechanical Comparison Between TightRope and Suture-Post Fixation: A Novel Technique

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Purpose: Screw fixation for syndesmotic repair is widely accepted and remains the primary surgical method of choice for ankle syndesmotic injury fixation. However, flexible implants such as the TightRope (Arthrex) have gained tremendous popularity given lower hardware removal rates and theoretically allowing more consistent reduction and physiologic motion. A primary argument against the use of flexible implants is cost. The purpose of this study was to evaluate a novel suture-post construct using cost-effective materials and compare biomechanical stability with the TightRope device.

Methods: Eight matched pairs, 16 fresh-frozen cadaveric through-tibia/fibula specimens, were used. The specimens were fitted with positional reference markers at the mid-tibia and mid-fibula. Radiographs were obtained with the specimens intact (pre-test), with severed syndesmosis (severed), and after syndesmotic repair (fixed) with either a TightRope or novel suture-post fixation. TightRopes were applied per manufacturer recommendations. Suture-posts were created by drilling a 2.5-mm transosseous tunnel 1-2 cm proximal and parallel to the tibiotalar joint line. Then, a single 15-mm × 3.5-mm unicortical screw was placed in the tibia and the fibula each 1 cm proximal to the medial and lateral drill holes. #5 FiberWire was passed from lateral to medial, wrapped twice around the medial suture-post tightened, then the suture was passed back laterally where it was tied around the fibular screw. The fibular screw was then tightened, placing tension on the construct and applying a reduction force. A moderate 100-N axial load and a 6.5-Nm external torque was applied to pre-test, severed, and fixed specimens. Torque to failure was completed at 0.7°/sec up to the yield strength.

Results: Syndesmosis disruption was confirmed with external stress radiographs. The average external rotation required to achieve a 6.5-Nm torque was similar between the TightRope and suture-post groups, 23.56° (standard deviation [SD] 1.61) and 22.88° (SD 3.39), respectively ($P = 0.550$). Torque to failure was also equivalent between groups at 20.2 (SD 11.17) and 16.9 Nm (SD 5.61) for the TightRope and suture-post, respectively ($P = 0.375$), with an average of 77.8° (SD 37.6) and 68.1° (SD 10) of external rotation ($P = 0.565$) at failure. The most common mode of failure in both groups was fibula fracture. Suture cut-out was seen in 50% of suture-post group and fracture at the suture button insertion was seen in 37.5% of cases in the TightRope group.

Conclusion: The suture-post construct performed similarly to the TightRope in all metrics. The failure mode most commonly involved a fracture of the fibula in both groups. There was no significant difference in the degree of biomechanical stability between constructs. The suture-post construct provides similar biomechanical stability and can be considered a suitable alternative to the TightRope device at one-fifth the cost.

A Short Course of Dehydroepiadrosterone is Associated with Accelerated Fracture Healing in a Mouse Fracture Model

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Purpose: Dehydroepiandrosterone (DHEA) is a metabolic intermediate in the biosynthesis of androgens and estrogens. DHEA supplementation in humans has been associated with increased bone mineral density and elevated systemic levels of insulin growth factor (IGF)-1, indicating that DHEA supplementation has the potential to improve fracture healing. The aim of this study is to assess the impact of a short course of DHEA on fracture healing in the setting of a translational fracture model. We hypothesize that DHEA will improve fracture healing and manifest this effect through osteoblast differentiation and matrix deposition.

Methods: A well-established murine fracture model generated middiaphyseal femur fractures in 10 young (12-week-old) and 10 aged (60-week-old) female C57BL/6 mice, stabilized with retrograde intramedullary pin placement. Half of the mice from each group were supplemented with 5 mg/kg/day DHEA. Micro-CT was performed at 2 weeks to assess callus morphology and mineral density. Histomorphometry of representative pentachrome-stained sections was performed to assess new bone formation. Skeletal stem and progenitor cells (SSPCs) were also harvested and grown in vitro in osteogenic culture medium to evaluate the effect of DHEA on osteoblasts.

Results: A total of 20 mice were available for analysis. Micro-CT demonstrates that DHEA significantly increases callus bone volume, bone volume/tissue volume (BV/TV), bone surface, and mineral density in aged mice, and significantly increases callus BV/TV, trabecular number, and mineral density in young mice. Histomorphometry demonstrates that DHEA significantly increases new bone formation in aged and young mice without affecting callus cartilage formation. Histologic evaluation revealed that mice treated with DHEA had a significant increase in the concentration of osteoblasts lining the fracture callus osteoid. In vitro studies demonstrated increased osteoblastogenesis in samples treated with DHEA in a dose-dependent manner, which is inhibited by androgen and estrogen receptor blockers.

Conclusion: Our study shows the positive effect of DHEA on the fracture healing process, likely through increased osteoblastogenesis via androgen and estrogen receptor signaling. DHEA is an oral supplement that may be beneficial for fracture repair.

Adult Collagen X Fracture Biomarker Levels Demonstrate Early Peak After Fracture to Match Preclinical Model

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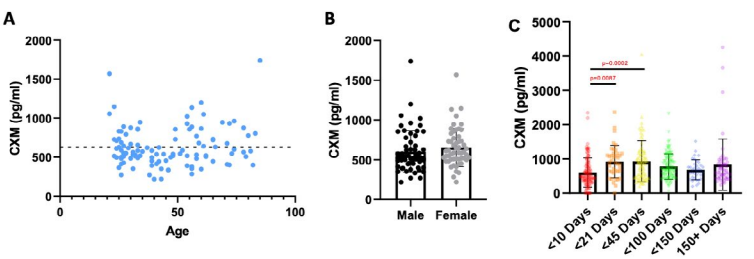
Purpose: There exists no validated method to quantify biologic fracture healing. Many fractures heal via callus and a cartilage intermediate. Collagen X (ColX) is expressed during cartilage-to-bone transformation, providing a diagnostic opportunity. A published preclinical murine fracture model (novel validated sandwich ELISA [enzyme-linked immunosorbent assay]-based assay: "CXM") demonstrates early gene expression (day 7) after fracture, a delayed serum CXM peak (day 14), and supportive immunohistochemistry staining (ColX). Here we present preliminary CXM data from an adult fracture observational cohort.

Methods: After IRB approval, patients presenting within 14 days (isolated fracture) were approached. Dried blood spots (DBS) were collected from lancet/fingerprick via protein cards (injury/2/6/12 weeks, all other visits). DBS sampling involved 3.1-mm punch in duplicate, +250 mL of sample diluent, and overnight extraction (4C) before assay. Fracture patients required 3 samples for analysis. We expected a sharp early peak followed by resolution to match our preclinical model. Healthy volunteers were also assayed.

Results: Healthy controls: 113 patients; no difference between baseline CXM in men and women (603.3 pg/mL, n = 59 vs 653.5 pg/mL, n = 54; $P = 0.29$) nor by age ($P = 0.24$, r = 0.11). Adult fracture cohort: 110 of 160 produced 3 sequential samples for analysis (424 samples, median days from fracture = 43, maximum 597, median age 48.5 years [range, 19.7-83.2]; 60 of 110 [54.5%] male). Samples were binned by days from fracture: 0-9, 10-20, 21-44, 45-99, 100-149, and 150+. There was a significant difference between samples at 10 to 20 days ($P = 0.0087$) and samples at 21 to 44 days ($P = 0.0002$) compared to 0 to 9 days, signifying an early CXM spike post-fracture.

Conclusion: CXM levels in humans demonstrate an early peak post-fracture, matching published preclinical findings, providing an opportunity to develop a biomarker for adult fracture care. Future efforts remain focused on cohort expansion to account for broad heterogeneity in an adult fracture population.

FIGURE 1: CXM LEVELS IN ADULTS



CXM in healthy adults: (A) No correlation between age and CXM levels (r=0.112, p=0.241). (B) No statistically significant difference between CXM levels between males and females (p=0.287).
CXM in adult fracture patients: (C) Significant differences found in CXM magnitude between samples from 0-9 days after fracture to both 10-20 day samples and 21-44 day samples, illustrating expected spike in CXM response.

Δ Novel Profiling Method to Detect Hypoxia Biomarker After Cold Therapy at Bone Injury Site

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Purpose: Applying a cold stimulus onto bone has been shown to clearly increase the healing response. However, the mechanisms upon which acute cold stimulates bone-forming cells are paradoxical and not well understood. It has been previously established that when the vascular network in and around bone is compromised, hypoxia occurs near the fracture site, leading to the activation of a key mechanism in fracture healing to restore the blood flow, ie, angiogenesis. Here we hypothesize that localized application of cold temperature positively stimulates fracture healing and bone formation by inducing physiological changes near the injury site indirectly by modifying the vasomotor tone and reducing the bone blood flow. The objective of this study is to elucidate the mechanism by which cold therapy affects bone formation in vivo at the injury site through a new methodology to detect hypoxia markers.

Methods: Nine C3H strain mice aged 2 to 3 months played the role of the control and experimental group by using both hind legs. Cortical rectangular window defects within the ventrolateral aspect of the femoral diaphysis were created. Hypoxyprobe consisting of pimonidazole, a hypoxia marker, was intraperitoneally injected 7 days post operation into the mice. 15 minutes after the time of injection, the experimental hindlimb of the mouse was exposed to a cold-water bath for 15 minutes. Immediately after, the mice were euthanized and their femurs were harvested. Each femur was fixated, decalcified, processed, and embedded for staining. Adducts formed between pimonidazole and hypoxic cells was detected by incorporating anti-pimonidazole fluorescein isothiocyanate (FITC)-conjugated IgG1 mouse monoclonal antibody and horse radish peroxidase conjugated rabbit anti-FITC. 3,3′-diaminobenzidine (DAB) staining was then utilized to visualize the areas of interest through immunoperoxidase staining. ImageJ analysis was applied to assess the area indicative of DAB staining.

Results: ImageJ analysis revealed a noticeable increase in area marked by DAB staining between experimental and control groups. Furthermore, results indicate a strong increase in the number of hypoxic cells within and around the cortical bone defect in the hindlimbs of mice exposed to a cold stimulus in comparison to the control hindlimbs. This demonstrates detectable localized hypoxia induction through the application of a cold stimulus.

Conclusion: A new analytical approach has been developed to measure hypoxic levels at the bone injury site. By detecting adduct formation created through pimonidazole reduction with hypoxic cells, hypoxia levels were assessed at the bone defect site following exposure to a cold stimulus. The results illustrate the development of a detectable hypoxic environment that provides a conjunctive avenue to explore the facilitation or fluctuation of certain regenerative pathways dependent upon hypoxic conditions within the stages of bone repair.

Δ OTA Grant

Three-Dimensional Ultrasound Reconstruction of Sonographic Callus: A Novel Imaging Modality for Early Evaluation of Fracture Healing

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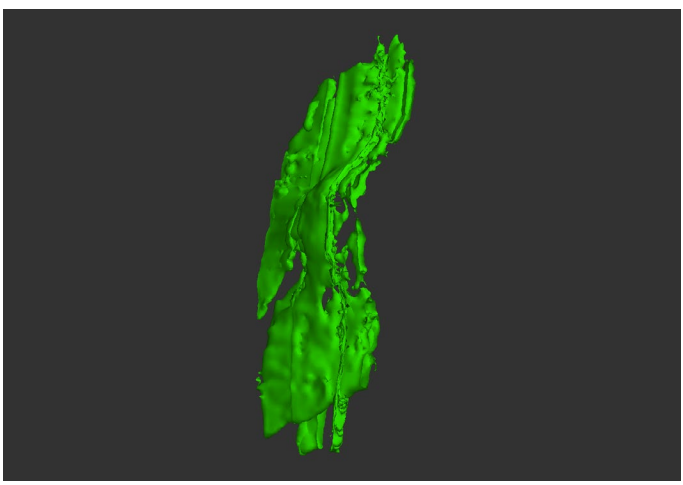
Purpose: Sonographic callus may enable assessment of fracture healing. The aim of this study was to establish a reliable method for 3-dimensional reconstruction of sonographic callus.

Methods: Patients who underwent nonoperative management of displaced midshaft clavicle fractures and intramedullary nailing of tibia fractures were prospectively recruited and followed to union. Ultrasound scanning was performed at periodical time points following injury. Infrared tracking technology was used to map each image to a 3-dimensional lattice. Criteria were first established for 2-dimensional bridging callus detection in a pilot study. Using echo intensity of the ultrasound image, semi-automated mapping was used to create an anatomic 3-dimensional representation of fracture healing. Agreement on the presence of sonographic bridging callus was assessed using the kappa coefficient and intraclass correlation coefficient (ICC) between observers.

Results: 112 clavicle fractures and 10 tibia fractures completed follow-up at 6 months. Sonographic bridging callus was detected in 62.5% (n = 70 of 112) of the clavicles at 6 weeks post-injury. If present, union occurred in 98.6% of the fractures (n = 69 of 70). If absent, nonunion developed in 40.5% of cases (n = 17 of 42) (73.4% sensitive and 100% specific to predict union). Out of 10 tibia fractures, 7 had bridging callus of at least 1 cortex at 6 weeks and when present all united. Of the three patients lacking sonographic bridging callus, one went on to nonunion (77.8% sensitive and 100% specific to predict union). Figure 1 shows medial tibia cortex bridging callus with extensive remodeling at 3 months post-injury in a patient who united. The ICC for sonographic callus between four reviewers was 0.82 (95% confidence interval 0.68-0.91).

Conclusion: Three-dimensional ultrasound reconstruction of bridging callus has the potential to identify impaired fracture healing at an early stage in fracture management.



The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

Δ Advanced Imaging Evaluation of Distal Radius Fractures Using Finite Element (FE) Analysis of High-Resolution Peripheral Quantitative CT

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Purpose: The objective of our study is to develop a numerical model that is capable of accurately predicting the mechanical behaviors of distal radius fractures (DRFs), including the stiffness of the fractured wrist, throughout the fracture healing process. The performance of 3 finite element (FE) methods, 2 density-based (continuum) methods and a homogeneous micro-FE (μFE) method, was evaluated. High-resolution peripheral quantitative CT (HR-pQCT) images were used to generate continuum and homogeneous μFE models. Stiffness of the fractured wrist was compared to stiffness of the uninjured contralateral wrist to quantify the change in stiffness over time.

Methods: Serial micro-CT imaging was collected for patients with DRFs over 6-month follow-up. The three types of μFE models generated included a homogeneous μFE approach and 2 continuum μFE approaches. The homogeneous μFE models were generated from segmented images through the direct conversion of voxels to 8-node hexahedral elements. A global threshold of 320 mg HA/cm3 was used to segment the distal radius bone. The resulting bone elements were assigned linear elastic material properties, with a Young's modulus of E = 8748 MPa and a Poisson ratio of v = 0.3. The 2 continuum μFE models were generated from the grey-scale HR-pQCT data using methods developed by Homminga et al or Shefelbine et al to define material properties. The Homminga and Shefelbine approaches relate densities to elastic moduli through an exponential and a piecewise linear relationship, respectively. All models were subjected to uniaxial compression and torsional loading. Models were solved using a custom FE solver.

Results: There were 30 participants in this study (27 females and 3 males), with an average age of (51.8 ± 16.5 years). Each participant had imaging performed at 2, 4, 6, 8, 12, and 26 weeks. For uniaxial compression, an initial change in stiffness of –10%, –20%, and –54% is predicted by the Homminga, Shefelbine, and homogeneous μFE models, respectively. The results of continuum and homogeneous μFE models demonstrated 1% and 3% of recovery of stiffness per week, respectively. The Homminga μFE approach did not capture significant longitudinal changes during the early follow-ups for either loading condition. The Shefelbine approach appears to be more sensitive to stages of fracture healing than the Homminga approach. The homogeneous μFE model illustrated a rapid recovery of stiffness.

Conclusion: Both the Shefelbine and homogeneous μFE approaches captured significant longitudinal changes in fracture stiffness. The homogeneous μFE method produced a rapid recovery of stiffness, suggesting it is more sensitive than continuum μFE approaches; therefore, it may better predict the mechanical characteristics of the injured wrist during fracture healing.

Δ OTA Grant

A Micro-CT and Biomechanical Analysis of the Effects of Intra-Wound Vancomycin Powder on Infection and Bone Healing in a Rat Model

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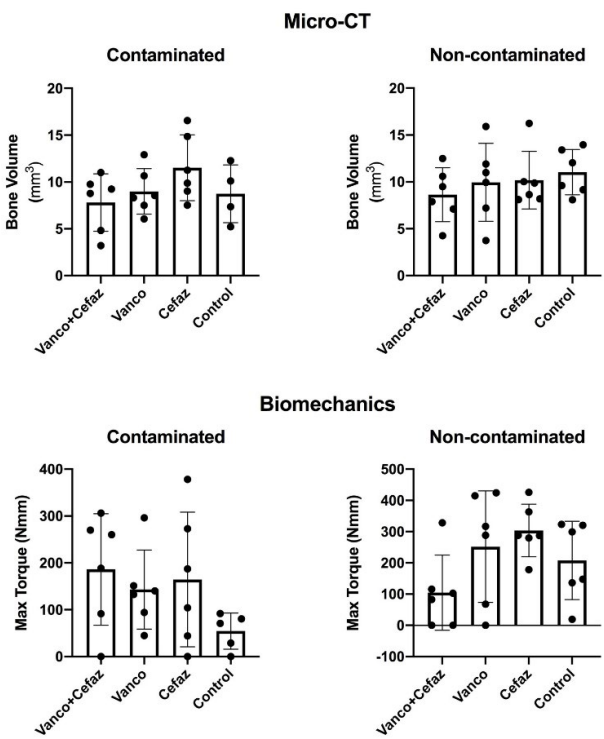
Purpose: The purpose of this study was to investigate the effects of intrawound vancomycin on the treatment of infection and fracture healing using micro-CT and biomechanics. We hypothesized that the application of vancomycin would be effective in preventing infection, without negatively affecting fracture healing.

Methods: Rats were assigned to 1 of 4 groups: (1) no antibiotics, (2) local vancomycin powder, (3) systemic cefazolin, or (4) local + systemic antibiotics. Animals either received an inoculum of Staphylococcus aureus or a control solution at the fracture site, creating 8 groups. The fracture was created by performing a midshaft osteotomy, followed by plate fixation. Local vancomycin powder was administered at the fracture site based on the treatment group. Animals allocated to systemic cefazolin received this every 8 hours for 4 doses. Study end point was 10 weeks, at which point tissue/implants were harvested for culture and bone healing was assessed with micro-CT and biomechanics.

Results: In the noncontaminated groups, no positive cultures occurred (0/24). The contaminated groups showed no positive cultures with local vancomycin (0/6) or local vancomycin + cefazolin (0/6). However, positive cultures were associated with one of the rats that received cefazolin only (1/6) and all animals that did not receive any antibiotics (6/6). Micro-CT and biomechanical results are shown in Figure 1. There were no statistically significant differences between groups with respect to bone formation or functional strength of the healed bone.



Conclusion: Our results suggest that the application of local intrawound vancomycin is effective for the prevention of infection and does not have a negative effect on fracture healing, thus supporting its use in contaminated or at-risk fractures.

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

Microgel-Enhanced Delivery of Adenosine to Accelerate Fracture Healing

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Purpose: Extracellular adenosine (ADO) has been shown to play a key role in bone health by supporting osteoblastogenesis and inhibiting osteoclastogenesis. However, direct administration of extracellular ADO to promote tissue repair is challenging because of the ubiquitous nature of ADO receptors in other tissues and short half-life of ADO in circulation. To deliver ADO to the target tissue, minimally invasive therapies such as in situ–forming injectable scaffolds are highly desirable. Herein, we propose an injectable hydrogel-based scaffold to deliver ADO at the bone tissue and promote fracture healing.

Methods: The scaffold was prepared in the form of a composite hydrogel and developed by using ADO containing microgels and cross-linkable hyaluronic acid (HA) polymers. The microgels were developed upon copolymerization of 3-acrylamidophenylboronic acid (3-APBA) and 2-aminoethylmethacrylamide (2-AEMA) conjugated hyaluronic acid (HA-AEMA) in an emulsion suspension. Mixing of the ADO loaded microgels with clickable HA polymers containing dibenzocyclooctyne (DBCO) and azide functional groups (HA-DBCO and HA-Azide) facilitated the entrapment of the microgels, formation of the composite scaffold, and provided injectibility.

Results: Scaffold showed gradual release of encapsulated ADO over a 2-week period. Negligible cell death was observed upon encapsulation of mouse mesenchymal stem cells (mMSCs) and osteoblastic cell line MC3T3-E1 in the scaffolds after 72 hours. In vivo experiments demonstrated that scaffold with ADO carrying microgel significantly enhances fracture repair in a mouse tibial fracture model with reduced callus size, higher bone volume, and tissue mineral density compared to the non-treated cohorts.

Conclusion: Extracellular ADO containing microgel-based scaffolds holds promise as an injectable bone-repairing platform to improve fracture healing.

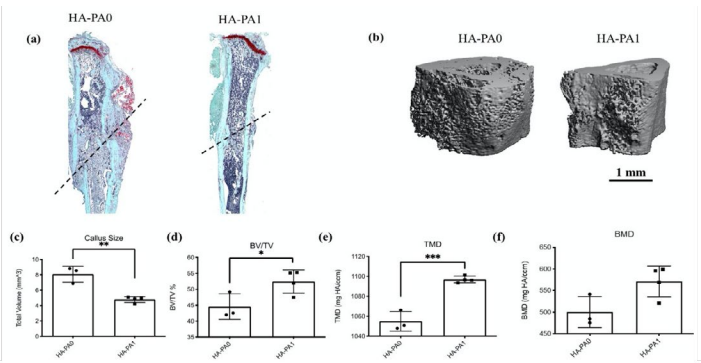

Figure 1. ADO loaded microgel based scaffolds promote callus remodeling. (a) Representative safranin-O staining images of fractured tibiae treated with either HA-PA0 or ADO loaded HA-PA1 scaffold at 21 days. Dotted lines indicate fracture site and subsequent tissue repair. (b) Radiographs, corresponding 3D reconstructions, of the callus regions of fractured tibiae. Tissues were harvested at 21 days following injury. (c-f) Callus size, bone volume ratios (BV/TV) of calluses, tissue mineral density (TMD) and bone mineral density (BMD) at 21 days. *p<0.05, **p<0.01, ***p<0.001.

Human Mesenchymal Stromal Subcellular Composition Depends on Bone Mass Density: A Single Cell Level Study by Mass Cytometry

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Purpose: Osteoporosis is a major health concern in societies with aging populations. In general, osteoporosis is a disease characterized by low bone mineral density (BMD) and increased skeletal fragility leading to increased fracture risk, primarily in the vertebra, wrist, and the hip. Osteoporosis-related fractures will cause costs of more than $28.5 billion USD by 2025, representing a serious economical burden. Osteoporosis is caused by an activity imbalance between osteoblast-mediated bone formation and osteoclastic bone resorption processes. Various studies reported protein expression patterns that are either associated with high or low BMD. However, there is a lack of insight into the molecular and cellular biology of the bone remodeling process at single cell resolution. In this study we aimed at analyzing at single cell level by mass cytometry differences in bone marrow stromal cell subpopulations between healthy patients and patients with low BMD.

Methods: Mesenchymal stromal cells (MSCs), which are the origin of osteoblasts, were the subject of this study. MSCs were isolated from patients either with a healthy BMD (dual energy x-ray absorptiometry [DEXA] T-score >–1) or with a reduced BMD (DEXA T-score <–1). We characterized MSCs on a phenotypic level based on their in vitro differentiation potential towards osteoblasts, chondroblasts, and adipocytes as well as on a molecular level using single cell mass cytometry.

Results: We report that phenotypical characterization revealed that MSCs from healthy BMD individuals showed a full trilineage potential toward osteoblasts, chondroblasts, and adipocytes. MSCs from low BMD individuals showed strong osteoblast differentiation potential, moderate chondrogenic potential, and poor adipogenic potential, reconfirming that MSCs are highly heterogeneous. Further, a large variation in the MSC subset composition between donors with healthy BMD and reduced BMD was detected. Single cell mass cytometry revealed two distinct MSC subsets. One of the subsets is primarily present in healthy BMD individuals and the other subset is mainly present in patients with low BMD.

Conclusion: In summary, our study shows, at single cell level, a high intra- and interpatient heterogeneity in protein expression and cell composition. The molecular expression indicates that specific MSC subpopulations are involved in the changed molecular mechanisms that are associated with low BMD diseases like osteopenia or osteoporosis. On a phenotypic level, our data showed that low-BMD individuals are still capable of forming bone extracellular matrix in vitro. These observations lead to the conclusion that the treatment of osteoporosis requires an individual approach with a focus on bone resorption processes.

Bone Targeting Nanocarrier-Assisted Delivery of Adenosine to Treat Osteoporotic Bone Loss

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Purpose: Extracellular adenosine has been shown to play a key role in maintaining bone health and could potentially be used to treat bone loss. However, systemic administration of exogenous adenosine to treat bone disorders remains a challenge due to the ubiquitous presence of adenosine receptors in different organs and the short half-life of adenosine in circulation. Toward this, we have developed a bone-targeting nanocarrier and determined its potential for systemic administration of adenosine.

Methods: The nanocarrier, synthesized via emulsion suspension photopolymerization, is comprised of hyaluronic acid (HA) copolymerized with phenylboronic acid (PBA), a moiety that can form reversible bonds with adenosine. The bone binding affinity of the nanocarrier was achieved by alendronate (Aln) conjugation.

Results: Nanocarriers functionalized with the alendronate (Aln-NC) showed a 45% higher accumulation in the mice vertebrae in vivo compared to those lacking alendronate molecules (NCs). Systemic administration of adenosine via bone-targeting nanocarriers (Aln-NC) showed attenuated bone loss in ovariectomized (OVX) mice. Furthermore, bone tissue of mice treated with adenosine-loaded Aln-NC displayed trabecular bone characteristics comparable to healthy controls as shown by micro-CT, histochemical staining, bone labeling, and mechanical strength.

Conclusion: We demonstrate that a bone-targeting nanocarrier can be used towards systemic administration of adenosine. Further, this mechanism is shown to prevent bone loss in an osteoporotic model and promote new bone formation and improved bone mechanical strength. These results suggest that systemic administration of exogenous adenosine via a bone-targeting nanocarrier could be a potential therapeutic strategy to treat osteoporosis and promote bone recovery.

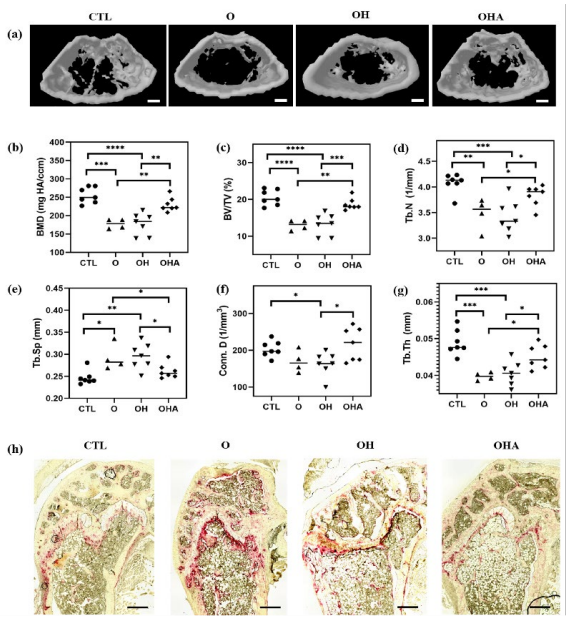

Figure. 1. Adenosine-encapsulated nanocarriers attenuate femoral bone loss in OVX mice. Administration of Aln-NC containing adenosine (OHA) and Aln-NC without adenosine (OH) in OVX mice for 8 weeks. (a) Reconstructed microcomputed tomography (μCT) images of distal femur (Scale bar: 500 μm). Quantification of μCT images: (b) bone mineral density (BMD); (c) bone volume (BV/TV); (d) trabecular number (Tb.N); (e) trabecular spacing (Tb. Sp); (f) connectivity density (Conn. D) (g) trabecular thickness (Tb. Th). (h) Tartrate-resistant acid phosphatase (TRAP; red) staining of the distal femur (Scale bars: 50 μm). *p<0.05, **p<0.01, ***p<0.001.

Thrombelastography Platelet Mapping Identifies Platelet-Mediated Hypercoagulability Following a Hip Fracture

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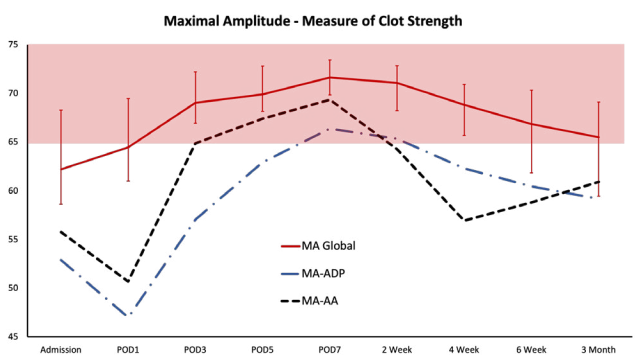
Purpose: Thrombelastography (TEG) has been used to define hypercoagulability and increased venous thromboembolism (VTE) risk that ensues following a hip fracture. Platelet mapping (PLM) using TEG analysis can be used to activate platelets at either the adenosine diphosphate (ADP) receptor or at the thromboxane A2 (AA) receptor, in order to evaluate platelet contribution to clot strength when activated only through those specific receptors. The study aim was to evaluate platelet contribution to hypercoagulability, in order to identify potential therapeutic targets for VTE prevention.

Methods: Serial TEG and PLM analyses were performed on admission, postoperative day (POD) 1, 3, 5, and 7, and then at 2, 4, 6, and 12 weeks postoperatively. All patients received thromboprophylaxis with low molecular weight heparin. All specimens were analyzed with a TEG 6S hemostasis analyzer. Inclusion criteria were adult patients aged 50 years or older with an acute hip fracture treated surgically. Exclusion criteria were prior history of VTE, active malignancy, or anticoagulation use. Hypercoagulability was defined as maximal amplitude (MA, a measure of clot strength) >65 on TEG analysis. Independent samples t tests and $\chi 2$ analyses were used.

Results: 21 patients were included, with a mean age of 72.7 years (standard deviation 13.2) and 52.3% (N = 11) being female. 11 patients (52.3%) were treated with arthroplasty. TEG analysis demonstrated hypercoagulability (mean MA>65) at all time points until 12 weeks (Fig. 1). PLM identified platelet-mediated hypercoagulability based on elevated ADP-MA and AA-MA, with more pronounced platelet contribution demonstrated by the AA pathway. Patients treated with arthroplasty had significantly increased AA-MA compared with ADP-MA at POD 3 and 12 weeks.

Conclusion: TEG can be used to identify hypercoagulability and increased VTE risk following a hip fracture. PLM analysis suggests a platelet-mediated hypercoagulable state that may benefit from an anti-platelet agent that targets the AA platelet activation pathway, such as ASA.



Greater Acute Articular Inflammatory Response in Tibial Plafond Fractures as Compared to Rotational Ankle Fractures

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Purpose: Several factors are thought to contribute to posttraumatic osteoarthritis (PTOA) development including the post-injury inflammatory response. Previous work has demonstrated a significant intra-articular inflammatory response after tibial plafond fracture that is greater than the response after tibial plateau fracture. However, these injuries affect different joints and therefore may not be truly comparable. The purpose of this study was to compare two injuries in one joint (the ankle) that have a presumed different severity and different prognosis. This study compared the inflammatory response after rotational ankle fracture with tibial plafond fracture.

Methods: This prospective comparative study was conducted at a Level I trauma center between 2014 and 2019. Patients between 18 and 60 years of age with acute ankle (AO/OTA 44-A-C) or plafond (AO/OTA 43-B-C) fractures were prospectively enrolled. Patients with preexisting ankle OA, autoimmune disease, additional intra-articular injury, or open fractures were excluded. Synovial fluid aspirations were obtained within 24 hours of injury. The concentrations of interleukin (IL)-1β, IL-1RA, IL-6, IL-8, IL-10, and matrix metalloproteinase (MMP)-1, MMP-3, and MMP-13 were quantified using a multiplex assay. Wilcoxon rank sum test and Kruskal Wallis tests were used for statistical analysis.

Results: Aspirations were obtained from 29 plafond fractures and 38 ankle fractures. Average age was 43 years (range, 20-59 years). Of the plafond fractures 13 were partial articular and 16 were complete articular injuries. Ankle fractures were predominately trimalleolar (23 fractures) in nature and 15 ankle fractures had articular impaction. IL-10 ($P = 0.002$), IL-1b ($P = 0.005$), IL-6 ($P<0.005$), IL-8 ($P<0.005$), MMP-3 ($P<0.005$), and MMP-13 ($P = 0.006$) were significantly higher in acute plafond fractures as compared to acute ankle fractures. Complete articular plafond fractures had higher levels of several inflammatory markers (IL-10, $P<0.005$; IL-1b, $P = 0.002$; IL-6, $P = 0.05$; IL-8, $P<0.005$) than partial articular plafond fractures. In contrast, inflammatory marker levels for ankle fractures with articular impaction were not significantly different compared to those ankle fractures without impaction.

Conclusion: This is the first study to compare articular inflammatory marker profiles for injuries of different presumed severities occurring at the same joint. Several cytokines were significantly elevated in plafond fractures as compared to ankle fractures, suggesting the inflammatory response is greater in plafond fractures. Given the difference in prognosis and the higher rate of PTOA after plafond fractures compared to ankle fractures, these data strengthen the case that the post-injury inflammatory response plays a role in PTOA development.

Articular Fragment Restoration Is Critical to Mitigate Post-traumatic Osteoarthritis in a Porcine Pilon Fracture Model

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Purpose: During articular fracture reconstruction, orthopaedic surgeons are frequently faced with the dilemma of retaining small articular fragments versus discarding these fragments. The purpose of this study was to compare posttraumatic osteoarthritis (PTOA) development between pilon fractures and pilon fractures with missing articular fragment (MF) in a live porcine model.

Methods: High-energy tibial plafond fractures were created in skeletally mature Yucatan mini-pigs using a validated, custom apparatus to deliver a linear impaction force. The anterior tibia cortex was cut with a saw in order to create a reproducible, partial articular fracture. The fractures were anatomically reconstructed with 3.5-mm plates. During surgery, a 2 × 2-mm section of plafond articular surface along the fracture was removed in 6 animals (MF group). Contralateral ankle joints served as controls. Animals were casted for 2 weeks and permitted to be full weight-bearing. Ankle joint synovial fluid was obtained at initial surgery and at 12-week necropsy. Synovial fluid was analyzed for inflammatory cytokine concentrations including interleukin (IL)-1b, IL-1Ra, IL-6, IL-8, and IL-10. The tibial samples were explanted, fixed in 10% neutral buffered formalin (NBF), and processed for histological analyses. Scanning electron microscopy was performed to evaluate subchondral bone porosity. Histologic sections were stained with Sanderson's rapid bone stain, Toluidine blue, or Safranin O and evaluated for vascular invasion (VI) and osteoarthritis score (Osteoarthritis Research Society International [OARSI] system) by a blinded bone pathology technician. Paired and unpaired two-tailed Student t tests were performed after confirming data normality using the Wilk Shapiro test. A P value <0.05 was considered significant.

Results: 11 of the 12 animals made it to the 3-month end point. One animal developed a postoperative infection and underwent early euthanasia. Fractured ankles had significantly greater concentrations of IL-1b, IL-1Ra, IL-6, IL-8, and IL-10 as compared to control ankles at T0 ($P<0.05$). There was no difference in cytokine concentrations between fractured and fractured + MF ankles at either T0 or T12weeks. Fractured ankles had significantly greater bone porosity, VI, and OARSI grade as compared to the control group, all consistent with greater development of PTOA. In comparing the fracture group with the MF group, the MF group had significantly more bone porosity (35% vs 19%, $P = 0.001$), more VI (1.15 vs 0.5, $P = 0.013$), and higher average OARSI grade (3.8 vs 2.3, $P = 0.011$) than the fracture group.

Conclusion: Articular fractures with a missing fragment had significantly worse PTOA development as measured by bone porosity, VI, and cartilage histologic grade than anatomically reconstructed articular fractures. Clinically, orthopaedic surgeons should make every effort to retain and reconstruct articular fragments in order to mitigate PTOA development.

Articular Fracture Increases Inflammatory Chondrocyte Gene Expression more than Compression with a High-Synovitis Co-culture Model

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Purpose: Posttraumatic arthritis (PTA) develops after various joint injuries. Previous models loaded osteochondral cores in compression to 70% strain or to fracture via a point load. To better simulate the articular environment, we co-cultured injured osteochondral cores with synovial cells from normal or inflamed synovium. We hypothesize that the synovial environment alters the physiologic responses of chondrocytes to injurious loading.

Methods: Synovial cells and osteochondral cores were isolated from fresh porcine knees obtained from an abattoir. Based on underlying synovitis, cells were pooled into low (normal) and high (inflamed) superlots and precultured for 4 days. Uninjured, compressed, or fractured osteochondral cores were then co-cultured for 3 days with plated synovial cells or alone. RNA was extracted from cartilage and combined from two cores (n = 3/group). Real-time polymerase chain reaction was performed for 84 inflammatory cytokine genes (Qiagen) and analyzed by multifactor analysis of variance. Ingenuity Pathway Analysis (IPA) software (Qiagen) was used and identified interleukin (IL)-1 as an upstream regulator for these injury states. For this reason, the above conditions were repeated with IL-1 inhibited using IL-1Ra (1000 ng/mL).

Results: Effect of injury with low-synovitis cells: Compression of cores co-cultured with low-synovitis cells significantly upregulated 9 genes and downregulated 0 relative to uninjured state; fracture only upregulated 5 genes and downregulated 0. When co-cultured with normal synovium, compression was more proinflammatory than fracture. Adding IL-1Ra downregulated 1 gene with compression and 7 genes with fracture relative to the injury state without IL-1Ra. In co-cultures with normal synovium, IL-1Ra was more effective (anti-inflammatory) for fracture than compression. Effect of injury with high-synovitis cells: Compression of cores co-cultured with high-synovitis cells significantly upregulated 2 genes and downregulated 1 gene relative to uninjured state with low synovitis; fracture upregulated 6 genes and downregulated 1 gene. With inflamed synovium, fracture induced more inflammatory genes than compression. Adding IL-1Ra downregulated 7 genes with compression but upregulated 5 genes with fracture relative to the injury state without IL-1Ra. In co-cultures with inflamed synovium and fracture, IL-1Ra was unable to downregulate inflammation. IPA: NF-κB (nuclear factor κB) was the top canonical pathway activated in all conditions. Additional activated pathways were the osteoarthritis pathway, HMGB1 (high mobility group box 1) signaling, and toll-like receptor signaling.

Conclusion: The mechanism of injury and level of synovial inflammation significantly regulated chondrocyte gene expression, revealing that fracture and compression are different injury mechanisms. The hypothesis was accepted. Future PTA studies should consider the injury mechanism and synovial environment for in vitro and preclinical experimental models.

Combination of Lidocaine and IL-1Ra Is Effective at Reducing Degradation of Porcine Cartilage Explants

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Purpose: Posttraumatic inflammation following joint injury, like articular fracture, contributes to the development of arthritis, and the administration of interleukin 1 receptor antagonist (IL-1Ra) is a potential intervention to mitigate this response. It is currently known that IL-1Ra mitigates cartilage degenerative changes induced by IL-1α and that lidocaine is used for local pain management in acute joint injury. Intra-articular delivery of both drugs in combination would be a novel and possibly disease-modifying treatment. However, it is not known if the interaction with lidocaine at clinical concentrations (1%) would alter the efficacy of IL-1Ra to protect cartilage from the catabolic effects of IL-1. We hypothesized that the treatment of articular cartilage with IL-1Ra in combination with a clinically relevant concentration of lidocaine (1%) will inhibit proteoglycan loss due to IL-1α equally to IL-1Ra alone.

Methods: Fresh porcine cartilage explants were harvested, challenged with IL-1α, and incubated for 72 hours with IL-1Ra or a combination of IL-1Ra and lidocaine. The primary outcome was total sulfated glycosaminoglycan (sGAG) release. Additional experiments assessed the effect of premixing and storage temperature of IL-1Ra and lidocaine on sGAG release.

Results: The combination of IL-1Ra and lidocaine was as effective as IL-1Ra alone at inhibiting IL-1α-mediated sGAG release. Regardless of the time point at which IL-1Ra and lidocaine were premixed or storage temperature prior to adding to explants, IL-1Ra and lidocaine significantly decreased total sGAG release to control levels and was not significantly different from IL-1Ra alone.

Conclusion: Our hypothesis was supported, and results indicate IL-1Ra and lidocaine combination treatment for inflammatory cartilage injury with IL-1α are not inferior to IL-1Ra treatment alone. Further, the combination is stable when reagents are stored in advance of administration at varying temperatures, providing clinically relevant information about storage of medications. The combination of IL-1Ra and lidocaine is equally as efficacious as IL-1Ra treatment alone in mediating biologic cartilage injury due to IL-1α in an explant model of the acute inflammatory state. The ability to premix and store this drug combination for intra-articular delivery may provide a novel treatment following joint injury to provide pain relief and block inflammation-induced catabolism of joint tissues.

Systemic Glucose-Insulin-Potassium Reduces Skeletal Muscle Injury, Kidney Injury, and Pain in a Murine Ischemia-Reperfusion Model

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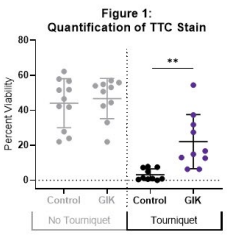
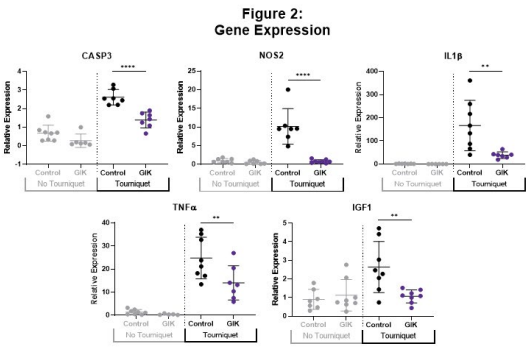
Purpose: Glucose-insulin-potassium (GIK) protects cardiac muscle from ischemia reperfusion (IR) injury; however, GIK's ability to protect skeletal muscle from IR injury is unknown. Given the similarities between cardiac and skeletal muscle, we hypothesized that GIK would reduce skeletal muscle damage and thus kidney injury following extremity IR injury.

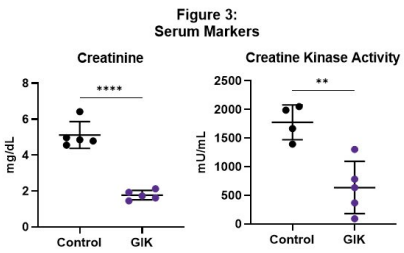
Methods: 20 C57BL/6 mice (10 control, 10 GIK) sustained IR injury (2.5-hour ischemia, 24-hour reperfusion) using a hindlimb rubber band tourniquet. From tourniquet placement until euthanasia, continuous subcutaneous osmotic pumps infused either saline control (0.9% sodium chloride) or GIK (40% glucose, 50 U/L insulin, 80 mEq/L KCl, pH 4.5) at 16 μL/hr. At sacrifice, skeletal muscle viability (triphenyltetrazolium chloride [TTC]) and gene expression were analyzed, serum creatinine and creatine kinase activity were measured, and a validated murine ethogram was used to quantify pain before euthanasia.

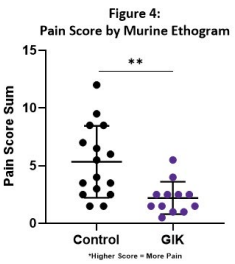
Results: GIK treatment resulted in a significant protection of skeletal muscle with increased viability (GIK 22.1%) compared to saline control (control 3.1%) ($P = 0.006$) (Fig. 1), a significant reduction in gene expression markers of cell death (caspase 3 [CASP3], $P<0.001$) and inflammation (nitric oxide synthase 2 [NOS2], $P<0.001$; interleukin [IL]1β, $P = 0.002$; tumor necrosis factor [TNF]α, $P = 0.012$; insulin-like growth factor [IGF]1, $p=0.007$) (Fig. 2), and a significant reduction in serum creatinine ($P<0.0001$) and serum creatine kinase activity ($P = 0.0037$) (Fig. 3). Lastly, GIK led to a significant reduction in IR-related pain ($P = 0.003$) (Fig. 4).

Conclusion: Systemic GIK infusion protects murine skeletal muscle from cell death, kidneys from reperfusion metabolites, and reduces pain following IR injury through reducing post-ischemic inflammation. Future human studies are required to evaluate GIK's role in elective and traumatic orthopaedic settings.









See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Humanitarian Scholar – Kenya

Post-Traumatic Inflammatory Load: Interleukin-6 and -8 Levels, Associated Potential Surrogate Markers, and Regression Analysis for Impact of Various Injury Properties

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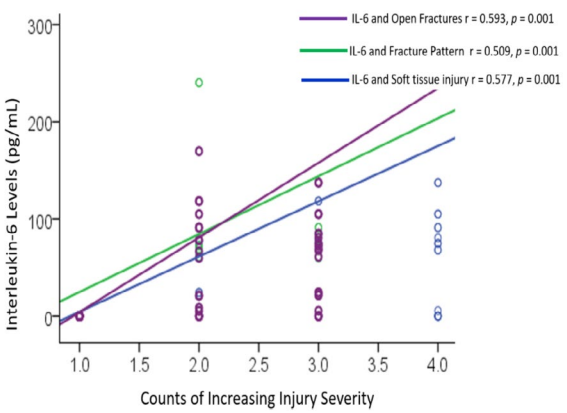
Purpose: The study sought to evaluate the levels of interleukin (IL)-6 and IL-8 following various fractures; to explore correlations between inflammatory cytokines, vital signs, complete blood count parameters, and injury severity following various fractures; and to perform regression analysis for the impact of various injury properties on the posttraumatic inflammatory load.

Methods: This controlled analytic study was conducted at a tertiary referral facility. A total of 70 adult participants comprised of 56 patients with fractures and 14 age- and gender-matched controls were studied. Fractures were evaluated for bone involved, number, pattern, extent of soft-tissue involvement, and whether they were open or closed. Flow-cytometry bead assay was used to analyze IL-6 and IL-8. One-way analysis of variance was used to compare the means. Pearson and Spearman rank correlation tests were used to check for association between IL-6 and IL-8 versus vital signs, complete blood count parameters, and fracture properties. A multiple linear regression model was used to determine whether fracture properties could predict the level of inflammation.

Results: The fracture groups had higher mean IL-6 and IL-8 levels ($P<0.01$). The polytrauma patients had statistically significant higher pulse rate, respiratory rate, and shock index than the negative controls ($P<0.01$). There was positive correlation between IL-6 and both shock index ($r = 0.312$, $P<0.05$). In addition, there was inverse correlation between IL-6 and platelet count ($r = –0.252$, $P = 0.05$). Soft-tissue involvement ($\beta = 0.646$, $P = 0.004$) and fracture pattern ($\beta = –0.497$, $P = 0.04$) significantly predicted the level of inflammation.

Conclusion: The IL-6 and IL-8 levels are elevated following various fractures, being highest in the polytrauma patients. The level of inflammation is inversely correlated with platelet count and positively correlated with shock index, offering potential surrogate markers. Extent of soft-tissue injury and fracture pattern are significant predictors of the level of inflammation.

An Overlay Scatter Plot of Interleukin-6 versus Severity of Fracture Pattern, Soft Tissue Injury and Open Fractures



Lipidomic Analysis in a Porcine Polytrauma Model Shows Significant Posttraumatic Changes to the Circulating Lipid Profile

***Yohei Kumabe, MD**; Yannik Kalbas, MD; Sascha Halvachizadeh, MD; Thorsten Hornemann, PhD; Roman Pfeifer, MD; Paolo Cinelli PhD; Hans-Christoph Pape, MD*
Zurich University Hospital, Zurich, Switzerland

Purpose: Posttraumatic release of pro-inflammatory mediators and the subsequent inflammatory response are key components in the development of complications in polytraumatized patients. New methods for the investigation of specific circulating and organ-bound lipids have found rapidly increasing usage investigating metabolic and cardiovascular disease; however, they have not yet been applied in the field of trauma. Several lipid subgroups have been shown to mediate inflammatory response. In this study, we investigated the posttraumatic intravasation of 233 specific lipids in a well-established porcine polytrauma model.

Methods: 54 male pigs (Swiss landrace) weighing 50 ± 5 kg underwent general anesthesia for 6 hours. Pigs were split in polytrauma (PT), monotrauma (MT), and sham group. PT received a combined injury of blunt chest trauma with a lung contusion, a grade II (AAST) liver laceration, controlled hemorrhagic shock (mean arterial pressure [MAP] 30 ± 5 mm Hg for 60 minutes), and femoral shaft fracture. MT received an isolated femoral shaft fracture. After 60 minutes animals were resuscitated with crystalloid fluids and fractures received intramedullary nailing. Venous blood was taken regularly from baseline (B) to 6 hours (6h) post-trauma. Lipid concentrations and lipid composition were investigated using mass spectrometry. 233 specific lipids were analyzed.

Results: Lipids were organized into 17 subgroups based on molecular characteristics. Dilution was normalized for albumin. Total lipid concentration, especially CEs (cholesteric esters) showed a significant ($P<0.05$) decrease in PT (total: 30,609 ± 17,459 nM/mL at B and 14,570 ± 6660 nM/mL at 6h). AcCa (acylcarnitines), PC (phosphatidylcholine), and FA (fatty acyls) showed a significant ($P<0.05$) increased directly after polytrauma. Five subgroups (Cers [ceramides], DAGs [diacylglyceroles], LPCs [lysophosphatidylcholines], PEs [phosphatidylethanolamines], and TGs [triacylglycerols]) showed a significant increase in MT group after trauma and in in both groups after treatment ($P<0.05$). Almost all subgroups of lipids in MT and PT showed significant decrease 6 hours post-trauma.

Conclusion: Our data clearly suggest significant changes to intravasal lipid composition after trauma and treatment with intramedullary reaming and nailing. Corresponding factors might be the posttraumatic intravasation of lipids from bone marrow, a response to posttraumatic cytokine storm, or the onset of a hypermetabolic state. Individual pathways have yet to be investigated and collation with clinical data is needed.

Protective Effects of New Femoral Reaming Techniques (Reamer Irrigator Aspirator, RIA I and II) on Pulmonary Function and Posttraumatic Contusion (CT Morphology): Results From a Standardized Large Animal Model

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Purpose: The effects of reaming for preparation of intramedullary fixation in long bone fractures have been widely studied. We compared pulmonary and systemic effects between conventional reaming with reamer irrigator aspirator (RIA) and unreamed nailing in an acute porcine trauma model with a standardized femur fracture.

Methods: In a standardized porcine model (moderate blunt chest trauma, abdominal injury and femoral shaft fracture), the femur was submitted to intramedullary nailing after resuscitation and normalization of pulmonary function. The treatment groups included 3 reamer types (group RFN: conventional reaming with Synream; group RIA1: reamer irrigator aspirator, version 2005; group RIA 2: reamer irrigator aspirator, version 2019) and were compared to unreamed femoral nailing (group UFN). Pulmonary function measurements included arterial partial carbon-dioxide pressure (paCO2 [kPa]) (baseline, post reaming, 2, 4, 6 hours) and volumetric measures of contusion in chest CT (at 6 hours). Systemic inflammatory response was measured at baseline and every second hour until 6 hours after trauma.

Results: This study included 24 male animals, mean weight 50.76 ± 4.1 kg, n = 6 per group). Group RFN developed a significantly higher partial CO2 (pCO2) at 1 hour after reaming when compared with all other groups (7.4 ± 0.4 kPa vs 5.4 ± 0.6 RIA 1, 5.6 ± 0.4 RIA 2, and 5.5 ± 0.5 UFN, $P<0.001$), along with a had lower pO2 (12.3 ± 1.3 kPa vs 17.2 ± 1.9 RIA 1, 17.4 ± 1.6 RIA 2, and 16.4 ± 0.7 UFN, $P<0.001$) and the degree of pulmonary hyperdense changes in the CT analysis was higher in RFN (485.2 ± 98.5 cm3 vs 344.4 ± 74.4 cm3 RIA 1 and 335.2 ± 58.1 cm3 RIA 2, $P<0.01$). The inflammatory reaction was lowest in both RIA groups when compared with group RFN or UFN ($P<0.001$).

Conclusion: Both RIA 1 and RIA 2 protect the lung from reaming induced dysfunction and have no systemic inflammatory effects, while the negative effects were more sustained after reamed or unreamed nailing. Both RIA 1 and RIA II appear to be of value in terms of a Safe Definitive Surgery (SDS) strategy.

In Vivo Intramuscular pH in Tibia Fractures Is Acidic But Normalizes After Stabilization and Resuscitation

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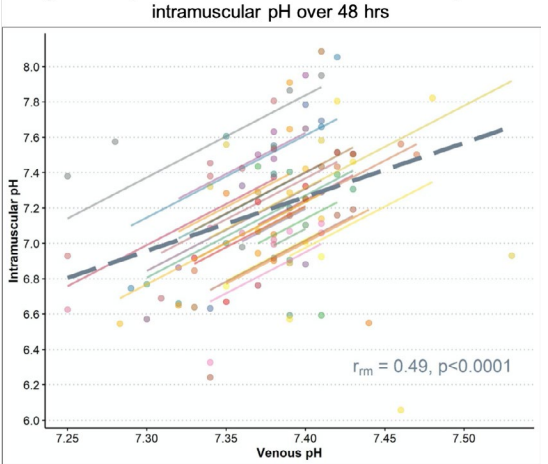
Purpose: Systemic tissue damage and resuscitation in trauma patients is evaluated via systemic pH. Little is known about intramuscular pH after tibia fracture. Our purpose was to study the in vivo intramuscular physiology adjacent to tibia fractures.

Methods: Adults with acute tibia shaft and plateau fractures (Level I, academic, 2019-2021) were offered enrollment in an observational cohort. During operative stabilization (nailing/framing) a sterile validated intramuscular pH (IpH) probe was placed into the anterior tibialis for 48 hours (<6 cm from fracture, continuous sampling) and venous pH (VpH) was drawn (0, 12, 24, 36, 48 hours). For analysis VpH and IpH were compared using a repeated measures correlation analysis; IpH values were extracted at 1-minute averages matching VpH timing. After informed consent, patients received standard of care via independent research team; no study data were available to the treating surgeon.

Results: 25 patients with tibia fractures (9 plateau, 16 shaft) were observed. Initial IpH sampling began post fracture at a mean of 38.2 hours (standard deviation [SD] 30.5). Initial IpH was universally acidic (mean 6.68, SD 0.18) and compared to initial VpH (mean 7.35, SD 0.06). Time from injury to surgery was not correlated with initial IpH (Spearmans, P = 0.56). Final IpH at 48 hours universally converged to VpH (means: 7.52, SD 0.44 vs 7.40, SD 0.03). IpH and VpH demonstrated a significant positive correlation over all 48 hours (rrm [df = 79] = 0.49, bootstrap 95% confidence interval 0.32, 0.65; P<0.0001).

Conclusion: In tibia fractures requiring operative stabilization, adjacent musculature remains nearly 1 order of magnitude more acidic than systemic circulating physiology prior to skeletal stabilization and resuscitation. After stabilization, limb IpH converged to systemic VpH within 48 hours; nearly 50% of the convergence can likely be attributed to acid-base equilibrium between extremity and systemic spaces.

Figure 1. Repeated measure correlation for venous pH and intramuscular pH over 48 hrs



[a]Each point represents a paired observation for a participant. Observations of the same color are from the same participants, with corresponding lines that indicate the repeated measures correlation fit.
[b]Measurements for venous pH were taken at the following intervals: preoperative, 12 hrs, 24 hrs, 36 hrs, and 48 hrs. Corresponding measurements for Intramuscular pH were recorded at the same interval, but starting with the first incision.

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Pre-Clinical Acute Compartment Syndrome with a Porcine Continuous Measurement Model

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Purpose: Acute compartment syndrome (ACS) is a surgical emergency that can have lasting and devastating consequences if not treated adequately or within an appropriate time. With the risk of missed diagnosis or overtreatment, there exists a need to reliably and accurately identify a compartment syndrome. Our laboratory has validated a wireless micro-electro-mechanical sensor to continuously and accurately monitor compartment pressures. We investigated the use of a balloon catheter versus an ischemia-reperfusion injury with superimposed direct crush of the anterior compartment in a porcine model. The objective of the study is twofold: (1) to establish and validate a porcine model of ACS, and (2) to determine the consistency of in vivo monitoring using novel pressure sensing technology. The ideal model would be reproducible and quantifiable increase in pressure after injury with return to normal pressures after compartment release.

Methods: In each hindlimb of six anesthetized Landrace Hybrid swine, two techniques were simultaneously performed to induce compartment syndrome. In one hindlimb, a balloon catheter was inserted in the anterior compartment and inflated between the tibia and the muscle. In the contralateral limb, two custom-made tourniquet cuffs were used to induce an ischemia-reperfusion injury with superimposed direct crush of the anterior compartment. The inflation was for a period of 5 hours. A 2-hour observation period ensued after deflation of both the balloon catheter and tourniquet cuffs. Percutaneous fasciotomy using a fasciotome was attempted in all hindlimbs before opening the complete compartment.

Results: Continuous monitoring of compartment pressure was successfully performed in vivo using novel pressure sensing technology. The ischemia-reperfusion with superimposed direct crush injury model was found to consistently yield higher post injury compartment pressures than the balloon catheter model. All animal legs had a return to baseline after complete release.

Conclusion: The use of novel pressure sensing technology can successfully measure compartment pressures in vivo. Both porcine models are effective at inducing compartment syndrome; however, the ischemia-reperfusion + crush model was found to be superior in numerous aspects including consistency, reproducibility, and ease of set-up. Release of the fascia resulted in an ideal modeling of return to baseline pressures.

Biomimetic Hematoma: Novel Carrier Delivers Extremely Low Dose rhBMP-2 for Highly Effective Healing of Large Bone Defects in Goats

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Purpose: The management of patients with large bone defects remains one of the most challenging clinical problems. One of the most promising treatments is the use of recombinant human bone morphogenetic protein 2 (rhBMP-2) delivered on an absorbable collagen sponge (ACS). However, it uses extremely high doses of BMPs, and has been associated with severe side effects, such as the inability of the collagen sponge to contain the rhBMP-2, allowing it to leach out into surrounding tissues. The fracture hematoma naturally serves as a scaffold that activates a cascade of biological events to initiate bone repair. Studies have shown that the removal of hematoma delays fracture healing, and that the structural properties of it, such as the porosity and thickness of fibrin fibers, influences bone repair. Our previous rat study demonstrated an ex vivo–created "biomimetic hematoma" (BH) that mimics the intrinsic structural properties of normal fracture hematoma, and consistently and efficiently enhanced the healing of large bone defects at extremely low doses of rhBMP-2 (0.33 μg). The aim of this study was to test if an extremely low dose of rhBMP-2 delivered within BH can efficiently heal large bone defects in goats.

Methods: Goat 2.5-cm tibial defects were stabilized with circular fixators, and divided into groups (n = 2-3): 2.1 mg rhBMP2 delivered on an ACS, 52.5 μg rhBMP-2 delivered within BH, and empty group. BH was created using autologous blood with a mixture of calcium and thrombin at specific concentrations. Healing was monitored with radiographs. After 8 weeks, femurs were assessed using micro-CT. Histology is in progress.

Results: Using 2.1 mg on ACS was sufficient to heal 2.5-cm bone defects. Empty defects resulted in a nonunion after 8 weeks. Radiographic evaluation showed earlier and more robust callus formation with 97.5% (52.5 μg) less of rhBMP-2 delivered within the BH, and all tibias were fully bridged at 3 weeks. The bone mineral density was significantly higher in defects treated with BH than with ACS. Defects in the BH group had smaller amounts of intramedullary and cortical trabeculation compared to the ACS group, indicating advanced remodeling.

Conclusion: Consistent with our study in rats, the results confirm that the ex vivo BH is able to mimic the function of innate fracture hematoma, which is the natural reservoir for rhBMP-2 and many other growth factors essential for bone healing, while also more efficiently regulating their release into the defect. The delivery of rhBMP-2 within the BH was much more efficient than on an ACS. Not only did the large bone defects heal consistently with a 40× lower dose of rhBMP-2, but the quality of the healing was also superior in the BH group based on the callus size and the bone morphometric parameters at 8 weeks. These findings should significantly influence how rhBMP-2 is delivered clinically to maximize the regenerative capacity of bone healing while minimizing the dose required. This would reduce the risk of adverse effects associated with BMPs, the treatment costs, and the nonunion rate.

Short Platelet-Rich Plasma Exposure Induces a Priming Effect on the Biophysiological Potency of Bone Marrow Mesenchymal Stem Cells in Humans

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Purpose: Platelet-rich plasma (PRP) and bone marrow mesenchymal stem cells (BM-MSCs) find application in the surgical treatment of nonunions and bone defects. Due to their different mechanisms of action, combination therapy has been popularized. However, there remains a lack of high-quality in vitro evidence supporting their use in combination. We therefore undertook a donor-matched laboratory study examining the biological effects of PRP on BM-MSC in humans. We therefore aim to investigate the effect of short autologous PRP exposure of 30 minutes on BM-MSC growth at the single-cell level.

Methods: 17 patients (median age 30 years [interquartile range (IQR): 27-42; range: 19-73]; male: female ratio = 1.8) undergoing surgery for nonunion (n = 6), osteonecrosis (n = 7), and second-stage Masquelet procedure (n = 4) were recruited. Bone marrow aspirate (BMA) was harvested from the patient's iliac crest, and PRP was generated following centrifugation of the same patient's peripheral blood. Donor-matched comparative groups were: (1) BMA and (2) BMA + PRP mixed at a 1:1 ratio to reflect clinical practice. Samples underwent 30-minute laboratory incubation at room temperature to mimic average surgical time (time from harvest to implantation), prior to processing for colony forming units–fibroblast (CFU-F) assay. Samples were assessed for BM-MSC characteristics by measuring MSC colony number/mL of BMA, colony area, and colony integrated density (ID) at day 14 of culture.

Results: A total of 1310 and 1324 colonies were analysed for the BMA and BMA + PRP group, respectively. In comparison to BMA alone, incubation of BMA with PRP resulted in a statistically significant increase in average colony ID (1.5-fold; $P<0.0001$) and colony area (1.5-fold; $P<0.0001$). Paired analysis (n = 17) demonstrated a statistically significant increase in both the median colony area (1.6-fold; $P<0.0001$) and median colony ID (n = 1.6-fold; $P<0.0001$), with a trend toward increased median colony number/mL.

Conclusion: This study demonstrates that short exposure to autologous PRP as seen in clinical practice induces a beneficial and long-lasting priming effect on the proliferative capacity of BM-MSC at the single-cell level. Further studies are needed to uncover molecular mechanisms behind this physiological phenomenon towards further optimization of bone regeneration strategies.

Bone Graft Composition with RIA from a Native Versus Previously Reamed Long Bone for Bone Graft Harvest?

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Purpose: Collection of autogenous bone graft from the intramedullary canals of long bones with the reamer-irrigator-aspirator (RIA) system has become common practice across the field of orthopaedic surgery. Prior studies have demonstrated that viable grafting material can be obtained with the RIA system, leading to similar union rates, but significantly less donor-site pain compared to iliac crest grafting. Supported by these prior studies, RIA has been employed in the treatment of nonunions and bone defects. RIA bone graft can be harvested from a "native" long bone or from a long bone that has previously had an intramedullary nail (IMN) placed but is removed as part of the procedure. Little is known regarding the biologic properties of graft obtained by RIA from a native long bone compared to RIA graft obtained after removing an IMN from a long bone. The primary aim of this study was to compare the biologic potential of bone graft harvested from a native long bone (native RIA graft - NR) or previously reamed long bone (re-reamed RIA – RRR) graft.

Methods: NR and RRR aspirates were collected intraoperatively and 5 mL of the aqueous filtrate was collected for analysis. The aqueous filtrate samples underwent stepwise centrifugation to remove cellular debris before analysis on a Luminex multiplex assay. Panel markers included bone morphogenic protein 2, vascular endothelial growth factor, fibroblast growth factor, interleukin-6, interleukin-1beta, osteopontin, and osteoprotegerin. Analyte levels were compared between NR and RRR using multiple t test with a Holm-Sidak correction for multiple comparisons. Threshold for significance was set at $\alpha = 0.05$.

Results: 11 NR and 10 RRR samples were collected as part of this study. Patient demographics, including age, sex, and graft isolation location, were comparable between cohorts. Analyte levels were detected in all aqueous filtrate samples. When comparing NR to RRR aspirates, no statistically significant differences were detected between cohorts for any of the analyte assessed including bone morphogenic protein 2, vascular endothelial growth factor, fibroblast growth factor, interleukin-6, interleukin-1beta, osteopontin, or osteoprotegerin.

Conclusion: These findings demonstrate that the quantitative biological potential of bone grafts from NR and RRR are equivalent. While the liquid aspirate from RIA has been previously demonstrated to be a source for osteoinductive proteins, future analysis of the hard tissue component will aid in further confirmation of the equivalency of RRR to NR bone graft.

Comparison of Reamer-Irrigator-Aspirator to Bone Marrow Aspirate Concentrate for Osteoprogenitor Cell Retention and Osteoinductive Protein Release on Cancellous Bone

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Purpose: This study was undertaken to determine if bone harvested with RIA (Reamer-Irrigator-Aspirator) is associated with significantly higher osteoprogenitor cell concentration and osteoinductive protein elution compared to bone marrow aspirate concentrate (BMC) when cultured on human cancellous allograft.

Methods: With Animal Care and Use Committee approval (ACUC #9167), both BMC percutaneously harvested from iliac crest (7%) and 10-mm RIA from ipsilateral femur (3 passes) were collected from skeletally mature purpose-bred hounds (n = 3, F). ~250 μL of BMC or RIA were used to saturate 2 cancellous allograft bone cubes per dog. Bone cubes (n = 6/type) were cultured individually in a 6-well plate for 7 or 14 days. On days 7 and 14 (n = 3/type/time point) cellular adherence to the bone block was determined using the microscopic cell viability stain calcein AM, and cellular adherence to the plate well was assessed. On day 3, 7, and 14 media were collected and assessed for leptin, platelet-derived growth factor (PDGF)-AA, PDGF-BB, SOST, vascular endothelial growth factor (VEGF), DKK-1, fibroblast growth factor (FGF)-23, osteocalcin, osteoprotegerin (OPG), osteopontin (OPN), and adrenocorticotropic hormone (ACTH).

Results: Media Biomarker Concentration On day 3, BMC had significantly higher concentrations of DKK-1, EGF, OPN, and OPG compared to RIA. On day 7 BMC only had significantly higher concentrations of DKK-1, however RIA had a higher concentration of PTH. On Day 14 there were no significant differences in the concentrations between RIA and BMC. Bone Block Cell Adherence On day 7 and 14, BMC had extensive cell adhesion to bone block surface and infiltration into block. On the other hand, RIA had minimal cell adhesion to bone block surface and no infiltration into block. Well Surface Cell Adherence On day 14, BMC had both cell adhesion and expansion compared to RIA with no cell adhesion or expansion.

Conclusion: In this canine in vitro model with human allograft bone cubes, BMC had significantly higher concentrations of DKK-I, EGF, OPN, and OPG, while RIA had a significantly higher concentration parathyroid hormone. Furthermore, BMC had a higher number of progenitor cells on the bottom of the well and on the allograft cubes. These results were somewhat unexpected and prove the null hypothesis. To see if this holds true in humans, we are in the process of performing a prospective human clinical study. These results will help delineate the effectiveness and indications for each technique to augment bone healing.

Plate Fixation of Midshaft Clavicle Fractures for Delayed Union and Nonunion Is a Cost-Effective Intervention But Functional Deficits Persist at Long-Term Follow-up

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Purpose: The primary aim of this study was to compare the long-term functional outcome of midshaft clavicle fracture fixation for delayed (≥3 months) and nonunion (≥6 months) compared to a matched cohort of patients who achieved union with nonoperative management. The secondary aim was to assess cost-effectiveness of fixation.

Methods: A consecutive series of patients over 10 years were retrospectively reviewed using the QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand [DASH] questionnaire), Oxford Shoulder Score (OSS) and EuroQol 5 Dimensions (EQ-5D). These patients were compared to a matched cohort that achieved union after nonoperative management using propensity score matching. The time horizon for the cost-effectiveness analysis was 4.1 years, which was the mean time of follow-up. Costs were derived from the Scottish National Tariff and local hospital procurement costs. The health-care cost of delayed union fixation was modeled for each patient at time of follow-up retrospectively, factoring in any secondary procedures or complications.

Results: 60 patients (follow-up 79%, n = 60 of 76) at 4.1 years postoperatively (range, 1.1-10.0 years) had a QuickDASH of 16.5 (95% confidence interval [CI] 11.6-21.5), OSS of 41.5 (39.0-44.1) and EQ-5D of 0.7621 (0.6822-0.8421). One in five patients were dissatisfied with their final outcome (n = 13 of 60). Functional outcome was inferior following fixation when compared to patients who united with nonoperative management (QuickDASH 16.5 vs 5.5, P<0.001; and EQ-5D 0.7621 vs 0.9073, P = 0.001). However, significant improvements were found when compared to preoperative scores (QuickDASH P<0.001 and EQ-5D P<0.001). The cost per quality-adjusted life year for fixation was £5624.62 ($7691.02) for the study cohort.

Conclusion: Clavicle fixation for delayed and nonunion is a cost-effective intervention but outcomes are worse compared to patients who unite with nonoperative management.

Prospective Study: Functional Results of the Reverse Shoulder Fracture Prosthesis Versus Conservative Treatment and Plate Osteosynthesis in Displaced Multipart Proximal Humerus Fractures

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Purpose: Despite the PROFHER (PROximal Fracture of the Humerus: Evaluation by Randomisation) trial that proposes conservative treatment for all proximal humerus fractures (PHFs), the optimal treatment for displaced PHFs remains controversial, especially complex fractures with 3 or 4 displaced parts. PROFHER did not distinguish complex PHFs from mildly displaced fractures, and furthermore complex 3- and 4-part fractures were underrepresented. Sound evidence guiding us in the treatment of complex displaced multipart PHFs is therefore still required. Our hypothesis is that the reverse shoulder arthroplasty (RSA) reduces pain and increases functional results in comparison to conservative treatment in displaced multipart PHFs.

Methods: In this case-control study, patients were included with a multipart PHF that were treated with an RSA. At 1-year follow-up, three questionnaires were administered: Constant Shoulder Score (CSS), the Oxford Shoulder Score (OSS), and the Disabilities of the Arm, Shoulder and Hand (DASH) score. Pain was assessed through the visual analog scale (VAS). Patients were matched to patients treated conservatively for morphologically similar fractures (based on the Neer classification) and matched for age and comorbidities.

Results: 131 patients were treated with an RSA. Until now, 62 patients had a 1-year follow-up and were included. The median pain score was 2 (interquartile range [IQR] 4), median forward flexion 108° (IQR 53), external rotation 16° (IQR 26), and abduction 96° (IQR 43). The median score of CSS was 27 (IQR 21.75), the DASH score was mean 26.7 (IQR 23.3), and the OSS 39 (12.75).

Conclusion: Initial results of the study of the optimal treatment of complex, displaced PHFs are promising. To put results in perspective, the above-mentioned patient cohort will be matched to patients treated conservatively in this ongoing study.

Operatively Managed Distal Radius Fractures: Complications and Reintervention Rates From a Single Center

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Purpose: The primary aim was to determine the rate of complications and the reintervention rate in a consecutive series of operatively managed distal radius fractures.

Methods: Data were retrospectively collected on a consecutive series of 304 operatively managed adult distal radius fractures (OTA / AO 2R3) treated at our institution in a single year. Inclusion criteria were acute unstable displaced distal radius fractures that were managed with surgery within 28 days of injury. Demographic and injury data, as well as details of intraoperative and postoperative complications and their subsequent management, were recorded.

Results: There were 304 fractures in 302 patients over the 1-year period. The mean age was 57 years and 74% were female. The majority of patients were managed with open reduction and internal fixation (ORIF) (n = 278, 91%), with 6% (n = 17) managed with manipulation and Kirschner wires and 3% (n = 9) with bridging external fixation. There were 27% (n = 81) with a postoperative complication. Complex regional pain syndrome (CRPS) was most common (5%, n = 14), followed by loss of reduction in 4% (n = 11). Ten patients (3%) had a superficial wound infection that was managed with oral antibiotics. Deep infection occurred in one patient and was managed with washout, antibiotics, and revision to bridging external fixator. Tendon rupture occurred in 3% (n = 10) of patients; six involved extensor pollicis longus (EPL), three involved flexor pollicis longus (FPL), and one involved both FPL and flexor digitorum profundus (FDP) to the index finger. 14% (n = 42) underwent further surgery. The most common indication was removal of metalwork (9%, n = 27), followed by carpal tunnel decompression (n = 4), revision ORIF (n = 4), and tendon transfer for EPL rupture (n = 4). Increasing age ($P = 0.02$), female gender ($P = 0.02$), and high-energy mechanism of injury ($P<0.001$) were associated with developing a complication. High-energy mechanism injury was the only factor associated with requiring further surgery ($P<0.001$).

Conclusion: This study has documented the complication and reintervention rates following distal radius fracture fixation in a consecutive series of patients from a large center with a defined catchment population. Given the increased risk of complications associated with surgery and the positive outcomes reported in the literature, nonoperative management of displaced fractures should be considered in older patients.

3D Virtual Pre-Operative Planning Lowers the Risk of Dorsal Screw Penetration in Volar Plating of Intra-Articular Distal Radius Fractures

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Purpose: The purpose of this study was to evaluate the effect of 3-dimensional virtual preoperative planning (3DVP) on the incidence of dorsal screw penetration after volar plating of distal radius fractures.

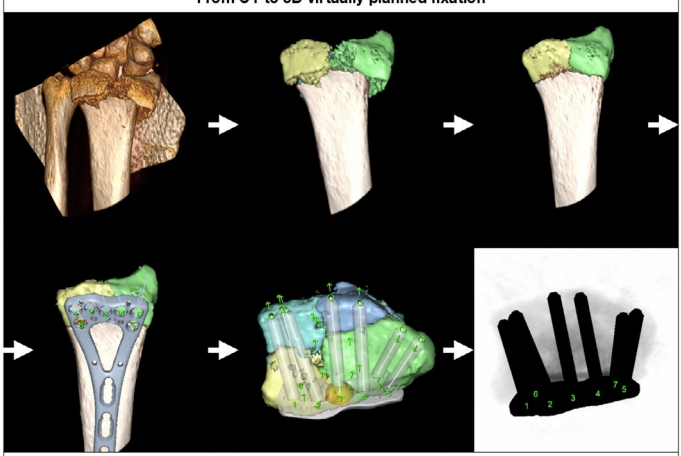
Methods: A cross-sectional diagnostic imaging study was performed. 20 out of 50 patients were randomly selected (computerized) from our index prospective cohort (IPC), a prior study to evaluate dorsal tangential views (DTVs) to reduce dorsal screw penetration in patients undergoing open reduction and internal fixation for an intra-articular distal radius fracture using postoperative CT scans to quantify screw protrusion. Preoperative CT scans from this cohort were now used for 3DVP by three experienced orthopaedic trauma surgeons. 3DVP was compared with the corresponding postoperative CT for assessing screw lengths, appropriate screw lengths (75% to 100% of radius diameter) and incidence of dorsal penetration. The Wilcoxon signed rank test was used to compare screw lengths and the Fisher's exact test for incidence of penetration.

Results: Three surgeons performed 3DVP for 20 distal radius fractures and virtually applied 60 volar plates and 273 screws. The median screw length was shorter in the 3DVP when compared to IPC: 18 mm (range, 12-22) versus 20 mm (range, 14-26) (P<0.001). The number of screws of appropriate length was similar between groups: 81% (222 of 273) for the 3DVP group versus 86% (78 of 91) for the IPC (P = 0.472). The number of penetrating screws was 5% (13 of 273 screws) in the 3DVP group compared to 11% (10 of 91 screws) in the IPC (P = 0.047). This corresponds to a reduction in incidence of at least one dorsally penetrating screw in 40% of patients in the IPC group, to 18% in the 3DVP group (P = 0.069).

Conclusion: 3DVP potentially reduces the incidence of dorsally penetrating screws in patients treated with volar plating for intra-articular distal radius fractures.

Figure III – Workflow Overview

From CT to 3D virtually planned fixation



First a 3D model is generated from a 2D CT scan, then removal of cast, surrounding bones and segmentation of individual fracture fragments is carried out. Next, reduction of fragments to their anatomical position, after which positioning of volar plate and positioning of screws is performed (bottom left, with screws 1-5 from ulnar to radial). Bottom middle is a view onto articular surface with screws 1-7 positioned. Bottom right presents the Dorsal Tangential view in Fluoroscopy mode

Urinary and Sexual Dysfunction Following Pelvic Fractures: A Retrospective Cross-Sectional Study

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Purpose: Traumatic pelvic fractures are known to be associated with urological injuries and sexual dysfunction. However, accurate estimates of their frequency are lacking and as such they are often overlooked during recovery. The aim of this study was to investigate patterns of urological injury and prevalence of urinary symptoms and sexual dysfunction following pelvic fractures.

Methods: A retrospective cross-sectional cohort study was conducted of male patients treated for pelvic ring fractures at a UK trauma center between 2015 and 2019. Identified patients were administered two questionnaires by telephone: a specially designed questionnaire assessing urinary and sexual dysfunction, and the validated International Index of Erectile Function-5 (IIEF-5) questionnaire diagnosing post-injury erectile dysfunction (ED).

Results: The final sample included 93 eligible patients, of whom 28 patients sustained a urological injury. Patients with pelvic fractures caused by anterior posterior compression (APC) forces were found to be at higher risk of urological injury compared xto lateral compression (LC) (relative risk: 2.37, 95% confidence interval: 1.17-4.82, $P = 0.0168$). Of the full sample, 26 patients completed both telephone questionnaires; 18 patients reported having urinary symptoms and 19 patients had sexual dysfunction, including 10 patients diagnosed with post pelvic fracture ED.

Conclusion: Urinary and sexual dysfunction post pelvic fracture was common in our cohort, affecting over half of patients. Patients with APC fractures may be at increased risk of urological injury. Symptoms unfortunately often remain unmanaged in these predominantly young men and have important implications for quality-of-life post injury, calling for proactive collaboration between orthopaedic and urology clinicians.

Pelvis and Acetabular Fractures: Patterns, Etiology, Management, and Early Outcomes at a National Trauma Hospital in Eldoret, Kenya

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Purpose: We undertook to describe the epidemiology, etiology, and management options of pelvic and acetabular fractures at a Level VI teaching and referral institution in Kenya, Africa. The hospital recently set up a 24-hour trauma unit, which has made it popular in the region for patient care. Pelvic and trauma cases presenting to the center have also significantly increased. Due to the complexity of these injuries, surgeons have had to seek specialized training and conduct research in order to achieve good outcomes.

Methods: This was a descriptive cross-sectional study evaluating all adult patients who presented with pelvic and acetabular fractures in the trauma unit. Data were collected using an interviewer-administered questionnaire. Radiographs were analyzed, and diagnosis and standard care administered.

Results: The mean age of presentation was 35.56 ± 12.14 years. There was a male preponderance of 70%. The etiologies were motor vehicle accidents (49%), motorized two-wheelers (33%), falls from height (11%), collapsing buildings (6%), and gunshots (1%). Among the pelvic fractures, the vertical shear pattern was 37%, anteroposterior compression 24%, lateral compression 17%, and combined mechanism 22%. Among the acetabular fractures the proportions were posterior wall (56%), posterior column and wall (16%), transverse and posterior wall (13%), posterior column (9%), and T-type (6%). Open reduction and internal fixation using the standard approaches was the mainstay of definitive management. Reconstruction plates and screws were the most popular choice of implants. External fixators were used definitively for open pelvic fractures.

Conclusion: The young productive male patients were the ones most afflicted. They are primarily the group in the population that is actively on the move trying to provide for their families and communities. Family distress and poverty has been witnessed following such occurrences. Poor safety standards within the public transport systems and motorbike safety is a major contributor in the occurrence of these severe pelvic injuries. Local biomechanical/crush studies should be conducted in order to inform policy. Acquisition of skill in the management of pelvic and acetabular fractures should be encouraged and invested in order to have good outcomes. Although associated with a relatively high mortality and morbidity, the majority of patients in the study had satisfactory short-term outcomes. More extensive long-term outcomes should be examined in the future. National or regional registries on pelvic and acetabular fractures should be established as this would encourage sharing of knowledge among surgeons in Kenya, Africa, and the world at large.

Pelvic and Acetabular Fractures Secondary to Horse Riding: Experience From a Major Trauma Center in England

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Purpose: Horse riding is a popular sport, enjoyed by millions of people recreationally and professionally. Pelvic and acetabular (P&A) fractures sustained through the sport may be life-threatening, while the treatment and potential sequalae of these injuries may prevent patients from riding and reduce quality of life. Despite this, there is a lack of literature on P&A injuries incurred through horse riding. We aim to describe P&A injuries sustained in equestrian accidents, discuss management, and establish their outcomes.

Methods: A retrospective analysis of all P&A injuries referred to the P&A service of a major trauma center (MTC) was undertaken, covering approximately 6 million people from January 1, 2016 to December 31, 2020. Data were extracted from a prospectively collected database of P&A injuries and cross-referenced with medical records to gather additional information.

Results: 60 of the 1218 P&A referrals were from patients sustaining fractures due to a horse riding accident. The mean age was 46 years (standard deviation [SD] 16.59), with 46 females. In total, 27 patients were treated operatively at the MTC, 15 of whom were transfers from other hospitals. One case was excluded for insufficient information; the remaining (n = 59) were classified. Pelvic fractures represented 78% of the injuries (n = 46). Lateral compression injuries were the most frequent (n = 29), followed by anterior-posterior compression (n = 10), sacral (n = 4), and pubic rami fractures (n = 3). The pattern of acetabular injuries (n = 13) was varied with transverse fractures (n = 4) being most common. The remaining consisted of anterior column fractures (n = 2), associated both columns (n = 2), T-shaped (n = 2) posterior column and posterior wall (n = 1), posterior wall (n = 1), and anterior wall (n = 1). Associated injuries were common and often significant. The nonoperative group comprised 55% (n = 33) of referrals. The operative group was managed by examination under anesthesia (n = 3), open reduction and internal fixation (n = 22), or percutaneous fixation (n = 2). Mean postoperative drop in hemoglobin was 17.67 g (SD 12.59). The mean postoperative length of stay (LOS) was 9.6 days (SD 5.38). The majority (81%) of patients were non–weight-bearing postoperatively. The mean time to independent mobilization was 12.6 weeks (SD 7.09). Return to riding information was available for 8 patients, with a mean of 29.5 weeks (SD 11.55). There were 4 significant postoperative complications.

Conclusion: Horse riding can result in significant P&A injuries. Associated injuries occur less commonly than in other high-energy mechanisms, such as road traffic collisions; however, they can be significant, should be suspected, and must not be missed. Individuals should be counseled that recovery can be protracted and it may take a significant amount of time before they are able to return to horse riding, if they are able to at all.

Outcomes of Surgical Implant Generation Network (SIGN) Intramedullary Nail in Treatment of Lower Limb Implant Failure in Herat Regional Hospital, Herat, Afghanistan

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Purpose: The aim of fracture treatment is to achieve union with timely functional recovery. Internal fixation with adherence to strict biomechanical principles is often required to achieve this. However, a fixation device may fail to hold a reduced fracture until union, giving rise to nonunion or delayed union with implant failure. The aim of this study was to see the efficacy of exchange of failed implant with Surgical Implant Generation Network) SIGN, an intramedullary interlocking nail.

Methods: 41 cases of long bone fractures that had the problem of poor fracture healing because of the fracture pattern of implant were prospectively studied for 6 months postoperation. The failed implants were exchanged with SIGN interlocking intramedullary nails. Only 15 cases completed the duration.

Results: 80% of patients were males and the other 20% were females. Range in age was 9 to 48 years. The femur was more frequently involved than the tibia, and the rate of infection was 6%. 75% of patients were able to squat and smile. Painless full weight bearing was 93% and healing by radiographic evidence was observed in 93%. Knee flexion >90° was present in 87.5%. There were no cases of screw loosening, implant failure, or deformity.

Conclusion: The SIGN intramedullary nail has excellent outcomes in treatment of lower limb implant failure. It is the option of choice in our hospital, as in any hospital in low- and middle-income countries.

Preventable Trauma Deaths and Corrective Actions to Prevent Them: A 10-Year Comparative Study at the Komfo Anokye Teaching Hospital, Kumasi, Ghana

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Purpose: We sought to determine the rate of preventable trauma deaths in an African hospital, identify the potential effect of improvements in trauma care over the past decade, and identify deficiencies in care that still need to be addressed.

Methods: A multidisciplinary panel assessed pre-hospital, hospital, and postmortem data on 89 consecutive in-hospital trauma deaths over 5 months in 2017 at the Komfo Anokye Teaching Hospital. The panel judged the preventability of each death. For definitely and potentially preventable deaths, the panel identified deficiencies in care.

Results: 13% of trauma deaths were definitely preventable, 47% potentially preventable, and 39% non-preventable. In comparison with a panel review in 2007, there was no change in total preventable deaths, but there had been a modest decrease in definitely preventable deaths (25% in 2007 to 13% in 2017). There was a notable change in the pattern of deficiency ($P = 0.001$) with decreases in pre-hospital delay (19% of all trauma deaths in 2007 to 3% in 2017) and inadequate resuscitation (17% to 8%), but an increase in delay in treatment at the hospital (23% to 40%).

Conclusion: Over the past decade, there have been improvements in pre-hospital transport and in-hospital resuscitation. However, the preventable death rate remains unacceptably high and there are still deficiencies to address. This study also demonstrates that preventable death panel reviews are a feasible method of trauma quality improvement in the low- and middle-income country setting.

Experience and Outcomes of the SIGN Fin Nail in the Treatment of Fractures of the Femoral Shaft

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Purpose: The Surgical Implant Generation Network (SIGN) nail is a solid stainless steel intramedullary nail, produced for austere environments such as ours in a lower middle-income country. It does not require fluoroscopy or power tools and it has dynamic and static locking options through an external targeting jig. All surgical cases and their subsequent follow-ups are logged into an online surgical database. The standard SIGN nail has been shown to have good results in femoral fracture treatment. The fin nail variant uses distal flanges in lieu of distal locking, which interdigitate with the canal wall, giving rotational and longitudinal contact stability. These qualities appear to make the nail more user-friendly with a less steep learning curve and it reduces surgical time. There is also purportedly less of a distal stress riser. We looked to evaluate our early results of its use in our patients.

Methods: We treated 71 femoral shaft fractures over 18 months using the fin nail. 25 were anterograde (mainly for midshaft fractures), and 46 were retrograde, mainly for distal-third fractures of various configurations. The case mix includes fresh features as well as nonunion treatments. The ages of the patients ranged from 12 to 80 years, and there were 51 male and 20 female patients. Patients were followed up at 6 weeks, 3 months, and 6 months if required. 50 patients had follow-up radiographs logged on the database. Clinical outcomes logged on the database were «squat and smile», painless weight bearing, and knee flexion greater than 90°. Hip flexion could be estimated from squat and smile pictures. Implant breakage and complications such as infection are also logged.

Results: All patients with radiographic follow-up at 3 months showed radiographic evidence of union. 90% of patients with follow-up at 6 weeks had painless weight bearing. 88% had knee flexion greater than 90° at 3-month follow-up. Radiographically, only 3 patients (4%) showed loss of position with shortening and/or significant displacement at all follow-up way points. 2 of these patients underwent revision of nailing. 2 of the patients had breakage of locking screws; only 1 of these was among the revisions. There were no infections in the cohort. No incidences of peri-implant fracture were reported. All the patients who were able to perform «squat and smile» at 6-week follow-up also had evidence of radiographic union. Operating times for the fin nail were shown to be 20 minutes shorter on average compared to standard SIGN nailing for femurs.

Conclusion: The SIGN fin nail is a useful nail in resource-limited settings for the treatment of stable and unstable femoral fractures, and in our hands has shown encouraging results despite the relative inexperience of many of our surgeons and procedures carried out without the use of fluoroscopy. It cuts operating time and has a lower stress riser distally, with no significant loss of stability or inferior fixation, even in length-unstable fracture patterns.

Functional Outcome of Distal Fibula Fractures Comparing Conventional AO-Semitubular Plating to Minimally Invasive Intramedullary "Photodynamic Bone Stabilization"

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Purpose: Since in the modern Western world people grow older and older, the incidence of fractures (eg, of the distal fibula) increases correspondingly. Regarding surgical treatment, soft tissue needs to be preserved especially in the elderly patients in delicate anatomic regions such as the ankle. The aim of the study was to find out whether the use of a novel, minimally invasive intramedullary osteosynthesis technique in distal fibula fractures in an elderly population results in a reduction of postoperative complications and hospitalization time and might lead to improved clinical outcome.

Methods: In this prospective study, all patients older than 65 years, with a Charlson comorbidity index ≥1 suffering from a distal fibula fracture (AO 44 B1.1, B1.2, B1.3) with indication for surgery were included. Patients were randomized to a treatment using either the one-third semitubular plate (group I) or a minimally invasive intramedullary (group II). In group II, early weight bearing was allowed immediately after surgery. Primary outcome parameters were function of the ankle joint, assessed by the Olerud and Molander ankle score (OMAS) and Karlsson and Peterson Scoring System for ankle function (KPSS). Secondary outcome parameters were postoperative complications divided into minor (eg, superficial wound infection) and major (eg, deep wound infection requiring revision surgery). Clinical and radiological follow-up were performed 6 and 12 weeks as well as 6 and 12 months postoperatively.

Results: 45 patients (27 F/18 M) with a mean age of 77 years (range, 65-93) were enrolled. 6 patients (13%) were excluded, so that 39 patients were available for follow-up. Group I patients (n = 18, 46%) were treated with one-third semitubular plate while 21 patients were treated minimally invasively with an intramedullary Photodynamic Bone Stabilization System (54%, group II). Four minor complications were detected in group I (22%), compared to none in group II. One patient in each group showed a major complication (group I: 5%, group II: 4.7%). Group II patients presented significantly better clinical results in OMAS ($P<0.01$, $P<0.01$) as well as in KPSS ($P<0.01$, $P = 0.02$) 6 and 12 weeks after surgery. Regarding the interval between trauma and surgery, a significantly shortened interval was found for group II ($P<0.01$).

Conclusion: In our study, a significantly better clinical function during the early postoperative follow-ups (6 and 12 weeks postoperatively) resulted in distal fibula fractures of elderly patients treated with minimally invasive intramedullary Photodynamic Bone Stabilization System (IlluminOss). Furthermore, the use of this new intramedullary stabilization system in combination with immediate postoperative weight bearing seems to be a safe, stable treatment option for ankle fractures in geriatric patients especially in the early stages of recovery.

Humanitarian Scholar – Nepal

Use of Kirschner Wires and Sutures for Anchorage of Partial Avulsion of the Heel Pad

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Purpose: Injuries of the heel pad are uncommon but difficult to repair and have poor outcomes. In the situation where partially avulsed heel pads are viable with intact sensation, simple suture after debridement may not be enough. Wound breakdown, infection, and flap necrosis are frequent. Accordingly, we used multiple Kirschner wires (K-wires) to fix the heel pad to calcanium and minimal skin sutures for anchorage of partially avulsed heel pads following proper debridement.

Methods: We reviewed cases of partial avulsion of heel pad anchorage treated in our hospital over a period of 4.5 years (April 2015 to October 2019). Data were taken from the hospital computer system.

Results: 30 patients with partial avulsion of the heel pad were found over 4.5 years. There were 14 males (46.7%) and 16 females (53.3%) ranging from age 10 to 81 years. Right-side heel pads were 20 and left-sided 10. Majority of injury mechanisms were road traffic accidents. Heel pads were fixed to calcanium with multiple K-wires and sutures applied to flap edges. The average time of injury to surgery was 12 hours. Four patients had superficial wound infection and were managed with regular saline dressing and intravenous antibiotics not needing further surgery. Two patients had migration of K-wires because of early weight-bearing against our advice. All patients were followed for an average of 18 months (range, 5-48) Clinical assessments were done by using the American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot score. AOFAS hindfoot score was good to excellent in most of the patients.

Conclusion: Treatment of heel pad avulsion is fairly difficult, with guarded outcome. The management goal of partial heel pad avulsion injury is to preserve as much viable heel pad tissue as possible to provide sensation and stable coverage. This method of anchorage ensures stable reattachment of the viable avulsed heel pad tissue with the least amount of possible trauma to the flap. There are controversies in the use of K-wires for fixation of heel pads. In our setup, with poor access to plastic surgery facilities, our treatment method has attained good outcomes.

Post-Operative CT Scan Findings and Functional Outcome in Patients Treated by Syndesmotaxis with an Ilizarov External Fixator for Tibial Plateau Fractures

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Purpose: We evaluated postoperative CT scan findings and the clinical outcome of tibial plateau fractures treated by syndesmotaxis with an Ilizarov external fixator.

Methods: This was a prospective study spanning between March 2010 and September 2018 involving 45 patients with a mean age of 39.5 years. Inclusion criteria were tibial plateau fractures Schatzker II to VI, in patients aged over 18 years. All of the patients were treated by syndesmotaxis with the application of an Ilizarov external fixator, with knee-bridging and mini-open reduction. Pre- and postoperatively, the patients underwent a CT scan of the knee, and the postoperative functional outcome was assessed according to the American Knee Society Score (AKSS). Mean follow-up was 12 months. Statistical analysis was carried out using SPSS version 21.00 (IBM Corporation).

Results: According to postoperative CT scan and articular impaction, the patients were divided into three groups. Eleven patients had less than 2 mm of impaction, 27 had 2 to 4 mm, and 7 had >4 mm. Patients with an articular impaction less than 4 mm showed a 95% chance for an excellent AKSS, in contrast to those with a greater impaction who presented with poor AKSS results. Every additional 1 mm of articular impaction reduced the AKSS by 15 points, as proved by the very high value of R2 in statistical analysis. An up to 5° deviation of the mechanical axis compared to the other limb presented a positive correlation to a good clinical outcome without being related to AKSS.

Conclusion: Syndesmotaxis combined with an lIizarov external fixator with knee-bridging and mini-open reduction provides adequate stabilization and restores the articular surface. CT scan of the knee is the sole most valuable imaging tool for preoperative planning no matter which classification system is used. Postoperative articular impaction is a useful prognostic tool for the final functional result.

Management of Open Tibia Fractures in Cuba

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Purpose: Musculoskeletal conditions, such as open tibia fractures, are a significant subset of the overall burden of trauma in Latin America, the region with the greatest proportion of road traffic fatalities per capita worldwide. Given Latin America's diverse resource settings, there is a need to examine country-specific characteristics that determine orthopaedic standards of care. In an effort to address potentially critical treatment questions facing specific patient populations in Latin America, regional preferences and differences for open tibia fractures in Cuba were examined. Cuba, a country with limited resources, is a unique country to evaluate given its standardized national health program, consistencies in education, and similarities across postgraduate training programs.

Methods: This cross-sectional study surveyed Cuban orthopaedic surgeons who treat open fractures. Treatment was evaluated across four domains: antibiotic prophylaxis, irrigation and debridement, fracture stabilization, and wound management. Management preferences were grouped by Gustilo Anderson fracture Type I and II (GA-I/II) and Gustilo Anderson fracture Type III (GA-III). Demographic information was also collected. A convenience sampling method was utilized to identify local surgeons through the national Cuban Orthopaedic and Traumatology Society (SCOT) and the academic Latin American orthopaedic research consortium, the Asociación de Cirujanos Traumatólogos de las Americas (ACTUAR). Data analysis was performed using the Fisher exact test ($P<0.05$).

Results: 67 orthopaedic surgeons completed the survey, representing 7 of 15 provinces in Cuba: Havana, Matanzas, Cienfuegos, Villa Clara, Sancti Spiritus, Camaguey, and Guantanamo. Open fracture postoperative antibiotics were administered for more than 72 hours for GA-I/II fractures (49%) and GA-III fractures (70%). Stratifying by Cuban province, surgeons practicing in Havana (n = 35) utilized primary internal fixation more commonly for GA-I/II fractures than surgeons in the other 6 provinces (n = 32) (64% vs 30%, $P = 0.008$). Further, surgeons in the 6 provinces performed primary closure at the time of definitive fixation for GA-I/II fractures more commonly than those in Havana (63% vs 32%, $P = 0.013$). For GA-III fractures, the surgeons in Havana (89%) and in the other 6 provinces (97%) preferred treating these injuries with delayed closure.

Conclusion: This study describes management characteristics of open tibia fractures in Cuba. Notably, there were some reported differences in fracture stabilization and wound management methods between the provinces, identifying an opportunity to evaluate whether these are a result of differences in surgical training or availability of resources. These findings can assist in addressing potential ways to optimize patient care, specifically through specialty training, resource allocation, and health-care policy priority setting.

Individualized Determination of Mechanical Fracture Environment and Healing Potential in Tibial Fractures: Clinical Feasibility of a Novel Simulation Workflow

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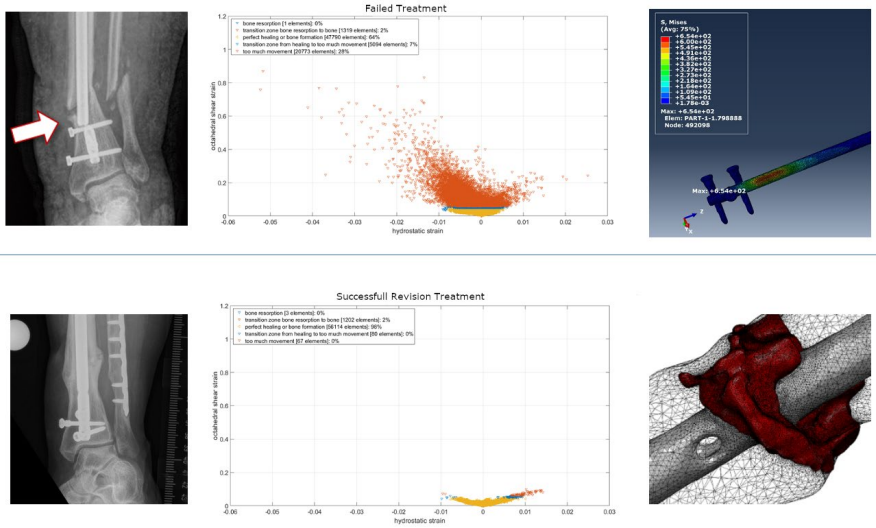
Purpose: Nonunion rate after tibial shaft fractures is a challenging problem. Apart from individual biology, injury pattern, and other patient-specific factors, the mechanical fracture environment is a key determinant of healing. The objective of this project was to establish a patient-specific simulation workflow that is able to determine the mechanical fracture environment and its mechanical healing potential.

Methods: A case of early mechanical failure after nail osteosynthesis of a tibial shaft fracture was referred to our institution for further treatment. After ruling out infection, a two-step exchange nailing was performed. A three-dimensional model of the implant and fracture situation was constructed from a postoperative CT scan. A simulation-driven workflow based on patient monitoring and motion capturing data were used to calculate the resulting biomechanical forces as an input for the simulation of the mechanical fracture environment before and after revision surgery. Implant stresses, interfragmentary movement, and resulting hydrostatic and octahedral shear strain were calculated and compared to the clinical treatment course.

Results: The simulation was able to accurately determine hardware stresses and adequately predict the site of hardware failure. In addition hydrostatic and octahedral shear strain of the revision situation were calculated to be within published healing boundaries (Claes, Shefelbine; Fig. 1). Accordingly the clinical course was uneventful with timely fracture healing.

Conclusion: We present a workflow that is able to determine the critical mechanical boundary conditions for fracture healing in relation to individual loading parameters early on during fracture healing. This allows for individualized treatment recommendations (weight bearing / revision) during the early postoperative phase.



See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Δ A Pilot, Masked, Randomized Controlled Trial to Evaluate Local Gentamicin Versus Saline in Open Tibia Fractures

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Purpose: Open fractures have a high risk of infection with increased patient mortality, delayed healing, reoperation, and decreased functional outcome and quality of life. Antibiotics administered locally at the site of the open wound are a potentially effective preventive measure, but there are limited data evaluating aminoglycosides. The objective of this study is to assess the feasibility of a clinical trial aimed to test the efficacy of local gentamicin in reducing the risk of fracture-related infection (FRI) after open tibial fracture.

Methods: This study is a single-center pilot, masked, randomized controlled trial. All patients 18 years and older presenting to the emergency department with an open tibia fracture (Gustilo-Anderson types I, II, or IIIA; OTA Type 42) were eligible for this study. Patients were excluded if time from injury to presentation was >48 hours or time from injury to surgery was >7 days. Participants were randomized intraoperatively after wound closure to receive gentamicin solution (treatment) or normal saline solution (control) injected at the fracture site. Follow-ups were completed at 2 weeks, 6 weeks, 3 months, 6 months, 9 months, and 1 year postoperatively. The primary feasibility outcomes were the rate of enrollment and retention. The primary clinical outcome was the occurrence of FRI. Secondary outcomes measured were the occurrence of nonunion, unplanned fracture-related reoperations, EuroQol 5 Dimensions (EQ-5D) score, Function Index for Trauma (FIX-IT) score, and modified Radiographic Union Scale for Tibial Fractures (RUST) score.

Results: Of 199 patients screened, 100 eligible patients were successfully enrolled and randomized over 9 months (11.1 patients/mo). Most of the study population were male (80%) with an average age of 34 years (standard deviation 12.3). The primary mechanism was road traffic injury (85%). Complete data were recorded at baseline and follow-up for >95% of cases. The final rates of follow-up will be presented at the OTA Annual Meeting.

Conclusion: This pilot study is among the first to evaluate locally administered gentamicin in open tibial fractures. Results indicate a rigorous clinical trial with acceptable rates of enrollment and follow-up to address this topic is possible in this setting. We therefore plan to proceed with a well-powered definitive trial.

Δ OTA Grant

Clinical Frailty Score on Admission Predicts 30-Day Survival, Post-operative Complications, and Institutionalization in Patients with Fragility Hip Fractures: A Cohort Study of 1255 Patients

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Purpose: We assessed the value of the Clinical Frailty Scale (CFS) scores in the prediction of adverse outcomes after fragility hip fracture. Our aims were to determine the relationship between the CFS score and 30-day mortality, inpatient complication rate, institutionalization, and length of hospital stay; and to compare the predictive value of the CFS compared to the Nottingham Hip Fracture Score (NHFS), currently the most widely used tool in the UK to predict 30-day mortality after hip fracture.

Methods: Consecutive patients aged greater than 65 years with a fragility hip fracture admitted to one institution were studied. Clinicians estimated CFS scores on admission. Routine audit personnel prospectively collected thorough data sets including demographics and the following outcomes: 30-day survival, in-hospital complications, length of acute hospital stay, and new institutionalization. The relationship between CFS scores and these outcomes was examined graphically and the visual interpretations were tested statistically using Spearman's correlation coefficient. The predictive value of the CFS to predict 30-day mortality was compared to that of the NHFS using receiver operating characteristic curves and area under the curve (AUC) analysis.

Results: We demonstrate significant nonlinear associations between CFS scores and 30-day mortality, the incidence of complications, length of hospital stay, and new institutionalization. The CFS predicted 30-day survival equally as well as the NHFS: CFS (95% confidence interval) AUC 0.631 (0.572, 0.690); NHFS (95% confidence interval) AUC 0.631 (0.571, 0.690).

Conclusion: These findings have immediate value to clinicians, patients, and their families. At the point of being admitted with a hip fracture, the health-care team can use the CFS score to discuss likely prognosis and hence produce more informed care plans. For example, many patients with high CFS scores, who are therefore at higher risk of death, complications, and institutionalization may choose care plans that focus on symptom control rather than life extension. While this work demonstrates the value of the principle of the measurement of frailty, the quantification of frailty remains a matter of considerable debate. The value of the CFS is its utility in that in can be scored rapidly and immediately by a clinician in almost all patients without the need for special equipment.

A Novel Mesh-Free Method for Accurately Simulating the Crushing and Cracking Behavior of Trabecular Bone Tissue With a Wide Range of Clinically Relevant Bone Mineral Density Values

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Purpose: Accurate simulation of trabecular bone biomechanics is critical to the development of orthopaedic implants resistant to postsurgical migration, particularly for patients with osteoporosis. Conventional mesh-based simulation techniques such as finite element analysis (FEA) are limited in their ability to model the crushing, cracking, fragmentation, and compaction phenomena that occur during implant migration. Recent studies have shown that newer mesh-free simulation techniques, such as smoothed-particle hydrodynamics (SPH), can overcome many such limitations, although validation was only completed for a narrow range of bone densities and morphologies. In the present study, an improved mesh-free simulation method was developed capable of accurately simulating the cracking, fragmentation, and compaction of trabecular bone specimens with a wide range of bone densities and morphologies. Results were validated by examining the concordance between physical and simulated results when crushing human cadaveric trabecular tissue.

Methods: Cylindrical trabecular bone specimens (n = 22) with height of 12 mm and radius of 3.7 mm were extracted from the proximal heads of 9 fresh-frozen human cadaveric humeri (7 female, 2 male donors; mean age 73.7 years; range, 45-86). MicroCT scans of these specimens (15 μm/pixel) were used to measure volumetric bone mineral density (vBMD; range, 0.040–0.214 gHA/cm3) and to construct mesh-free models for simulation. Physical and simulated specimens were compressed under axial loading to 20% to 30% of their original height while recording force-displacement data. To improve concordance with the physical data, simulation parameters were systematically iterated to develop an equation (power law) that adjusted the Young modulus for each specimen according its vBMD score.

Results: Across all vBMD values (0.040-0.214 gHA/cm3), the concordance correlation coefficient (CCC) between physical and simulated force-displacement data was 0.762, with a 95% confidence interval (CI) of 0.746-0.777, a Pearson ϱ (precision) value of 0.911, and a bias correction factor Cb (accuracy) value of 0.837. For the 15 least-dense specimens (vBMD values of 0.040-0.150 gHA/cm3), the CCC was 0.8792 (95% CI 0.866-0.891, ϱ = 0.936, Cb = 0.940). From the literature, this range of density (0.040-0.150 gHA/cm3) accounts for between 80% and 99.9%, 91%, and 87% of the trabecular bone tissue present in the proximal humeri, proximal femora, and lumbar vertebrae of postmenopausal women, respectively.

Conclusion: The improved mesh-free model presented here accurately simulated the behavior of trabecular bone specimens with a range of densities representing the majority of trabecular bone present in the humeri, femora, and lumbar vertebrae of postmenopausal women. Further research is necessary to improve accuracy for denser tissue. This is the first such model of which the authors are presently aware.

Is the Use of Short Cephalomedullary Nails a Risk Factor for Thigh Pain and Re-fractures?

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Purpose: Our objective was to determine whether the use of short cephalomedullary nails (170 mm and 200 mm) for intertrochanteric fractures in elderly patients is associated with increased rates of thigh pain and peri-implant fractures.

Methods: This was a prospective observational study conducted at a Level I trauma center. 122 patients with intertrochanteric fractures who were operated on using short cephalomedullary nails (170-mm and 200-mm lengths) between January 2018 to June 2019 were included in the study. Main outcomes measured were the functional outcomes and the incidence of thigh pain and peri-implant fractures.

Results: At the time of final follow-up (mean follow-up 14.1 months), fracture union occurred in all patients. Out of the 122 patients, only 12 patients had thigh pain at last follow-up. Six patients had the helical blade protruding from the lateral cortex, which may explain the cause of their pain. Only two patients had pain for which no other obvious cause was found and had to be attributed to the nail length. There were no cases of peri-implant fractures in our study, even though five of the patients had sustained re-trauma during the follow-up period.

Conclusion: Short (170 mm and 200 mm) cephalomedullary nails were not associated with increased risk of thigh pain and refractures. Thigh pain associated with these nails is often unrelated to nail length and can be prevented by using proper surgical technique.

Details of patient with thigh pain at follow up

S No.	Age	Sex	Nail Size	Pain score (using Visual analogue scale)	Associated radiological findings	Activity level and mHHS at follow up
1.	64 yrs	M	170mm	3	Long blade	68
2.	70 yrs	F	170mm	2	Long blade, Proud nail	77
3.	70 yrs	M	170mm	3	Long blade, Proud nail	83
4.	67 yrs	M	170mm	3	Posterior entry point	77
5.	75 yrs	M	170mm	4	Long blade	81
6.	78 yrs	M	170mm	3	Long blade, Excessive bowing of femur	68
7.	72 yrs	F	170mm	3	Excessive bowing of femur, Proud nail	63
8.	65 yrs	M	200mm	3	No specific finding	87
9.	72 yrs	F	200mm	4	Long blade, posterior entry	55
10.	65 yrs	F	200mm	4	Proud nail	83
11.	74 yrs	M	200mm	3	No specific finding	87
12.	76 yrs	M	200mm	4	Excessive bowing of femur	83

Associated radiographic findings	***Number of cases***
Improper blade length (Lateral soft tissue irritation)	6
Proud nail segment proximally	4
Excessive bowing of femur	3
Posterior entry point	2
No immediate cause found	2

Osteotomy and Intramedullary Nailing for Incomplete Diaphyseal Atypical Femoral Fracture with Increased Anterolateral Bowing

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Purpose: Increased anterolateral bowing is known as the main cause of atypical femoral fractures (AFFs) in the diaphysis, compared to the subtrochanteric region. While prophylactic intramedullary (IM) nailing is a preferred method for incomplete diaphyseal AFFs, increased anterolateral bowing is an obstacle to perform it. We executed the femoral osteotomy and IM nailing, which straightens the exaggerated anterolateral curvature. We hypothesized that this technique may heal the incomplete diaphyseal AFF, eliminating its primary pathology.

Methods: From October 2015 through March 2020, 17 female patients (20 cases; mean age 75.4 years, range 68-86) who underwent a surgical procedure for AFF with anterolateral bowing at our institute were evaluated. The surgical technique consists of minimally invasive osteotomy and reconstruction IM nailing, with or without an additional plate. Preoperative and postoperative values of the radiologic index (anterolateral bowing grade and anterior and lateral bowing angles) were compared. Primary union, the time to union, and complications were evaluated as outcomes.

Results: All the radiologic indices were improved after osteotomy (anterolateral bowing grade: 2.2 to 0.10; $P<0.05$, anterior bowing angle: 17.3° to 11.5°; $P<0.001$, lateral bowing angle: 12.0° to 3.3°; $P<0.001$). 21 of 22 cases achieved the primary union at an average of 24.9 weeks (20 to 36 weeks). There was one case of nonunion, which healed after autogenous bone graft and the plate augmentation.

Conclusion: Osteotomy and IM nailing technique may be appropriate in incomplete diaphyseal AFF with increased anterolateral bowing, not only to resolve the primary pathology and but also to prevent the complete fracture.

For the Better Outcome for Hip Fracture Patients: The First Orthogeriatric Co-management in Japan

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Purpose: Although the prognosis of hip fracture has improved over recent decades, mortality following hip fracture is still high. Hip fracture patients are often frail, with several comorbidities. Therefore, the fracture often represents only one of a number of medical problems. These problems are often beyond the scope and expertise of orthopaedic surgeons. To better deal with the special needs of these patients, models for collaborative care of patients with fragility fractures have been developed in which orthopaedic surgeons and geriatricians work together, called orthogeriatric comanagement (OGCM). Recently, some studies have reported lower mortality rates among the patients with OGCM. However, there are no hospitals to provide OGCM to hip fracture patients in Japan. Therefore, general physicians and orthopaedic surgeons in our hospital have collaborated and established a hip fracture center since 2019; furthermore, we started to provide the first OGCM in Japan in 2020. The purpose of this study was to investigate the effectiveness of OGCM in Japan.

Methods: There were 165, 211, and 219 cases of proximal femur fractures operated during 2018 (management by orthopaedic surgeon alone), 2019 (transitional period), and 2020 (OGCM by general physicians and orthopaedic surgeons), respectively. In these 3 groups, 46, 48, and 41 patients were treated during the 3 months from April to June. We compared the waiting time for the surgery, length of hospital stays, and mortality rate of 30 days, 3 months, and 6 months after operation among these 3 groups. We also investigated the osteoporosis treatment intervention (secondary prevention) rate in this study.

Results: The waiting time for surgery was 0.89 days in 2018, 1.5 days in 2019, and 1.56 days in 2020, and the delay of the surgery was found after the collaboration with general physicians. There was no significant difference in the 30-day, 3-month, and 6-month mortality rates among these 3 groups. On the other hand, the length of hospital stay was shortened every year (2018, 20.4 days; 2019, 17.7 days; 2020, 16.1 days). The osteoporosis treatment intervention (secondary prevention) rate improved from 88% in 2018, to 98% in 2019, and 100% in 2020.

Conclusion: There was no significant difference of the postoperative mortality rate among non-OGCM period, transitional period, and OGCM period in this study. It may be partly because the postoperative mortality rate following hip fracture is lower in Japan than in Europe and the United States. Actually, mortality rates 3 months and 6 months after operation in 2018 (non-OGCM period) were 4.3% and 11% in this study. However, an improvement in the osteoporosis treatment intervention rate and a reduction in the length of hospital stays were observed. We concluded that OGCM was considered to be effective in Japan as well as in Europe and the United States.

Multidisciplinary Approach to Prevent Secondary Fractures After Geriatric Hip Fractures: What Has Changed After This Approach?

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Purpose: Proximal femoral fractures have increased significantly with the increasing average lifespan. The risk of contralateral hip fracture after first hip fracture is reported more than twice. Recently, a multidisciplinary approach around a core of fracture liaison management to prevent secondary fracture after geriatric hip fracture is spreading. In this study, we investigated what has changed after this approach.

Methods: We started this multidisciplinary approach called N-POP (Nishinomiya support service of Prevention for secondary Osteoporotic Proximal femur fracture) on January 2019. We investigated 149 patients over 65 years of age who had surgery for hip fracture. 69 patients (control group: C group) were before this approach (January-December 2018) and 80 patients (N-POP group) were after this approach (January-December 2019). The days from admission to surgery, admission period, medication for osteoporosis at discharge and follow-up, and another fracture during follow-up were investigated. Student t test and $\chi 2$ examination were performed.

Results: The days from admission to surgery were 1.5 days in N-POP group, 1.8 days in C group; admission period is 28 days in N-POP group, 31 days in C group. There were no differences in these periods of both groups. 72 patients of N-POP group had medication for osteoporosis at discharge, while 14 patients in C group had medication. There was a significant difference between groups ($P<0.001$). 11 patients have not visited outpatient clinic (3 patients died) in N-POP group after discharge and also 11 patients have not come to outpatient clinic in C group (2 patients died). Medication at follow-up was 65 of 69 patients in N-POP group and 18 of 58 patients in C group. There was also significant difference in both groups ($P<0.001$). Another fracture occurred in 10 of 67 patients in N-POP group and 5 of 45 patients in C group. There was no difference between groups ($P = 0.52$).

Conclusion: Medication for osteoporosis was much improved in this approach. However, occurrence of another fracture was not prevented.

Teaching the "HECTOR" Approach to Daily Reviews Results in Sustained Improvements in Medical Management of Elderly Trauma Patients

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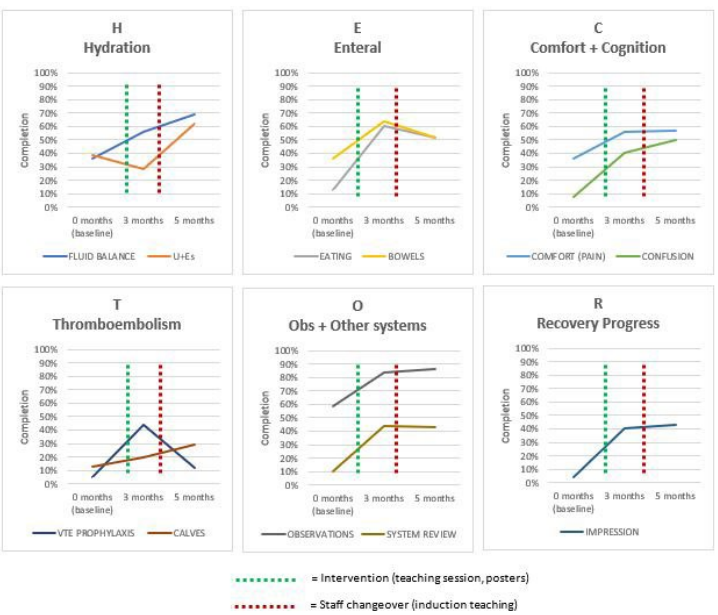
Purpose: Despite elderly patients making up a significant volume of inpatient trauma workload, there are often limited orthogeriatric resources to review their medical needs. Staff redeployment during the COVID-19 pandemic has stretched resources further. The Heartlands' Elderly Care Trauma & Ongoing Recovery (HECTOR) program recommends a daily review considering hydration, nutrition, bowel care, comfort, confusion, thromboembolism, vitals, systems, and recovery for all elderly trauma patients. This study assessed the sustained impact of introducing a HECTOR daily review of elderly orthopaedic trauma patients on documentation of medical considerations.

Methods: Documentation of HECTOR daily ward round domains formed the compliance standard. This was examined by reviewing daily ward round entries for all orthopaedic trauma patients over 65 years of age within an orthopaedic department. Hip fractures were excluded as they routinely receive geriatric medicine review. Interventions included ward posters, teaching for existing junior staff, and trust induction teaching at staff changeover. Data were collected at baseline, 2 weeks post-intervention, and 4 weeks post-staff changeover.

Results: 104 ward round entries were reviewed over 5 months. Following introduction of the HECTOR concept, documentation sustainably improved in all domains, despite a staff changeover (Fig. 1). The largest percentage increases were in confusion and nutrition (42% and 39%, respectively). The least sustained improvements were seen in thromboembolism and bowels (7% to 16% and 16%, respectively).

Conclusion: Mandatory teaching of a structured approach to daily reviews improves consideration of common medical issues in elderly orthopaedic patients. Introduction of a HECTOR template into documentation should improve and sustain compliance further. Further research should review the impact of HECTOR on patient outcomes.



Excess Death in Fragility Fracture Patients During the First Wave May Be Due to Altered Care Pathways

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Purpose: Despite the COVID-19 pandemic being a threat to health-care systems worldwide, care for certain emergency medical conditions, such as those presenting with fragility fractures, continues. In this vulnerable population, changes to established care pathways and safe discharge thresholds, to allow increased hospital bed capacity during the pandemic peak, may influence the excess death rate. The aim of this study is to identify the excess death rate in this vulnerable group and the factors that may be associated with it.

Methods: Using specific ICD-10 codes to screen all admissions to a 1700-bed hospital group, patients presenting with fragility fractures during the COVID-19 pandemic were identified. The pandemic period was defined as the 3-month period between March 1 and June 1, 2020. A control group was identified, using the same methodology for the 3-month period between March 1 and June 1, 2019. Using Cox proportional hazards, analysis of survival between groups was carried out; further, a detailed subanalysis, aiming to identify factors that may have influenced excess deaths, was carried out on patients presenting with hip fractures.

Results: 832 patients with fragility fractures were admitted during the pandemic period, of which 104 were also diagnosed with COVID-19, compared to 1014 patients presenting with fragility fractures in the control group. Mortality among fragility fracture patients without COVID-19 was significantly higher among pandemic period admissions (14.7%) than in the pre-pandemic cohort (10.2%) after adjusting for age and sex (hazards ratio [HR] = 1.86; 95% confidence interval [CI] 1.41-2.45; $P<0.0001$). Length of stay was shorter during the pandemic period (effect size adjusting for age and sex = –4.2 days; 95% CI –5.8, –3.1; $P<0.0001$). A subanalysis of hip fracture patients revealed a mortality of 8.4% among 190 admissions in the pre-pandemic set, and of 15.48% among 168 pandemic admissions with no COVID diagnosis, resulting in an HR = 2.08; 95% CI 1.11-3.90; $P = 0.021$. After further adjustment for clinical frailty scores, this became HR = 2.15; 95% CI 1.15-4.04; $P = 0.0162$. Length of stay was also significantly shorter among pandemic non-COVID cases (10.7 days) than among those admitted in the pre-pandemic matched period (15.26 days $P<0.00001$).

Conclusion: There is a significant increase in excess deaths, not explained by confirmed COVID-19 infections. This increase is associated with a significant decrease in length of stay, both for the fragility fracture group as a whole and for the hip fracture subgroup. This evidence of altered care pathways and safe discharge thresholds across the two time periods may suggest a reason for the increase in excess deaths.

Orthopaedic Trauma Research Priorities in Latin America: Developing Consensus Through a Modified Delphi Approach

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Purpose: Despite a significant burden of musculoskeletal injury, studies of orthopaedic trauma in Latin America are lacking. The purpose of this study was to identify research priorities among orthopaedic trauma surgeons in Latin America in order to set an agenda for future studies.

Methods: A modified Delphi process was conducted. Research questions were solicited from members of the Asociación de Cirujanos Traumatólogos de las Américas (ACTUAR) network. Participants rated questions from 1 to 9 in order of importance. All questions were then redistributed along with aggregate rating, and participants rerated all questions with knowledge of the group responses.

Results: 79 participants completed the first survey and were included in subsequent survey distribution. Of these, 53 participants completed all subsequent surveys. Mean age was 51.8 years, and most participants were male (92%), completed an orthopaedic trauma fellowship (60.3%), and participated in research (80.8%). Five respondents were from a high-income country, 67 were from an upper middle-income country, and 6 were from a lower middle-income country; 15 countries were represented. A total of 65 questions were identified. Six questions were rated between 1 and 3 ("more important") by over 70% of participants, the threshold for consensus: 1. What is the optimal treatment protocol (timing of surgery, comanagement) for elderly patients with hip fracture? (76.9%) 2. What is the most effective initial and definitive management of musculoskeletal injury, including timing and surgical strategy, in the polytraumatized patient? (74.4%) 3. What is the ideal state of open fracture treatment, including timeliness and method of antibiotics, debridement, surgical fixation, and closure or coverage, at each hospital level in the health-care system (primary, secondary, tertiary)? (71.8%) 4. What patient and fracture characteristics predict infection after musculoskeletal injury? (70.5%) 5. What is the current state of treatment for fracture-related infection, including timeliness and method of antibiotics and surgical intervention, at each hospital level in the health-care system (primary, secondary, tertiary)? (70.5%) 6. What is the optimal protocol for temporary management for the hemodynamically unstable patient with a pelvic or acetabular fracture? (70.5%)

Conclusion: This modified Delphi study of 79 orthopaedic trauma surgeons in 15 countries in Latin America identified geriatric hip fracture, polytrauma, open fracture care, musculoskeletal infection, and care of patients with pelvic and acetabular fractures as top research priorities. This provides important information for resource allocation and goal setting for orthopaedic trauma in the region.

Prevalence and Sociodemographic Characteristics of Post-traumatic Stress Disorder in Adult Orthopaedic Trauma Patients in a Ugandan Referral Hospital

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Purpose: Attempts to ensure total care of the trauma patient in order to reduce morbidity and mortality has led to a drift of global concern toward the psychiatric sequelae of trauma patients. Psychiatric disorders following trauma are common, with one of the commonest being posttraumatic stress disorder (PTSD), and are associated with poor functional and occupational outcomes. In African settings, there is scarcity of data regarding the prevalence and sociodemographic characteristics of PTSD in trauma patients. The objective of this study was to determine the prevalence and sociodemographic characteristics of PTSD in adult orthopaedic trauma patients seen in a referral hospital in Uganda.

Methods: This was a hospital-based quantitative cross-sectional descriptive study of adult orthopaedic trauma patients at Mulago hospital from April to September, 2013. A structured questionnaire containing sociodemographic characteristics and module for PTSD diagnosis in Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition Text Revised (DSM-IV-TR) was administered to consenting patients who met the inclusion criteria by systematic random sampling. Data were entered in Epi Data software and exported to STATA 10.0 for descriptive bivariate analysis using Mantel Haenszel method.

Results: 297 patients were recruited into the study, where the period prevalence of PTSD in adult orthopaedic trauma patients seen at Mulago hospital was 17.85% (53 of 297). The mean age was 37.06 ± 14.61 years with majority of participants between the ages of 18 and 29 years (37.04%). 66.33% were males (197 of 297) and 33.67% females 33.67% (100). The educational level of majority of these participants was primary/secondary 74.07% (220 of 297). Most of the participants were self-employed (52.53% [156]) and 80.81% of participants (240) of participants ad an income level of less than one million Ugandan shillings ($397) per year.

Conclusion: The 6-month prevalence of PTSD in adult orthopaedic trauma patients was 17.85%. Also, female sex, older age group (over 40 years), divorced, widow/widower, government or private employment, and a low income level had a higher risk of PTSD following trauma. The need for a multidisciplinary approach to the management of the trauma patient involving a clinical psychologist or a psychiatrist will be vital for a better outcome.

Public Patronage and Its Associated Factors Toward Traditional Bonesetting for Musculoskeletal Injury Management: A Cross-Sectional Study

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Purpose: «A traditional bonesetter is a lay practitioner who deals with the management of musculoskeletal (MSK) injuries. They often use splints made from a split of bamboo or strips of wood tightly bound about the limb. Many Individuals who face musculoskeletal injuries utilizes traditional bonesetters (TBS) for their treatment.» P. Singh, 2013 Traditional bonesetting is associated with more treatment-related complications in its practice while modern health institutions deploy sophisticated techniques of treatment that result in satisfactory outcomes. A retrospective study by Eshete in 2002 showed that out of 49 major limb amputations done in 2 years in a single zonal hospital, 25 were because of gangrene from a tight splint applied by TBS for simple fractures. In spite of the relative accessibility of modern orthopaedic care, to date we roughly understand how much people do and the reason why yet they prefer to go to TBS for MSK injuries as a first treatment destination while facing major limb and life-threatening complications from their mismanagement. The objective of this study is to determine the proportion of the community who prefers traditional bonesetting as a primary treatment destination for MSK injuries and to identify factors that modulate this preference.

Methods: A community-based cross-sectional study was conducted from November 10 to December 20, 2020. A systematic random sampling technique was deployed for sample selection and data were collected using a pretested structured questionnaire. Finally, collected data were reviewed for completeness, coded, and fed to the computer using SPSS version 26 software. Descriptive tables were used for simple descriptive analysis and binary logistic regression analysis was deployed to identify associated factors, for which $\chi 2$ assumption was fulfilled. Ethical clearance was obtained from a local medical college.

Results: More than half (208 [53.5%]), of the study participants preferred traditional bonesetting as a primary treatment destination for possible MSK injury. 92.3% of them believe in superior skill of TBS in fracture management than doctors. Half of them prefer TBS, fearing perceived higher tendency of doing amputation in hospitals. The multivariable logistic regression revealed that gender, religion, educational status, previous TBS visit, and previous hospital visit were significantly associated ($P = 0.00$) with TBS preference for MSK injury treatment. Accessibility, cheap and negotiable price, and community trust in TBS positively affected their TBS preference for possible MSK injuries.

Conclusion: The community of the study area prefers TBS as primary treatment destination for MSK, while previous treatment in health facilities for similar incidents decreases the chance of preferring TBS.

Effect of Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) with Hydroxyapatite (HA) Carrier in Induced Membrane Technique (IMT): A Retrospective Propensity Score–Matched Study

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Purpose: We sought to determine the effect of rhBMP-2 with HA carrier augmentation in managing critical-sized bone defect with IMT.

Methods: This was a retrospective comparative study conducted at an academic Level I trauma center. The study included 14 patients who underwent rhBMP-2 with HA carrier (rhBMP-2/HA) augmentation in IMT for managing critical-sized bone defect (BMP group). Moreover, 14 patients who underwent IMT without rhBMP-2 augmentation were matched by propensity score analysis (non-BMP group). The volumetric measurements of the grafted bone were performed using immediate postoperative CT, and the volumetric measurements of regenerated bone were performed 1 year after CT. The changes within them were calculated as a percentage. Changes in density of the regenerated bone from grafted bone were measured by mean Hounsfield unit (HU). Moreover, we also measured changes in dense bone percentage relative to the total grafted bone and regenerated bone volumes (Fig. 1). Corticalization of the grafted bone under the plate was assessed. The ratio between total axial cuts of grafted bone under the plate and axial cuts that present corticalization under the plate within them was obtained, and the percentage was calculated (Fig. 2).

Results: In the BMP and non-BMP groups, the changes in densities from grafted bone to regenerated bone were +379.63 HU and +248.55 HU ($P = 0.034$), changes in dense bone percentage were +37.52% and +23.31% ($P = 0.027$), corticalization rates under the plate were 79.70% and 39.30% ($P = 0.007$), changes in volume were –20.77% and –23.35% ($P = 0.812$), union rates were 85.71% and 78.57% ($P = 0.622$), numbers of patients requiring additional procedures were 4 and 3 ($P = 0.663$), and times to union were 291.66 and 466.63 days ($P = 0.059$), respectively.

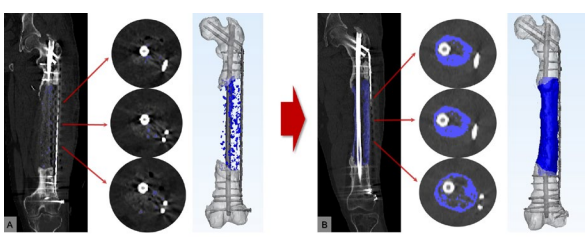

Fig. 1 A 24-year-old male patient underwent staged IMT and rhBMP-2 with HA carrier augmentation for managing critical-sized bone defect after osteomyelitis. **A** Dense bone percentage that is >370 HU in grafted bone was measured. **B** Dense bone percentage in regenerated bone was measured. The change of dense bone percentage was 62.75% in this patient.

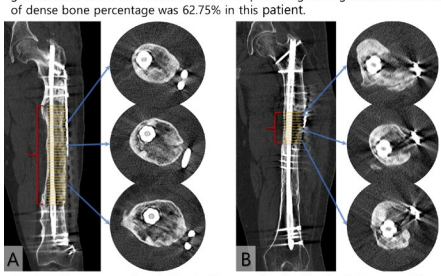

Fig. 2 **A** The same patient in Fig. 1 who was classified in the BMP group. The corticalization rate under the plate was 81.37% (83/102). **B** A 36-year-old male patient in the non-BMP group underwent staged IMT for osteomyelitis management. The corticalization rate under the plate was 6.43% (2/31).

Conclusion: rhBMP-2/HA augmentation in IMT increases the density of regenerated bone and enhances corticalization under the plate. rhBMP-2/HA augmentation can be a useful tool for overcoming incomplete consolidation issue in IMT.

CT-Based L1 Bone Mineral Density in Dutch Trauma Patients: Are North American Reference Values Valid in Europe?

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Purpose: Opportunistic screening for bone mineral density (BMD) of the first lumbar vertebra (L1) using CT is increasingly used to identify patients at risk for osteoporosis. An extensive study in the United States has reported sex-specific normative values of CT-based BMD across all ages. The purpose of the current study is to validate these North American references values for the Dutch trauma population.

Methods: All trauma patients aged 16 years or older, admitted to our Level I trauma center during 2017, who underwent a CT scan of the chest or abdomen at 120 kVp within 7 days of hospital admission, were included. BMD measurements in Hounsfield units (HU) were performed manually in L1 or an adjacent vertebra. Student t test was performed to compare the Dutch mean BMD value per age group to the North American reference value. Linear regression and Pearson correlation rho (ϱ) were performed to assess the correlation of BMD and age.

Results: 626 patients were included (68.1% men, aged 16-95 years). Mean BMD decreased linearly with 2.4 HU per year of age with a correlation coefficient (ϱ) of –0.77. Sex-specific analysis showed that BMD of women in the age groups <30 and 35-39 years was significantly higher than BMD of men at these ages. Dutch mean BMD values in the age groups over 35 years were significantly lower than the North American reference values.

Conclusion: Our findings indicate that using North American BMD thresholds in Dutch clinical practice would result in overdiagnosis of osteoporosis and osteopenia. Dutch guidelines may benefit from the population-specific thresholds reported here.

Humanitarian Scholar – Philippines

Shifting to an App-Based Method of Preoperative Templating in Orthopaedic Surgery

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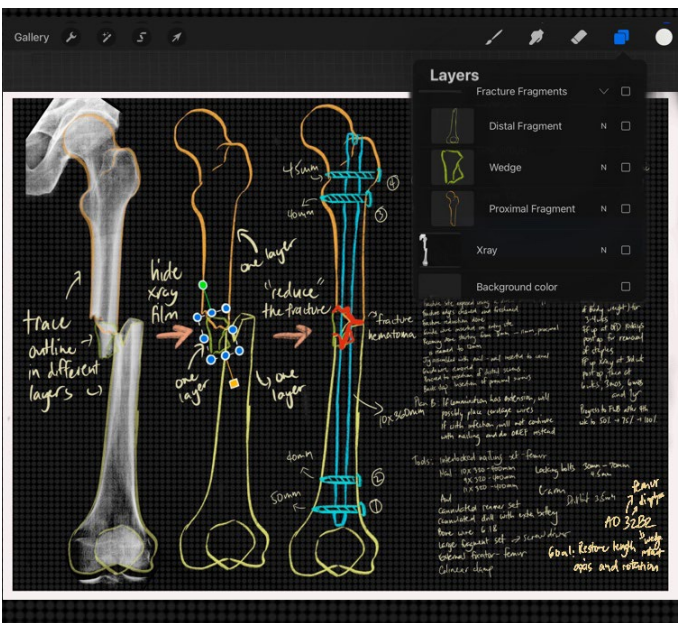
Corazon Locsin Montelibano Memorial Regional Hospital, Bacolod, Philippines

Purpose: The study will clarify if there are differences between conventional and digital preoperative templating for the resident trainee.

Methods: A retrospective study involving residents (n = 12) under the Department of Orthopaedics and Traumatology was conducted. The residents were divided into two groups: Group A (n = 6) assigned to do conventional template, Group B (n = 6) performing digital template. After doing their assigned work, the subjects cross over into the other task and the process starts over. Conventional templates are scored using the AO guidelines of template completeness. Digital templates are evaluated using image-based surgery planning. Each subject in both groups completed templates for three injury patterns: AO 2R2A3/2U2C2, 32B2, and 43C2. Wilcoxon signed rank and binomial tests (5% level of significance) were used as statistical tools.

Results: A total of 12 residents (10 male, 2 female; median age 31 years [range, 28-34]) participated in the study. Five first-years (4 male, 1 female), 4 second-year residents (3 male, 1 female), 2 third-year residents (2 male), and 1 fourth-year resident (1 male) were divided into two groups with equal sizes. Template processing, fracture classification, and plan elaboration were comparable with good interobserver and intraobserver reproducibility using the Wilcoxon signed ranks test with all z values below 1.96 and $P>0.05$. There was no significant difference in the evaluation scores used for either exercise, whether doing a traditional standard template or the digital template ($P>0.05$).

Conclusion: The study shows that shifting to an app-based method of preoperative digital templating can achieve the standard goals performed in traditional, paper-based practice. With an electronic platform for radiography, digital templating is an alternative manner to appreciate fracture configurations, reduction, and fixation for fracture surgery.



Final Program

ORTHOPAEDIC TRAUMA ASSOCIATION

OTA 37th Annual Meeting

Wednesday-Saturday

October 20 - 23, 2021

Fort Worth Convention Center
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A Randomized Controlled Trial Comparing Operative and Nonoperative Treatment of Humeral Diaphyseal Fractures

Stephane Bergeron, MD; Prism Schneider, MD; Allan Liew, FRCSC; Hans J Kreder, MD, MPH; ***Gregory Berry, MD***
McGill University, Montreal, QC, Canada

Purpose: Fractures of the humeral diaphysis occur in a bimodal distribution and represent 3% to 5% of all fractures. Presently, the standard treatment of isolated humeral diaphyseal fractures is nonoperative care using splints, braces, and slings. Recent data have questioned the effectiveness of this strategy in ensuring fracture healing and optimal patient function. The primary objective of this randomized controlled trial (RCT) was to assess whether operative treatment of humeral shaft fractures with a plate and screw construct provides a better functional outcome than nonoperative treatment. Secondary objectives compared union rates and both clinical and patient-reported outcomes.

Methods: Eligible patients with an isolated, closed humeral diaphyseal fracture were randomized to either nonoperative care (initial sugartong splint followed by functional coaptation brace) or open reduction and internal fixation (ORIF; plate and screw construct). The primary outcome measure was the Disabilities of the Arm, Shoulder and Hand (DASH) score assessed at 2, 6, 16, 24, and 52 weeks. Secondary outcomes included the Short Musculoskeletal Functional Assessment (SMFA), the Constant Shoulder Score, and radiographic parameters. Data accrual was completed a week prior to abstract submission. Preliminary results are reported and complete results will be available for presentation at the OTA Annual Meeting. Independent samples t tests and $\chi 2$ analyses were used to compare treatment groups.

Results: A total of 173 patients were included, with 86 treated nonoperatively and 87 treated with ORIF. There was no significant difference between the two treatment groups for age (mean = 45.7 years, standard deviation [SD] 16.6 for nonoperative group and 41.8, SD 17.1 years for ORIF group; $P = 0.13$), sex (59.3% female in nonoperative group and 62% female in ORIF group; $P = 0.78$), body mass index (mean = 28.7, SD 7.4 for nonoperative group and 27.6, SD 6.2 for ORIF group; $P = 0.30$), or smoking status ($P = 0.78$). There was a significant improvement in the DASH scores at 6 weeks in the ORIF group compared to the nonoperative group (mean = 33.8, SD 21.2 in the ORIF group vs mean = 56.5, SD = 21.1 in the nonoperative group; $P<0.0001$). At 4-month follow-up, the DASH scores were also significantly better in the ORIF group (mean = 21.6, SD = 19.7 in the ORIF group vs mean = 31.6, SD = 24.6 in the nonoperative group; $P = 0.009$. However, there was no difference in DASH scores at 12-month follow-up between the groups (mean = 8.8, SD = 10.9 vs mean = 11.0, SD = 16.9 in the nonoperative group; $P = 0.39$).

Conclusion: This RCT comparing operative and nonoperative treatment of humeral diaphyseal fractures found significantly improved functional outcome scores in patients treated surgically at 6 weeks and 4 months. However, the early functional improvement did not persist at 1-year follow-up. Further analysis and cost-effectiveness assessment could determine whether early functional improvements outweigh the costs associated with surgical treatment of humeral shaft fractures.

Is the Use of Bipolar Hemiarthroplasty Over Monopolar Hemiarthroplasty Justified? A Propensity Score-Weighted Analysis of a Multicenter Randomized Controlled Trial

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Purpose: The theoretical advantages of bipolar over unipolar hemiarthroplasty (HA) have yet to be demonstrated in clinical studies, and thus far, have not justified the higher initial cost associated with bipolar HA. Using data from another trial, we sought to determine if a difference exists between monopolar and bipolar HA using modern implants.

Methods: We compared the Western Ontario and McMaster University Arthritis Index (WOMAC) scores and Short Form (SF-12) component scores between participants with unipolar and bipolar HA at 24 months postoperatively. An inverse probability treatment weighting model was performed to calculate the propensity score and generate a weighted cohort for each functional outcome measure. The following variables were controlled for in each comparison group: age, sex, body mass index, American Society of Anesthesiologists classification (I-II versus III-IV), depression, prefracture living status, prefracture ambulatory status, surgical approach, type of femoral stem (cemented versus press-fit), and preinjury health-related quality of life score. We included the propensity score weights as an adjustment variable. A subgroup analysis was performed, including only those participants aged 70 years and younger.

Results: Of 746 HAs performed in the trial, 404 were bipolar prostheses and 342 were unipolar prostheses. After propensity score weighting, adequate balance between the bipolar and unipolar groups was obtained as shown by standardized mean differences less than 0.1 for each of the covariates. 24 months after HA, the overall WOMAC score and its subcomponents showed no statistically significant difference between the unipolar and bipolar groups. Similarly, no statistically significant difference was found in the physical component summary and mental component summary scores of the SF-12 questionnaire. In participants aged 70 years and younger, no differences were found in any of the functional outcomes.

Conclusion: From the results of this study, the use of bipolar HA over unipolar does not provide superior functional outcomes at 24 months postoperatively. The theoretical advantage of reduced acetabular wear with bipolar designs does not appear to influence functional outcomes in the first 2 years postoperatively in this cohort of hip fracture patients.

A Prospective Randomized Controlled Trial Comparing Subcutaneous Enoxaparin and Oral Rivaroxaban for Venous Thromboembolism Prophylaxis in Orthopaedic Trauma Patients

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Purpose: Venous thromboembolism (VTE) is a potential complication following orthopaedic trauma surgery. There is no standard for orthopaedic trauma patient VTE chemoprophylaxis. New oral anticoagulants (NOACs) have emerged as an effective, safe, and potentially less cumbersome alternative to subcutaneous injectable low molecular weight heparin (LMWH). NOACs, like LMWHs, have proven efficacy in preventing VTE. The purpose of our study was to compare VTE chemoprophylaxis with oral NOACs (rivaroxaban) versus injectable LMWH (enoxaparin) upon discharge home from the hospital.

Methods: We conducted a prospective randomized controlled trial of orthopaedic trauma patients at a single Level I trauma center. Inclusion criteria were adult patients (>18 years) with fractures requiring VTE prophylaxis based on service protocols upon discharge home from the hospital. Those who were discharged home on aspirin or without VTE prophylaxis, discharged to post-acute care facilities, non-English speakers (for validated surveys), pregnant or institutionalized individuals, and those on chronic anticoagulation were excluded. Patients were randomized to a 20-day course of subcutaneous injectable enoxaparin (Group A) or oral rivaroxaban (Group B). Primary outcomes were measured using validated survey tools, the Treatment Satisfaction Questionnaire for Medication (TSQM-9) and the Morisky Medication Adherence Scale (MMAS-8). Secondary outcomes included patient monitoring for VTE, major bleeding events, or adverse medication reactions. Data were obtained at 2, 6, and 12 weeks post discharge.

Results: Preliminary data includes 110 randomized patients (Group A = 58; Group B = 52) with no significant difference in demographic or injury characteristics. Patients had statistically significant higher medication satisfaction, confidence, ease of use, and convenience scores across all 9 items on the TSQM-9 (P values: <0.001 to 0.02). Group A had more overall low-compliance patients, but there was no significant difference overall based on the MMAS-8 ($P = 0.65$). No patients in either group suffered a diagnosed VTE or major bleeding event. Group A reported more adverse events, including injection site bruising and inability to self-administer their medication (22%). Group B experienced no reportable adverse events. For uninsured patients paying out of pocket, Group A medication costs were $40, and Group B costs were $4.

Conclusion: Patients were more satisfied using oral compared to injectable postoperative VTE prophylaxis following discharge after orthopaedic trauma surgery. While medication compliance, VTE, or bleeding events were not significantly different between subcutaneous injectables and oral medications, there were more adverse reactions and higher costs for the injectable group.

Intraoperative Hematoma Block Decreases Postoperative Pain and Narcotic Consumption After Intramedullary Rodding of Femoral Shaft Fractures: A Randomized Controlled Trial

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Purpose: The use of a hematoma block has been proven to be effective for local analgesia in the setting of an acute fracture at the time of closed reduction. However, its use as an adjunct to a standardized pain protocol in operative fracture management has not been validated. The purpose of this study is to evaluate the efficacy of an intraoperative, post-fixation fracture hematoma block on postoperative pain control and narcotic consumption in patients with acute femoral shaft fractures.

Methods: 58 consecutive patients with isolated femoral shaft fractures (AO/OTA 32) underwent intramedullary rodding for fracture stabilization at a Level I trauma center from 2019 to 2021. All patients were prospectively randomized to receive an intraoperative, post-fixation fracture hematoma injection containing 20 mL of 0.5% ropivacaine or normal saline in addition to a standardized multimodal pain regimen that included narcotics. Visual analog scale (VAS) pain scores were recorded in 8-hour intervals. Pain scores at each interval and total postoperative 24-hour narcotic consumptions were compared between the two experimental groups using Mann-Whitney U testing.

Results: There were no significant differences in age (median 33 vs 29.5 years, $P = 0.39$) or sex (7 vs 11 female, $P = 0.42$) between the anesthetic group (n = 28) and the control group (n = 30). The anesthetic group demonstrated significantly lower VAS pain scores than the control group in the total 24-hour period (5.7 vs 7.3, $P = 0.004$), and at 8 hours (6 vs 8, $P = 0.007$), 16 hours (6 vs 7, $P = 0.041$), and 24 hours (5 vs 7, $P = 0.006$). In addition, the narcotic consumption (morphine milligram equivalents) was significantly lower in the anesthetic group compared to the saline group over the first 24-hour postoperative period (36 vs 65, $P = 0.010$). No adverse effects were observed secondary to the saline or ropivacaine infiltration.

Conclusion: The results demonstrated that an intraoperative hematoma block following intramedullary rodding of femoral shaft fractures provides a safe and effective option for pain control that also decreases narcotic consumption. This treatment can be used as an adjunct to a standardized pain protocol in patients with femoral shaft fractures in order to decrease narcotic consumption in the immediate postoperative period.

Δ Periarticular Multimodal Analgesia Decreases Postoperative Pain in Tibial Plateau Fractures: A Double Blind Randomized Controlled Pilot Study

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Purpose: While some lower extremity fractures can be managed with a peripheral nerve block, the risk of masking symptoms of compartment syndrome in tibial plateau fractures may preclude these patients from receiving this treatment. The use of periarticular multimodal analgesia injections is increasing and has become commonplace in some surgeries. However, there are no data on the effectiveness of local periarticular multimodal analgesia for tibial plateau fractures. We hypothesized that closed tibial plateau fracture patients receiving the local multimodal analgesic medications would experience a significant decrease in visual analog scale (VAS) pain scores and require less narcotic usage for 24 hours postoperatively as compared to a placebo group.

Methods: Patients aged between 18 and 79 years with an isolated closed tibial plateau fracture (AO 41-B and C) were prospectively enrolled and randomized in a 1:1 double blinded fashion to either a placebo or active medication treatment arm. After open reduction and internal fixation of the tibial plateau fracture, gel-foam sponges soaked in either multimodal analgesic solution or normal saline were placed deep (morphine, clonidine, ketorolac) and superficial (morphine, epinephrine, bupivacaine) to the fascia. Patients were followed for 24 hours postoperatively every 4 hours with VAS pain scores and narcotic usage was recorded. Patients were monitored postoperatively for complications including compartment syndrome, infection, and nonunion.

Results: The planned study was terminated prior to completion due to higher than anticipated rates of infection (18%), distributed equally among active (3 infections) and placebo (2 infections) groups, raising concerns that this may have been due to the presence of the delivery device (gel foam). 28 patients were enrolled—15 in the active group and 13 in the placebo group. Patients in the active medication group had significantly decreased pain scores at hours 4 ($P = 0.005$, 4.2 vs 6.9), 8 ($P = 0.05$, 5 vs 7), and 12 ($P = 0.02$, 3.8 vs 6.2) postoperatively. Pain scores were also decreased in the active group at hours 16 ($P = 0.10$, 4.5 vs 6.5), 20 ($P = 0.08$, 4.6 vs 6.4), and 24 ($P = 0.10$, 4.8 vs 6.5) but did not reach significance. There was a nonsignificant trend toward decreased overall narcotic usage postoperatively in the treatment group ($P = 0.152$). No events of compartment syndrome or nonunion were noted.

Conclusion: The use of local multimodal periarticular analgesia for closed tibial plateau fractures appears to be beneficial for short-term pain control postoperatively, and improved acute pain control is associated with better long-term outcomes. Concerns regarding an implantable delivery vehicle leading to infection has warranted a change in method of drug administration, and the study is now being completed with medicine or control being locally injected rather than delivered with sponges. Completion of the full study will permit us to validate or refute these findings.

Δ OTA Grant

Definitive Flap Coverage Within 48 Hours of Definitive Fixation Reduces Deep Infection Rate in Open Tibial Shaft Fractures Requiring Flap Coverage

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Purpose: Many factors are associated with infection in open tibia fractures requiring flap coverage. Recently, several authors have identified the time from definitive fixation to flap coverage as a strong predictor of infection. This rationale for this hypothesis is that implants may become colonized when not covered with soft tissue. This study aimed to delineate whether a "safe window" exists for timing from definitive fixation to definitive flap coverage.

Methods: We studied a consecutive cohort of patients from 15 centers in the US and UK. Patients who underwent definitive fixation and flap coverage in the same sitting (defined as 0 days) were compared to those undergoing definitive fixation followed by flap coverage on a different day. The primary outcome was deep infection rate. We used receiver operating characteristic curves to identify the time points between definitive fixation and coverage that were associated with increases in infection rates.

Results: 373 consecutive patients (270M:103F, aged 42 ± 18 years) from 15 centers were evaluated. 183 patients (49%) had their definitive fixation and coverage on the same day and 190 (51%) had delayed coverage. Infection rates for immediate (0 days), 0-2 days, >2 to 5 days, and >5 days from definitive fixation to flap coverage were 14.3%, 19.3%, 25.0%, and 31.8%. A delay of up to 2 days was not associated with an increased risk of infection (relative risk [RR] 1.12, 95% confidence interval [CI] 0.92 to 1.37, $P = 0.26$). After that, there was an average RR increase of 55% for deep infection for delays between 2 and 5 days (RR 1.55, 95% CI 0.96 to 2.50, $P = 0.09$). This risk increased to 64% for patients whose coverage was obtained more than 5 days after definitive fixation (RR 1.64, 95% CI 1.01 to 2.65, $P = 0.04$). Delays in obtaining coverage of 2 to 5 days once definitive fixation was placed were associated with an increased infection rate of 4.9% (95% CI 0.1 to 10.5%) and this increased to 9.3% (95% CI 1.7 to 20.3%) after 5 days.

Conclusion: This multicenter multinational study is the largest report to focus on the timing from definitive fixation to flap coverage in type IIIB open tibial shaft fractures. Based on our data, a "safe window" of 48 hours exists between these stages. Minimizing the delay from definitive fixation to flap coverage is critical in decreasing infection rates.

Operative Versus Nonoperative Treatment of Severely Shortened or Comminuted Clavicle Fractures in Older Adolescent Athletes: Results from a Prospective, Multicenter, Level II Cohort Study

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Purpose: Operative management of clavicle fractures is increasingly advocated for athletes and young adults. Surgical indications and optimal treatment for comminuted or severely shortened clavicle fractures in adolescent athletes remain unclear. The purpose of this study is to evaluate the outcomes of nonoperatively and operatively treated comminuted and/or severely shortened (>25 mm) clavicle fractures in older adolescent athletes.

Methods: 14- to 18-year-old athletes with midshaft clavicle fractures (treated 2013-2016) with nonoperative (NONOP) or operative (OP) treatment at one of eight participating centers were screened for the presence of comminution and/or fracture shortening >25 mm. Demographics, injury mechanism, fracture characteristics, and treatment (NONOP vs OP) were prospectively recorded. Complications, rates and timing of return to sport (RTS), and patient-reported outcomes (PROs: American Shoulder and Elbow Surgeons [ASES]; QuickDASH, an abbreviated version of the Disabilities of the Arm Shoulder and Hand questionnaire; MARX shoulder activity; EuroQol 5 Dimensions [EQ-5D]; EuroQol Visual Analog Scale [EQ-VAS]; and patient satisfaction) were analyzed.

Results: 137 patients (70 NONOP, 67 OP) met inclusion, with a similar distribution of various sports and rates of competitive athletes (NONOP: 81%, OP: 85%) represented in the two treatment groups. 100 patients (NONOP n = 52, 15.3 years, 44 [84.6%] M; OP n = 48, 15.5 years, 40 [83.3%] M) provided PROs at >2 years. Comminution (C) and shortening (S) were no different (NONOP C = 24 [46.2%], S = 28 [24.5, 33.2] mm; OP C = 35 [72.9%], S = 28 [25.0, 36.5] mm), but the OP group demonstrated 3 mm greater mean superior displacement (NONOP 13.0 [9.6, 18.0] mm, OP 16.0 [11.8, 21.0] mm; $P<0.05$), which was controlled as a confounder in the comparative PRO analysis. There was no difference in nonunion (none), delayed union (NONOP = 2%; OP = 2%), symptomatic malunion (NONOP = 2%, OP = 0%), refracture (NONOP = 0%, OP = 2%), or clinically significant complications (NONOP = 4%, OP = 13%; $P = 0.27$) between treatment groups. Two years postinjury 75% of NONOP and 79% of OP patients reported RTS, with 61% and 57%, respectively, reporting achievement of same sport level, and similar RTS timing (OP = 10 weeks, NONOP = 11.6 weeks). When controlling for minor differences in superior displacement, regression and matching analyses demonstrated no difference in mean and dichotomized PRO scores between the NONOP and OP groups.

Conclusion: In this prospective multicenter cohort of comminuted and/or severely shortened (>25 mm) clavicle fractures in adolescent athletes, there was no difference in RTS or PROs between nonoperatively and operatively treated patients at 2 years. Despite several studies suggesting the contrary in adult populations, comparably excellent outcomes of severe clavicle fractures in adolescent athletes may be achieved with nonoperative treatment.

Risk of Iatrogenic Sciatic Nerve Injury During Posterior Acetabular Fracture Fixation: Does Patient Position Matter?

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Purpose: Iatrogenic sciatic nerve injury occurs in 2% to 16% of acetabular fracture fixations. Up to 55% of these patients have persistent motor deficits. This study is the first to our knowledge to assess the influence of patient positioning with iatrogenic sciatic nerve palsy as the primary outcome. We hypothesize there is no difference in iatrogenic sciatic nerve palsy with respect to patient position when controlling for other risk factors.

Methods: Electronic medical records from 2 Level I academic trauma centers were searched to identify patients with a posterior approach for acetabular fixation from 2010-2020. The prevalence of iatrogenic sciatic nerve palsy was found using pre- and postoperative documentation of motor and sensory deficits. Patients with inadequate documentation were excluded. The palsy group was compared to a random sample of non-palsy patients at a 1:4 ratio. The association between iatrogenic sciatic nerve palsy and patient positioning (prone vs lateral) was determined with adjustment for patient demographics and comorbidities (age, sex, body mass index, tobacco use, diabetes, neuropathy), injury characteristics (fracture pattern, associated hip dislocation), and surgical factors (time to surgery, intraoperative blood loss and transfusions, duration of surgery, staged approach, surgeon experience) by multivariate logistic regression analysis.

Results: 16 surgeons performed 922 posterior approaches for acetabular fixation. The rate of iatrogenic sciatic nerve palsy was 8.4% (36 of 428) in the prone position and 0.8% (4 of 494) in the lateral position ($P<0.001$). Comparison of palsies (n = 40) to the non-palsy subset (n = 171) showed that prone positioning (vs lateral) (adjusted odds ratio [aOR] 4.81, 95% confidence interval [CI] 1.60, 14.4; $P = 0.001$) was the most important independent predictor of postoperative sciatic nerve palsy, followed by intraoperative blood loss (per 100 mL increase, aOR 1.09, 95% CI 1.02, 1.17; $P = 0.008$), and a fracture pattern involving both the posterior wall and posterior column (aOR 2.56, 95% CI 1.16, 5.66; $P = 0.02$). These three risk factors in combination had good ability to predict likelihood of sciatic nerve palsy (C-statistic = 0.754, $P<0.0001$). Of the patients with an iatrogenic motor palsy and minimum of 6-month follow-up or earlier resolution, 68% (21/31) had transient palsy that resolved at a median of 70 days, while 32% had persistent foot drop.

Conclusion: Associations with nerve palsy included patient position, intraoperative blood loss, and fracture patterns that involve both the posterior column and posterior wall. Contrary to previously published data, the prone position had a higher prevalence of iatrogenic sciatic nerve palsy compared to lateral positioning when adjusting for other risk factors.

The Effect of Anterior Support Screw (AS2) for Unstable Femoral Trochanteric Fractures: A Multicenter Randomized Controlled Trial

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Purpose: The importance of reduction is recognized in the treatment of unstable femoral trochanteric fractures. There are many opinions that bony support of the anterior medial part is particularly important. We devised a new technique to add a screw anterior to the nail in order to prevent reduction loss (anterior support screw [AS2]).

Methods: A multicenter, prospective, randomized controlled trial was conducted to verify the effect of this procedure for unstable femoral trochanteric fractures. The subjects of this study were femoral trochanteric fractures with posterior comminution and intramedullary displacement of proximal fragments. The results of previous studies indicate that this study requires 240 cases. Then, 240 patients were enrolled at 15 institutions. All cases were randomly divided into 2 groups, an additional screw group (AS2 group) and a no-additional screw group (control group). Three cases dropped out during the course, resulting in 118 cases in the AS2 group and 119 cases in the control group included in the final analysis. ZNN CM Asia nail (180-mm length) was used in all cases, and 5.0-mm cannulated screw was added to AS2 group. CT scans were taken twice for each case, immediately after surgery and within 3 weeks after surgery (14-21 days after surgery). Medial bony contact in the AP view and anterior bony contact in the lateral view were evaluated, and sliding distance was also measured.

Results: There was no difference in the rate of reduction loss in the AP view between the 2 groups, but there was a significant difference in the lateral view. The rate of reduction loss was 5.5% in the AS2 group and 18.6% in the control group. The average sliding distance was 1.8 mm ± 1.4 mm in the AS2 group and 2.8 mm ± 2.1 mm in the control group. The rate of reduction loss was significantly lower in the AS2 group ($P = 0.003$), and the sliding distance was significantly smaller in the AS2 group ($P<0.0001$).

Conclusion: Our method of adding AS2 to intramedullary nail fixation for unstable femoral trochanteric fractures with posterior comminution was found to be effective in maintaining anterior bony contact in the early postoperative period. The sliding distance was also reduced.

Prospective Randomized Controlled Trial: Early Weight Bearing After Conservative Treatment of Weber B Ankle Fractures

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Purpose: The Weber B fracture is the most common among malleolar fractures. AO guidelines suggest non–weight-bearing with a cast for 4 to 6 weeks. Previous studies have shown weight bearing to be a safe treatment for stable Weber B fractures; however, these studies had low-quality evidence. Our aim was to compare mobilization and weight bearing to immobilization and non–weight-bearing.

Methods: All patients, 16 years and older, with an isolated Weber B fracture (Lauge Hansen supination-eversion stage 2-4A) and congruent ankle mortise in primary radiographs were screened. After assessment of ankle stability on weight-bearing radiographs, patients were randomized between mobilization and weight bearing with a walker (intervention group) and immobilization and non–weight-bearing with a cast (control group). Primary outcome measure was the Olerud-Molander Ankle Score (OMAS). Secondary outcome measures were displacement of fracture after 6 weeks (based on radiographs), range of motion of the ankle, calf circumference, and the 36-Item Short Form Survey (SF-36). Follow-up was planned at 1, 6, and 12 weeks after trauma.

Results: Baseline OMAS was comparable between both groups. A 30-point difference ($P<0.001$) on a 0-100 scale was observed between study arms after 6 weeks and a 10-point difference ($P = 0.015$) was observed after 12 weeks. Patients randomized to the walker group scored significantly better on SF-36 after 6 and 12 weeks compared to the cast group. Range of motion was significantly better ($P<0.001$) after 6 weeks of weight bearing. This difference was leveled out after 12 weeks ($P>0.05$). No radiological displacement was observed in any patient.

Conclusion: The current AO guideline for stable Weber B fractures is outdated. Weight bearing using a walker is a safe and patient-friendly treatment for patients with stable Weber B ankle fractures.

Ankle Functionality and Health Related Qualty of Life

Factor	General (n=49)	Control group (n=25)	Intervention group (n=24)	Significance (p-value)
*Functionality**				
OMAS baseline (median (IQR))	100 (100-100)	100 (100-100)	100 (100-100)	
OMAS 6 weeks (Median (IQR))	55 (40-71)	40 (30-55)	70 (65-80)	p < 0.001
OMAS 12 weeks (Median (IQR))	80 (60-90)	75 (43-80)	85 (64-95)	p = 0.015
ROM baseline (Median (IQR))	35 (26-42)	36 (27-42)	35 (26-43)	
ROM 6 weeks (Median (IQR))	43 (30-50)	32 (28-44)	48 (42-52)	p < 0.001
ROM 12 weeks (Median (IQR))	51 (46-56)	50 (46-53)	54 (48-57)	
Quality of life				
*Baseline vs 6 week follow-up***				
Physical functioning (significance)		p = 0.002	p > 0.001	
Role Limitations due to physical problems (significance)		p = 0.001	p > 0.001	
Role Limitations due to emotionel problems (significance)		p = 0.017	p = 0.042	
Energy (significance)		p = 0.039		
Emotional well-being (significance)				
Social functioning (significance)		p < 0.001	p = 0.032	
Pain (significance)		p < 0.001	p = 0.025	
General health (significance)				
*6 week vs 12 week follow-up***				
Physical functioning (significance)		p = 0.007		
Role Limitations due to physical problems (significance)		p = 0.012	p = 0.020	
Role Limitations due to emotionel problems (significance)				
Energy (significance)		p = 0.049		
Emotional well-being (significance)			p = 0.044	
Social functioning (significance)		p = 0.007	p = 0.046	
Pain (significance)				
General health (significance)				
*Baseline vs 12 week follow-up***				
Physical functioning (significance)				
Role Limitations due to physical problems (significance)		p = 0.039	p = 0.031	
Role Limitations due to emotionel problems (significance)				
Energy (significance)				
Emotional well-being (significance)				
Social functioning (significance)		p = 0.049		
Pain (significance)		p = 0.030		
General health (significance)				

**Measured using Mann-Whitney U test*
***Measured using Wilcoxon-Ranked test*
If not significant, p-value was left blank

Does Hindfoot Nailing Decrease Unplanned Return to the Operating Room After Geriatric Open Ankle Fracture?

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Purpose: The optimal treatment for open ankle/pilon fractures in geriatric hosts should be a surgical procedure that stabilizes the soft tissues, promotes early mobilization, and can serve as a reliable form of definitive fixation with minimal risk of subsequent surgeries. Current management strategies do not reliably achieve these goals. We sought to determine the risk factors for an unplanned return to the operating room (OR) after a geriatric open ankle fracture and the difference in the host demographics, outcomes, and postoperative mobilization rate of patients who underwent hindfoot nail (HFN) versus open reduction and internal fixation (ORIF).

Methods: A retrospective analysis of patients 60 years of age and older treated for a low-energy open ankle or pilon fracture (AO/OTA types 43 and 44) by a single academic department at two Level I trauma centers from January 1, 2007 to September 1, 2019 was performed. Our primary outcome was an unplanned return to the OR, defined as any procedure that was not considered a part of the definitive fixation plan. A multivariable logistic regression was performed using factors associated with an unplanned return to the OR with a *P* value <0.1 on univariate analysis using either Fisher's exact test for categorical comparisons or Student's t test for continuous comparisons. Demographics, injury characteristics, and postoperative complications and remobilization were also compared between ORIF and HFN. In all cases a *P* value <0.05 was considered significant.

Results: A total of 96 patients (60 ORIF, 36 HFN) met our inclusion criteria (mean age 75.3 ± 10.1 years). In total, 17 patients underwent an unplanned return to the OR (17.7%). 9 patients (9.4%) developed deep infections, and 4 (4.2%) went on to nonunion. Patients who underwent HFN were older (ORIF 71.1 ± 8.4, HFN 81.2 ± 10.1, *P*<0.0001) and had higher age-adjusted comorbidity scores as measured with the Age-Adjusted Charlson Comorbidity (ORIF 4.9 ± 2.0, HFN 6.3 ± 2.0, *P* = 0.003). However, unplanned return to OR was more common after ORIF (15 of 60, 25%) than HFN (0 of 36, 0%, *P* = 0.02), and deep infections were also more likely after ORIF (9 of 60, 15.0%) than HFN (0 of 36, 0%; *P* = 0.02). In addition, male sex (odds ratio [OR] 4.48, 95% confidence interval [CI] 1.34 to 16.26) and Gustilo Type III open fracture (OR 4.73, 95% CI 1.39 to 18.64) were found to be significant predictors of an unplanned return to the OR with an area under the receiver operating characteristic curve of 0.84.

Conclusion: Single institution analysis of geriatric low-energy open ankle/pilon fractures suggests that both deep infection and an unplanned return to the OR are significantly less frequent following HFN when compared to ORIF. While a larger sample size analysis and patient-reported outcomes are necessary, HFN is proposed as an alternative to ORIF in elderly, comorbid patients with an open ankle fracture in whom a single definitive surgery is preferred.

Fractures and Macroscopic Osteochondral Injuries of the Talar Dome Associated with Pilon Fractures

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Purpose: When tibial pilon fractures occur, the dome of the talus is exposed to the identical forces and also at risk of sustaining injuries. There are no studies examining the nature or extent of injuries to the talar dome associated with fractures of the tibial plafond. We present here a study that prospectively evaluated these potential injuries in a large series of pilon fractures.

Methods: Comprehensive visual inspection of the talar dome was performed in a series of 104 tibial plafond fractures (AO/OTA 43B/C) in adults, to document the presence of any acute macroscopic injuries. Associated injuries of the talar dome were detected in 58 cases (56%). Injuries were graded Type 1 if purely chondral, Type 2 if osteochondral, and Type 3 if an overt fracture was present. Detailed maps were created of the injuries, and transposed onto digital reconstructions of an idealized talus (male and female specific). Injuries were mapped onto 1 × 1-mm locations on the talar dome, digitally superimposed to create files suitable for data analysis. The talar dome was arbitrarily divided into 9 regions: lateral, central, and medial, and posterior, superior, and anterior. Routine statistical analysis was conducted using the $\chi 2$ test.

Results: The study cohort included 58 cases where an injury to the talar dome was documented intraoperatively; 41 men and 16 women were affected (one bilateral). The mean age was 43.2 years (range, 20-76), with 33 right and 25 left. The most frequent mechanism of injury was a motorbike accident or motor vehicle accident (62%), or a fall from a height (34%). Risk of injury to the talar dome was greater with a B-type fracture (53.5%) than a C-type fracture (31.5%) ($P = 0.011644$). There were 3 complete fractures through the talar body, and 10 osteochondral fractures stabilized with screws. 11 pure chondral injuries were extensive in nature (>200 mm2), and the remaining 34 cases were considered minor chondral injuries of varying degree. There was no difference in the distribution of injuries when comparing right to left ($P = 0.598645$). Associated talar dome injuries were more common in men than in women; the extent of injury was also greater in men than women, perhaps reflecting higher-energy injuries. There was no correlation of any specific distribution of injuries with a particular mechanism of injury, but the distribution differed between men and women ($P = 0.03206$). These injuries were principally concentrated on the lateral third of the talar dome in men; in women the injuries were spread more evenly across the dome of the talus, although the bulk of the injuries were still on the lateral aspect.

Conclusion: Concomitant injuries to the articular surface of the dome of the talus are relatively common, observed in over 50% of the pilon fractures subjected to careful scrutiny. Inspection of the dome of the talus should be considered in selected cases to assess the possibility of associated osteochondral injuries of the talar dome, and to provide care as indicated when identified.

Is the Sinus Tarsi Approach Safer Than the Extended Lateral Approach for Calcaneal Fractures?

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Purpose: There is debate regarding the safety of the extended lateral approach (EL) vs the sinus tarsi (ST) approach for ORIF of acute calcaneal fractures. We sought to evaluate the risk of deep infection as well as patient and injury factors that are associated with infection in a large series of acute calcaneal fractures.

Methods: We reviewed a consecutive series of adult patients with intraarticular calcaneal fractures treated surgically at 15 institutions. We excluded ipsilateral distal tibia or foot fractures and those lost to FU. Demographics, comorbidities, injury characteristics, treatment, and radiographic data were collected. The primary outcome was deep infection. Secondary outcomes were restoration of Bohler's angle and other short-term complications. Univariate analysis was performed for entire population and separately for the EL and ST groups to identify risk factors for infection. Multivariate regression was performed for significant variables.

Results: 782 intraarticular calcaneal fractures (Avg age 44, 74% male) were included. 444 patients were fixed via EL and 338 via ST. The ST had higher rates of diabetes (6.8% vs 3.6% p<.001) and peripheral vascular disease (3.9% vs 1.4% p=.033). However, the EL group had higher rates of LE fx (22% vs 16% p<.022), and fall >10' (52% vs 35% P<.001). Overall, there were 40 (5%) deep infections, 30 (6.8%) in the EL and 10 (3%) in the ST groups. Univariate analysis of the entire population showed that surgical approach (p=.017), age (P<.001), peripheral vascular disease (p=.048) and pre-injury occupation (p=.011) were risk factors for infection. Diabetes, smoking, open fracture, injury mechanism, lumbar fracture, and BMI were not risk factors. Only surgical approach (P=.023) and age (P<.001) were risk factors after multivariate regression. The EL group had higher rates of wound separation (10% vs 4% p=.002) and wound edge necrosis (10% vs 2% p<.001), but lower rates of symptomatic hardware (4% vs 10% p<.001) and superficial infection(3% vs 6% p=.023). We found no difference post traumatic arthritis or postop Bohler's angle. Sustaining a deep infection was associated with less likely return to work (p<.001).

Conclusion: The ST approach was chosen more often in perceived high-risk patients (DM, PVD) and is associated with unadjusted lower rates of deep infection and wound healing issues. This is still true after correcting for patient factors. Only increasing age was also associated with infection. Choice of approach did not affect the quality of the restoration of Bohler's angle.

Δ Patients with Hip Fractures Treated with Arthroplasty Demonstrate Prolonged Hypercoagulability and Increased Venous Thromboembolism Risk

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Purpose: The venous thromboembolism (VTE) risk after hip fracture surgery (HFS) is among the highest for all procedures. Recent clinical studies have demonstrated an increased VTE rate following surgical treatment of hip fractures with arthroplasty compared to surgical fixation. Thrombelastography (TEG) is a whole-blood viscoelastic assay capable of providing real-time hemostasis analysis. An elevated TEG maximal amplitude (MA) value >65 (measure of maximal clot strength) is indicative of a hypercoagulable state. This study's objective was to perform serial TEG analysis in patients with hip fracture, in order to (1) compare hypercoagulability between patients treated with arthroplasty compared to fixation and (2) determine the duration of postoperative hypercoagulability.

Methods: Consecutive patients >50 years of age with a hip fracture amenable to surgical treatment (AO 31A1-3 and 31B1-3) were recruited at a Level I trauma center. Whole blood was collected every 24 hours from admission until 5 days postoperatively, and in follow-up at 2, 4, and 6 weeks for TEG analysis. All patients received 28 days of pharmacological thromboprophylaxis. Results were summarized using descriptive statistics. Logistic regression analysis was performed using the presence or absence of MA >65 for patient and surgical factors associated with hypercoagulability.

Results: In total, 121 patients (81 female) with a median age of 81 (interquartile range 71-87) were included. 64 patients had intertrochanteric fractures (AO 31A) and 57 patients had femoral neck fractures (AO 31B). Patients treated with arthroplasty were significantly more hypercoagulable on postoperative day (POD) 3 (odds ratio [OR] = 7.08, 95% confidence interval [CI] = 2.00-34.09; $P = 0.005$), at 2 weeks postoperative (OR = 2.84, 95% CI = 1.10-7.68, $P = 0.034$), and at 6 weeks postoperative (OR = 5.14, 95% CI = 1.73-17.16) compared to patients treated with surgical fixation. All three patients (2.5%) who developed symptomatic VTE following hip fracture were treated with arthroplasty procedures. At 6 weeks, the majority of patients remained above the MA >65 hypercoagulable threshold (mean MA = 65.9, standard deviation = 4.0; $P<0.04$).

Conclusion: This study demonstrates for the first time that patients with hip fracture treated with arthroplasty were significantly more hypercoagulable postoperatively (based on MA >65) than patients treated with surgical fixation. The increased VTE risk may be associated with more invasive surgical approaches and leg manipulation during arthroplasty, leading to increased activation of the coagulation cascade. Additionally, blood flow has been shown to be reduced in the operated leg following arthroplasty up to 6 weeks postoperatively coinciding with our findings. Risk stratification with TEG and TEG-guided thromboprophylaxis regimens may reduce VTE risk in patients with hip fracture requiring arthroplasty and with prolonged hypercoagulability.

Δ OTA Grant

Who, If Anyone, May Benefit From a Total Hip Arthroplasty After a Displaced Femoral Neck Fracture? A Subgroup Analysis of the HEALTH Trial

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Purpose: Guidelines recommend arthroplasty as the preferred treatment method for displaced femoral neck fractures in the elderly. A total hip arthroplasty (THA) is recommended typically for a healthier and younger subset of patients with longer life expectancy. In the National Institute for Health and Care Excellence guidelines, patients who are independent walkers, not cognitively impaired, and medically fit for the procedure should be considered for a THA. According to the American Academy of Orthopaedic Surgeons, there is a moderate recommendation to use THA in higher functioning patients. Other reviews and meta-analyses also recommend a select group of the fittest patients for THA. This recommendation is based on a few randomized trials showing a modest functional benefit and fewer reoperations after THA compared with hemiarthroplasty (HA). The Hip Fracture Evaluation with Alternatives of Total Hip Arthroplasty versus Hemi-Arthroplasty (HEALTH) multicenter randomized controlled trial of 1441 patients aged ≥50 years with a displaced femoral neck fracture found that there was a benefit, although not clinically meaningful, in function for THA measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Using data from the HEALTH trial, we aimed to compare health-related quality of life and functional outcomes between THA and HA in a subset of the fittest patients.

Methods: The fittest subgroup of the HEALTH trial was defined as those participants who were aged ≤70 years, with an American Society of Anesthesiologists I or II classification, not using assistive devices for ambulation prior to injury, and living independently prior to injury. We used multilevel models to separately estimate the effect of implant on function (WOMAC), quality of life (12-item Short Form Health Survey [SF-12]), EuroQol-5 Dimensions (EQ-5D), and mobility (Timed Up and Go [TUG]) in the fittest subgroup. Randomized treatment and visit were included as independent variables. We performed the same analysis on the remainder of participants who were not included as part of the fittest subgroup.

Results: 143 patients met the criteria to be included in the fittest subgroup. The overall WOMAC score and its subcomponents, the SF-12, EQ-5D, and TUG scores showed no statistically significant differences between the THA and HA groups in the fittest subgroup. Similarly, in participants who were not included in the fittest subgroup, no differences were found in any of the functional outcomes.

Conclusion: Our results show similar findings and strengthen the conclusions from the HEALTH trial. We were unable to identify a subgroup where THA should be the recommended treatment for displaced femoral neck fractures over HA in participants aged ≥50 years.

Surgical Approach and Dislocation Rate Following Hemiarthroplasty in Geriatric Femoral Neck Fracture Patients with Cognitive Impairment: Is There an Association?

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Purpose: Our objective was to evaluate patients who sustained femoral neck fractures treated with hemiarthroplasty (HA) to determine if there is an association between surgical approach and cognitive impairment on dislocation rate.

Methods: A retrospective chart review was conducted of 1481 patients who underwent HA for femoral neck fractures between January 1, 2014 and October 31, 2018, within our health system. Inclusion criteria included age greater than 60 years, traumatic femoral neck fractures treated with HA, and at least 1 month of radiographic and/or clinical follow-up. Exclusion criteria included history of previous surgery to the injured hip, and HA for non-trauma indications (ie, tumor, infection, or atraumatic fracture). Included patients were divided into three groups based on surgical approach: direct anterior approach (DA), modified Hardinge approach (MH), and posterior approach (PA).

Results: 828 hips met inclusion criteria. 290 hips (35%) also had a documented diagnosis of cognitive impairment. Median follow-up was 329 days (range, 26 to 2034 days). The overall dislocation rate was 17 of 828 (2.05%), with a median of 20.5 days (range, 2 to 326 days) from surgery to dislocation. A significant association between surgical approach and dislocation rate was detected among the three intervention groups ($P = 0.0035$). Patients in the PA group had a greater association with dislocation compared to the MH group ($P = 0.0017$). Six of 533 patients (1.08%) in the MH cohort dislocated while 11 of 217 patients (5.07%) in the PA group dislocated. There were no dislocations observed in the DA group. 10 of the 17 dislocations (58.8%) were observed in patients with a diagnosis of cognitive impairment. In patients without cognitive impairment, a significant difference was not detected in the dislocation rate of patients between the various approaches ($P = 0.2660$) (3 of 351 MH, 4 of 148 PA, and 0 of 39 DA). Within subjects who underwent the MH approach, no association between cognitive impairment and dislocation was demonstrated ($P = 0.6735$), while a significant association was demonstrated between these variables within the PA group ($P = 0.0397$). Lastly, among patients with a diagnosis of cognitive impairment, a significant association between surgical approach and dislocation rate was detected among the three intervention groups ($P = 0.0061$). Patients who underwent a PA had a greater association with dislocation compared to the MH group ($P = 0.0033$). Three of 202 patients (1.49%) dislocated who underwent MH, while 7 of 69 patients (10.14%) in this cohort who underwent PA dislocated.

Conclusion: The results of our study suggest that patients with cognitive impairment who undergo a PA have a higher rate of dislocation than patients treated using a MH or DA surgical approach. The authors of this study suggest careful surgical approach selection in patients with cognitive impairment.

Peri-Implant Femur Fractures After Intertrochanteric Hip Fractures Occur Late and are More Common in Short Nails in Long-term Follow-up

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Purpose: The surgical treatment of intertrochanteric femur fractures varies widely between orthopaedic providers. While small cohorts of intertrochanteric femur fractures show similar outcomes between short and long cephalomedullary nails (CMNs), the long-term failure and peri-implant fracture rates remain incompletely described. The purpose of this study is to better understand the complication rates of intertrochanteric femur fractures treated with short versus long CMNs.

Methods: 1013 patients were identified as having an intertrochanteric fracture that was fixed surgically with a CMN at a Level I trauma center over a 10-year period. For all patients, we recorded AO classification, patient demographics, operative details, imaging, and follow-up data.

Results: Of the 1013 patients, 922 were long CMNs and 91 were short CMNs. The average orthopaedic follow-up was 11.3 months, and average primary care follow-up in our hospital system was 21.9 months. 48 patients (4.7%) needed a revision of their initial surgery, with 24 being from distal fractures after mechanical falls and 22 from fixation failure/cutout. Fixation failure/screw cutout occurred in 18 (2.0%) of 922 long nails, compared to 4 of 91 (4.4%) for the short nails, which was not statistically significant ($P = 0.13$). Femur fracture distal to the implant occurred in 13 (1.4%) of the 922 long nails, compared to 11 of 91 (12.1%) of the short nails, which was statistically significant ($P < 0.0001$). These fractures occurred at a median of 8.0 months (range, 0.8-122 months) out from surgery.

Conclusion: In a large cohort of hip fracture patients with reliable longitudinal follow-up, there was an 8.5× higher rate of peri-implant distal femur fractures requiring surgery in short CMNs compared to long IMNs. This suggests that the clinical equivalence of short versus long nails that has previously been reported should undergo further scrutiny.

Risk Factors for Nonunion of Distal Femur Fractures

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Purpose: Distal femur fracture are challenging injuries and represent a significant source of patient morbidity. In some series, treatment with lateral locked plating (LLP) has high rates of nonunion, and with a paucity of clinical data on intramedullary nailing (IMN), there is continued debate over the optimal construct choice in the treatment of distal femur fractures. The purpose of this study was to identify patient comorbidities, injury characteristics, fixation constructs, and construct variables that are associated with increased risk of distal femur nonunion.

Methods: After IRB approval was obtained, a retrospective review of all OTA 33A and 33C distal femur fractures over a 17-year period (2004-2020) was performed at a single Level I trauma center. Minimum 6-month follow-up was required and all periprosthetic fractures were excluded. Nonunion was defined as a return to the operating room for management of inadequate bony healing with persistent pain and or broken implants. The nonunion group included staged bone grafting of segmental bone defects. Patient demographics, comorbidities, injury characteristics, fixation type, and construct variables were assessed for association with distal femur fracture nonunion.

Results: A total of 439 patients were identified who met inclusion criteria. There were no differences in age, sex, mechanism of injury, ISS, and time to surgery between the groups. Increased body mass index ($P = 0.01$), open fracture ($P<0.0001$), and postoperative infection ($P<0.0001$) were associated with nonunion. AO/OTA 33C2 and 33C3 fractures had higher rates of nonunion (14.7% and 24.8% respectively, $P = 0.0002$) than other fracture types. There was a significant difference in nonunion rate based on implant type favoring nail + plate and retrograde IMN over titanium and stainless steel lateral locked plating (3.0% vs 7.1% vs 15.8% vs 20%, $P = 0.0002$) in spite of similar fracture characteristics between the groups. There was no difference in nonunion rate based on implant metallurgy (titanium 12.7% vs stainless steel 23.5%, $P = 0.248$), and no difference in average plate length (11 vs 11, $P = 0.86$).

Conclusion: In spite of similar fracture complexity in both groups, articular fixation and the use of an intramedullary nail or a nail/plate construct led to significantly lower rates of distal femoral nonunion than lateral locked plating. Obesity, increasing fracture complexity (AO 33C2 and 33C3), and open fracture also carry a significantly increased rate of fracture nonunion. Plate metallurgy and plate length do not appear to play a role in the development of nonunion.

Midterm Outcomes After the Surgical Treatment of Atypical Femoral Fractures: Minimum 3-Year Follow-up

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Purpose: The incidence of atypical femoral fractures (AFFs) continues to increase. However, there are currently limited long-term studies on the complications of AFFs and factors affecting them. Therefore, we attempted to investigate the outcomes, complications, and affecting risk factors for complication through mid-term follow-up of more than 3 years.

Methods: From January 2003 to January 2016, 305 patients who underwent surgery for AFFs at 6 hospitals were enrolled. After exclusion, a total of 147 patients were included. We retrospectively evaluated medical records, and reviewed radiographic images to investigate the fracture site, femur bowing angle, presence of delayed/nonunion, contralateral AFFs, and peri-implant fracture. Statistical analysis was performed on the affecting factors.

Results: The mean follow-up period was 70.2 months (range, 36-191). There were 146 cases (99.3%) in women and the average age was 71.6 years (range, 48-89). The subtrochanter and shaft fractures were in 52 cases (35.4%) and 95 cases (64.6%), respectively. The preoperative mean anterior/lateral femoral bowing angle were 10.5° ± 5.7°/6.1° ± 6.2°. The postoperative mean anterior/lateral bowing value were changed by 8.7° ± 5.4°/4.6° ± 5.9°, respectively. Bisphosphonates were used in 115 cases (78.2%) for an average of 52.4 months preoperatively. Nailing was performed in 133 cases (90.5%), and bony union was obtained at an average of 23.6 weeks (range, 7-85). Delayed union occurred in 41 cases (27.9%), and nonunion occurred in 13 cases (8.8%). Contralateral AFF occurred in 79 cases (53.7%), and the use of a bisphosphonate significantly influenced the occurrence of contralateral AFFs ($P = 0.019$). Peri-implant fractures occurred in a total of 13 cases (8.8%), and a significant increase was observed in cases with plating ($P = 0.021$) and high-grade postoperative anterolateral bowing ($P = 0.044$).

Conclusion: The use of a bisphosphonate was found to be a risk factor for contralateral AFF, and high-grade postoperative anterolateral bowing and plate fixation significantly increased the occurrence of peri-implant fractures. Therefore, long-term follow-up studies on the bilaterality of AFFs and peri-implant fractures are necessary.

Risk Factors for Early Conversion Total Hip Arthroplasty After Pipkin 4 Femoral Head Fracture

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Purpose: The purpose of this study is to determine risk factors for early conversion total hip arthroplasty (THA) after Pipkin 4 femoral head fractures.

Methods: 262 patients with Pipkin 4 fractures managed at two Level I trauma centers treated from 2009 to 2019 were identified. The average follow-up was 18 months (range, 3-111 months) with exclusion of all with less than 1-year follow-up. Patients were separated for analysis into 2 groups by AO/OTA classification of femoral head fracture: 31C1 (shear-type fractures) and 31C2 (impaction-type fractures). Patients with 31C2.1 fractures (chondral lesions) were excluded. Demographics, operative, and in-hospital variables were compared between patients undergoing conversion THA and those with native hip survival.

Results: Of the 65 total AO/OTA 31C1 fractures, 19 (29%) underwent conversion THA within 1 year, at a mean of 7 months from index surgery (3-12 months); 25 of 65 (38%) underwent conversion within 2 years. The conversion THA patients were similar to those not requiring conversion THA in body mass index (BMI), acetabular fracture classification (Letournel), femoral head comminution, management of femoral head fracture (excision vs open reduction and internal fixation [ORIF]), dislocation at time of injury, posterior wall comminution, no difference in postoperative acetabular fracture reduction (Matta reduction criteria), femoral head fracture location (suprafoveal vs infrafoveal [47% vs 28%, $P = 0.12$]), operative duration, blood loss, and time to surgery from admission. Patients with conversion THA in this group had increased rates of surgical site infection (SSI) after index ORIF (32% vs 2%, $P = 0.002$) and postoperative recurrent hip instability (42% vs 4%, $P<0.0001$) and were older on average at time of injury (46 vs 38 years, $P = 0.049$). Of the 72 total AO/OTA 31C2 fractures, 20 (27.8%) underwent conversion THA within 1 year, at a mean of 7 months from index surgery (0-12 months), and 31 of 72 (43%) underwent conversion within 2 years. In this group of patients, those requiring conversion THA had increased rates of age (51 vs 43 years, $P = 0.048$), time to surgery from admission (4.2 days vs 3.3 days, $P = 0.02$), femoral head fracture location—suprafoveal (80% vs 46%, $P = 0.008$), and femoral head fracture location—posterior ($P = 0.008$). All other variables were similar between the two groups.

Conclusion: Pipkin 4 fractures have a high overall rate of conversion THA within 1 year (28.5%). Outcomes of shear-type (AO/OTA 31C1) fractures depend on the age of the patient and post-ORIF outcomes such as SSI and redislocation. Femoral head fixation compared to excision in these cases does not impact the rate of conversion THA. Outcomes of patients with impaction-type (AO/OTA 31C2) fractures depend on the location of the femoral head impaction (suprafoveal and posterior location are high risk), age of the patient, and delayed time to surgery from admission, which likely increases the risk of osteonecrosis development resulting in early conversion THA.

Hip Fracture with Elevated Troponin: Harbinger of Mortality or Need for Accelerated Surgery?

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Purpose: Current guidelines recommend hip fracture patients receive surgery within 48 hours of injury to reduce mortality and complications; however, the optimal management of hip fracture patients who present with a concomitant acute heart injury (diagnosed by elevated troponin) is unclear. Current practice typically involves prolonged preoperative medical management until the troponin levels improve. The purpose of this study is to describe the clinical outcomes of this hip fracture population.

Methods: We performed a single-center retrospective cohort study of all hip fracture patients aged 60 years who received surgical fixation between 2015 and 2020. At least one preoperative troponin measurement was required to be included. The decision to measure preoperative troponin was at the treating physician›s discretion or part of the routine preoperative risk stratification. Baseline demographic and cardiac injury information was collected, as well as the time to surgery in hours. Elevated troponin was defined as cardiac troponin I ≥0.06 ng/mL. The primary outcome was mortality at 90 days. The secondary outcome was a composite of mortality and major cardiovascular complications.

Results: From a larger cohort of 452 hip fracture patients, we included the 299 patients (66%) who had a preoperative troponin measurement. 43 patients (14%) had troponin elevation, with a median level of 0.13 ng/mL (interquartile range, 0.08-0.34 ng/mL). Three patients underwent preoperative percutaneous coronary intervention. Patients with elevated troponin waited longer for surgery compared to patients without elevated troponin (median 43 vs 22 hours; median difference 21 hours, 95% confidence interval [CI] 13-29 hours, $P<0.01$). Elevated troponin was also associated with a 14% 90-day mortality risk increase (29% vs 14%; 95% CI, 0% to 29%, $P = 0.05$) and a 14% increase in the 90-day risk of a major complication (38% vs 24%; 95% CI: –0.01 to 30%, $P = 0.07$).

Conclusion: Hip fracture patients with concomitant acute heart injury had a longer time to surgery and an increased risk of mortality and major complications. Data from the HIP ATTACK trial suggest that accelerated surgical care (<6 hours) for patients with elevated troponin is safe and may have a mortality benefit (90-day mortality 10% vs 24%; hazard ratio 0.38; 95% CI 0.21-0.66). Our study confirms the association between elevated preoperative troponin and increased risk for surgical delay, mortality, and major complications. These results highlight the urgent need to determine if accelerated hip fracture care can reduce mortality in patients with acute heart injury.

Risk of Conversion to Total Hip Arthroplasty Following Hemiarthroplasty for Hip Fracture

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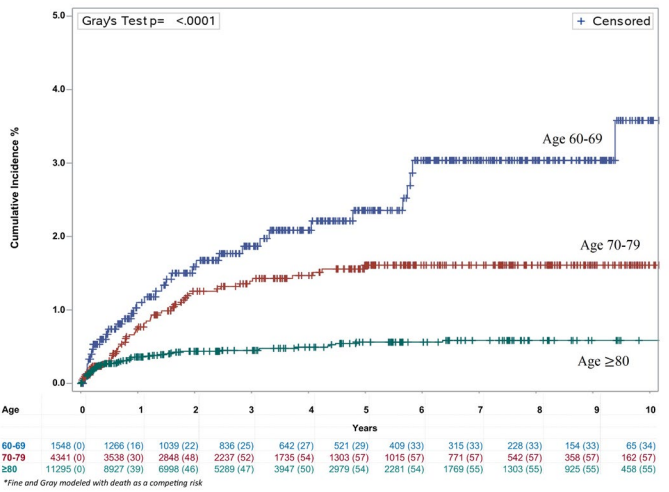
Purpose: Arthroplasty is the standard of care for displaced femoral neck fractures in the elderly, but the decision of whether to perform hemiarthroplasty (HA) or total hip arthroplasty (THA) is often a subjective one. Patients who initially receive HA but go on to require conversion THA may have been better treated with THA at the outset. The purpose of this study was to determine the incidence of, and risk factors for, conversion THA following HA for hip fracture among elderly individuals.

Methods: We used a U.S. integrated health-care system's hip fracture registry to identify 17,184 patients aged ≥60 years who underwent HA (2009-2019), and retrospectively assessed 5- and 10-year THA conversion and mortality. Risk factors for conversion THA—including patient and surgical characteristics, comorbidities, and hospital discharge information—were assessed using time-dependent multivariable Cox proportional hazards regression with a competing risk of death. Final model selection was based on change in comparison of the Akaike Information Criterion (AIC) in subsequent paired nested models.

Results: At the time of injury, the percentage of patients who underwent HA (as opposed to THA) was 97.8% for age ≥80 years, 91.3% for age 70-79, and 73.3% for age 60-69. The cumulative incidence of conversion THA at 5 years following HA was 1.1%. By age group, the rates of conversion THA were 0.49% for age ≥80 years, 1.3% for 70-79, and 2.2% for 60-69 (Figure 1). In addition to younger age, discharge to home (as opposed to a facility) was associated with a higher risk of conversion THA (hazard ratio [HR] 1.74, 95% confidence interval [CI] 1.21-2.49, $P = 0.003$) as was depression (HR 1.73, 95% CI 1.14-2.61, $P = 0.009$). Underweight (body mass index <18.5 kg / m2) was associated with a lower risk of conversion THA (HR 0.33, 95% CI 0.12-0.92, $P = 0.03$).

Conclusion: When following current treatment guidelines, the risk of conversion THA following HA for femoral neck fracture is low. Patients who were younger, were discharged home, or had depression were at higher risk of conversion THA, while patients who were underweight were at lower risk.

Figure 1. Cumulative Incidence* of THA Conversion after Hemiarthroplasty by Age Group, 2009-2019, N=17,184



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Persistent Opioid Usage Following Hip Fracture Surgery in Opioid-Naïve Older Patients

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Purpose: While the risk of long-term dependence following opioid treatment of musculoskeletal injury is often studied in younger populations, most studies of opioids in older patients have centered on short-term risks such as oversedation and delirium. The purpose of this study was to assess the prevalence of, and risk factors for, prolonged opioid usage following hip fracture in opioid-naïve older individuals.

Methods: This was a retrospective cohort study of opioid-naïve patients aged ≥60 years who underwent surgical treatment of a hip fracture at 1 of 35 hospitals owned by a large US health maintenance organization (2009-2018). Postoperative outpatient opioid use was evaluated in the following time periods: P1 (day 0-30 post-surgery), P2 (day 31-90), and P3 (day 91-180). The primary outcome was prolonged outpatient opioid use, defined as having 1 or more opioid prescriptions dispensed in all 3 time periods (P1, P2, and P3). Multivariable logistic regression was performed while adjusting for potential confounders.

Results: 29,618 opioid-naïve patients underwent surgical treatment of a hip fracture during the study period. Of patients who were alive during the time period in question, the proportion of outpatient opioid usage was 83.7% (24,776/29,618) in P1, 69.0% (19,380/28,068) in P2, and 16.7% (4435/26,481) in P3. In the multivariable analysis controlling for confounders, risk factors for prolonged opioid usage included young age (60-69 years), female sex, body mass index ≥30 kg/m2, current/former smoking, American Society of Anesthesiologists classification ≥3, and a history of substance abuse. Prolonged opioid usage was less common among patients who were Asian, had an annual income ≥$150,000, or had undergone regional anesthesia.

Table: Risk factors for persistent opioid usage following hip fracture surgery (N=26,481)

Characteristic	Crude incidence of persistent opioid use	Multivariable Odds Ratio (95% CI)	P
Age			
60-69	19.2% (687/3574)	**1.24 (1.11-1.38)**	**<0.0001**
70-79	17.6% (1200/6818)	1.05 (0.97-1.14)	0.24
80-89*	16.3% (1846/11,346)	1.00	---
90 or older	14.8% (702/4743)	0.94 (0.86-1.04)	0.24
Sex			
Female	17.3% (3286/19,053)	**1.24 (1.14-1.34)**	**<0.0001**
Male*	15.5% (1149/7428)	1.00	---
Race/ethnicity**			
Asian	10.9% (252/2307)	**0.66 (0.57-0.76)**	**<0.0001**
Black	19.7% (213/1083)	1.10 (0.93-1.29)	0.27
Hispanic	16.8% (423/2521)	0.91 (0.81-1.02)	0.10
White*	17.2% (3510/20,366)	1.00	---
Income			
Less than $25,000	17.6% (740/4212)	1.04 (0.65-1.68)	0.86
$25,000-$49,999	17.6% (906/5154)	1.53 (0.86-2.73)	0.15
$50,000-$74,999*	17.3% (777/4487)	1.00	---
$75,000-149,999	16.6% (1337/8059)	1.25 (0.77-2.02)	0.37
$150,000 or more	15.0% (669/4457)	**0.56 (0.37-0.83)**	**0.004**
Body mass index			
Less than 22	15.6% (1466/9411)	1.02 (0.93-1.11)	0.70
22-24.9*	15.7% (1124/7145)	1.00	---
25-29.9	17.7% (1255/7091)	1.07 (0.98-1.18)	0.12
30 or more	22.1% (581/2634)	**1.15 (1.00-1.33)**	**0.047**
ASA classification			
1-2*	14.3% (1111/7797)	1.00	---
3 or greater	18.0% (3043/16,880)	**1.16 (1.01-1.16)**	**<0.0001**
Smoking status			
Current/former	18.8% (2115/11,271)	**1.08 (1.01-1.16)**	**0.033**
Never*	15.6% (2271/14,539)	1.00	---
Anxiety			
Yes	20.4% (587/2872)	1.07 (0.96-1.19)	0.20
No*	16.3% (3848/23,609)	1.00	---
Depression			
Yes	21.7% (369/1700)	1.13 (0.99-1.29)	0.08
No*	16.4% (4066/24,781)	1.00	---
Substance abuse			
Yes	24.4% (461/1891)	**1.18 (1.03-1.35)**	**0.015**
No*	16.2% (3974/24,590)	1.00	---
Surgery type**			
Fracture fixation	17.7% (2794/15,796)	**1.12 (1.05-1.21)**	**0.001**
Hemiarthroplasty*	15.6% (1488/9542)	1.00	---
Total hip arthroplasty	13.1% (94/717)	**0.78 (0.62-0.98)**	**0.036**
Anesthesia type			
Regional	15.6% (1736/11,117)	**0.92 (0.86-0.99)**	**0.022**
General*	17.6% (2681/15,222)	1.00	---

Analysis excludes 3137 patients who died prior to Q2. The following variables had missing data: BMI (n=9; 0.0%), smoking status (n=49; 0.2%), ASA (n=281; n=1.1%), anesthesia type (n=18; 0.1%).
*Reference group.
**Excludes 37 patients with race/ethnicity classified as other and 59 patients with surgery type classified as other.

Conclusion: In this study, 1 in 6 elderly hip fracture patients were still taking opioid pain medications at 3 to 6 months postoperatively. While prior research on the hazards of opioids in the elderly has primarily focused on short-term risks such as oversedation and delirium, these findings suggest that addiction and chronic opioid use may represent risks for this older population as well.

The Results: NIHR Feasibility Randomized Controlled Trial: Acetabular Fractures in Older Patients Intervention Trial (AceFIT)

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Purpose: Displaced acetabular fractures in the older patient present significant treatment challenges. There is evidence that the morbidity and mortality associated with these injuries is similar to the fractured neck of femur cohort. Despite growing literature in this patient population, there remains significant controversy regarding treatment algorithms, varying between conservative management, to fracture fixation, and finally «fix and replace» surgical strategies to allow immediate full weight bearing.

Methods: £250,000 National Health Service funding was secured from the National Institute for Health Research (NIHR), Research for Patient Benefit and trial ethical approval granted from East of England Research Ethics Committee. After national consultation, 3 trial arms were included: conservative management, fracture fixation, and simultaneous fracture fixation with total hip arthroplasty (THA). Statistical analysis required a minimum 12 patients in each of the 3 arms to show feasibility, with an optimum trial recruitment of 20 in each arm. Inclusion criteria included patients >60 years with a displaced acetabular fracture with the following exclusion criteria: open fracture, THA in situ, preinjury immobility, and/or polytrauma. Primary outcome measure was ability to recruit with EuroQol 5 Dimensions 5-level (EQ-5D-5L) at 6 months. Secondary outcome measures at 9 months included Oxford Hip Score; Disability Rating Index; radiographic evaluation; perioperative physiological variables including surgery duration, blood loss, and complications; and health economics.

Results: 11 UK Level I major trauma centers were enrolled into the trial, which commenced in a staged manner from December 2017. Failure of surgical equipoise was identified as an issue regarding recruitment. Full trial recruitment (60 patients) was achieved with 333 patients screened. 66% of patients recruited were male, median age 76 years (range, 63-93), median body mass index 25 kg/m2 (range, 18-37), 87% patients had full mental capacity, and 77% were admitted from own home. 75% of injuries were due to a fall from standing height. 60% of fractures were classified anterior column posterior hemi-transverse. Trial feasibility was confirmed with full data acquisition completed in December 2020. Presented data will show (9-month study period) secondary outcome measures that are statistically significant in improvement from baseline for only the fix and replace arm, with acceptable low complication rates. Issues are highlighted with conservative management in this patient cohort.

Conclusion: This unique randomized controlled trial (RCT) feasibility study represents the first opportunity to understand the intricacies of each of these agreed treatment modalities, including patient-reported outcomes and health economics. The primary outcome measure has shown feasibility for a fully powered RCT. This RCT will provide clinicians with information on how best to provide a holistic management strategy for this medically complex patient cohort.

Outcomes for Geriatric Proximal Humerus Fractures: A Matched Comparison of Nonoperative Management and Reverse Shoulder Arthroplasty

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Purpose: The purpose of this study is to evaluate differences in patient-reported outcomes (PROs), range of motion (ROM), and complication rates after geriatric proximal humerus fractures managed nonoperatively or with reverse shoulder arthroplasty (RSA).

Methods: Patients >55 years old with a proximal humerus fracture managed nonoperatively or with RSA from 2015 to 2018 were included. Patients were matched by age, Charleson Comorbidity Index, and fracture type (AO/OTA 11A, 11B, 11C) using coarsened exact matching. Visual analog scale (VAS) pain scores, Patient-Reported Outcomes Measurement Information System (PROMIS) scores, ROM values, and complication and reoperation rates were compared between treatment groups.

Results: 95 patients were included in this analysis (62 nonoperative, 33 RSA). Results are listed in Table 1. At 2 weeks RSA showed lower VAS scores, and better ROM and PROMIS scores (P<0.05) compared to nonoperative treatment. At 6 weeks, RSA had lower VAS scores, better ROM and PROMIS scores (P<0.05) compared to nonoperative treatment. At 3 months, RSA showed similar VAS scores (P>0.05), but better ROM and PROMIS scores (P<0.05) compared to nonoperative treatment. At 6 months, RSA showed similar VAS scores and PROMIS scores (P>0.05), but better ROM (P<0.05) compared to nonoperative treatment. Complication rates were significantly higher in the nonoperative group (P<0.01). There was no difference in reoperation rates between groups (P>0.05).

Table 1. Matched Analysis Outcomes*

	Nonoperative (N=62)	RSA (N=33)	†p-value
Any Complication (n)ǂ	**75.8% (47)**	**12.1% (4)ǂ**	**<0.001**
Varus Malunion	48.4% (30)	--	--
Reoperation (n)§	8.1% (5)	3.0% (1)	0.142
Range of Motion (Mean ± SD, °)			
Active Forward Flexion			
2-week follow up	0.5 ± 3.7	0.7 ± 5.8	0.816
6-week follow up	**20.7 ± 30.6**	**62.2 ± 47.5**	**<0.001**
3-month follow up	**75.1 ± 45.5**	**125.0 ± 21.1**	**<0.001**
6-month follow up	**101.4 ± 31.9**	**135.5 ± 20.5**	**<0.001**
Passive Forward Flexion			
2-week follow up	**1.5 ± 9.5**	**49.0 ± 45.6**	**<0.001**
6-week follow up	**55.9 ± 37.6**	**114.2 ± 31.1**	**<0.001**
3-month follow up	**82.7 ± 52.3**	**140.9 ± 19.2**	**<0.001**
6-month follow up	**120.9 ± 23.2**	**149.0 ± 16.4**	**<0.001**
External Rotation			
2-week follow up	**0.2 ± 2.9**	**4.0 ± 6.3**	**<0.001**
6-week follow up	**14.6 ± 13.7**	**24.3 ± 12.7**	**<0.001**
3-month follow up	32.2 ± 23.5	37.4 ± 20.7	0.246
6-month follow up	41.7 ± 20.2	45.0 ± 17.1	0.453
Patient Reported Outcomes (Mean ± SD)			
VAS Pain Score			
2-week follow up	**6.2 ± 3.1**	**2.9 ± 2.6**	**<0.001**
6-week follow up	**3.7 ± 2.6**	**1.3 ± 1.8**	**<0.001**
3-month follow up	2.1 ± 2.1	1.4 ± 1.9	0.079
6-month follow up	1.4 ± 1.8	1.0 ± 1.8	0.296
PROMIS Depression			
2-week follow up	53.7 ± 10.4	55.3 ± 7.3	0.425
6-week follow up	**47.6 ± 9.1**	**51.9 ± 8.3**	**0.024**
3-month follow up	47.8 ± 7.5	46.6 ± 10.1	0.535
6-month follow up	48.0 ± 10.0	44.1 ± 9.4	0.101
PROMIS Pain Interference			
2-week follow up	**68.1 ± 5.9**	**64.3 ± 7.4**	**0.013**
6-week follow up	**60.5 ± 5.8**	**57.4 ± 6.8**	**0.025**
3-month follow up	**56.9 ± 6.3**	**50.4 ± 7.2**	**<0.001**
6-month follow up	55.7 ± 7.8	52.6 ± 6.4	0.074
PROMIS Physical Function			
2-week follow up	29.9 ± 8.1	28.4 ± 4.3	0.303
6-week follow up	32.6 ± 5.8	32.3 ± 4.5	0.757
3-month follow up	38.3 ± 9.1	39.3 ± 5.1	0.565
6-month follow up	41.6 ± 9.1	43.0 ± 5.0	0.457

SD = Standard deviation; RSA = Reverse shoulder arthroplasty; HS = Head-shaft; AVN = Avascular necrosis; VAS = Visual analog scale; PROMIS = Patient reported outcomes measurement information system
***Boldface** indicates statistical significance.
†P-value calculated using linear and poisson regression for continuous and categorical variables, respectively
ǂ Additional complications: Nonoperative – valgus malunion (9), head-shaft translation (5, nonunion (3), avascular necrosis (2); RSA – intraoperative humerus fracture (1), musculocutaneous/radial nerve palsy (1), acromion stress fracture (1), and deep infection (1)
§ Includes failure of nonoperative management with conversion to plate fixation (2), intramedullary fixation (1), or arthroplasty (2); and irrigation & debridement with staged revision arthroplasty for deep infection (1)

Conclusion: RSA was associated with early decreased pain, and better ROM and PROMIS scores compared to nonoperative treatment. This suggests that RSA may be superior to nonoperative management in the early recovery period for proximal humerus fractures.

Intravenous Tranexamic Acid Given at Femoral Fragility Fracture Surgery Reduces Blood Transfusion Requirements Fourfold

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Purpose: Tranexamic acid (TXA) is an inexpensive antifibrinolytic. TXA use in major trauma and hip and knee arthroplasty is promoted through national guidelines. Currently there are no national guidelines in the UK or US that promote the use of TXA in femoral fragility fracture (FFF) management. The aim of the study was to determine whether intraoperative intravenous TXA affects blood loss following the surgical management of FFFs. The primary outcome measure was blood transfusion requirement. Secondary outcomes included calculated blood loss (CBL), percentage drop in hemoglobin (Hb), early postoperative complications, and 30-day mortality.

Methods: This was a single center (university teaching hospital), prospective, nonrandomized case-control study. 361 consecutive patients with FFF admitted over a 4-month period were included (mean age, 81.4 years; mean body mass index, 23.5 kg/m2; 73.7% female). Patient demographics, comorbidities, preoperative anticoagulation use, surgical management, intravenous TXA use, perioperative Hb and hematocrit, and requirement for blood transfusion were recorded prospectively. Intravenous TXA 1 g was given at the beginning of surgery at the discretion of the operating team: 178 (49%) received TXA and 183 (51%) did not. The primary outcome was postoperative blood transfusion requirement. Secondary outcomes included postoperative day 1 CBL (using the Nadler and Gross formula) and fall in Hb (percentage) from preoperative levels, and the incidence of thrombotic events and mortality up to 30 days.

Results: Groups were well matched at baseline in terms of patient demographics, comorbidities, preoperative anticoagulation use, injury types, and surgical management. The requirement for postoperative blood transfusion was significantly reduced in the TXA group: 15 of 178 (8.4%) compared to control group at 58 of 163 (31.7%) ($P<0.001$, $\chi 2$). This was the case for all types of fracture surgery: intracapsular fracture surgery 5 of 101 versus 12 of 87, $P = 0.035$; dynamic hip screw 2 of 40 versus 22 of 62, $P<0.001$; cephalomedullary nail 7 of 23 versus 16 of 26, $P = 0.029$; and open reduction and internal fixation 1 of 12 versus 8 of 10, $P = 0.002$. TXA significantly reduced both the percentage fall in Hb (mean difference 4.3% (–6.3 to –2.3, 95% confidence interval [CI]), $P<0.001$) and the CBL (mean difference –222 mL (–337 to –106, 95% CI), $P<0.001$). The difference in CBL was greatest in patients treated with intramedullary nail (n = 49: mean difference –394 mL (–751 to 36, 95% CI), $P = 0.030$) and dynamic hip screw (n = 101, mean difference –216 mL (–411 to –21, 95% CI), $P = 0.032$). There was no difference in the rate of complications between TXA and control groups. Specifically, there was no difference in the rate of image-proven venous thromboembolism (2 vs 1, respectively; $P = 0.620$).

Conclusion: Intraoperative intravenous TXA during the surgical management of FFF significantly reduced the rate of transfusion, CBL, and the percentage drop in Hb.

Long-Leg Versus Short-Leg Cast Immobilization for Displaced Distal Tibial Physeal Fractures

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Purpose: The traditional treatment recommendation for distal tibial physeal injuries is a long-leg cast (LLC) for initial immobilization. The purpose of this study was to compare the efficacy of LLCs versus short-leg casts (SLCs) for immobilization of distal tibial physeal fractures after closed reduction.

Methods: A retrospective chart and radiographic review was performed of all patients undergoing closed reduction of a displaced, extra-articular distal tibial physeal fractures treated at 3 Level I pediatric trauma centers between January 2012 and December 2018. Patients were divided into groups based on initial postreduction immobilization, either LLC or SLC. Loss of reduction (LOR) was defined as >3 mm of displacement or >5° of angulation from postreduction radiographs. Bivariate analysis was used to assess explanatory variables associated with LOC comparing SLCs to LLCs and assess the influence of these variables on the overall LOR.

Results: 148 fractures (148 patients) were identified with 108 LLC and 40 SLC cases. The average age was 12.2 years (interquartile range, 11.2-13.7); 73% of the patients were male. The average displacement on injury films was 12 mm with an average of 2 mm of postreduction displacement. 14 fractures (9.5%) experienced LOR identified at the time of cast removal, 13 in LLCs and 1 in an SLC ($P = 0.08$). LOR was associated with the location of the reduction (operating room vs emergency department (ED) as all 14 fractures with LOR were reduced in the ED ($P<0.01$). Residents had a higher LOR, 18.5%, than advanced practice providers (LOR, 8.9%) or attending physicians (LOR, 0%) ($P = 0.01$).

Conclusion: The average rate of LOR is 9.5% for extra-articular distal tibia physeal fractures after closed reduction, with SLCs and LLCs having similar rates of LOR. LOR is associated with the location in which the reduction is performed and the level of training of the person performing the reduction. Our findings would suggest that SLC immobilization can adequately maintain alignment of extra-articular distal tibial fractures. This creates an opportunity to provide increased patient mobility and early knee range of motion.

Non-Operative Versus Operative Treatment of Z-Type Comminuted Clavicle Fractures in Adolescents: A Prospective Substratified Cohort Analysis

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Purpose: This study was conducted to assess clinical, radiographic, and patient-reported outcomes (PROs) in adolescents with comminuted «Z-type» midshaft clavicle fractures by comparing nonoperative and operative subcohorts.

Methods: A subcohort analysis was performed from a prospective observational cohort study at 8 tertiary-care pediatric centers on 909 patients 10 to 18 years old treated for a diaphyseal clavicle fracture, specifically evaluating patients with comminuted Z-type fracture patterns. 82 patients with Z-type comminuted fractures (37 that were treated nonoperatively and 45 treated operatively) were included, 60 (73%) of whom provided 2-year PROs. We compared operative and nonoperative cohorts with regard to complications and validated PROs.

Results: The only significant difference in demographic or fracture characteristics between the two cohorts was shortening, which was greater in the operative cohort (23 mm vs 29 mm, $P = 0.01$). After controlling for this confounder through both regression and matched subgroup analysis, nonoperative versus operative cohorts showed no difference in rates of nonunion (none), delayed union (0% vs 2%, $P = 1.0$), symptomatic malunion (3% vs 0%, $P = 0.4$), refracture (3% vs 4%, $P = 1.0$), unexpected surgery (5% vs 11%, $P = 0.45$), or clinically significant complications (5% vs 16%, $P = 0.17$). There were no differences in PROs between cohorts, even when controlling for fracture shortening.

Conclusion: In this comparative investigation of complications and 2-year PROs in adolescents with comminuted Z-type clavicle fractures, nonoperative and operative treatment demonstrated similar outcomes.

Two-Year Patient Reported Outcomes (PROs), by Treatment Group

PRO	Non-Operative (n=26)	Operative (n= 34)	p-value*
ASES			
Mean Score (SD)	99.0 (4.8)	97.0 (8.1)	1.00
Patients (%) with Score <90†	1 (4.2%)	2 (5.7%)	
QuickDASH			
Mean (SD)	0.4 (1.8)	2.2 (4.6)	0.50
Patients (%) with Score >10†	0 (0.0%)	2 (5.9%)	
EQ-VAS			
Mean (SD)	94.5 (5.6)	92.6 (7.4)	0.50
Patients (%) with Score <80†	0 (0.0%)	2 (5.9%)	
EQ-5D Score			
Mean (SD)	0.98 (0.1)	0.95 (0.1)	1.00
Patients (%) with Score <0.80†	1 (3.8%)	1 (2.9%)	
General Satisfaction			
Mean (SD)	1.5 (0.8)	1.4 (0.7)	0.39
Patients (%) with Score >2†	4 (15.4%)	2 (5.9%)	
Mars Shoulder Activity			
Mean (SD)	11.8 (5.5)	12.9 (5.8)	0.53
Patients (%) with Score ≤7†	4 (10.9%)	8 (17.8%)	

*Due to a severely skewed distribution of PRO scores seen on interim analyses, thresholds were established for dichotomized score adjustments for both †ceiling effects (ASES, EQ-VAS, EQ-5D, Mars Shoulder) and ‡floor effects (QuickDASH, General Satisfaction). P-values were calculated for the distribution of patients with suboptimal scores, rather than for mean scores.

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Changes in Superior Displacement, Angulation, and Shortening in the Early Phase of Healing for Completely Displaced Midshaft Clavicle Fractures in Adolescents: Results from a Prospective, Multicenter Study

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Purpose: Progressive displacement of diaphyseal clavicle fractures has been observed in adult patients, at times necessitating a change from nonoperative to operative treatment. Whether this occurs in adolescent patients has not been well investigated. The purpose of this study was to assess the rate and extent of progressive clavicle fracture displacement in adolescent patients following injury and during the early stages of healing.

Methods: This was an IRB-approved multicenter study evaluating prospective data that had previously been collected as part of a larger study evaluating the functional outcomes of adolescent clavicle fractures. A consecutive series of completely displaced diaphyseal clavicle fractures in patients age 10-18 years treated at one of three tertiary care pediatric trauma centers were included; all of them had standardized imaging within 2 weeks of the date of injury and throughout the course of healing (5-20 weeks post-injury). Measurements of clavicle shortening, superior displacement, and angulation were performed using validated techniques. Progressive displacement and/or interval improvement in fracture alignment were noted, as well as the subsequent need for surgical intervention. Patient demographic and radiographic parameters were assessed as possible risk factors for interval displacement.

Results: 100 patients met the inclusion criteria. The mean shortening, superior displacement, and angulation at the time of injury were 24 mm, 15 mm, and 7°, respectively. At a mean of 10 weeks post-injury, the fracture alignment improved across all three measurements for the overall cohort, with mean improvements in shortening of 15%, superior displacement of 15%, and angulation of 21%. Using a clinical threshold of a change in shortening or displacement of 10 mm or angulation of 10°, 21% of fractures improved, 4% worsened, and 75% remain unchanged. Patients with more severe fractures were more likely to have improved alignment than less displaced fractures ($P<0.001$). No patient underwent surgical intervention for progressive displacement.

Conclusion: Significant improvements in fracture alignment were observed in a substantial percentage of adolescent patients with completely displaced clavicle fractures in the first 10 weeks of healing. Among the most severely displaced fractures, a 20% improvement in shortening and 50% improvement in angulation was identified. In 4% of cases, increased displacement was observed, but this tended to be mild, and in no cases did it prompt surgical intervention.

Is External Beam Radiation Therapy Really Associated with Low Rates of Heterotopic Ossification After Acetabular Surgery?

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Purpose: Heterotopic ossification (HO) after surgical fixation of acetabular fractures is known to be common and potentially debilitating, but unfortunately it is still unclear what the best HO prophylaxis treatment should be. Currently, there are only small series on the use of use external beam radiation therapy (XRT) for HO prophylaxis (range, 12-78 patients). Our hypothesis is that XRT will demonstrate lower HO than patients without XRT in a larger dataset even after controlling for risk factors associated with development of HO.

Methods: We report on 178 consecutive patients from a single center who underwent surgical fixation of an acetabular fracture via a posterior or combined surgical approach. All patients were offered XRT within 72 hours of surgery. Patients who refused or had contraindications to XRT were offered indomethacin therapy (25 mg TID) for 6 weeks. Patients who received no prophylaxis were those whowere unable to undergo XRT and had contraindications to indomethacin therapy. Fractures were classified according to the Judet and Letournel system. The primary outcome measure was radiographic evidence of HO based on the Brooker classification. Severe HO was defined as Brooker class 3 or 4. Logistic regression analyses were performed and odds ratios (ORs) reported with 95% confidence intervals (CIs).

Results: Of the 178 patients included in this study, 158 patients (89%) underwent XRT therapy, 7 patients (4%) received indomethacin, and 13 patients (7%) received no HO prophylaxis. There was a significant difference in overall HO rates between groups ($P = 0.02$). 48 patients (30%) who received XRT developed HO compared to 5 patients (71%) in the indomethacin group and 7 patients (54%) in the no prophylaxis group. Patients who did not receive XRT were over 3× more likely to develop HO (OR 3.4, 95% CI 1.3-8.9; $P = 0.01$). Postoperative HO was associated with need for mechanical ventilation (OR 2.1, 95% CI 1.1-4.1; $P = 0.02$) and nonelementary (associated) fracture patterns (OR 2.0, 95% CI 1.0-3.7; $P = 0.04$). After controlling for need for mechanical ventilation and associated fracture patterns, patients who did not receive XRT were still 3× more likely to develop HO (OR 3.0, 95% CI 1.1-8.1; $P = 0.03$). The severe HO rate for the XRT group was 4.4% compared to 15.0% for patients who did not receive XRT ($P = 0.05$). There was no significant association between HO formation and hip dislocation or need for trochanteric osteotomy during surgical fixation.

Conclusion: This series represents the largest study to date on HO after a protocol of XRT for acetabular surgery. Patients who receive XRT as HO prophylaxis after acetabular surgery are 3× less likely to develop postoperative HO, even after attempting to control for previously identified HO risk factors. These data may inform clinicians and patients considering HO treatment options. The rate of severe HO (4%) compares favorably with prior studies on severe HO after debridement only (12%-19%).

Delayed Fixation of Acetabular Fractures in Polytrauma Patients With and Without Concomitant Lower Extremity Fractures Significantly Increases the Odds of Complications

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Purpose: We sought to evaluate the effect of time to acetabular fracture fixation (AFF) in polytrauma patients with and without concomitant lower extremity fractures.

Methods: We identified adult polytrauma patients with acetabular fractures from the Trauma Quality Improvement Program database between 2010 and 2016. We propensity-score matched patients who underwent AFF within 2 to 3 days of admission to those who underwent AFF within 24 hours, 4 to 6 days, and 7 to 21 days. We used logistic regression to determine the influence of time to AFF on the odds of complications.

Results: We identified 11,992 polytrauma patients with acetabular fractures. Of these, 2046 (17%) received AFF within 24 hours, 4157 (35%) within 2 to 3 days, 3576 (30%) within 4 to 6 days, and 2213 (18%) within 7 to 21 days. Post-matching, we retained 4736 patients (1184 per group). In patients with isolated acetabular fractures, AFF within 24 hours was associated with a 0.72 (0.55-0.94) decreased odds of complications versus 2 to 3 days. In contrast, patients with isolated acetabular fractures who underwent AFF 4 to 6 days or 7 to 21 days from admission had a 1.17 (1.02-1.47) and 1.98 (1.57-2.49) increased odds of complications, respectively. In patients with concomitant femur, tibia, or ankle fractures, AFF within 24 hours or 4 to 6 days was associated with a similar odds of complications as fixation within 2 to 3 days, while AFF 7 to 21 days from admission was associated with an increased odds of complications (femur odds ratio [OR] 1.46 [1.08-1.96]), tibia OR 1.87 [1.31-2.67], and ankle OR 1.89 [1.16-3.09]) versu. 2 to 3 days.

Conclusion: Prompt fixation of isolated acetabular fractures in polytrauma patients appears to be associated with a lower odds of complications. In patients with concomitant lower extremity fractures, there appears to be a similar odds of complications for patients who receive AFF within 24 hours, 2 to 3 days, or 4 to 6 days from admission. In contrast, patients with concomitant lower extremity fractures who undergo AFF 7 to 21 days from admission appear to have an increased odds of complications compared to 2 to 3 days. This suggests that delayed AFF in polytrauma patients with lower extremity fractures beyond 1 week should be avoided to reduce the risk of deleterious outcomes.

PAPER ABSTRACTS

Administration of Venous Thromboembolism Chemoprophylaxis Within 12 Hours of Pelvic and Acetabular Surgery Has No Effect on Estimated Blood Loss, Perioperative Change in Hemoglobin, or Need for Transfusion

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Purpose: Pelvic and acetabular trauma predisposes patients to venous thromboembolism (VTE). However, pelvic and acetabular surgery carries a 40% to 50% rate of transfusion, and blood loss may be increased by anticoagulation. The local VTE chemoprophylaxis (PPx) protocol was changed in July 2016. Low molecular weight heparin (LMWH) 30 mg Q12H was standard pre- and post-change. Prior to July 2016, PPx would be held 12 to 24 hours preoperatively for orthopaedic surgery. After July 2016, PPx would not be held. We hypothesized that this would have no effect on estimated blood loss (EBL), perioperative change in hemoglobin (Δ Hgb), or transfusion rates following pelvic and acetabular trauma surgery.

Methods: In this retrospective cohort study at a Level I trauma center in the southeastern U.S., all pelvic and acetabular surgeries between April 2014 and February 2020 were reviewed. Outcomes were EBL, immediate and 24-hour postoperative Δ Hgb, and intra- or postoperative transfusion. Per-protocol and as-treated analyses were performed.

Results: In all, 267 surgeries were included: 97 pre- and 170 post-change. Median ISS was 17 before versus 14 after the change. One surgeon retired and two started during the study, producing differences in acetabular approaches. Median surgical duration was longer post-change. Cohorts were otherwise similar (Table 1). No differences were observed in EBL, Δ Hgb, or transfusion rates. Rates of VTE and surgical site complications were unchanged. No VTE-related deaths occurred. In the as-treated analysis (63 patients given LMWH <12 hours preop vs 190 patients not given PPx), no differences were observed.

Conclusion: Administration of VTE PPx within 12 hours of pelvic and acetabular surgery had no effect on perioperative blood loss. This study is limited by changes in faculty, but it suggests that traumatologists need not advocate for holding VTE PPx before pelvic and acetabular trauma surgery.

	Before Protocol Change (LMWH held/delayed) (n=97)	After Protocol Change (LMWH administered) (n=170)	p-value*
Age at injury (years)	39 (24)	39 (25)	0.800
Sex, n (%)			
Female	24 (25)	46 (27)	0.679
Male	73 (75)	124 (73)	
Body mass index	30 (9)	28 (7)	0.244
Mechanism of injury, n (%)			
Fall from height	6 (6)	16 (9)	
Fall from standing	6 (6)	6 (4)	
MVC	55 (57)	98 (58)	0.771
MCC	12 (12)	25 (15)	
Pedestrian vs auto	10 (10)	12 (7)	
Other	8 (8)	13 (8)	
Injury Severity Score (ISS)	17 (9)	14 (13)	**<0.001**
AO-OTA Classification, pelvic fractures, n (%)†	30	56	
61A1 - avulsion of ASIS/AIIS/ischial tub.	0 (0)	1 (2)	
61B2 - APC2 or LC2	15 (50)	29 (52)	0.783
61B3 (or 61C2) - LC3	4 (13)	4 (7)	
61C1 (or 61C3) - APC3 or VS	11 (37)	22 (39)	
AO-OTA Classification, acetabular fractures, n (%)†	70	122	
62A1 - posterior wall	25 (36)	36 (30)	
62A2 - posterior column ± posterior wall	4 (6)	11 (9)	
62A3 - anterior wall/column	4 (6)	2 (2)	0.193
62B1 - transverse ± posterior wall	20 (29)	52 (43)	
62B2 - T-type	1 (1)	4 (3)	
62B3 - anterior w/c + post. hemitransverse	3 (4)	3 (2)	
62C - associated both column	13 (19)	14 (11)	
Surgeon			
Surgeon 1	48 (49)	11 (6)	
Surgeon 2	48 (49)	62 (36)	**<0.001**
Surgeon 3	1 (1)	85 (50)	
Surgeon 4	0 (0)	12 (7)	
Surgical approach/fixation of pelvis, n (%)‡	30	56	
ORIF pubic symphysis	10 (33)	14 (25)	
Percutaneous screws	6 (20)	10 (18)	
ORIF pubic symphysis + percutaneous screws	7 (23)	13 (23)	0.949
Ex-fix + percutaneous screws	2 (7)	4 (7)	
ORIF posterior ilium	2 (7)	6 (11)	
Other	3 (10)	9 (16)	
Surgical approach(es) to acetabulum, n (%)‡	70	122	
Kocher-Langenbeck	20 (29)	92 (75)	
Ilioinguinal	16 (23)	16 (13)	**<0.001**
Modified Ollier trans-trochanteric	26 (37)	4 (3)	
Percutaneous fixation	6 (9)	4 (3)	
Other	2 (3)	6 (5)	
Duration of surgery (minutes)	133 (88)	183 (135)	**<0.001**
Estimated blood loss (mL)	250 (400)	250 (400)	0.588
Pre-op hemoglobin (g/dL)	10.2 (3.0)	9.9 (3.6)	0.167
Δ Hemoglobin immediately post-op (g/dL)	-0.5 (1.7)	0 (2.2)	0.111
Δ Hemoglobin 24 hours post-op (g/dL)	-1.1 (1.9)	-0.8 (2.2)	0.467
Blood transfusion given intra- or post-op, n (%)	31 (32)	63 (37)	0.401
Volume transfused (mL)	658 (550)	600 (650)	0.904
Any pelvic/acetabular surgical site complication, n (%)	4 (4)	12 (7)	0.427
Venous thromboembolism, n (%)			
None	90 (93)	160 (94)	0.855
DVT	4 (4)	5 (3)	
DVT + PE	3 (3)	5 (3)	
Death within 90 days postoperatively, n (%)	0 (0)	3 (2)	0.556

*Chi-squared test for categorical variables with all cell counts ≥10, Fisher's exact for categorical variables with any cell count <10, Wilcoxon rank sum (Mann-Whitney U) test for continuous variables
†Total greater than 267 due to combined acetabular/pelvic injuries
‡Total greater than 267 due to combined approaches

Table 1. Comparison of pelvic and acetabular trauma surgery before and after implementation of an institutional protocol to administer rather than hold venous thromboembolism prophylaxis within 12h preoperatively, values shown are median (IQR) unless otherwise specified

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Results of Emergency Department Stress of Lateral Compression Type 1 Fracture Correlates with Validated Instability Scoring System

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Purpose: Lateral compression type 1 (LC1) pelvic ring injuries represent a heterogenous group of fractures with controversy surrounding operative indications. Recently, multiple institutions have suggested the safety and reliability of an emergency department (ED) stress to evaluate minimally displaced LC1 fractures. However, it remains unknowns how the results of an ED stress examination correlates with prior measures of instability. The purpose of this study was to correlate the displacement of ED stress examination of LC1 fractures against a validated fracture instability scoring system.

Methods: This was a retrospective review of a prospectively collected cohort at a Level I academic trauma center. A consecutive series of 70 patients, presenting with minimally displaced LC1 fractures, were stressed in the ED radiology suite over a 2-year study period. Displacement was measured by comparing calibrated inlet films to static films. Radiographic scores were assigned according to the validated Beckmann scoring system based on fracture pattern and confirmed markers of instability in LC pelvic ring injuries. Three cohorts were created: score <7 (stable, predictive of nonoperative recommendation), score 7 to 9 (indeterminant recommendation), and score >9 (unstable, predictive of operative recommendation). These groups were compared to ED stress positivity defined as greater than 10-mm displacement on calibrated radiographs. Analysis of variance comparisons were performed to determine statistical significance between groups. Multivariate linear regression was performed between gender and Beckmann score categories to determine predictors of ED stress-positive pelvises.

Results: The mean age of the population was 59.2 years with 55.7% females. 13 patients had a positive ED stress examination and 57 stressed negative. The mean displacement was significantly different between the three groups (Beckmann 5-6: 3.31 mm, $\sigma = 2.4$; Beckmann 7-9: 4.23 mm, $\sigma = 3.2$; Beckmann 10+: 12.1 mm, $\sigma = 8.6$; $P<0.001$). Furthermore, the scoring system was predictive of stress positivity. Zero of 18 patients in the Beckmann 5-6 group stressed positive and only 3 of 38 patients in the indeterminant group stressed positive (7.9%). However, 10 of 14 patients in the Beckmann 10+ group stressed positive ($P<0.001$). Sacral displacement ($P = 0.001$), superior ramus location ($P <0.02$), and sacral columns ($P<0.001$) significantly predicted ED stress positivity.

Conclusion: ED stress of LC1 pelvic ring injuries is an emerging diagnostic adjunct in determining pelvic ring stability. Comparison of a validated instability scoring system to ED stress examination of minimally displaced LC1 fractures showed moderate to excellent correlation, suggesting that the ED stress examination is a useful treatment adjunct. LC1 fracture characteristics should be analyzed to determine which pelvic fracture characteristics determine occult instability prior to stress examination.

Contralateral Lateral Stress Radiographs to Evaluate Stability of Minimally Displaced Lateral Compression Type 1 Pelvic Ring Injuries Are Equivalent to Ipsilateral Lateral Stress Radiographs

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Purpose: The lateral stress radiograph (LSR) to evaluate the stability of minimally displaced lateral compression type 1 (LC1) pelvic ring injuries consists of an anteroposterior pelvis radiograph taken in the lateral decubitus position in awake non-sedated patients with the injured side down. The LSR has been shown to correlate perfectly with an examination under anesthesia (EUA); however, lying on the injured side does result in patient discomfort. The purpose of this study was to determine if performing the LSR with the uninjured contralateral side down is as effective for detecting occult pelvic instability.

Methods: Patients with minimally displaced LC1 injuries with both an ipsilateral and contralateral LSR were identified. Radiographic magnification was corrected for by measuring the diameter of the femoral head on the coronal CT scout image and each subsequent radiograph. The amount of displacement of the pelvic ring was assessed on all images by measuring the distance between the radiographic teardrop landmark. Pelvic rings that displaced 10 mm or more were considered unstable. Matched pairs analysis was used to compare displacement between radiographs. The sensitivity and specificity of the contralateral LSR to detect instability was calculated.

Results: 21 patients were identified for analysis. Median age was 60 years (range, 20-94 years) and 14 (67%) were female. Injury mechanism included 5 (24%) low-energy ground level falls and the remainder included high-energy mechanisms. Eight patients had complete sacral fractures (40%). Pelvic ring displacement of 10 mm of more was seen in 13 patients (62%). There was no difference in displacement between ipsilateral and contralateral LSRs (mean difference –0.6 mm, 95% confidence interval –2.9 to 1.6 mm, $P = 0.5$). The sensitivity and specificity of the contralateral LSR to detect 10 mm or more of displacement was 100% and 100%.

Conclusion: Performing the LSR with the uninjured contralateral side down resulted in the same amount of displacement as with the injured ipsilateral side down and successfully identified all cases of occult instability in minimally displaced LC1 injuries. The contralateral LSR should be considered over the ipsilateral LSR to decrease patient discomfort.

Percutaneous Posterior Pelvic Stabilization for Spinopelvic Dissociation: A 20-Year Series of Displaced and Nondisplaced Fracture Patterns

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Purpose: Spinopelvic dissociation is a rare injury pattern. The choice of percutaneous, open, or a combined approach is dictated by displacement, neurologic status, associated injuries, individual surgeon preference, and institutional protocols. We sought to assess the success and complication rate of treating spinopelvic dissociation with percutaneous iliosacral (IS) and/or transiliac-transsacral (TS) screw fixation.

Methods: We identified and reviewed all sacral fractures treated operatively over a 20-year period. From an initial cohort of 156 patients with spinopelvic dissociation, we identified 63 patients treated using percutaneous IS and/or TS screw fixation with a minimum 3-month follow-up. Fracture displacement, kyphosis, and neurologic status were collected. Clinical outcomes were collected through chart review, including evidence of union, hardware failure, wound complications, and reoperation.

Results: 27 patients (43%) had displaced sacral fractures (Roy-Camille 2 or 3) with an average preoperative kyphosis of 31.5°. The remaining fractures (n = 36) were nondisplaced. A variety of fixation constructs were used, ranging from one IS screw placed bilaterally at one sacral segment to three TS screws placed with fixation at multiple levels. 42 patients were neurologically intact (66%), 7 patients had a documented neurologic deficit prior to surgery, and the remaining cases had an unknown neurologic examination prior to surgery. The mean follow-up was 376 days. Radiographic and clinical follow-up demonstrated no cases of fixation failure or nonunion. Four patients (6%) had radiographic evidence of screw loosening, all of whom had fixation with a single IS screw placed bilaterally. All progressed to eventual radiographic and clinical union. Two patients (3%) underwent hardware removal and two patients (3%) had screw breakage at the level of the sacroiliac joint following union. In patients with a documented preoperative neurologic deficit, two patients (29%) had persistent deficits at final follow-up. Neurologic recovery occurred at an average of 202 days (range, 82-363 days). Radicular pain and paresthesias were the most common long-term neurologic complication present among all patients at final follow-up (n = 5, 8%).

Conclusion: Percutaneous treatment of spinopelvic dissociation appears to be safe with a low complication rate and reliable union. In a cohort of displaced fractures with kyphosis that were fixed in situ, we found no cases of late displacement or fixation failure. Fixation with one IS screw placed bilaterally was associated with screw loosening prior to union. Radicular pain and paresthesias were the most common long-term neurologic sequelae.

A Comparison of Open Versus Percutaneous Approaches to Spinopelvic Dissociation: Presentation, Complications, and Outcome

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Purpose: Spinopelvic dissociation is a rare and potentially devastating injury. Displacement, neurologic compromise, surgeon preference, and institutional protocols all factor into the treatment decision on the appropriate approach. Most commonly, either an open approach with lumbopelvic fixation, or percutaneous approach with iliosacral and / or transiliac-transsacral screws, is utilized. There is limited literature to guide a surgeon's decision on approach, and significant variability exists in the treatment of these injuries. We sought to compare the complication rates of open and percutaneous treatments for spinopelvic dissociation.

Methods: We reviewed all cases of sacral fractures treated operatively over a 20-year period at our busy Level I trauma center. Patients with a U-, H-, Y-, or lambda-type sacral fracture treated operatively were identified. All imaging was reviewed for associated fractures about the pelvic ring, pre- and postoperative kyphosis, fixation construct, and evidence of postoperative hardware complication. ISS, Charleston Comorbidity Index (CCI), and other demographic data were collected. Clinical outcomes, including wound complication, infection, and reoperation were identified through chart review. Minimum follow-up was 3 months.

Results: We identified a total of 96 patients that underwent fixation for a traumatic spinopelvic dissociation over a 20-year period. 63 patients (66%) were repaired using a percutaneous-only approach (*P*) and 33 patients (34%) were repaired with open lumbopelvic fixation (LP) or a combined approach. There was no difference in age ($P = 0.6$) or the incidence of associated pelvic ring fractures ($P = 0.13$) between the two groups. The patients treated percutaneously were an overall more injured cohort when compared to the lumbopelvic patients (mean ISS of 28 vs 19, $P = 0.003$) Patients treated with open lumbopelvic fixation had more kyphosis (25° vs 14°, $P = 0.009$) and a higher incidence of preoperative neurologic injury (51% vs 11%, $P<0.0001$) when compared to patients in the percutaneous cohort. We found a statistically significant increase in wound complications in the LP cohort compared to the percutaneous cohort (20% vs 0%, $P<0.0001$). There were no cases of hardware failure in either cohort with no cases of nonunion. There was no difference in the rate of hardware removal (9% LP vs 3% *P*, $P = 0.22$).

Conclusion: Open and percutaneous treatments for spinopelvic dissociation yield a high rate of union without hardware complication. Patients with increased kyphosis and neurologic compromise were more likely to undergoing open repair of their injuries. In patients undergoing an open approach, a higher rate of wound complication and infection was seen when compared to a similar cohort undergoing percutaneous fixation.

Agricultural Trauma Causing Open Fractures:
Is Antibiotic Coverage Against Anaerobic Organisms Indicated?

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Purpose: Open fractures resulting from agricultural trauma are historically associated with high rates of infection. Prophylactic antibiotic coverage for anaerobic organisms is generally recommended because of the environment in which injuries occur. However, little is known about deep infection rate and causative organisms. The aim of this study was to compare deep infection rate and causative organisms in open fractures of the lower extremity from agricultural trauma to similar injuries in non-agricultural trauma.

Methods: Open lower extremity fractures sustained between 2003 and 2018 by agriculture-related trauma in adult patients from two tertiary-care institutions were retrospectively reviewed. A non-agriculture open fracture control group was identified for comparison. Patient demographics and injury characteristics were assessed. Outcomes included occurrence of deep infection and causative organism.

Results: 178 patients were identified in the agriculture (AG) (n = 89) and control (NAG) (n = 89) groups. Among agricultural injury patients, farm machinery was the most common mechanism in 69 patients (77.5%). Average age was 44.4 years in the AG and 39.7 years in the NAG group ($P = 0.07$). Open injuries of the foot (38.2%) were most common in the AG group and tibial shaft (25.8%) in the NAG group. Deep infection was seen in 21% of the AG group compared to 10% in the NAG group ($P<0.05$). AG group anaerobic infection occurred in 44% of patients with deep infection versus 9.1% in NAG group ($P<0.05$). The most common anaerobic organisms included Enterococcus, Pseudomonas aeruginosa, and Clostridium perfringens.

Conclusion: This study supports that open fractures due to agricultural trauma have a high infection rate, with anaerobic infection occurring at higher rates than in non-agricultural trauma. Prophylactic treatment with antibiotics directed against anaerobes is indicated in these injuries.

Table 1. Bacterial profile of deep infections in agriculture and non-agriculture related injury groups.

Infection Organism	AG* # of Infections	NAG** # of Infections	p-value
Anaerobic			
Enterococcus‡,	**11**	**1**	
Pseudomonas‡	5	1	**0.0002**
Clostridium	3	0	
perfringes‡	3	0	
Aerobic	**7**	**8**	
MSSA£	2	5	
MRSA¥	2	1	
Streptococcus	2	0	
No growth/Unknown	2	4	
Klebsiella	1	0	**0.0002**
Serratia	1	1	
Citrobacter	1	0	
Proteus	1	0	
Bacillus cereus	1	0	
Enterobacter	1	0	

*AG=agriculture related injury group; **NAG=non-agriculture related injury group; £MSSA=methicillin-sensitive staphylococcal aureus; ¥MRSA=methicillin-resistant staphylococcal aureus; ‡=anaerobic bacteria

Does Cumulative Topical Antibiotic Powder Use Increase the Risk of Nephrotoxicity?

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Purpose: Topical antibiotic powders are increasingly used in an effort to reduce surgical site infections. Although prior research suggests a minimal risk of nephrotoxicity with a single 1.0-g dose of vancomycin powder, patients often have multiple procedures providing additional doses of vancomycin powder and other topical antibiotics, such as tobramycin. The study's primary aim was to determine if cumulative doses of vancomycin or tobramycin powder prophylaxis increase the risk of nephrotoxicity among fracture patients.

Methods: The study was a secondary analysis of single-center data from the PREP-IT trial. We included patients with one or more surgically treated appendicular fractures who received intrawound vancomycin or tobramycin powder. The primary outcome was nephrotoxicity, previously defined as a rise in serum creatinine up to 7 days post-surgery that is at least twice the lowest preoperative value. We used Bayesian logistic regression models to calculate the odds of nephrotoxicity per gram of powder after adjusting for age, sex, and ISS and accounted for the interactive effects of vancomycin and tobramycin.

Results: The study included 782 patients with a median age of 47 years, a median ISS of 9, and 59% were male. 83% of patients received at least one vancomycin dose, with the cumulative vancomycin dose per patient ranging from 0 to 12 g (median, 1 g). 45% of the sample received at least one tobramycin dose, and the cumulative tobramycin dose varied from 0 to 9.4 g. The mean number of surgeries for each patient was 1.4 (23% had more than one surgery). Nephrotoxicity occurred in 10 patients (1.3%). There was no association between the cumulative dose of vancomycin and nephrotoxicity (odds ratio [OR]: 1.16, 95% credible interval [CrI]: 0.60-2.12). However, additional doses of tobramycin were associated with a 2.92 increase in the adjusted odds of nephrotoxicity (95% CrI: 1.47-6.34). Specifically, patients who did not receive tobramycin powder had a nephrotoxicity risk of 0.1% (95% CrI: 0.0%-0.5%). Patients with a cumulative tobramycin dose of 3.6 g had a 3.6% risk of nephrotoxicity (95% CrI: 0.8% to 12.7%), and a 4.8-g cumulative dose was associated with an 11.1% (95% CrI: 1.6%-46.1%) nephrotoxicity risk.

Conclusion: The findings are reassuring, especially regarding vancomycin, and suggest cumulative doses do not increase the risk of nephrotoxicity among fracture patients. The nephrotoxicity risk also remains low after three cumulative 1.2-g doses of tobramycin. However, our data suggest that 4.8 g or more cumulative doses of tobramycin powder was associated with some increased risk of nephrotoxicity. Unlike the typical doses of vancomycin powder, the typical dose of tobramycin powder (1.2 g) is much higher than a standard IV dose; therefore, it seems plausible that transient rises in creatinine are more likely to be associated with higher tobramycin than vancomycin powder doses even if this level of creatinine increase is of unknown clinical importance.

What Is Most Important to Patients When Pursuing Limb Salvage Following a Limb-Threatening Injury?

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Purpose: The choice between limb salvage and amputation is complex, and the determinants of patient preferences are poorly understood. In attempts to better understand the relative value of patient preferences in limb salvage, we performed a discrete choice experiment (DCE). We hypothesized that physical function would be the most important factor, and that its relative importance would be impacted by overall health state and time since injury.

Methods: This was a cross-sectional analysis of patients with a history of limb salvage after lower extremity traumatic injuries at a single institution over a 10-year period. The DCE was developed using data from focus groups, literature review, expert opinion, and past experience with DCEs in the trauma population. The attributes of the DCE were: (1) recovery time: time until walking without assistive device; (2) function: percent of preinjury distance that can be walked without assistance post-recovery; (3) appearance: noticeability of the leg injury; (4) cost: total out-of-pocket expenses; and (5) time in hospital: cumulative admission in weeks. In a pilot study, we randomly selected 5 patients from each of 2 time points (1 year ± 3 months, >5 years) to complete the survey. The pilot study confirmed the validity of our attributes and levels. We then widely administered the survey. In addition to the DCE, each participant completed the Patient-Reported Outcomes Measurement Information System (PROMIS) Global-10 measure for overall health.

Results: 50 patients completed the final survey (mean age: 50 years [standard deviation: 14], 72% male) sampled from 1 to 10 years after their index injury (median: 5 years). The median PROMIS physical (41, interquartile range [IQR]: 33-45) and mental health (10, IQR: 35-46) scores were approximately 1 standard deviation below population norms. Regaining preinjury function and minimizing costs were of greatest importance, each respectively capturing 49% and 38% of the patient's overall recovery concern. In comparison, recovery time (9%), time in hospital (2%), and the physical appearance of the limb (1%) were of considerably less concern. Despite their aversion to increased costs, patients were willing to pay $12,082 (95% confidence interval: $12,021 to $12,413) for each 10% gain in function. Each 10-point increase in current physical health decreased the value patients were willing to pay for improved outcomes by 27%. For each decade of age, the value of each incremental gain in function was diminished by 5% ± 4%. There was no effect of time since injury.

Conclusion: Patients who underwent limb salvage surgery valued physical recovery, followed by cost. The strength of these preferences correlated with age and physical health, and were not impacted by time from injury. This is the first study to investigate the relative value of patient preferences following limb salvage surgery, highlighting the importance of treatment options that balance and optimize function, out-of-pocket cost, and recovery time.

Effects of the Trauma Collaborative Care Intervention: 12-Month Results from a Prospective Multicenter Cluster Clinical Trial

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Purpose: Our objective was to evaluate the impact of the Trauma Collaborative Care (TCC) program on 1-year outcomes. TCC was developed to improve early psychosocial sequelae of orthopaedic trauma and includes the Trauma Survivors Network (TSN) and additional collaborative care services. Prior results showed that there was a small benefit to TCC program recipients, at 6 weeks post injury, compared to controls and our hypothesis is that there would be a benefit at 12 months from injury.

Methods: The study design was a prospective, multicenter, cluster clinical trial at 6 Level I trauma centers. The study included patients with high-energy orthopaedic injuries requiring surgery and hospital admission: 378 patients at 6 trauma centers implementing the TCC program, and 344 patients at 6 trauma centers receiving usual care. The TCC early intervention included patient education, peer visits, and coaching calls. The main validated outcome measures were the Short Musculoskeletal Function Assessment (SMFA), Patient Health Questionnaire 9 (PHQ-9), and Posttraumatic Stress Disorder (PTSD) Checklist (PCL). The primary outcome was a composite outcome defined to be positive if SMFA Dysfunction Index >18.2 or SMFA Bother Index >23.7 or Depression (PHQ-9) >9 or PCL >35. A 2-stage Bayesian hierarchical statistical procedure was used to characterize treatment effects under an intention-to-treat and full intervention model. 28% of patients received incorrect recommendations for action on one of seven items in their 6-week risk assessment. Sensitivity analyses did not suggest this error altered our conclusions.

Results: The posterior estimates of the intention-to-treat effect (odds ratio scale) for all five end points suggest the intervention did not affect outcomes. The effect of treatment on the composite end point was 1.05 (95% confidence interval [CI]: 0.60-1.63); SMFA dysfunction >18.2 0.99 (0.55-1.53); SMFA bother >23.7 0.95 (0.57-1.45); PHQ-9 >9 1.27 (0.72-1.96), and PCL >35 1.16 (0.66-1.81). The posterior probabilities that the TCC program had a beneficial treatment effect were as follows: composite outcome (43%), SMFA bother index (59%), SMFA dysfunction index (25%), depression (14%), and PTSD (30%). The estimated effect of receiving the intervention was similar under both the intention-to-treat and full receipt models of analysis. Substantial variation existed across the 6 intervention sites in utilizing intervention component with only 29% of intervention patients receiving all 5 components.

Conclusion: Despite showing early positive effects and in contrast to our hypothesis, results of this analysis suggest the TCC as delivered had no effect on 1-year outcomes among these patients.

Orthopaedic Surgery I-PASS Intervention Leads to Sustained Improvement in Quality of Patient Handoffs

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Purpose: Interventions to improve patient handoff communication have been shown to reduce medical errors. The I-PASS tool (Illness severity, Patient summary, Action list, Situational awareness, Synthesis by receiver) is a structured handoff tool that reduces errors and preventable adverse events. Adoption of I-PASS on surgical services has been inconsistent. We evaluated the quality of handoffs and sustainability of a multicenter I-PASS protocol intervention for orthopaedic surgery.

Methods: This was a prospective, interventional study of a multicenter handoff improvement program conducted at two Level I trauma centers. A preintervention handoff needs assessment survey was administered to orthopaedic providers, followed by electronic handoff and communication training to introduce a standardized handoff template that adapted the I-PASS tool specifically for orthopaedic surgery patients. Handoff quality was evaluated preintervention and at 1, 6, and 9 months postintervention; handoffs were analyzed for the key data elements defined by I-PASS. A postintervention survey was administered to providers at 6 months postintervention.

Results: 605 electronic patient handoffs were analyzed. 56 orthopaedic providers (nurse practioners, physician assistants, residents) completed the handoff needs assessment survey. 56% of respondents reported they were "sometimes" or "often" uncertain about making a clinical decision as they lacked patient information from a handoff; 91% of respondents stated they would support a standardized electronic handoff template. Adherence to the standardized handoff format increased substantially over the study period (72% at 1 month, 89% at 6 months, and 93% at 9 months). From preintervention to the 9-month time point, significant improvement was noted in 8 of 9 targeted quality elements (two identifiers, illness severity, past medical history, action list, situational awareness, contingencies, anticoagulation plan, and antibiotic plan, $P = 0.006$ for two identifiers, $P<0.001$ for all others). 54 providers (73% response rate) completed the postintervention survey. 70% felt that the intervention improved communication and patient safety; 60% felt it reduced patient errors and near-misses. 87% stated they would support implementation as a requirement for new trainees moving forward.

Conclusion: This prospective study analyzed the impact of a handoff improvement program on the quality of handoff communication for orthopaedic inpatients. The implementation of the handoff protocol produced a high, sustained compliance rate from a group of over 50 orthopaedic providers. Objective quality of handoffs improved significantly as defined by the I-PASS gold standard. Nearly 90% of providers supported its ongoing use, with a 70% stating that communication and patient safety improved. This intervention is the first example of I-PASS for orthopaedic surgery and has the potential to prevent adverse events and reduce medical errors by standardizing care.

How Many Sites Should an Orthopaedic Trauma Prospective Multicenter Trial Have? A Marginal Analysis of Completed Trials

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Purpose: Multicenter clinical trials in orthopaedic trauma are crucial to advance the science behind clinical care but are also complex and costly. The orthopaedic trauma research community is called upon to propose gold-standard studies that address the most critical questions while government funding for trials has leveled if not declined. Currently there are no evidence-based approaches for the financial management of multicenter trials in an orthopaedic trauma population. One key cost driver in multicenter trials is the number of participating sites. This project proposes a model for determining the optimal number of sites in a prospective multicenter trial. Our hypothesis is that the optimal number of sites can be determined based on study characteristics, known costs, and predictable site enrollment contributions.

Methods: This study is a retrospective marginal analysis of studies conducted as part of a large orthopaedic research consortium. The analysis utilized the first 12 consortium-sponsored trials that completed enrollment. The studies represented a wide range of consortium research priorities such as infection prevention and reconstructive surgery. The studies varied by injury volume, with the highest enrolling 1054 patients and the lowest enrolling just over 30. The studies also varied by design complexity. The least complex was an observational study with light data collection. The most complex was a placebo-controlled, double-blinded randomized controlled trial. Using enrollment and financial data, the primary analysis was to determine the optimal number of sites for each study by modeling their total cost curves where the curves reflect the marginal cost of each site added to the study. To determine the sensitivity of the model to variation in infrastructure costs, secondary analyses were performed using 2 additional, plausible infrastructure cost models.

Results: For every study, the optimal number of sites was lower than the actual number of sites that participated. Excess sites ranged from 2 to 39 sites. The excess costs associated with these "extra" sites ranged from $17,000 to $330,000 across the 12 studies, with a median excess cost of $96,000. These costs represented, on average, 7% (95% confidence interval: 6%, 9%] of the study budget. The results of the sensitivity analysis demonstrated that as infrastructure costs increase, so does the optimal number of sites as it becomes more advantageous to complete the study as quickly as possible.

Conclusion: Consistent with our hypothesis, we were able to develop a model that determines a clear optimal number of sites based on study characteristics and when costs and site enrollment contributions are predictable. The results indicate that previous trials were not optimized in terms of the number of sites. Hopefully this model can be used by future clinical researchers to answer critical clinical questions in a more cost-effective manner.

Transfusion After Harvesting Bone Graft with RIA: Practice Changes Reduced Transfusion Rate by More Than Half

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Purpose: The reamer-irrigator-aspirator (RIA) device is frequently used as a tool for bone graft harvesting. The initial enthusiasm for using this instrument for bone graft harvest was dampened by significant blood loss and transfusion rates published at 44% at our center, while catastrophic and even fatal blood loss has been reported elsewhere in the literature. However, the RIA device remains an excellent tool to obtain large volumes of biologically active autograft. The aim of this study was to investigate how practice changes in the technical use of the RIA have impacted blood loss.

Methods: We conducted a retrospective chart review of all patients who underwent RIA bone graft harvest over a 12-year study period. The patients were split into two cohorts based upon changes in the technique used to obtain autograft harvest with the RIA device. The traditional cohort (2008-2012) were drawn from the previously published series of the first 5 years harvesting graft with RIA. Given the blood loss concerns, three major changes in RIA harvest technique (reduced power of suction, altered reamer sizing method, and canal suction technique) were developed following that study. The modified cohort (2013-2020) was collected from RIA harvest in the subsequent 7 years. Demographic information, surgical details, preoperative hematocrit (HCT), postoperative HCT, transfusion rates, intraoperative blood loss, reported volume of graft harvested, and iatrogenic fracture were recorded.

Results: In total 201 patients were included in the study with 61 patients in the traditional and 140 patients in the modified cohort. The average age was 51 years (range, 18-97) with 107 males (53%). There was no difference in the demographic data between the two cohorts. The most common indications for graft harvest were femoral nonunion (49%), tibial nonunion (32%), and other nonunions/fusion procedures (19%). No difference was noted between the traditional and modified cohorts in terms of the amount of average graft harvested (54 cc vs 51 cc; $P = 0.34$) or iatrogenic fractures (1 vs 2; $P = 0.91$). However, when comparing the traditional versus modified cohorts, the modified technique demonstrated a lower average blood loss (675 cc vs 500 cc; $P<0.01$), HCT drop (13.7 vs 9.5; $P<0.01$), and lower transfusion rate (44% vs 19%; $P = 0.001$).

Conclusion: This series demonstrated a significant improvement in blood loss and transfusion with modified techniques used to obtain autologous bone graft with the RIA device. Importantly, these techniques do not appear to limit bone graft harvest yield and can therefore be efficiently implemented without limiting the utility of the RIA.

Primary Closure of External Fixator Pin Sites Does Not Increase the Incidence of Surgical Site Infection

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Purpose: Provisional external fixation is a commonly employed treatment strategy in the management of traumatic orthopaedic injuries. There are little data to guide the management of pin site wounds following removal. The purpose of this study was to compare the rates of infection of pin site wounds managed with curettage, debridement, and primary closure versus those allowed to heal secondarily. We hypothesized that there would be no difference in rates of infection between the two groups.

Methods: Patients who had received a lower extremity external fixator for trauma between 2010 and 2016 were reviewed. Demographics, injury characteristics, and medical history were collected. Patients were placed into cohorts based on whether their pin site wounds were closed primarily or allowed to heal by secondary intention. Primarily closed pin sites were treated with curettage, irrigation, and debridement prior to closure. The primary outcome was the incidence of deep or superficial infection involving the pin site wounds following removal of the external fixator. Development of a surgical site infection (SSI) was a secondary outcome measure. A pin site infection was defined as erythema and drainage from the pin site necessitating antibiotics after the external fixator was removed. An SSI was an infection at the site of the fracture after definitive fixation.

Results: A total of 216 patients were evaluated, representing 92 in the primary closure group and 124 in the secondary closure groups. The groups were similar regarding age, sex, body mass index, and medical comorbidities. There was no difference between the groups regarding the incidence and grade of open fracture ($P = 0.55$). There was no difference in duration of external fixation between the primary group (11.7 ± 8.5 days) and secondary group (13.5 ± 8.0 days, $P<0.01$). The infection rate of the pin site wounds following external fixator removal was significantly higher in the secondary closure group (10, 8.1%) than the primary closure group (0, 0.0%; $P<0.01$). There was a trend toward increased SSI in the secondary closure group; however, this was not significant ($P = 0.16$).

Conclusion: Traditionally, pin sites have been left open to close secondarily. However, we identified a significant reduction in pin site infections after primary closure. There was also a trend toward decreased SSI after primary external fixator pin site closure, although this was not significant. Our study suggests that there may be a benefit to debriding and closing pin sites primarily.

Intimate Partner Violence During Recovery from an Orthopaedic Injury: An Observational Cohort Study

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Purpose: Orthopaedic injuries may lead to an increased incidence of intimate partner violence (IPV) during the recovery period as people dependent on others' help and care are at higher risk of abuse. In addition, there is a lack of understanding of how IPV affects injury recovery. In women being treated for an orthopaedic injury, we aimed to determine: (1) the number of new IPV disclosures in the 12 months following an orthopaedic injury and (2) the impact of IPV on recovery.

Methods: We enrolled 250 female participants from 6 orthopaedic fracture clinics in 4 countries. IPV disclosure, using 3 direct questions from the Woman Abuse Screening Tool, and outcomes were assessed at the participants' initial visit, and at 1, 3, 6, and 12 months following enrollment. Outcomes included: return to function (measured by the Return to Function questionnaire), injury-related complications, serious adverse events, and quality of life (measured using the EuroQol-5 Dimensions [EQ-5D]).

Results: 81 of 250 participants (33%, 95% confidence interval [CI]: 27.4% to 39.4%) had experienced IPV in their lifetime and disclosed this at their initial orthopaedic clinic appointment. 21 participants (12.4%) who did not disclose abuse at the initial visit later disclosed IPV during the 12-month follow-up. History of IPV led to a 32% lower likelihood of returning to preinjury level of function for responsibilities around the home (hazard ratio 0.68, 95% CI 0.46 to 0.99; $P = 0.046$). While the results did not reach statistical significance, estimates suggested that IPV victims also suffered more injury-related complications (16.7% vs 14.2%, $P = 0.64$) and more serious adverse events (7.8% vs 4.9%, $P = 0.12$). Participants with a history of IPV had lower health-related quality of life at their initial post-fracture visit and at all follow-up time points than participants who did not have a history of IPV. The greatest mean differences were at 6 months for both the EQ-5D Visual Analog Scale (6.1 points lower, 95% CI: –11.0 to –1.2; $P = 0.02$) and EQ-5D function index (0.07 points lower, 95% CI: –0.12 to –0.02; $P = 0.01$).

Conclusion: A surprisingly high proportion of women disclosed IPV during the 12 months following their orthopaedic injury. In addition, IPV victims suffered a more difficult recovery than patients without a history of IPV and had both delayed and reduced return to function. This study supports the need to optimize orthopaedic clinics to provide the appropriate support for asking about and providing assistance to IPV victims.

Efficacy of a Multimodal Analgesic Protocol at Reducing Opioid Use After Orthopaedic Trauma

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Purpose: Use of opioid therapy, which has been the mainstay of analgesia after orthopaedic trauma, can quickly lead to dependence after short-term use. Half of patients on opioids for at least 3 months progress to lifelong use. Limiting use during hospitalization may decrease the need for secondary prescriptions, which may decrease rates of dependence. The goal of this study was to determine the efficacy of two multimodal analgesic protocols at minimizing inpatient opioid utilization and decreasing outpatient secondary prescriptions following orthopaedic trauma. We hypothesized that our programs would decrease the rate of new long-term opioid use.

Methods: This IRB-approved, retrospective cohort study compared pre/post-implementation of state guidelines and implementation of a multimodal protocol informed by OTA guidelines. Patients were categorized into three cohorts: control, partial intervention (PI), and full intervention (FI). Control patients had no standardized protocol and pain was managed at surgeon's discretion. PI included state regulations regarding maximum days' supply prescribing limits, hiring of dedicated staff (pharmacist and nurse), and educational pamphlets. FI included the multimodal analgesic protocol emphasizing nonopioid pharmacologic therapy. The medical record and prescription data from our state prescription drug monitoring program (PDMP) were primary sources of data. The primary outcome of our study was rate of new long-term opioid use defined as 60 cumulative days of opioid therapy in the first 90 days post-discharge. Secondary outcome measures included receipt of an opioid prescription at discharge, days' supply of the opioid prescription at discharge, average daily morphine milligram equivalents (MME) of the discharge opioid prescription, and cumulative MME through post-discharge day 14.

Results: 1130 patients were included (393 in control, 359 in PI, 378 in FI). New long-term opioid use was significantly decreased for both interventions when compared to control (12.7%, 8.1%, and 7.9%, $P = 0.045$). Patients in either intervention cohort were discharged with shorter days' supply (8.1 ± 6.2, 5.9 ± 4.4, and 5.7 ± 4.1, $P<0.001$) and lower average daily MME (51.5 ± 44.0, 35.3 ± 25.1, and 34.8 ± 24.9, $P<0.001$) compared to the control cohort. However, the differences in end points between PI and FI cohorts were not significant. Cumulative MME through post-discharge day 14 was significantly less for both interventions and between PI and FI cohorts (563 ± 500, 330 ± 298, and 269 ± 249, $P<0.001$).

Conclusion: Implementation of both a state-based protocol and our multimodal protocol led to decreased opioid use in the immediate post-discharge period as well as decreased long-term opioid prescriptions following discharge. This is promising evidence that protocols informed by the OTA guidelines likely result in decreased opioid dependence.

Early Pain Self-Efficacy Predicts Chronic Pain and Pain-Related Disability 24 Months After Lower Extremity Fracture

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Purpose: Psychosocial factors carry important associations with pain-related disability after lower extremity fracture (LEF). However, no study to date has evaluated multiple psychosocial variables simultaneously to assess which construct carries the most consistent association with pain outcomes. The purpose of this study was to assess pain catastrophizing, pain self-efficacy, and depression 3 months after surgery for LEF and determine which construct was consistently predictive of the development of chronic pain and pain-related disability at 24 months. We hypothesized that pain self-efficacy would be consistently associated with all pain outcomes.

Methods: 122 patients (41.7 ± 14.7 years) with an LEF requiring surgical fixation and no history of chronic pain were recruited from a Level I trauma center for participation in a prospective cohort study. Three months after definitive surgical fixation, patients completed the Pain Catastrophizing Scale, Pain Self-Efficacy Questionnaire, and PROMIS (Patient-Reported Outcomes Measurement Information System) Depression computer adaptive test. Demographic and injury characteristics were extracted from the patient's medical record. Chronic pain development was assessed 24 months after surgery, and was defined using the National Institutes of Health recommendation of pain present greater than 3 months and bothersome at least half the days over the last 6 months. Patients also completed the Brief Pain Inventory Pain Severity Subscale and the PROMIS Pain Interference, with higher scores indicating worse pain outcomes. Separate multivariable linear regression analyses were conducted for each outcome, controlling for the outcome at baseline, ISS, age, smoking status, body mass index, education level, and depression, pain catastrophizing, and self-efficacy at 3 months.

Results: 99 patients (81%) completed this study. Of these patients, 28 (28.3%) reported chronic pain at 2 years. Pain self-efficacy at 3 months was associated with chronic pain development (odds ratio: 0.93; 95% confidence interval [CI]: 0.88 to 0.98; $P = 0.007$), pain severity (β: –0.06; 95% CI: –0.1 to –0.02; $P = 0.008$), and pain interference (β: –0.28; 95% CI: –0.47 to –0.08; $P = 0.006$) at 24 months. Pain catastrophizing and depression were not related to any outcomes (P>0.05).

Conclusion: Low pain self-efficacy at 3 months was consistently predictive of chronic pain, pain severity, and pain interference at 24 months after surgery for LEF. These results indicate that the patient's early confidence and beliefs regarding their recovery potential strongly influence their actual outcome. This is especially relevant given that most patients begin a functional rehabilitation progression 3 months after surgery. Physicians can utilize this 10-item questionnaire early in recovery to identify patients at risk for poor outcomes and identify meaningful interventions to improve the recovery trajectory.

Outcomes of Intramedullary Nailing Versus External Fixation in the Treatment of Open Tibial Fractures: 3 to 5-Year Follow-up Study of a Randomized Clinical Trial

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Purpose: Open tibial fractures are common injuries in low and middle-income countries. A randomized clinical trial (RCT) compared outcomes of intramedullary nailing (IMN) versus external fixation (EF) in adults with open tibial fractures in sub-Saharan Africa and found no difference in reoperation, although questions about late infection and union remained after 1 year. The purpose is to ascertain any differences in outcomes with longer-term follow-up.

Methods: The RCT included adults ≥18 years with acute AO/OTA type-42 open tibial shaft fractures who were randomly assigned to statically locked, hand-reamed IMN or uniplanar external fixation. These patients were re-evaluated 2 to 5 years after treatment. The primary outcome was death or reoperation for the treatment of deep infection, nonunion, or malalignment. Ongoing complications such as persistent fracture-related infection, nonunion, or malalignment were collected and analyzed. Secondary outcomes included quality of life as measured with the EuroQol-5 Dimensions (EQ-5D) questionnaire, function as measured with the Function IndeX for Trauma (FIX-IT) score, radiographic alignment, and healing as measured with the modified Radiographic Union Scale for Tibial fractures (mRUST).

Results: Of the 240 RCT patients, 121 (50.4%) (65 managed with IMN and 56 managed with EF) returned for follow-up at a mean of 4.0 years (range, 2.9-5.1 years). There were no significant differences in demographic factors or key injury characteristics between those with and without longer-term follow-up. 27 composite primary events occurred with rates of 21.5% and 23.2% in the IMN and EF groups, respectively (relative risk [RR] = 0.93, 95% confidence interval [CI] 0.48-1.80; $P = 0.83$). There were no significant differences between the groups in terms of the rates of deep infection, nonunion, and malalignment. Four of these events (2 in the IMN group and 2 in the EF group; $P = 0.88$) were newly detected at longer-term follow-up. Persistent complications in the form of ongoing fracture-related infection or nonunion were present at long-term follow-up in 29.6% of patients who sustained a primary event. FIX-IT scores, EQ-5D index, radiographic alignment, and mRUST scores were similar between the two groups at longer-term follow-up.

Conclusion: This study expands follow-up for the first RCT assessing IMN versus EF for the treatment of open tibial fractures in sub-Saharan Africa. While no differences in primary events were detected at a mean of 4 years after injury, fracture-related infection and nonunion complicate management of these severe injuries in nearly a quarter of patients.

Gentamicin-Coated Nail Is Effective Fracture-Related Infection Prophylaxis in Open Tibial Fractures

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Purpose: Fracture related infection (FRI) has been vastly described as a complication of open fracture. Risk is increased secondary to high-energy trauma, which frequently is associated with soft-tissue damage in this segment. Among surgical alternatives, the gentamicin-coated nail (GCN) is available. Its prophylaxis use is theory-based, preventing bacterial colonization and avoiding secondary biofilm formation. GCN is indicated in patients at high risk of presenting FRIs, such as those with open fractures. There are a couple of studies with a small sample of patients to validate its use clinically. The purpose of this study is to test the efficacy of GCN as a prophylactic method of FRI in a tibial open fracture.

Methods: In a mixed cohort study, a prospective group of patients managed with GCN, as compared to a retrospective group of patients managed with non-gentamycin-coated nails (NGCNs). Inclusion criteria were patients with open tibial fracture, surgical stabilization with GCN or NGCN, and follow-up of at least 6 months. The treatment protocol for every patient included: less than 3 hours for antibiotic prophylaxis initiation, less than 24 hours for surgical irrigation and debridement, pin holiday if time frame between external fixator and definitive fixation was more than 14 days, and, if required, local or microvascular coverage flaps as soon as possible. Traumatic amputation, protocol violation, and loss of follow-up were the exclusion criteria. Demographic variables, comorbidities, use of external fixation (EF), need of pin holiday, days with EF, flap coverage, time to flap coverage, open or closed reduction, and FRI incidence were studied. Later we evaluated any confounding variables in the association between GCN and FRI. Statistical analysis was done in Stata, v14.0, with $P<0.05$ as significance level.

Results: 214 patients were included, of whom 74 underwent GCN and 140 NGCN. No statistical differences were found in age, diabetes, obesity, requirement and type to flap coverage, days with EF, or reduction type. Smoke habit prevalence was higher in the GCN group (35.14% vs 20.93%, $P = 0.02$) and pin holiday was higher in the GCN group (13.79% vs 2.09%, $P<0.01$). We found no association between pin holiday and FRI incidence ($P = 0.46$). EF use was higher in the NGCN group (72.14 vs 40.54%, $P<0.01$), without any association between EF and FRI incidence ($P = 0.23$). There was a statistically significant association between use of GCN and FRI incidence being lower in the GCN group (1.35% vs 8.57%, $P = 0.03$). We found no confounding variables between GCN and FRI.

Conclusion: The use of GCNs in open tibial fracture provides an effective prophylactic method to reduce the risk of presenting FRIs at 6-month follow-up.

How Long Can Debridement Wait in Type IIIB Open Tibia Fractures?

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Purpose: Excessive time from injury to debridement in open fractures increases infection rates. However, the safe window to surgical debridement in grossly contaminated Gustilo type IIIB fractures requiring flap coverage has not been specifically analyzed.

Methods: This was a multicenter study. Consecutive patients with Gustilo type III tibial fractures requiring flap coverage were included. We evaluated data from a compiled registry that included patient factors, timing of injury, antibiotic administration, debridement, as well as the contamination level. An analysis was performed to determine the time to debridement at which an increase in infection rates occurred. We did separate analyses for highly and moderately contaminated injuries including adjustments with a propensity methodology. Finally, we used a spline regression analysis, controlling for timing of antibiotics (early was considered to be ≤1 hour) to determine the inflection points for increases in infection based on the time to initial debridement.

Results: 407 patients were included, of which 383 (94.1%) had a recorded contamination level. 131 patients had severe contamination. The overall infection rate was 21.0%. Severely contaminated fractures had a higher infection rate than non–grossly contaminated fractures (29.0% vs 15.9%; $P = 0.02$). After propensity adjustment for patient, injury, and treatment factors, severely contaminated fractures demonstrated a higher infection rate than less contaminated fractures by only 8.8% (95% confidence interval [CI] 0.2 to 17.3%, $P = 0.04$). Along the time to debridement axis, grossly contaminated fractures became infected at earlier debridement times than non–severely contaminated fractures, suggesting a shorter "safe window" to debridement. In spline regression analyses, after controlling for early antibiotics, there was a significant rise in the odds per hour of infection for highly contaminated injuries after 12 hours (odds ratio [OR] 1.14, 95% CI 1.00 to 1.30, $P = 0.05$) that further increased at 15 hours (OR 1.16, 95% CI 1.01 to 1.34, $P = 0.04$). Less contaminated fractures demonstrated a rise only at 15 hours (OR 1.08, 95% CI 1.0 to 1.18, $P = 0.051$). Importantly, when not controlling for time to antibiotics there was a plausible increment in the odds per hour infection rate as early as 9 hours after injury (OR 1.11, 95% CI 0.98 to 1.25, $P = 0.09$).

Conclusion: In Gustilo type IIIB fractures requiring flap coverage, the safe window to debridement is dependent on both the timing of antibiotic administration and contamination of the wound. Ideally the earlier the debridement, the better, but this becomes more crucial if antibiotics are not delivered in the first hour and if the wound is grossly contaminated. With early antibiotic administration, severely contaminated fractures show increases in infection at 12 and then again at 15 hours to debridement while non–severely contaminated injuries do not demonstrate an infection risk increase until after 15 hours from injury.

Pace of Recovery of Physical Function After Tibial Plateau Fractures

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Purpose: While the rate of complication and arthritis after open reduction and internal fixation of tibial plateau fractures has been studied, the time frame for the recovery of physical function (PF) is not well understood. Previous studies have evaluated outcomes to 12 months, but there is a paucity of data on the rate of progress. The objective of this study was to evaluate the progression of intermediate-term outcomes using PROMIS (Patient-Reported Outcomes Measurement Information System) PF scores.

Methods: A retrospective review of all patients over a 5-year period with isolated, operatively treated tibial plateau fractures were identified by CPT codes (27535 and 27536). PROMIS PF scores were collected for all patients with unicondylar (uni) and bicondylar (bi) injuries. Scores were then divided based on follow-up: immediately postoperative, 6 weeks, 3 months, 6 months, 12 months, and 24 months after surgery. Scores were averaged and 95% confidence intervals (CIs) were calculated to create a recovery curve. Student t tests were performed across follow-up periods for the same injury pattern as well as comparing between similar time points for the two types of injury (uni vs bi).

Results: There were 184 patients (96 uni and 88 bi) with PROMIS scores immediately postoperative, 154 patients (80 uni and 74 bi) at 6 weeks, 180 (90 uni and 90 bi) at 12 weeks, 123 (60 uni and 63 bi) at 24 weeks, 93 (45 uni and 48 bi) at 1 year, and 36 (16 uni and 20 bi) at 2 years. For unicondylar plateaus, there was no change between immediately postoperative and 6 weeks (28 vs 28, $P = 0.65$). There was a rapid increase in PF from 6 weeks to 3 months (28 vs 37, $P<0.001$) and 3 months to 6 months (37 vs 43, $P<0.001$). Then from 6 months to 1 year (43 vs 44, $P = 0.52$) and 1 year to 2 years (44 vs 46, $P = 0.35$) there was a subtle increase in PF. For bicondylar plateaus, there was a difference between each sequential time point under 1 year (27 vs 30, $P = 0.05$; 30 vs 34, $P<0.001$; 34 vs 40, $P<0.001$; 40 vs 44, $P = 0.04$), but then a very slight decline between 1 year and 2 years (44 vs 42, $P = 0.88$). When comparing unicondylar versus bicondylar injuries, no difference was found between PF scores at all times points except at 3 months ($P<0.001$), where unis were doing better.

Conclusion: Interestingly, patients with a unicondylar plateau fracture continue to see improvements in PF up to 2 years postoperatively. Conversely, patients with bicondylar plateau fractures continue to see improvements until a year postoperatively, but show a slight decrease beyond that. This information can be very helpful for setting patient expectations postoperatively, which is something we do currently based on some mix of gestalt and anecdote.

An International Comparison of Acute Versus Staged Fixation of Bicondylar Tibial Plateau Fractures

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Purpose: Bicondylar tibial plateau fractures can pose treatment challenges due to complex fracture patterns and associated soft-tissue compromise. Historically these are treated with external fixation followed by staged open reduction and internal fixation (sORIF). Limitations of sORIF include increased cost, need for additional procedures, and increased difficulty of the definitive ORIF. Some surgeons perform acute ORIF (aORIF) of selected bicondylar tibial plateau fractures based upon clinical experience. This study evaluates the outcomes of aORIF versus sORIF of bicondylar tibial plateau fractures at two high-volume international trauma centers with similar treatment protocols.

Methods: A retrospective review of all operatively treated patients with AO/OTA 41-C fractures from 2011 to 2019 at two busy Level I trauma centers located in the US and UK was conducted. Adult patients with >6 months of follow-up were included. Patients were stratified into aORIF and sORIF groups. Patient demographics, comorbidities, American Society of Anesthesiologists class (ASA), mechanism of injury, associated injuries, open fracture grade, and ISS were collected. Outcomes included operative time, wound dehiscence, superficial and deep infection, nonunion, flap coverage, arthrodesis, arthroplasty, and posttraumatic arthritis. Groups were compared with Fisher exact, t tests, and Wilcoxon rank sum.

Results: 186 patients met all inclusion criteria, with median follow-up of 17 months (range, 6-98 months). 112 patients underwent aORIF and 74 underwent sORIF. The sORIF group had a higher percentage of men (77% vs 63%, $P = 0.05$), a higher ISS ($P = 0.01$), and a higher rate of open fractures (25.7% vs 12.5%, $P = 0.03$). The groups were statistically similar in other demographics, comorbidities, ASA, mechanism, and associated injuries. Operative time was significantly shorter in the aORIF group (149 vs 231 min, $P<0.001$). There was no statistically significant difference in wound dehiscence, deep infection, flap coverage, nonunion, unplanned reoperation, posttraumatic arthritis, and arthroplasty between groups. However, aORIF was associated with a significantly lower rate of superficial infection ($P = 0.01$).

Conclusion: We found no increased risk of complications with aORIF compared to sORIF for bicondylar tibial plateau fractures. While not all injuries may be appropriate for aORIF, our results demonstrate the safety of aORIF when patients are properly selected by experienced fracture surgeons.

Prepping in the External Fixator to Facilitate Staged Open Reduction and Internal Fixation of Bicondylar Tibial Plateau Fractures Does Not Increase Infection Rates

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Purpose: Staged treatment of complex bicondylar tibial plateau (BTP) fractures using an external fixator is common. Some surgeons prep the entire external fixator into the surgical field during definitive open reduction and internal fixation (ORIF) or use existing external fixation pins to apply the femoral distractor. Other surgeons prefer to remove the external fixator and debride and exclude the pin sites from the sterile field to minimize contamination. Several studies have evaluated risk of infection related to external fixation pin site overlap, but to our knowledge no study has previously evaluated the safety of prepping in the external fixator during staged ORIF. The aim of this study was to compare infection and reoperation rates between patients who had their external fixation prepped in and those who did not during definitive ORIF of BTP fractures.

Methods: This was a retrospective cohort study of consecutive patients >8 years undergoing ORIF of an OTA/AO 41-C (Schatzker 6) BTP fracture at two Level I trauma centers between 2001 and 2018. Patients who had single-stage definitive fixation without the use of an external fixator were excluded. Surgical prep was betadine in all cases. Primary outcomes were deep infection and reoperation for any reason. $\chi 2$ analyses were used for categorical comparisons.

Results: 508 AO/OTA 41C BTP fractures were identified. 162 fractures (31.9%) underwent staged treatment using an external fixator (mean follow-up 3.42 years, standard error [SE] 101 days). 14 fractures were excluded because operative notes did not clearly indicate whether the external fixator was prepped in; one additional fracture was excluded due to pin removal for pin site infection. This narrowed the final cohort to 147 fractures: 78 with retained external fixation elements (REF) during surgery for definitive fixation and 69 with no retained external fixation elements (NEF). Comparing the REF to NEF groups, there was no difference in deep infection (26.9% vs 25.7%, $P = 0.868$) or reoperation (30.8% vs 34.3%, $P = 0.648$). Within the REF group, there was no difference in infection with retention of the entire external fixator (28.1%, n = 32) compared to only the external fixator pins (26.1%, n = 46) ($P = 0.842$).

Conclusion: The practice of prepping in the external fixator to facilitate ORIF of BTP fractures did not increase the risk of deep surgical site infection in this cohort. The relatively high infection rate in both groups is likely the result of an institutional tendency for early ORIF, resulting in selection of the most severe BTP fractures for staged ORIF. This study may reassure surgeons who prefer to use the existing external fixator frame or pins as a tool to facilitate ORIF that they are not placing their patients at higher risk of infection with this practice, assuming thorough prepping of retained elements. These findings do not apply to patients for whom there is an obvious pin site infection at the time of ORIF.

Rates of Early Revision Surgery in Operatively Treated Patella Fractures: A Retrospective Review of 286 Cases

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Purpose: The purpose of this study was to assess the overall revision rate for operatively treated patella fractures and to assess which treatment variables were associated with a higher rate of early revision surgery.

Methods: We performed a retrospective review of all operatively treated patella fractures at two tertiary academic hospitals between November 2007 and July 2020. The primary outcome was revision surgery for any cause within 3 months of the index procedure. Multivariate analysis was performed to assess the association between risk of revision surgery and the following variables: fixation strategy, presence/absence of preoperative CT scan, and the use of an arthrotomy.

Results: Overall, 286 fractures were identified and included in our review. All-cause revision rate was 9.8%. Failure of fixation accounted for 81% of all revisions. Revision rates varied among the different types of fixation: combined screw and Kirschner-wire (K-wire) fixation (36.4%, 4 of 11), cannulated screws with nonabsorbable sutures (20%, 3 of 15), inferior rim/basket plate fixation (14.3%, 2 of 12), suture repair (11.8%, 4 of 34), K-wire tension band wiring (9.4%, 13 of 139), cannulated screw tension band wiring (5.3%, 2 of 38), partial patellectomy (0%, 0 of 3), interfragmentary screw fixation (0%, 0 of 20), and mesh plate fixation (0%, 0 of 12). A medial or lateral arthrotomy to expose the articular surface was performed in 16.3% of patients with an overall revision rate of 6.5% ($P = 0.289$). In patients with preoperative CT, revision rate was 6.5% ($P = 0.750$). In cases in which a cerclage wire was used as an adjunct to fixation, the revision rate was 17.4% (4 of 23) and when a detensioning wire was used, the revision rate was 12.5% (3 of 24).

Conclusion: Early revision surgery occurs in nearly 10% of operatively treated patella fractures, with the majority being for loss of fixation. Direct visualization of the articular surface with an arthrotomy and the use of CT scan for operative planning may help reduce revision risk. Certain fixation strategies may also reduce the risk of revision surgery, with mesh plate fixation showing promising early results.

Fasciotomies in Bicondylar Tibial Plateau Fractures Do Not Have Increased Rates of Infection or Nonunion

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Purpose: Acute compartment syndrome can occur in upper and lower extremity fractures and most commonly occurs after tibial fractures. Acute compartment syndrome and fasciotomies have been associated with higher complication rates, including higher rates of nonunion and increased surgical site infections. These studies have been small series that do not consider time to closure or have prolonged time to closure. We aimed to look at the largest retrospective series of bicondylar tibial plateau fractures and compare infection rates, reoperation rates, nonunion rates, and PROMIS (Patient-Reported Outcomes Measurement Information System) scores between patients with and without fasciotomies.

Methods: This is a retrospective study examining patients with bicondylar tibial plateau fractures between 2003 to 2018 at two Level I trauma centers. Infection, nonunion, reoperation rates, and PROMIS scores were compared between patients who had fasciotomies for acute compartment syndrome or impending compartment syndromes and those who did not have fasciotomies.

Results: 498 patients were evaluated who had bicondylar tibial plateau fractures. 84 patients (16.9%) had fasciotomies for either impending compartment syndrome or acute compartment syndrome. On average patients required 2 return trips to the operating room prior to closure post fasciotomies. Rates or infection, nonunion, and reoperation were the same between patients who had fasciotomies and those who did not. There were no differences in PROMIS scores between groups at final follow-up.

Conclusion: Fasciotomies have been associated with nonunions and infections in tibial plateau fractures. Previous studies have either not assessed time to closure or have had a prolonged time to closure. Our study did not demonstrate increased complication rates post fasciotomies. The patients in this study had a lower average time to closure than previously reported in the literature, which may explain the lower rates than previously reported. This suggests that time to closure may be the most important factor in complications post-fasciotomy.

Tibial Plateau Fractures in the Elderly Have Clinical Outcomes Similar to Those in Younger Patients

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Purpose: The purpose of this study is to compare outcomes following surgical treatment of tibial plateau fractures in an elderly (≥65 years) and a non-elderly (<65 years) population.

Methods: Between January 2005 and January 2019, 310 patients (264 <65 years, 46 ≥65 years) with surgically treated tibial plateau fractures were identified prospectively; followed at 3, 6, and 12-month intervals; and had a minimum 1-year follow-up. The surgical and postoperative protocol was similar for all patients. Baseline demographic characteristics, Schatzker and Moore fracture classifications, and surgical details were recorded. Outcomes included patient-reported function, knee range of motion, fracture union, and the development of any complications or the need for additional surgery. Data were analyzed using an independent sample t test, Whitney-Mann U test, $\chi 2$ test, or contingency table using SPSS version 25.0.

Results: 264 patients were <65 years old (45.11 ± 12.23), and 46 patients were ≥65 years old (71.27 ± 5.77). Average follow-up was 27.5 months. Average time to radiographic fracture union was 5.0 months. There was no difference in distribution of Schatzker or Moore types between young and elderly populations (P>0.05), and no difference in time to healing (P>0.05). Patient-reported function differed at baseline, with patients <65 years more functional (P = 0.001). Short Musculoskeletal Function Assessment (SMFA) scores were better in younger patients at 3 months (P = 0.001) and better in the elderly at 12 months (P<0.0005). The difference between baseline and 12-month SMFA scores was statistically significant for both groups as well. Younger patients reported a greater difference between baseline and 12-month SMFA scores than the elderly. At 1 year, the SMFA scores for patients ≥65 years represented a clinical return to baseline, while scores for patients <65 years did not. There was no difference in range of knee motion between young and elderly groups at 3 months and 6 months (P>0.05), but at 12 months, the under-65 group had better range of knee motion (P = 0.028). There were no differences in reoperation rates or wound complications between the 2 groups at 3, 6, and 12 months (P>0.05).

Conclusion: Age greater than 65 years does not appear to portend poorer outcomes after surgical repair of a tibial plateau fracture. The complication profiles are similar. Older patients showed greater improvement in functionality compared to baseline than younger patients and younger patients end up with 4° more motion. While the differences may be statistically significant, they are likely not clinically significant. These data suggest that age should not be a disqualifying factor when considering whether a patient with a tibial plateau fracture should be treated operatively.

Ten-Year Incidence and Possible Predictors of Conversion to Total Knee Arthroplasty Following Operative Fixation of Distal Femur Fractures: Analysis of 6,086 Patients

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Purpose: Fractures of the distal femur may be associated with the development of posttraumatic arthritis. Little investigation has been undertaken regarding the rate of conversion to total knee arthroplasty (TKA) following treatment of distal femur fractures. The purpose of this study is to review a large database to calculate incidence and identify possible risk factors (injury, patient, subsequent surgery) associated with conversion to TKA following operative treatment of distal femur fractures.

Methods: All adult patients (>18 years) who underwent fixation of a distal femur fracture from 2007 to 2020 were identified using CPT codes (27511, 27513, 27514) within the PearlDiver database. Age, sex, body mass index, mechanism of injury, medical comorbidities, fracture characteristics, subsequent surgical procedures, time from index surgery to TKA, and 10-year incidence of conversion to TKA were recorded.

Results: A total of 6086 subjects who had undergone surgical fixation of a distal femur fracture were identified. 1464 (24%) were male. 10.2% of subjects were between 18 and 49 years, 26.7% were between the ages of 50 and 65, and 63.1% were over the age of 65. 9% of fractures were open. A total of 1651 secondary surgical procedures were documented: 735 underwent removal of implants, 97 underwent knee arthroscopy, 21 underwent open lysis of adhesions, 427 underwent debridement, 196 underwent revision fixation, and 175 underwent repair of nonunion. 132 subjects underwent TKA within 10 years, for an overall incidence of 2.17%, with 73.5% of TKAs occurring within 2 years. The rate of conversion to TKA was 0.8% in subjects 18 to 50 years of age, 3.7% in those age 50 to 65, and 1.7% in those over 65. When compared to subjects 18 to 50 years of age, age 50 to 65 years was a significant predictor of conversion to TKA (P<0.001). The rate of conversion was 1.66% for extra-articular fractures (CPT 27511), 2.29% for partial articular fractures (CPT 27514), and 2.25% for complete articular fractures (CPT 27513) ($P = 0.25$). Subsequent removal of implants was predictive of conversion to TKA, with 5.8% of patients undergoing removal of implants eventually undergoing TKA compared to 1.7% in those who did not (P<0.001). No other injury (open/closed), patient (sex, body mass index, comorbidities), or surgical (subsequent surgery type) factors were predictive of conversion to TKA.

Conclusion: Our findings demonstrate that the 10-year incidence of conversion to TKA of a distal femur fracture is low (2.17%). The majority of patients undergoing conversion to TKA did so <2 years from index surgery. No injury, patient, or surgical factors were predictive of TKA other than age and implant removal, but that may have been part of the staging process for TKA. Technical factors certainly play a role (eg, quality of reduction, fixation construct), but cannot be analyzed in large database studies.

Lower Complications in Acute THA for Intertrochanteric Femur Fractures than Delayed Conversion THA After Failed Operative Fixation

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Purpose: Although arthroplasty in the setting of a femoral neck fracture is well studied, the use of total hip arthroplasty (THA) for intertrochanteric (IT) femur fractures is relatively rare. The complication rates for both hip fracture-related arthroplasty as well as conversion THA are known to be significantly higher than elective arthroplasty for osteoarthritis. It is unknown if arthroplasty in the acute setting has higher complication rates than conversion following IT fracture fixation failure. The goal of this study is to compare complication rates between these cohorts in the setting of IT hip fractures.

Methods: A retrospective review of all patients with IT fracture and hip arthroplasty at a single tertiary referral academic institution were identified by ICD-9 and -10 codes over a 19-year period. Patients who had a THA as the index procedure for their IT fracture were included in the acute cohort. Those patients who had a conversion THA after a documented IT fracture for any reason were included in the conversion cohort. Patient records and radiographs were reviewed. Demographics data complications including reoperation, infection, and dislocation, fracture stability, and Tönnis grade were documented.

Results: There were 16 patients in the acute cohort and 34 patients in the conversion cohort with an average follow up of 18 months (standard deviation [SD] 22). There was no difference in age between the acute (mean 76, SD 9.7) and conversion (72,17) cohorts ($P = 0.34$) or in Charlson Comorbidity Index between the acute (3, 4.5) and conversion (2.1, 2.5) patients. The average time to conversion was 10 months (SD 12). Of the conversions, cut-out happened in 38% (13 of 34), of which 62% were in unstable fracture patterns. The overall reoperation rate was 12% for the acute and 29.4% conversion cohorts, respectively ($P = 0.29$). There were 2 infections (12.5%) and 1 dislocation (6.25%) in the acute cohort and 8 infections (24%) and 3 dislocations (8.8%) in the conversion cohort. Death rate was no different ($P = 0.17$) between the two groups (acute: 5 of 16 [31%]; conversion 5 of 34 [17%]). There was no correlation of Tönnis grade and dislocation ($P = 0.63$) or body mass index with infection ($P = 0.64$).

Conclusion: Patients who receive THA in the traumatic or posttraumatic setting of an intertrochanteric femur fracture face high complication rates. These treatments are rare, with small numbers even over a 19-year span at a high-volume academic center. Despite this, the conversion cohort demonstrated a two-fold increased incidence of reoperation and infection rate compared to the acute cohort. While these findings are limited by the small number of patients, acute THA is associated with less complications and this should be weighed when making the decision for patients that may require eventual THA due to preexisting arthritis or other factors.

Outcomes and Survivorship of Vascularized Fibular Grafting for Post-Traumatic Osteonecrosis of the Femoral Head

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Purpose: Posttraumatic osteonecrosis of the femoral head (ONFH) is a challenging condition to treat in the young patient. Free vascularized fibular grafting (FVFG) is a well-recognized method of treatment for these patients; however, there is a paucity of literature evaluating the long-term outcomes and survivorship of FVFG performed specifically for posttraumatic ONFH. The purpose of this study was to evaluate the longevity of FVFG in traumatic injuries resulting in ONFH, with conversion to total hip arthroplasty (THA) as the primary outcome. Secondary aims included evaluation of outcome scores. Our hypothesis was that patients who received FVFG for posttraumatic ONFH would have a low overall conversion rate to arthroplasty and have clinically significant improvement in Harris hip (HH) scores.

Methods: Patients with a minimum of 5-year follow-up were retrospectively identified from our institutional database for having undergone FVFG from 1980 to 2006 for posttraumatic ONFH. Posttraumatic indications for FVFG were grouped as: (1) ONFH after fixation of femoral fractures involving the head, neck, or peritrochanteric region; (2) ONFH after dislocation without femoral fracture; (3) ONFH after trauma without fracture or dislocation; or (4) chronic nonunion correction after femoral neck fracture. Data collected included demographics, preoperative disease stage, HH scores, Short Form (SF)-12 scores, and conversion to THA.

Results: 72 hips in 68 patients with a mean age at surgery of 27.8 years (range, 11.5-50.5) met inclusion criteria. Mean follow up was 11.6 years (range, 5.1-33.2). Etiology included femoral neck fracture in 36 patients (61%), hip dislocation in 7 (12%), trauma without fracture or dislocation in 11 (19%), and femoral neck nonunion in 4 (8%). The most common stage at presentation was stage IV (n = 48 patients), followed by stage II (n = 11), stage III (n = 9), and stage I (n = 4). Graft survival at final follow-up (mean 10.9 years) was 64%, with mean time to conversion to THA in those that did not survive (36%) occurring at 8.4 years. There was no difference between THA conversion rates in hips with pre-collapse (stage I and II) versus impending or post-collapse (stage III or IV) lesions ($P = 0.227$). In hips with surviving grafts at final follow up, mean HH scores improved from 56.7 to 77.3 (standard deviation 24.57, range 69-93), a mean improvement of 20.6 ($P<0.001$).

Conclusion: Our results reveal an acceptable overall conversion rate to THA of 36% at 8.4 years with no difference in conversion rate between stages, and significant postoperative improvement in HH score. FVFG remains a viable option for treatment of posttraumatic ONFH in young patients with both pre- and post-collapse lesions.

Induced Membrane Technique Is Effective for Both Metaphyseal and Diaphyseal Fractures with Acute Bone Loss

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Purpose: The induced membrane (IM) (Masquelet) technique is a two-stage procedure that was originally described for reconstructing diaphyseal defects. There is currently no literature guiding the usage of this technique for metaphyseal defects. Given the differences in bony structure and vascular supply between the diaphysis and metaphysis of a long bone, the purpose of this study was to compare outcomes of metaphyseal and diaphyseal fractures with acute bone loss treated with IM technique.

Methods: Patients acutely treated with IM technique for traumatic bone loss in the lower extremity at three Level I trauma centers between 2010 and 2020 were retrospectively reviewed. Patient demographics and fracture characteristics were collected. Fracture union was the primary outcome and was defined as radiographic healing on at least three cortices without clinical symptoms. Secondary outcomes measured were infection rate, revision grafting, time to union, or amputation. Patients were followed to union or a minimum of 12 months. $\chi 2$ and Wilcoxon rank sum tests were performed on categorical and continuous variables, respectively. Multivariate regression was used to compare successful union across fracture zone while controlling for patient age.

Results: Six patients underwent lower extremity amputation due to soft-tissue compromise or infection prior to receiving the second stage surgery and were excluded from analysis, leaving 96 patients with an average follow-up of 24 months. 43 had diaphyseal IM (DIM) and 53 patients had metaphyseal IM (MIM). Metaphyseal patients were significantly older (43 years) than diaphyseal patients (32 years) ($P = 0.004$). Demographic and fracture characteristics including gender, tobacco use, open fracture, number of tibia fractures, defect size, and follow-up were similar between groups. After controlling for age, there was no difference in final union rate between the diaphyseal (39 of 43, 93%) and metaphyseal cohorts (44 of 53, 83%) (odds ratio [OR] 0.95, $P = 0.91$). Similarly, there was no difference in time to union from second stage (DIM 13.8 months, MIM 10.8 months, $P = 0.20$), infection (DIM 30%, MIM 25%, $P = 0.53$), revision grafting (DIM 16%, MIM 15%, $P = 0.86$), or amputation (DIM 5%, MIM 7.5%, $P = 0.52$) between groups.

Conclusion: This study represents the largest series of lower extremity fractures treated acutely with the IM technique. Induced membrane for acute fractures with bone loss had an overall success rate of 86%. There was no difference in rates of successful union or complications between diaphyseal fractures and metaphyseal fractures treated with the IM technique.

Risk Factors and Characteristics of Recalcitrant Osteomyelitis Following Appropriate Initial Surgical and Antibiotic Treatment

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Purpose: Posttraumatic osteomyelitis is a known complication of fracture fixation that can result in a protracted treatment course involving multiple surgeries and prolonged antibiotic therapy. The purpose of this study was to evaluate which injury, patient, and microbiological characteristics place patients at risk for recalcitrant osteomyelitis despite appropriate initial treatment.

Methods: Patients undergoing surgical debridement and antibiotic therapy for osteomyelitis from 2003 to 2019 were identified using databases at three Level I trauma centers. Patients were categorized as having undergone serial bone debridement if they had two procedures a minimum of 6 weeks apart with a full course of appropriate antibiotics in between. Patient records were reviewed for age, injury location, body mass index (BMI), smoking status, comorbidities, and culture results including the presence of multidrug resistant organisms (MDROs). Multivariate regression was used to identify independent associations between the aforementioned variables and serial debridement events.

Results: A total of 244 patients were identified; 52% (n = 127) had a successful index treatment, and 48% (n = 117) underwent repeat debridement for osteomyelitis. At the index treatment, the most common organisms in both groups were methicillin-resistant (MRSA) and methicillin-sensitive *Staphylococcus aureus* (MSSA). Negative cultures at the index procedure were obtained in 24% (n = 31) of patients treated successfully and in 16% (n = 19) of patients treated unsuccessfully. The most common organisms at the time of repeat saucerization remained MRSA and MSSA; however, the same organism was cultured from both the index and repeat procedure in only 18% (n = 21) of cases. Of the patients with a positive culture following initial debridement, 34% (n = 40) had a negative culture at the time of repeat procedure. While intravenous drug use, smoking, peripheral vascular disease, BMI, polymicrobial infection, MDRO, and culture-negative infections were not associated with repeated treatment, diabetes (odds ratio [OR] 1.2, $P = 0.02$), open fractures (OR 1.2, $P = 0.04$), and injuries of the lower extremity (OR 1.3, $P<0.001$) were.

Conclusion: To our knowledge, this study is the first to examine the implications of patient, organism, and injury characteristics on the treatment of osteomyelitis. Successful eradication of posttraumatic osteomyelitis is difficult to achieve despite appropriate surgical and antibiotic therapy. Diabetic patients and open fractures of the lower extremity are independent risk factors for failure of initial treatment. While MRSA and MSSA continue to be the most common organisms, patients presenting for repeat saucerization rarely culture the same organism. These findings will help clinicians identify patients who require more careful management prior to definitive reconstruction due to their risk of recalcitrant infection.

The Effect of Free Versus Local Flaps on Time to Union in Open Tibia Fractures

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Purpose: Open fractures of the tibia are associated with increased risk of soft-tissue infection, osteomyelitis, and nonunion. Early soft-tissue reconstruction with either local or free tissue has been shown to decrease infection rates and improve rates of bony union. The purpose of this study was to compare the rates and time to union of open tibia fractures that underwent free tissue or local flaps for soft-tissue coverage.

Methods: A retrospective chart review of 140 patients with open tibia fractures requiring soft-tissue reconstruction treated at a single Level I trauma center was performed. Demographic data as well as AO/OTA fracture classification, flap type, type and timing of revision procedures, and time to union were collected. Union status was determined using radiographic union scale in tibia fractures (modified RUST) score >11. Nonunion was defined as failure of radiographic progression of union over a 6-month period after the time point of 6 months, failure to reach a modified Radiographic Union Score for Tibial Fractures (RUST score) of 12 after 1 year, surgery for nonunion, or catastrophic hardware failure after 6 months.

Results: 15 flaps (11%) were AO/OTA 41 (3A, 1B, 11C), 80 (57%) were AO/OTA 42 (21A, 37B, 22C), 30 (21%) were AO/OTA 43 (9A, 3B, 18C), and 15 (11%) were AO/OTA 44 (5A, 0B, 10C). Limb salvage was achieved in 90% of patients. The overall rate of nonunion was 31%. Flap type significantly affected time to union, with local fasciocutaneous and keystone flaps having significantly longer time to union (202 days) than all other flaproups ($P = 0.01$). Additionally, free flaps had significantly shorter time to union than local flaps (115 vs 149 days $P = 0.02$). Muscle flaps (local and free) had significantly shorter time to union than fasciocutaneous flaps (123 days vs 164 days, $P = 0.04$). Patients who underwent an initial soft-tissue reconstruction with a local muscle flap were more likely to require a second flap to achieve wound closure (odds ratio [OR] = 3.4, $P = 0.009$) and this significantly increased time to union (162 vs 122 days, P = 0.03). Patients treated with local flaps were more likely to develop osteomyelitis and undergo amputation when compared with those treated with free flaps (OR = 9.7, $P = 0.0147$).

Conclusion: Local fasciocutaneous flaps had a significantly longer time to bony union than other local or free flaps. Local flaps demonstrated an increased risk of osteomyelitis and necessity of a second flap procedure and increased time to union. Flap type and composition significantly affected time to bony union.

Percutaneous Strain Reduction Screws Are a Cost-Effective and Reproducible Method to Treat Long Bone Nonunion

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Purpose: Nonunions often arise because of high strain environments at fracture sites. Revision fixation, bone grafting, and biologic treatments to treat long bone fracture nonunion can be expensive and invasive. Percutaneous strain reduction screws (PSRSs) can be inserted as a day-case surgical procedure to supplement primary fixation at a fraction of the cost of traditional treatments. Screw insertion perpendicular to the plane of a nonunion can resist shear forces and achieve union by modifying the strain environment. A multicenter retrospective study was undertaken to confirm the results of the initial published case series, ascertain whether this technique can be adopted outside of the developing institution, and assess the financial impact of this technique.

Methods: Retrospective analysis was performed for all PSRS cases used to treat ununited long bone fractures in four Level I trauma centers from 2016 to 2020. All patients were followed until union was achieved or further management was required. Demographic data were collected on patients, as were data about their injuries, initial management, and timing of all treatments received. A comparative cost analysis was performed comparing patients treated with PSRS and with traditional nonunion surgery methods.

Results: 51 patients were treated with the PSRS technique. 45 patients (88%) achieved union at a median time of 5.2 months (range, 1.0-24.7 months). Comparable results were seen between the developing institution and independent units. No patients experienced adverse events beyond failure to achieve union. PSRS appears to offer savings of between £2957 (US$4035) to £11,231 (US$15,324) per case compared with traditional methods of nonunion surgery.

Conclusion: PSRS is a safe, cost-effective treatment for long bone nonunion. The promising results of the initial case series have now been replicated outside of the developing institution.

Orthoplastic Treatment of Open Lower Limb Fractures Improves Outcomes: A 12-Year Review

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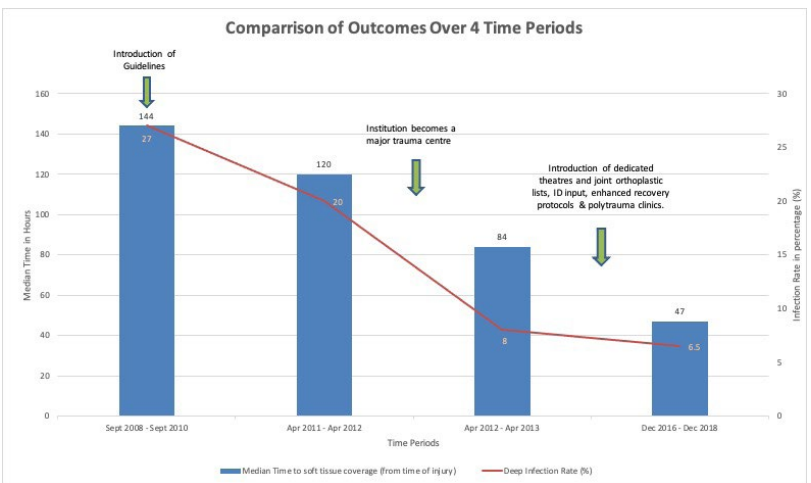
Purpose: Standards to improve the management of open lower limb injuries were developed over a decade ago. These mandate wound excision and skeletal stabilization within 24 hours and definitive soft-tissue coverage within 72 hours. Deep infection rate is considered a marker of performance in open fracture management. This paper is the fourth audit of all Gustilo-Anderson IIIB/IIIC open lower limb fractures presenting to a major trauma center, establishing improvements in care over 12 years.

Methods: All patients presenting between December 2016 and December 2018 with Gustilo-Anderson IIIB/IIIC open lower limb fractures were assessed against national guidelines. Time to debridement, skeletal stabilization, and definitive soft-tissue coverage were evaluated. Primary end point was the rate of deep infection.

Results: 42 of 61 patients (69%) were compliant, compared to 38% in the previous audit. Median time to stabilization was 14.2 hours; 90% of patients underwent debridement and stabilization within 24 hours. The median time to definitive soft-tissue covererage and microsurgical reconstruction was 47 hours, with 71% of patients meeting the standards. The overall deep infection rate was 6.5% within this cohort, compared to 8% in the previous cycle. The rate of deep infection in national standard–compliant patients was 2%; the rate of deep infection in non-compliant patients was 16% ($P = 0.05$).

Conclusion: Improvements in deep infection rates have correlated with improvements in standard of care adherence over the last 8 years, in conjunction with the systematic introduction of service changes. These changes include the initiation of a polytrauma clinic, infectious disease specialty input, and an enhanced recovery protocol. Compared to internationally published deep infection rates in open fractures of 10% to 52%, our rate of infection represents excellent treatment. This is strong evidence that these key performance indicators are significant in achieving good outcomes, supporting a joint orthoplastic approach for optimal management of these complex injuries.



Spin in the Abstracts of Meta-Analyses and Systematic Reviews: Midshaft Clavicle Fractures

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Purpose: Spin is a reporting bias that misrepresents research. Ultimately it can impact surgeon decision-making and patient care. Midshaft clavicle fractures are common; however, debate continues over optimal treatment modalities. The purpose of this study is to identify the prevalence of spin in meta-analyses and systematic review abstracts regarding the treatment of midshaft clavicle fractures.

Methods: Electronic libraries (MEDLINE, Embase, Web of Science, Google Scholar) were systematically searched for meta-analyses and systematic reviews regarding the treatment of midshaft clavicular fractures. The nine most severe types of spin commonly found in abstracts were used as an evaluation tool to assess the articles. Other variables analyzed include year of publication, journal impact factor, number of citations, and methodologic quality according to A Measurement Tool to Assess Systematic Reviews (AMSTAR 2).

Results: The electronic database search resulted in 401 articles, of which 53 met our inclusion criteria. After review of these papers, it was found that 47.2% (25 of 53) of the included articles contained spin within the abstract. Of the nine most severe types of spin found in abstracts, type 3 spin (selective reporting of or overemphasis on efficacy outcomes or analysis favoring the beneficial effect of the experimental intervention) was found to be the most prevalent (12 of 53, 22.6%). Further analysis showed that there was no significant correlation between the presence of spin in a manuscript and its AMSTAR 2 grade, year of publication, number of citations, or the impact factor of the journal in which the manuscript was published.

Conclusion: This study demonstrated the presence of spin in a significant portion (50%) of meta-analyses and systematic review abstracts pertaining to midshaft clavicular fractures. Orthopaedic surgeons should learn to recognize spin as they review articles when deciding the treatment course for such injuries. Additionally, strict criteria should be considered to reduce the prevalence of spin in orthopaedic literature.

Acute Plate Fixation of Displaced Midshaft Clavicle Fractures Is Not Associated With Earlier Return of Normal Shoulder Function When Union Is Achieved

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Purpose: It is unclear whether acute plate fixation facilitates earlier return of normal shoulder function following a displaced midshaft clavicle fracture compared to nonoperative management when union occurs.

Methods: Patient data from a randomized controlled trial was used to compare acute plate fixation with nonoperative management of united fractures. Return of shoulder function was based on the age and sex-matched Disabilities of the Arm, Shoulder and Hand (DASH) scores for the cohort. Independent predictors of an early recovery of normal shoulder function was investigated using a separate prospective series of consecutive nonoperative displaced midshaft clavicle fractures recruited over a 2-year period (≥16 years). Patient demographics and functional recovery were assessed over the 6 months post-injury using a standardized protocol.

Results: Data from the randomized controlled trial consisted of 86 patients who underwent operative fixation compared to 76 patients who united with nonoperative treatment. The recovery of normal shoulder function, as defined by a DASH score within the predicted 95% confidence interval for each respective patient, was similar between each group at 6 weeks (operative 26.7% vs nonoperative 25.0%, $P = 0.80$), 3 months (52.3% vs 44.2%, $P = 0.77$), and 6 months post-injury (86.0% vs 90.8%, $P = 0.35$). The mean DASH score and return to work was also comparable at each time point. In the prospective cohort 86.5% (n = 173 of 200) achieved union by 6 months post-injury (follow-up rate 88.5%, n = 200 of 226). Regression analysis found no specific patient, injury, or fracture predictor was associated with an early return of function at 6 or 12 weeks.

Conclusion: Return of normal shoulder function was comparable between acute plate fixation and nonoperative management when union was achieved. One in two patients will have recovery of normal shoulder function at 3 months, increasing to 9 out of 10 patients at 6 months following injury when union occurs irrespective of initial treatment.

Δ Multicenter, Prospective, Observational Trial of Non-Operative Versus Operative Treatment for High-Energy Midshaft Clavicle Fractures

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Purpose: We sought to determine if nonoperative or operative treatment of displaced clavicle fractures delivers better clinical and patient-based outcomes, which will help the surgeon better determine the optimal treatment for a given patient with a clavicle fracture.

Methods: A multicenter, observational study was performed from 2003-2018 of displaced midshaft clavicle fractures (OTA 15.2). Adults with closed clavicle fractures displaced over 100% or shortened by more than 1.5 cm were eligible for enrollment. Seven Level I trauma centers participated throughout the United States. Patients were followed for 2 years following enrollment. Allowable fixation methods at the discretion of the surgeon consisted of anterior-inferior or superior plating, or intramedullary fixation. Patients were analyzed based on treatment type, DASH (Disabilities of the Arm, Shoulder and Hand) scores (3, 6, 12, and 24 months), and reoperation.

Results: A total of 412 patients were enrolled. Of these, 203 were treated with internal fixation by plate and screws, 26 were treated by intramedullary fixation, and 183 were treated nonoperatively. Average age of all patients treated by plate or intramedullary fixation was 35 years and the average age in the nonoperative group was 40 years. Fixation, whether pins or plates, versus nonoperative treatment showed similar DASH scores at 12 and 24 months. The pin group had poorer DASH scores at 3 and 6 months ($P<0.05$). At 3 and 6 months the plating group was not significantly better than the nonoperative group. The risk of surgery after initial treatment, whether operative or not, was not different (hazard ratio 1.20, 95% confidence interval 0.54, 2.66, $P = 0.65$). However, when surgery for hardware removal is excluded there is a significantly higher risk for surgery in the nonoperatively treated group (hazard ratio 0.32, 95% confidence interval 0.11, 0.96, $P = 0.04$).

Conclusion: At every time point studied up to 2 years, the DASH scores for operative fixation with plates and nonoperative treatment were no different. Hardware removal remains the most likely reason for repeat operative intervention in the plate and pin groups, while surgery for nonunion was the most likely reason for late surgery in the nonoperative group.

Δ OTA Grant

Not All Proximal Humerus Fractures Do Well Without Surgery: Anterior Translation Predicts the Need for Surgery

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Purpose: Proximal humerus fractures from low-energy mechanisms are commonly treated without surgery. While angulation, in particular valgus and varus, has been evaluated, little attention has been paid to translation. We hypothesized that substantial anterior translation of the shaft may have a negative impact on union and outcome due to impingement with the biceps and physical prominence. The purpose of this study was to evaluate the effect of translation on a large series of low-energy proximal humerus fractures initially treated nonoperatively.

Methods: We performed a multicenter analysis of isolated low-energy proximal humerus fractures (OTA 11-A-C) treated nonoperatively at 5 centers. Radiographic translation in the sagittal and coronal planes was measured at presentation and at union. Patients with anterior translation were compared to those with posterior or no translation. Patients with ≥80% anterior humeral translation were compared to those with <80% translation. The primary outcome was failure of nonoperative treatment resulting in surgery and the secondary outcome was symptomatic malunion. Patients with less than 3 months of follow-up were excluded even if they united.

Results: 210 patients (152F; 58M), average age 64 years, with 112 left and 98 right-sided proximal humerus fractures initially treated nonoperatively were followed for average 231 days (or until surgery was required). 171 (81%) were injured in a fall from standing. Average body mass index was 27 kg/m2. Nine patients (4%) had surgery, 8 for nonunion and 1 for malunion. All 9 patients (100%) had anterior translation. Additionally, 5 had medial translation and 4 had lateral translation (not significant). Anterior translation as compared with posterior or no sagittal plane translation was associated with failure of nonoperative management requiring surgery ($P = 0.012$). Additionally, of those with anterior translation, having ≥80% anterior translation as compared with <80% was also associated with surgery ($P = 0.001$). Finally, 26 patients were diagnosed with symptomatic malunion, of whom translation was anterior in 24 and posterior in 2 ($P = 0.0001$). Importantly, the presence of anterior translation did not change over time and in all cases was present on the initial radiographs.

Conclusion: In a multicenter series of proximal humerus fractures, anterior translation of >80% was associated with failure of nonoperative care resulting in symptomatic malunion and secondary surgery. While the vast majority of proximal humerus fractures can be treated nonoperatively, this pattern of displacement should be considered at risk for failure. This relationship has not been evaluated in any large trial and its association with symptomatic malunion has not been previously reported. Most importantly, the displacement is present on the initial Y view and can be addressed early.

Long-Term Outcomes of Secondary Implant Removal and Arthrolysis in Patients with a Painful Stiff Shoulder After Open Reduction and Locking Plate Fixation for a Proximal Humeral Fracture

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Purpose: Open reduction and plate fixation (ORPF) for displaced proximal humerus fractures can achieve reliably good long-term outcomes. However, a minority of patients persist with pain and stiffness. These patients can benefit from open arthrolysis, subacromial decompression, and hardware removal (ADROM). The long-term outcomes of ADROM remain unknown. Our primary aim was to assess long-term outcomes of patients undergoing ADROM for stiffness following proximal humerus ORPF.

Methods: Between 1998 and 2018, 424 consecutive patients were treated with primary ORPF for proximal humerus fracture. ADROM was offered to symptomatic patients with a healed fracture at 6 months postoperatively, and performed through a deltopectoral approach. Patients were followed up prospectively with demographic data, fracture characteristics, and complications recorded. Active range of movement (aROM), Oxford Shoulder Score (OSS), and EuroQol 5 Dimensions 3-Level (EQ-5D-3L) were recorded preoperatively and postoperatively.

Results: 138 patients underwent ADROM; 111 patients were available for long-term follow-up at a mean of 10.9 years (range, 1-20). Mean age was 50.8 years (18-75); 79 (57.2%) were female. Mean time from primary ORPF to ADROM was 11.9 months (6-19). Five patients developed superficial wound infection; 10 patients developed late symptomatic humeral head osteonecrosis. Four patients underwent revision arthrolysis. Median OSS improved from 17 (interquartile range, 12.0-22.0) preoperatively to 40.0 (31.5-48.0) postoperatively (P<0.001) and 39.0 (31.5-46.5) at long-term follow-up (P<0.001). Median EQ-5D improved from 0.079 (–0.057 to 0.215) to 0.691 (0.441-0.941) postoperatively (P<0.001) and 0.701 (0.570-0.832) at long-term follow-up (P<0.001). aROM improved in all planes (P<0.001). On multivariate regression analysis, a manual occupation and being more socioeconomically deprived were independent predictors of lower OSS. A worsening Charlson comorbidity index was an independent predictor of lower EQ-5D.

Conclusion: ADROM in patients with persistent symptomatic stiffness following proximal humerus ORPF can achieve excellent short- and long-term outcomes. More socioeconomically deprived patients, those in a manual occupation, and those with worsening comorbidities are at greater risk of poorer outcomes following ADROM.

No Change in Outcome Between 1 and 5 Years After Repair of Displaced Proximal Humerus Fractures

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Purpose: Proximal humerus fractures are common fragility fractures in the elderly and occur after high-energy fractures in younger patients. These serious injuries may affect a patient's quality of life long-term. This study aims to determine if greater than 1-year follow-up for patients treated with locking compression plates for proximal humerus fractures is clinically warranted.

Methods: Patients treated for proximal humerus fractures with a locking compression plate, by two of three orthopaedic trauma surgeons at our major academic center, prospectively enrolled in a database of 269 patients, were reviewed. Of the 269 patients enrolled in the database, 200 patients underwent surgical fixation greater than 5 years from date of query. After excluding for insufficient follow-up, incorrect patient contact information, and mortality, 75 patients (37.5%) met criteria for inclusion. For these 75 patients, mean long-term follow-up was 10.5 ± 3.2 years (range, 5.0-16.8 years). Clinical data collected included the Disabilities of the Arm, Shoulder and Hand (DASH) scores, complication rates, and shoulder range of motion at 1 and 5 years. Data were analyzed with paired t tests using IBM SPSS.

Results: Patient-reported functional outcome (DASH) scores between the 1-year and long-term follow-up did not differ (16.3 ± 17.4 vs 15.1 ± 18.2, $P = 0.555$). There was no difference in shoulder forward flexion (145.5 ± 32.4° vs 151.5 ± 39.1°, $P = 0.186$), external rotation (48.4 ± 16.6 vs 57.9 ± 23.5, $P = 0.074$), and internal rotation (T10 vs T9, $P = 0.204$) between 1 year and long-term follow-up. 18 patients experienced 26 complications within 1 year of initial fracture fixation. Of these, 9 patients underwent 13 reoperations. Complications included 11 screw penetrations, 7 cases of osteonecrosis, 3 infections, 3 malunions of the greater tuberosity, and 2 fracture nonunions. No patients experienced further complications related to the index surgery after one year follow up, and no patients developed osteonecrosis or infection following healing. Four patients underwent further shoulder surgery after 1-year follow-up, which included 1 removal of implant and soft-tissue mass excision, 1 patient who underwent removal of implant and revision fixation due to recurrent shoulder instability, 1 patient who underwent implant removal and rotator cuff repair due to a fall and dislocation, and 1 patient who underwent implant removal due to implant irritation without further complication.

Conclusion: Patient-reported functional outcome scores and shoulder range of motion both plateau after 1 year following proximal humerus fracture fixation, and outcomes do not deteriorate over 5 years. After 1 year, long-term follow-up of fixed proximal humerus fractures is unnecessary for those without symptoms.

Surgical Treatment of Dorsally Displaced Distal Radius Fractures with a Volar Locking Plate Versus Conventional Percutaneous Methods: Minimum 10-Year Follow-up of a Randomized Controlled Trial

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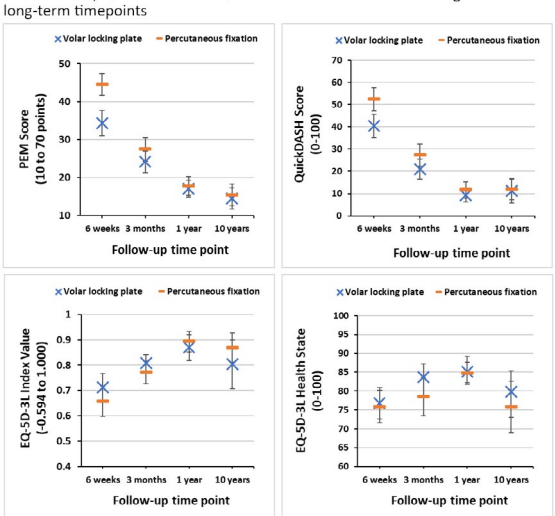
Purpose: We conducted minimum 10-year follow-up of a single-center, pragmatic, randomized controlled trial (RCT) conducted in a tertiary care UK institution that compared the functional outcomes of dorsally displaced distal radius fractures treated with volar locking plate or percutaneous wire fixation.

Methods: Of the original 130 trial cohort, 11 had not consented to further contact and 14 were deceased. Therefore 105 patients were sent the Patient Evaluation Measure (PEM), QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand questionnaire), and EuroQol-5D-3L (EQ-5D-3L) questionnaires at a minimum follow-up of 10 years. They were also asked if they had received further treatment for their injured wrist and whether additional problems had developed in the hand/wrist after the original 1-year follow-up period. A complete case analysis, and sensitivity analysis via a mixed-effects model, were performed.

Results: 75% of the 105 participants responded. There were no significant differences between the scores of the two treatment groups in the PEM $P = 0.651$ (95% confidence interval [CI], –-4.8 to 3.0), QuickDASH $P = 0.862$ (95% CI, –7.8 to 6.5), or the EQ-5D-3L index value $P = 0.256$ (95% CI, –0.18 to 0.05) and health state $P = 0.377$ (95% CI, –4.8 to 12.8). Results of mixed-effects model analysis were similar, suggesting that our findings were robust. One patient required plate removal 6 years after fixation. No major difference was found in the requirement for further treatments. No patients reported development of carpal tunnel syndrome.

Conclusion: This study has a high follow-up rate considering the protracted follow-up period with responses from 61% of the original trial participants. It demonstrates that, as with the original 1-year functional outcomes, the 10-year outcomes of these two treatments are not significantly different. The original trial reported better anatomical reduction of fractures treated with volar plate fixation; our findings in this study suggest that this does not make a difference to use of the hand or wrist in the long-term.

Trend in PEM, QuickDASH and EQ-5D-3L Index & Health State ratings at trial and long-term timepoints



Data are shown as means ± 95% confidence interval

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

Δ Delayed Fixation of Distal Radius Fractures Past 3 Weeks After Initial Failed Closed Reduction Increases the Odds of Reoperation

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Purpose: We aimed to compare reoperation rates following distal radius fractures (DRFs) managed with initial surgical fixation versus delayed fixation following initial closed reduction.

Methods: We identified all DRF patients aged 18 years and older between 2003 and 2016 in Ontario, Canada from administrative databases. We used procedural and fee codes within 30 days of the fracture to determine which patients underwent primary outpatient surgical fixation (within 7 days of the fracture), or underwent an initial closed reduction followed by secondary definitive fixation. We grouped patients who underwent secondary fixation by their time to definitive fixation (7-14 days, 15-21 days, and 22-30 days). We used intervention and diagnostic codes to identify reoperations within 2 years of fixation. We used multivariable logistic regression to compare the association between primary versus secondary fixation and reoperation while adjusting for other relevant covariables. We performed an age-stratified analysis to determine if the association between primary versus secondary fixation and reoperation differed by patient age.

Results: We identified 14,959 DRF patients managed with outpatient fixation within 30 days of the fracture. Of these, 8339 (55.7%) underwent primary surgical fixation (mean time to fixation 2.9 ± 1.8 days), while 4042 (27.0%) underwent secondary fixation between 8 and 14 days (mean time to fixation 10.2 ± 2.2 days), 1892 (12.7%) between 14 and 21 days (mean time to fixation 17.5 ± 1.9 days), and 687 (4.6%) more than 21 days (mean time to fixation 24.8 ± 2.4 days) following initial closed reduction. The secondary fixation groups had higher proportions of female and older patients compared to the primary group. The unadjusted proportion of reoperations was significantly higher in the group who waited more than 21 days for fixation (8.4%), compared to the primary fixation group (5.9%) and the secondary groups who waited between 7 and 14 days (5.2%), or between 15 and 21 days (5.4%) for fixation. Following covariable adjustment, patients who underwent secondary fixation more than 21 days from closed reduction had a significantly higher odds of reoperation (odds ratio [OR] 1.40 [1.05-1.86]) compared to the primary group. This association appeared to worsen for patients older than 60 (OR 1.92 [1.19-3.09]). We found no significant difference in the odds of reoperation for patients who underwent secondary fixation within 7 to 14, or 15 to 21 days following initial closed reduction compared to primary fixation within 7 days.

Conclusion: Patients with DRFs who wait longer than 3 weeks for surgical fixation following failed closed reduction appear to have a significantly higher odds of reoperation compared to those who undergo early primary fixation. These data suggest that patients with DRFs that are not amenable to closed reduction should be managed within 3 weeks to avoid detrimental outcomes. Prospective clinical studies are required to confirm these findings.

Δ OTA Grant

The Trajectory of Long-Term Recovery Following Open Reduction and Internal Fixation for Distal Radius Fractures

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Purpose: Distal radius fractures are common injuries. There has been a trend toward surgical treatment to improve patient outcomes. However, long-term studies evaluating the trajectory of recovery over time are lacking in the literature. Previous research on this injury has focused on the outcomes of open reduction and internal fixation (ORIF), yet most studies have drawn arbitrary end points to evaluate the success of this treatment. Trajectory studies help us understand the expected clinical course, which then inform prognosis and research planning.

Methods: Patients were enrolled between 2005 and 2013 in a prospective trauma database. All patients gave informed consent. Enrolled patients had a distal radius fracture treated by ORIF at a single Level I trauma center. Wrist function was assessed using the Patient-Related Wrist Evaluation (PRWE) score, with assessments performed at baseline, 6 months, 1 year, and 5 years. Medical comorbidities, ISS, age, and gender were also recorded. Proportionate change was assessed using minimal clinically important difference (MCID).

Results: 391 patients were recruited. Mean age was 51 years (range, 17-93); 67% were women. Mean pre-injury PRWE score at baseline was 1.3 (standard deviation [SD] 3.1). At 6 months the mean PWRE was 18.9 (SD 16.6, $P<0.001$). Substantive improvement was observed between 6 months and 1 year (1 year: 14.2 [SD 16.2], $P<0.001$). Although 23% of patients have at least an MCID between 6 months and 1 year, nearly half of patients are not within MCID from their baseline PRWE score at 1 year (39.5%). Improvement leveled off between 1 year and 5 years (8.9 [SD 13.4], $P<0.001$); however, 20% of patients did manage to achieve MCID improvements between 1 year and 5 years. At 5-year follow-up, PRWE scores remained statistically worse compared to baseline ($P = 0.01$), while 25% of patients were still at least 1 MCID from their baseline PRWE score.

Conclusion: The trajectory of recovery after ORIF for distal radius fractures showed an initial decline in PRWE scores after surgery, then an incline in trajectory with ongoing substantial disability at 6 months, followed by significant improvements up to 1 year. PRWE scores continued to improve between 1 year and 5 years, albeit to a lesser extent, as demonstrated by patients reporting MCIDs. Alas, there remains statistically and clinically relevant wrist disability at 5 years following ORIF for distal radius fractures.

Open Reduction and Internal Fixation of Multifragmentary Fractures of the Radial Head Does Not Lead to Worse Outcomes Compared to Arthroplasty

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Purpose: Current dogma states that open reduction and internal fixation (ORIF) of radial head fractures comprised of 3 or more fragments should be avoided due to high failure rates, and instead, these injuries should be treated with radial head arthroplasty (RHA). We hypothesized that ORIF would be associated with worse outcomes than RHA for multifragmentary radial head fractures.

Methods: The retrospective cohort study included adult patients with a radial head fracture comprised of 3 or more fragments treated with either ORIF or RHA at a Level I trauma center from 2007 to 2018. The primary outcome measure was unplanned return to the operating room for a complication including revision arthroplasty, loss of fixation, removal of hardware, ligament repair, nerve lysis, nonunion, or malunion. Secondary outcomes included range of motion and the presence of pain at the last follow-up. The association between treatment and the study outcomes was tested using generalized linear models, which controlled for age, comminution, dislocation, fracture type, Mason fracture type, and the number of radial head fragments.

Results: The study included 125 patients with radial head fractures comprised of 3 or more fragments, 80 treated with ORIF who were younger and more likely to be male (mean age, 43 years; 25% female) than the 45 treated with RHA (mean age, 61 years; 75% female; $P<0.05$). 19% of the ORIF patients experienced a postoperative complication requiring surgery compared to 17% of RHA patients (95% confidence interval [CI]: –21 to 14.5, $P = 0.72$). Only 1 patient experienced nonunion (1.3%), and 1 patient experienced malunion (1.3%) of the radial head requiring surgery in the ORIF group. Three patients (7%) in the RHA group had to undergo revision arthroplasty. The remaining reoperations in each group were related to removal of hardware, contracture, release, ligament repair, nerve lysis, or some combination of these issues. 65% of ORIF patients and 64% of RHA patients were able to achieve a >100° arc of forearm rotation at final follow-up ($P = 0.24$). Pain at the last follow-up was lower with RHA (47% vs 55%) but did not reach statistical significance ($P = 0.16$).

Conclusion: In contrast to existing dogma, we did not find that treatment with ORIF demonstrated worse outcomes than arthroplasty in terms of complications requiring surgery. This study provides additional data and indicates that clinicians should be aware that outcomes after RHA may not be superior to ORIF even in these comminuted fractures.

Percutaneous Fixation of Acute Scaphoid Waist Fractures: Long-Term Patient-Reported Functional Outcomes and Satisfaction at a Mean of 11 Years Following Surgery

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Purpose: There is a paucity of literature regarding the long-term outcomes of scaphoid fractures managed with acute percutaneous fixation. The aim of this study was to report the long-term functional outcomes and complication rates following early percutaneous fixation of acute fractures of the scaphoid.

Methods: A trauma database was searched to identify all skeletally mature patients with a scaphoid fracture managed with early percutaneous fixation over a 13-year period from 1997 to 2010. Medical records were retrospectively reviewed, and complications documented. Long-term follow-up was by a questionnaire-based review. The Patient-Rated Wrist Evaluation (PRWE) was the primary outcome measure. Secondary outcomes included the abbreviated version of the Disabilities of the Arm, Shoulder and Hand questionnaire (QuickDASH), the EuroQol 5-Dimensions 5-Level score (EQ-5D-5L), and complications.

Results: During the study period, 114 patients underwent this procedure. The mean age was 28 years (standard deviation [SD] 9; range, 17-62 years) and 97 patients (85%) were male. The median time from injury to surgery was 9 days (range, 1-27; interquartile range [IQR], 5-13 days). The mean time to radiographic union was 13 weeks (SD 7; range, 5-40 weeks). 12 patients (11%) reported a complication, all of whom required repeat surgical intervention (6 revision open reduction and internal fixation for nonunion, 5 elective removal of hardware, 1 acute revision fixation due to screw impingement). Long-term outcome data was available for 77 patients (68%) at mean follow-up of 11.4 years (range, 6.4-19.8 years). The median PRWE was 0 (IQR, 0-7.5), median QuickDASH 0 (IQR, 0-4.5) and median EQ-5D-5L 1.0 (IQR, 0.837-1.0). 97% of patients (n = 74) were satisfied with their outcome.

Conclusion: This study has demonstrated that early percutaneous fixation of acute nondisplaced or minimally displaced scaphoid fractures results in good long-term patient-reported outcomes and health-related quality of life. High patient satisfaction, along with return to work and physical activities, were also observed, with minimal morbidity and low overall pain scores.

Association of Preoperative Vitamin D Levels and Severity of Fracture Among Orthopaedic Trauma Patients in a Single, Tertiary-Level Hospital

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Purpose: The high prevalence of hypovitaminosis D among trauma patients has been related to conflicting reports on risk of fractures, falls, nonunion, and poor clinical outcomes after surgery. There is limited evidence that ties up vitamin D levels with fracture severity with specific fractures. The primary objective of this study is to determine the association of preoperative level of vitamin D and the fracture severity among adult trauma patients. No previous study used the AO classification to stratify fracture severity and related this to vitamin D levels at time of injury.

Methods: All patients operatively treated for extremity fractures with preoperative vitamin D levels were reviewed. AO classification was assigned to all fractures present at injury. Demographics, presence of osteoporosis, mechanism of injury, and comorbidities were obtained for each patient. Follow-up clinical and radiographic data and fracture union were all recorded.

Results: 96 patients with 104 surgically treated extremity fractures were included. Patients presenting with more severe fractures were associated with lower levels of vitamin D and higher prevalence of hypovitaminosis D compared to patients with less severe fractures ($\chi 2$ [4, N = 104] = 20.6, P<0.001). There was a strong, positive correlation between hypovitaminosis D and increasing fracture severity, which was statistically significant (rs [4] = 0.426, P<0.001). This association remains present in a subgroup analysis of patients without osteoporosis (P = 0.030), and in another subgroup of patients who sustained low-mechanism injuries (P<0.001). Union rate among our subjects is 97%.

Conclusion: Preoperative vitamin D level is associated with the severity of fracture as described in the AO classification sustained at the time of injury.

Δ The Effect of Cigarette Smoke Versus Vaporized Nicotine on Healing of a Rat Femur

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Purpose: Our objective was to characterize and compare the biomechanical, radiologic, and histologic changes that occur with femur fracture repair in an established Wistar rat model with vaporized nicotine ("vaping"), combusted tobacco, and controls.

Methods: 45 adult male Wistar rats were randomly divided into three cohorts (cigarette, vaping, and control), consisting of 15 rats each. Rats were exposed to either two unfiltered University of Kentucky 3R4F research cigarettes daily, an equivalent dose of vaporized nicotine, or placed into containment tubes for the same period of time as the exposures, 6 days a week. All rats received their daily exposures for 4 weeks prior to surgery where femurs were fractured and then repaired using Kirschner wire. Following surgery, the rats received 4 additional weeks of exposure. After sacrifice, femurs were harvested and imaged using micro-CT scans. Ten specimens from each cohort underwent biomechanical testing using a torsional, rotation-to-failure model. Remaining samples were sent for histologic analysis and graded and evaluated for union, spongiosa, compacta, inflammation, neovascularization, and necrosis.

Results: 42 rats completed 4 weeks of exposure after fracture and fixation. Micro-CT images revealed a significant difference between groups in mean bone mineral density (BMD) of mature bone ($P = 0.05$) with vaping having the highest value. Direct comparison of vaping and smoking groups for mean BMD of mature bone demonstrates increased density in the vaping group ($P = 0.04$). No significant difference between the three groups was identified for total callus volume ($P = 0.14$), total volume of immature bone ($P = 0.15$), mean BMD of immature bone ($P = 0.135$), or volume of mature bone ($P = 0.12$). Biomechanical testing revealed no significant difference with max torque ($P = 0.31$) or group torsional stiffness ($P = 0.92$) between the three groups. The smoking group had the highest maximum torque followed by the control and then the vaping group (0.24 Nm, 0.21 Nm, 0.20 Nm, respectively). For histology, $\chi 2$ analysis showed no significant difference in any category.

Conclusion: This study compared smoking cigarettes, vaping, and a control group by using CT scans, torsion testing, and histology. This animal fracture repair model found significance only in mean BMD of mature bone. No significant differences were seen in remaining CT imaging variables, biomechanical testing, or histology between the three groups. Larger studies must be completed for further understanding.

Δ OTA Grant

Does the Use of Locking Screws or Triceps Engagement Improve Resistance to Gapping in Small Olecranon Fragments?

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Purpose: Fixation of the olecranon must resist the pull of the triceps. Locking screw fixation in the displaced fragment and engagement of the triceps tendon using tines may improve fixation. We evaluated these two factors using a simulated in vivo cadaveric model.

Methods: 32 matched pairs of fresh-frozen, intact human cadaveric arms (age 59.7 ± 7.1 years) were used. After potting the distal humerus, high-tension cables were sutured directly to the triceps and brachialis tendons. A standardized OTA 21B1.1 transverse olecranon fracture was created in the posterior half of the joint yielding a small posterior fragment. Olecranon plates that have tines to engage the triceps and 2.7 locked screw holes in the proximal fragment were used. Four groups were evaluated. First, we divided the arms into Locked Screw (LS) and Nonlocked Screw (NS) groups (16 matched pairs each = 64 total limbs). For each pair, the tines were burred off the R or L side randomly. Screw trajectories were consistent through locking drill guides. Fragment fixation used only two 20-mm 2.7 locked or unlocked screws that did not lag the fracture site, simulating a worst-case scenario. Shaft screws were bicortical and unlocked. Simulated active motion was performed by driving the triceps and brachialis muscles using a custom, cable-actuator-driven robotic controller with real-time optical feedback (Optotrak Certus, NDI) of fracture gapping and motion. Dynamic fracture gapping data and applied triceps/brachialis loads were recorded during 200 flexion-extension cycles with forearm weight alone to assess physiologic function, followed by 30 cycles each with 1.25 lb, 2.5 lb, and 3.75-lb weights attached distally to assess supraphysiologic loading. Statistical data were analyzed using non-parametric Mann-Whitney U tests (α<0.05) using SPSS.

Results: Constructs with locked posterior screws demonstrated less gapping than unlocked screws irrespective of triceps engagement with tines (P<0.05). Tines with triceps engagement demonstrated less gapping in all conditions but fell short of statistical significance when unlocked screws were used, but not when locked screws were used.

Conclusion: In a cadaveric model of active motion after olecranon fracture fixation, locked posterior fixation performed better than unlocked fixation. Triceps engagement using tines was an advantage when unlocked screws were used posteriorly. We recommend the use of locking screws when limited fixation options are available for small olecranon fragments. When nonlocked screws are used in the olecranon, plates with tines may add to the stability of the fixation.

Intramuscular Compartment Pressures Do Not Correlate with Tissue Physiology After Tibia Fracture

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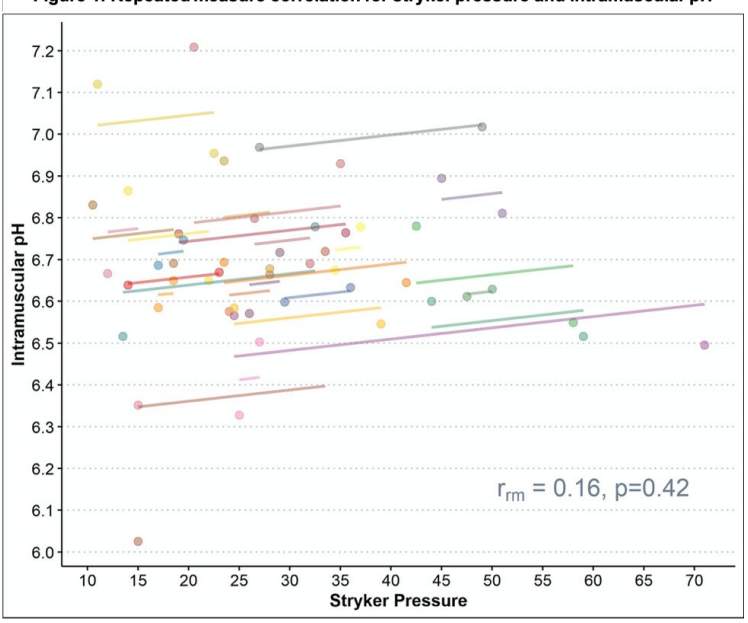
Purpose: Transcutaneous intramuscular pressure (TIMP) measurements are unreliable and prone to sentinel errors. Volumetrically intramuscular compartments are mostly filled with solids, making pressure measurements curious. Our purpose was to study the in vivo relationship between TIMP and intramuscular pH (IpH), a direct measure of muscular health.

Methods: Adults with acute tibia shaft and plateau fractures (Level I, academic, 2019-2021) were offered enrollment in an observational cohort. During operative stabilization (nailing/framing) a sterile validated IpH probe was placed into the anterior tibialis for 48 hours (continuous sampling). TIMP was measured at surgery start and end. TIMP and IpH were compared using a repeated measures correlation analysis; IpH values were extracted at 1-min averages matching TIMP timing. After informed consent patients received standard of care (independent research team; no study data available to treating surgeon).

Results: 25 patients with tibia fractures (9 plateau, 16 shaft) were observed. Starting and ending TIMP averaged 30.5 mm Hg (standard deviation [SD] 14.9) and 28.8 mm Hg (SD 12.4), respectively. 4 patients were clinically diagnosed with acute compartment syndrome (ACS) and fasciotomized. The average time from injury to surgery was 38.2 hours (SD 30.5). Starting and ending IpH was acidic and averaged 6.64 (SD 0.21) and 6.74 (SD 0.17), respectively. There was no correlation between TIMP and IpH ($r_{rm} = 0.16$, bootstrap 95% confidence interval [–0.05, 0.53], $P = 0.42$).

Conclusion: No correlation exists between TIMP measurements and direct measures of intramuscular physiology in the form of in vivo IpH; improvements in diagnostic modalities for muscular diagnoses such as compartment syndrome remain valuable.

Figure 1. Repeated measure correlation for stryker pressure and intramuscular pH



Lipidomic Analysis Shows Significant Changes in Circulating Di- and Triglycerides After Intramedullary Nailing in a Porcine Polytrauma Model With a Femur Fracture

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Purpose: Fat embolism is a recurring complication in patients with acute trauma and long bone fractures. Caused by the intravasation of bone marrow fat, it often occurs during intramedullary reaming and nailing. New methods of analyzing the circulating lipid profile are gaining attention in the field of trauma. Several lipid subgroups show high concentration in bone marrow fat. In this study, we investigated the posttraumatic and postinterventional Intravasation of 233 specific lipids in a well-established porcine polytrauma model with a femur fracture.

Methods: 54 male pigs (Swiss landrace) weighing 50 ± 5 kg underwent general anesthesia for 6 hours. Pigs were split in 3 groups: polytrauma (PT), monotrauma (MT), and sham (S). MT received an isolated femoral shaft fracture, while PT received an additional blunt chest trauma with lung contusion, a grade II (American Association for the Surgery of Trauma [AAST]) liver laceration and controlled hemorrhagic shock (mean arterial pressure [MAP] 30 ± 5 mm Hg for 60 minutes). After resuscitation, we used different means of intramedullary reaming and nailing (SynReam [SR], Reamer-Irrigator-Aspirator System [RIA], and introduction without reaming [NO]). Venous blood was taken regularly from baseline to 6 hours post trauma. Lipid concentrations and lipid composition were investigated using mass spectrometry. 233 specific lipids were analyzed.

Results: We organized lipids into 17 subgroups based on molecular characteristics. Total lipid concentration showed a significant ($P<0.01$) decrease after polytrauma and remained low over the course of observation. Di- and triglycerides (DAGs and TAGs) initially follow this trend but then show a significant increase right after intervention: 95.8 ± 52.4 to 235.2 ± 202.6 nM/mL ($P = 0.01$) and 241.5 ± 171.6 to 583.8 ± 620.9 nM/mL ($P = 0.036$). In MT, DAGs and TAGs show significant increases after fracture and remain elevated for 4 hours: 148.9 ± 63.6 (B) to 211.7 ± 77.7 nM/mL (2 hours) ($P<0.01$) and 366.4 ± 207.8 (B) to 552.8 ± 343.3 nM/mL (2 hours) ($P = 0.01$). SR and NO showed significant ($P<0.05$) increase of circulating DAGs and TAGs after intervention in every group (MT/PT/MT+PT), while RIA never did.

Conclusion: Our data clearly suggest significant changes to circulating lipid composition after trauma and treatment. Furthermore, we showed a significant decrease of intravasation of DAGs and TAGs by using RIA. Lipidomic analysis in our standardized porcine polytrauma model helps understand the role of lipids in acute trauma, treatment, and complications. Collation with data from the clinical setting is needed.

Δ Comparing BMP-2 Versus PDGF for the Treatment of Bone Defects in a Small Animal Model

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Purpose: Bone defects and nonunion continue to be challenging to treat. Consequently, innovations in the use and application of growth factors have been developed in an attempt to improve the rates of bone regeneration and healing. Two molecules of interest, bone morphogenetic protein-2 (BMP-2) and platelet-derived growth factor-BB (PDGF-BB) have been incorporated into commercially available delivery systems designed to improve bony union. Although evidence exists for their individual potency, their comparative efficacy is unknown. We therefore sought to evaluate their individual and relative effectiveness for the management of nonunions utilizing a critical-sized bone defect model.

Methods: Adult male rats had a 5-mm defect created in the right femur, stabilized with a mini-plate and screws, with the defect treated as follows. Animals were randomly assigned to 1 of 5 groups (n = 10 per group): control group: no treatment; PDGF-BB carrier group (n = 9): β-tricalcium phosphate (β-TCP) carrier; BMP-2 carrier group: absorbable collagen scaffold (ACS) carrier; PDGF-BB treatment group: β-TCP carrier with PDGF-BB; and BMP-2 treatment group: ACS with BMP-2. Radiographic assessment was performed at 10 weeks to compare rates of union and degree of healing within the defect using a standardized radiographic scoring system. Pairwise comparisons were made for observed rates of union between groups using Fisher's exact tests. One-way analysis of variance (ANOVA) with Tukey's post-hoc test was used to compare radiographic scores.

Results: BMP-2 treatment significantly improved healing relative to controls and all other treatment groups ($P<0.05$). Notably, 100% of all animals with BMP-2 treatment achieved full union, while only 20% of those with PDGF-BB treatment achieved radiographic union. This difference was statistically significant ($P<0.0001$). One-way analysis of variance demonstrated statistically significant differences in radiographic union scores in favor of BMP-2 treatment over controls (7.1 ± 0.32 vs 3.95 ± 2.27, $P = 0.0008$), BMP-2 treatment over PDGF-BB carrier (7.1 ± 0.32 vs 4.5 ± 1.73, $P = 0.0097$), and BMP-2 treatment over PDGF-BB treatment (7.1 ± 0.32 vs 4.6 ± 1.51, $P = 0.011$).

Conclusion: Our results demonstrated that BMP-2 treatment (ACS + BMP-2) is superior to PDGF-BB treatment (PDGF-BB + β-TCP) for inducing healing in a small animal model of fracture nonunion using a critical-sized defect. Further investigation of these powerful proteins with basic science and clinical studies across a variety of trauma applications is warranted.

Radiographic Union Rates

	Nonunion/Partial Union	Union
Control group	90% (9)	10% (1)
PDGF-BB carrier group	89% (8)	11% (1)
PDGF-BB treatment group	90% (8)	20% (2)
BMP-2 carrier group	50% (5)	50% (5)
BMP-2 treatment group	0% (0)	100% (10)

Δ OTA Grant

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Medial Plating of Pilon Fractures Is Predictive of Postoperative Soft-Tissue Complications

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Purpose: Pilon fractures are associated with significant soft-tissue injury and complications. The medial border of the distal tibia is subcutaneous and often the site of soft-tissue injury. The objective of this study was to assess the link between the application of distal tibial plates for pilon fracture fixation and soft-tissue complications requiring either nonoperative medical management or surgical management. We hypothesize that the application of medial plating for the fixation of pilon fractures is associated with an increased risk of overall soft-tissue complications and of those requiring subsequent surgical intervention.

Methods: This was a retrospective analysis of prospectively collected data on patients with a pilon fracture treated with open reduction and internal fixation at a Level I trauma center (2011-2017). Logistic regression was performed to determine the association between medial plating and (1) the incidence of soft-tissue complications and (2) the incidence of soft-tissue complications requiring surgical intervention. We controlled for other independent variables by introducing them into the regression model. Other independent variables introduced into the model included presence of open fracture, smoking status, diagnosis of diabetes, and radiological injury classification. Soft-tissue complications were defined as any documented wound or skin problems including hardware irritation resulting in hardware removal. We calculated the Cox and Snell r2 as a measure of the percentage of the explained variation. Significance was set at $P < 0.05$.

Results: The study included 168 patients, 165 of whom had full data with an average follow-up of 14.5 months. The incidence of soft-tissue complications was 29% (n = 48), while 23% (n = 39) required surgical treatment. Predictors of soft-tissue complications were (1) presence of open fracture (odds ratio [OR] 4.750, 95% confidence interval [CI] 2.060-10.950, $P < 0.001$), (2) smoking (OR 2.866, 95% CI 1.224-6.713, $P = 0.015$), and (3) medial plating (OR 2.619, 95% CI 1.033-6.641, $P = 0.042$). The r2 value was 0.18. Predictors of soft-tissue complications requiring surgical intervention were (1) presence of open fracture (OR 2.879, 95% CI 1.212-6.838, $P = 0.017$) and (2) medial plating (OR 4.167, 95% CI 1.401-12.389, $P = 0.010$). The r2 value was 0.14. Both models controlled for other independent variables.

Conclusion: The use of medial plating and the presence of an open pilon fracture were associated with an increased odds ratio of any soft-tissue complications, as well as those requiring surgical treatment. Although smoking was associated with an increased OR of postoperative soft-tissue complications, it did not predict a higher reoperation rate. We recommend careful consideration of the value of using a distal tibia medial plate, particularly in the presence of an open pilon fracture.

Simultaneous Posterolateral and Posteromedial Approaches for Posterior Pilon Fractures: A Safe Technique for Effective Reduction and Fixation

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Purpose: The posterior pilon fracture variant involves an injury to the entire posterior tibial plafond. This injury pattern is unique compared to a typical posterior malleolar fracture because the coronal plane fracture line extends medially to involve the posterior colliculus of the medial malleolus. The purpose of this study was to determine short-term outcomes in a series of patients treated with combined posteromedial and posterolateral approaches. We hypothesized that this technique would have a low rate of wound complications, and result in accurate articular reductions. Additionally, we sought to understand the role of mechanism of injury on fracture characteristics, and hypothesized that patients who sustained fractures as a result of a high-energy mechanism would have a higher rate of posteromedial impaction and syndesmosis injury.

Methods: A retrospective review was designed using the trauma database at a single Level I academic trauma center. Patients treated operatively from 2000 to 2019 for a posterior pilon fracture using dual posteromedial and posterolateral approaches were identified. Outcome measures were identified, including: (1) rate of wound complications and the accuracy of the articular reduction, and (2) fracture characteristics including the incidence of articular impaction, comminution interfering with reduction, syndesmosis injury, and the type of fibula fracture. To determine the association between mechanism of injury and fracture characteristics, patients were grouped into low (ground level event) or high (fall from height or motorized vehicle) energy cohorts. The presence of a syndesmosis injury requiring fixation, articular impaction, comminution preventing a reduction, and fibular fracture patterns were compared between these groups.

Results: 33 patients with 3-month minimum follow-up were included in the study. The rate of wound problems was low (6%), and 94% of patients had an articular reduction with <1 mm of step or gap. There were high rates of articular comminution (83%) and posteromedial articular impaction (63%), and a 17% rate of syndesmosis injury requiring repair. There were 24 patients with low-energy mechanisms and 9 with high-energy mechanisms. There were no differences in the rates of syndesmosis injury requiring fixation, articular impaction, reduction-blocking comminution, or type of fibula fracture between these 2 groups.

Conclusion: Surgical fixation using simultaneous, combined posterolateral and posteromedial approaches for posterior pilon fractures had a low rate of wound complications and was an effective strategy for obtaining an accurate reduction. The rate of syndesmotic instability requiring fixation was lower than previous work reporting on fixation using a single approach. This may be a useful technique for surgeons who treat these injuries. Careful assessment of the preoperative imaging is required in patients with posterior pilon fracture, even in those with low-energy mechanisms.

Posttraumatic Avascular Necrosis in Talar Neck Fractures with Extension Into the Talar Body

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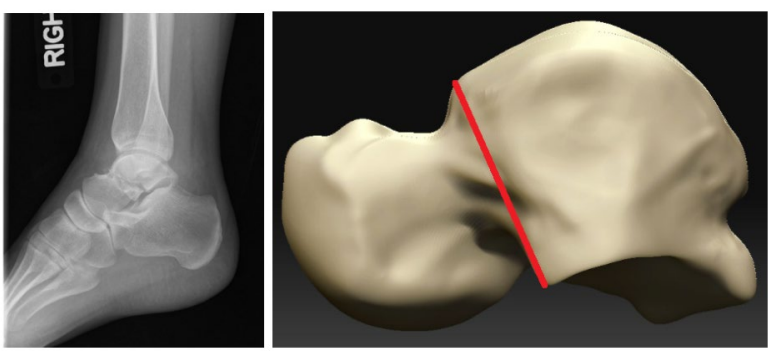
Purpose: The significance of a talar neck fracture with proximal extension into the body has not been well described. The purpose of this study was to determine if a talar neck fracture with a fracture line extending proximal into the talar body is associated with increased rates of avascular necrosis (AVN).

Methods: Retrospective review of 138 fractures in 129 patients from 2008 to 2016 was performed. Fractures were characterized as isolated talar neck fractures (TN) or talar neck fracture with proximal extension into the body (TNPE). We identified a line from the anterior aspect of the talar body to the anterior aspect of the lateral talar process defining the neck-body junction. Fractures that originated on the talar neck and extended proximal to this line were characterized as having proximal extension (see figure). Fractures were classified according to the Hawkins classification as modified by Canale and Kelly, and Vallier for analysis. Patient demographics and follow-up radiographs were analyzed for the presence of union/nonunion, AVN, and collapse. Secondary outcomes were to determine if time to reduction, time to surgery, age, sex, open versus closed fracture, patient smoking, or diabetes affected rates of AVN.

Results: There were 82 fractures in the TN group and 56 in the TNPE group with a mean follow up of 14.5 months (median, 9.5 mo). 43 fractures developed AVN (31.2%). 27 fractures in the TNPE group (48%) were found to have AVN, which was found to be significant (P = 0.0007) when compared to 16 (19.5%) from the TN group. Additionally, proximal extension into the body was statistically significant for subsequent collapse after AVN as 8 of 11 patients in this study with AVN and collapse had proximal extension into the body (P = 0.05).

Conclusion: Talar neck fractures with proximal extension into the talar body are at a higher risk of AVN and AVN with subsequent collapse compared to isolated fractures of the talar neck.



A. Lateral XR depicting a talar neck fracture with proximal extension
B. Schematic demonstrating the line defining proximal extension; subtending from the anterior aspect of the talar body to the anterior aspect of the lateral talar process

Weight-Bearing CT Can Effectively Diagnose Syndesmotic Instability in Patients with Weber B Ankle Fractures

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Purpose: Diagnosing syndesmotic instability accompanying Weber B ankle fractures is critical toward optimizing clinical outcome. We aimed to evaluate the diagnostic sensitivities of distances, area, and volumetric measurement of the injured syndesmotic joint on weight-bearing CT (WBCT) among patients having unilateral Weber B ankle fractures with surgically confirmed syndesmotic instability.

Methods: Patients with unilateral surgically confirmed syndesmotic instability accompanying type B malleolar fracture (n = 24) having preoperative bilateral ankle WBCT were included in the patient group. A separate group of patients with unilateral Weber B ankle fractures without syndesmotic instability confirmed operatively and having similar imaging were included as controls (n = 18). With the uninjured side serving as an internal control, measurements included: (1) syndesmotic area; (2) distances between the anterior, middle, and posterior quadrants within the incisura; (2) fibular rotation; (3) fibular length; (4) fracture displacement; (5) syndesmotic joint volume from the tibial plafond extending until 3 cm and 5 cm proximally; and (6) medial and lateral clear space volume.

Results: Among patient groups, all WBCT measurements except syndesmotic area as well as anterior and posterior difference within the incisura were increased on the injured as compared to the uninjured side (*P* values <0.001 to 0.004). Of these measurements, syndesmosis volumetric measurements spanning until 3 cm and 5 cm proximally had the highest relative ratio between the injured and uninjured side (*P* values = 0.001 to 0.036). In the control group, all WBCT parameters except for medial clear space volume showed no differences between the 2 sides.

Conclusion: WBCT scan can effectively diagnose syndesmotic instability among patients with Weber B ankle fractures. Syndesmosis volumetric measurements seem to be best suited to diagnose subtle instability compared to other WBCT measurements.

Table 1. Bilateral differences in weightbearing CT measurements in the patient group.

Measurement	Patient group (n=24)		Difference between the injured and uninjured ankle	95% CI	Median Ratio (IQR)*	p-value
	Injured side (mean ± SD)	Uninjured side (mean ± SD)				
Syndesmosis volume up to 3cm above TP (cm^3)	5.9±1.2	4.3±0.8	1.6	[1.2-2.1]	1.4 (1.2-1.4)	< 0.001
Syndesmosis volume up to 5cm above TP (cm^3)	12.7±2.1	9.2±1.1	3.5	[2.9-4.1]	1.4 (1.3-1.5)	< 0.001
MCS volume (mm^2)	677.9±165.2	547.3±145.2	130.6	[105.4-155.8]	1.3 (1.1-1.3)	< 0.001
LCS volume (cm^3)	3.6±0.9	3.0±1.0	0.6	[0.7-6.4]	1.2 (1.1-1.3)	< 0.001
Syndesmotic area (mm^2)	117.3±23.0	109.2±23.3	8.1	[-0.5-16.6]	1.1 (1.0-1.2)	0.07
Anterior difference within the incisura (mm)	4.5±1.8	4.4±0.9	0.1	[-0.7-0.9]	1.0 (0.7-1.2)	0.77
Middle difference within the incisura (mm)	4.4±1.0	3.7±0.7	0.7	[0.4 – 1.1]	1.2 (1.0-1.4)	< 0.001
Posterior difference within the incisura (mm)	9.6±2.5	9.0±1.3	0.6	[-0.5-1.8]	1.1 (0.9-1.2)	0.25
Fibular rotation (degrees)	13.2±4.4	10.3±3.7	2.9	[2.2-3.7]	1.3 (1.2-1.4)	< 0.001
Fibular length (mm)	22.5±2.5	24.9±2.8	2.4	[1.8-3.0]	0.9 (0.8-1.0)	< 0.001
Navicular to floor distance (mm)	26.9±6.3	25.2±5.9	1.7	[0.6-2.9]	-	0.004

Abbreviations: WBCT, weightbearing computed tomography; MCS, medial clear space; LCS, lateral clear space; TP, tibial plafond; SD, standard deviation; IQR, Interquartile range.
* Ratio: WBCT measurements in injured ankle/contralateral uninjured ankle

Potential Benefits of Limited Clinical and Radiographic Follow-up After Surgical Treatment of Ankle Fractures

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Purpose: Ankle fractures are one of the most prevalent musculoskeletal injuries, with a significant number requiring surgical treatment. Postoperative complications requiring further interventions frequently occur during the early postoperative period. We hypothesize that there is a limited need for routine clinical and radiographic follow-up once the fracture is deemed healed.

Methods: IRB approval was obtained at 4 academic trauma centers. A retrospective chart review was performed to identify adults with uncomplicated healed unimalleolar and bimalleolar ankle fractures treated surgically with at least 12 months of follow-up. Based on postoperative radiographs, changes in fracture alignment and implant position from radiographic union to final follow-up were documented. The average reimbursement for a final follow-up clinic visit and a set of ankle radiographs were estimated.

Results: A total of 141 patients met inclusion criteria. The mean age at injury was 49.5 years and 67.4% of subjects were female. The mean time to healing was 82 (±33) days. After radiographic healing, 2 patients had radiographic changes; both were asymptomatic and were full weight-bearing at their final follow-up. On average, our institution was reimbursed $46 to 49 for a follow-up clinic visit and $364 to $497 for a set of ankle radiographs.

Conclusion: Given the average time to healing, there is limited utility in routine radiographic and clinical follow-up beyond 16 weeks in asymptomatic patients. In our series, this would result in a savings of $950 to $1200 per patient. However, after ankle fractures were deemed healed, 1.4% of the patients had radiographic evidence of either changes in the fracture alignment or implant position. Documenting these changes did not modify the immediate course of fracture treatment. Surgeons will need to balance the need for routine follow-up with the potential economic benefits in reducing costs to the healthcare system.

Demographics	
Age, mean	49.5
Gender, N (%)	
Male	46 (32.6%)
Female	95 (67.4%)
Smoking, N (%)	37 (26.2%)
Diabetes, N (%)	21 (14.9%)
Fracture Characteristics	
Right, N (%)	80 (56.7%)
Left, N (%)	61 (43.3%)
Mechanism of Injury	
Fall, N (%)	71 (50.4%)
Twist, N(%)	35 (24.8%)
MVC, N (%)	20 (14.2%)
MCC, N (%)	4 (2.8%)
Sports, N (%)	2 (1.4%)
Other, N (%)	7 (5.0%)
Treatment	
Medial Malleolus	
Not Fractured, N (%)	33 (23.4%)
Not Fixed, N(%)	21 (14.9%)
Lag Screw, N (%)	60 (42.6%)
Buttress Plate, N (%)	5 (3.5%)
Tension Band, N (%)	2 (1.4%)
Other Fixation, N(%)	5 (3.5%)
Lateral Malleolus	
Not Fractured, N (%)	14 (9.9%)
Lateral Neutralization Plate, N (%)	40 (28.3%)
Lateral Compression Plate, N (%)	31 (22.0%)
Lateral Bridging Plate, N (%)	12 (8.5%)
Lateral Buttress plate, N (%)	18 (12.8%)
Posterolateral Buttress Plate, N (%)	20 (14.2%)
Other Fixation, N (%)	3 (2.1%)
Time to Surgery in Days, Mean	5.6
Time to Healing in Days, Mean	82
Time to Last Follow-up in Days, Mean	991.6

Ankle Fractures: No Correlation Between High Implant Cost and Better Patient-Reported Outcomes

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Purpose: The purpose of this study was to determine whether there is a relationship between increasing implant cost and patient-reported outcomes (PROs).

Methods: All ankle fractures treated with open reduction and internal fixation (ORIF) at a Level I academic trauma center from January 2017 to June 2019 were identified. Inclusion criteria included a minimum 3-month follow-up and complete PRO. Patients were excluded for polytrauma or open fracture. Variables assessed included demographics, OTA and Weber classifications, Foot and Ankle Ability Measure-Activities of Daily Living (FAAM-ADL) score, implant type, and implant cost. Implant cost was determined by cross-referencing implant model numbers across all institutions' charge-master database. Statistical analysis included a primary review of the study population, two- and multi-group comparisons consisting of t and rank sum tests, 1-way analysis of variance, Spearman rank correlation, and multivariate linear regression.

Results: A total of 125 ankle fracture surgical encounters were included in this investigation. The patient sample was predominantly female (n = 76, 60.8%). The mean patient age was 53.0 + 16.8 years. When stratified by fracture classification, the primary AO/OTA class was 44B, 91 (72.8%), and Weber class was B, 91 (72.8%). The most common fracture pattern was trimalleolar, 72 (57.6%), with a mean FAAM-ADL score of 70.6 + 19.5. Bimalleolar fractures, 41 (32.8%), had a mean score of 69.1 + 21.3. The remaining isolated malleolar fracture patients, 12 (9.6%), had a mean score of 86.0 + 15.3. The average total implant cost was $793.0 + $574.6 (range, $18.20-$2564.80). Differences in total implant cost were not significant across either OTA ($P = 0.075$) or Weber ($P = 0.336$) fracture classifications. Implant cost was greatest among OTA 44C and Weber C fractures, $931.70 + $645.70. No relationship was found between the total implant cost and the 3-month (Rs = –0.04; $P = 0.65$) FAAM-ADL clinical outcome scores.

Conclusion: The value of ankle ORIF is ripe for review given the growing focus on the cost of health care and the high prevalence of ankle fractures. PROs provide a reliable means of assessing the efficacy of surgical interventions in the ankle to promote patient-centric, data-driven care. This study is the first to directly examine whether the cost of ankle implant fixation influences PROs. The utilization of higher-cost ankle fixation does not correlate with better PROs. Consequently, orthopaedic surgeons may choose less expensive implants to improve the value of ankle fixation without impacting patient outcomes.

Complex Ankle and Distal Tibial Fracture Management: A National Observational Cohort Study of Short-Term Outcomes Following Operative Fixation Including Primary Hindfoot Nailing

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Purpose: There is no clear consensus regarding the best operative management for complex ankle and distal tibial fractures (AO44/43). Certain patient and fracture characteristics favor hindfoot nail technique (HFN) over other internal fixation or external fixation. Reported advantages of HFN include less soft-tissue dissection and early weight bearing at the expense of range of movement. Short-term outcomes for patients managed with HFN and standard or extended open reduction and internal fixation (ORIF; eg, fibula pro-tibial screws) were compared, as well as usage of HFN, patient factors, and comorbidities associated with these techniques.

Methods: This national collaborative study evaluated patients from January 1, 2019 to June 30, 2019. Inclusion criteria included adult patients with open/closed complex AO44 and AO43 in addition to the following patient factors: diabetes, neuropathy, rheumatoid arthritis, alcoholism, polytrauma, and cognitive impairment. Retrospective data were obtained from operative notes and trauma databases on comorbidities, American Society of Anesthesiologists class (ASA), clinical frailty score (CFS), fixation choice/technique, weight-bearing status, and patient outcomes: wound breakdown, infection, venous thromboembolism, further procedure, and removal of metalwork. Institutional approval was obtained at each center. Statistical analysis included propensity matching using SPSS.

Results: 56 centers provided data for 1360 fractures, 1222 were managed definitively with ORIF or HFN. 292 patients (23.9%) had diabetes and 229 (22.8%) were >65 years. Most fractures were AO44 (922 [75.45%]), median follow-up was 7.8 months (range, 1.2-12). 111 (9.1%) were managed using HFN, 1111 (90.9%) with ORIF, 43 (4%) underwent extended ORIF. After ORIF, 92 (8.3%) had wound infection, 66 (6.0%) wound breakdown, compared with 9 (8.1%) for both after HFN. Propensity matching for ASA and CFS showed only deep vein thrombosis/pulmonary embolism (DVT/PE) were more common in HFN than ORIF. Analysis of surgical technique showed higher postoperative complication rates in HFN fusion group (18 of 39 [46.2%]) compared to 3 of 72 (4.2%) HFN fixation without fusion. The majority of patients were instructed not to weight-bear postoperatively. After HFN, 35.1% were non-weight-bearing (NWB), 34.2% fully weight-bearing (FWB), and 30.6% partial weight-bearing (PWB). Following ORIF, 88.0% were NWB, 4.3% FWB, and 7.7% PWB.

Conclusion: This large dataset collected by a research collaborative provides Level-II data on the management of complex ankle fractures. Short-term complication rates were similar in those managed with ORIF or HFN; there was a trend toward higher complications in HFN with joint fusion. Our pragmatic study shows surgeons were cautious with postoperative weight-bearing instructions, even in patients managed with HFN. The role of HFN needs to be further defined—balancing weight bearing, postoperative complications, and functional needs in a challenging patient group.

Δ Four-Dimensional CT Analysis Confirms the Importance of Ankle Position When Assessing Syndesmotic Position

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Purpose: The syndesmosis ligament complex stabilizes the distal tibiofibular joint, while still allowing physiologic motion. This syndesmotic motion is important to maintain joint congruity through ankle range of motion (ROM). Syndesmosis injuries occur in 25% of ankle fractures. When injured, malreduction of the syndesmosis is the most important factor contributing to inferior functional outcomes. Syndesmotic reduction is a dynamic measure, which is not adequately captured by conventional CT. Four-dimensional CT (4DCT) can image joints as they move through ROM in real time. Our aim was to employ 4DCT to determine in vivo syndesmotic motion with ankle ROM in uninjured ankles.

Methods: Uninjured ankles were analyzed in patients with contralateral syndesmotic injuries, as well as healthy volunteers with bilateral uninjured ankles. Bilateral ankle 4DCT scans were performed as participants moved their ankles between maximal dorsiflexion and plantar flexion, capturing 10 time points through ankle ROM. Multiple measures of syndesmotic width, including anterior, middle, and posterior syndesmotic distances, tibiofibular clear space, and tibiofibular overlap, as well as sagittal translation, fibular rotation, and syndesmotic area were automatically extracted from 4DCT to determine the change in syndesmotic position with ankle ROM. Linear mixed-effects models determined syndesmotic motion with ankle ROM, while side-to-side variability was assessed with linear regression.

Results: 58 ankles were analyzed from 39 patients (24 males and 15 females). Mean ankle ROM was 46°. As ankles moved from dorsiflexion to plantar flexion, measures of syndesmotic width decreased by 0.7 to 1.1 mm ($P<0.001$ for each measure). The fibula externally rotated by 1.2° with ankle ROM ($P<0.001$), but there was no significant motion in the sagittal plane ($P = 0.43$). Syndesmotic area decreased by 21% ($P<0.001$). No participants with bilateral uninjured ankles had a side-to-side difference in syndesmotic width of 2 mm or greater.

Conclusion: There is substantial syndesmotic motion during ankle ROM, thereby impacting common measures of reduction. It is important to appreciate and standardize foot position when imaging or reducing the syndesmosis in order to optimize patient outcomes. Syndesmotic position and motion are consistent within subjects; therefore the contralateral ankle may be used to template for anatomic reduction, provided ankle position is standardized. Consideration should also be given to restoring motion, as well as position, after syndesmotic injuries. A syndesmosis rigidly fixed in dorsiflexion may be undercompressed, resulting in abnormal diastasis, and may result in excessive fibular external rotation. Conversely, fixation in plantar flexion may produce overcompression of the syndesmosis and excessive internal rotation of the fibula.

Δ OTA Grant

Recovery Curve for Patients with Pilon Fractures Using Patient-Reported Outcomes Measurement Information System (PROMIS)

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Purpose: The morbidity associated with pilon fractures is significant and has been well documented. However, the time frame in which patients can expect functional improvement is unclear. This information is important for both the patient and the surgeon to know in order to manage expectations post-injury.

Methods: Patients were reviewed retrospectively over a 5-year (2015-2020) period. All patients who suffered a unilateral, isolated pilon fracture were identified by CPT codes (27826-8). PROMIS Physical Function (PF) scores were collected and grouped by follow-up interval. Average PROMIS PF scores and 95% confidence intervals were calculated.

Results: There were 160 patients with PROMIS scores immediately postoperatively, 143 patients at 6 weeks, 146 patients at 12 weeks, 97 at 24 weeks, 84 at 1 year, and 45 at 2 years postoperatively. The average PROMIS PF score immediately postoperative was 28, at 6 weeks it was 30, at 12 weeks it was 36, at 24 weeks it was 40, at 1 year it was 41, and at 2 years it was 39 (Figure 1). There was a significant difference between PROMIS PF scores between 6 weeks and 12 weeks (P<0.001), and between 12 weeks and 24 weeks (P<0.001). Otherwise, no significant differences were noted between consecutive time points.

Conclusion: Patients with pilon fractures demonstrate the majority of their improvement in terms of physical function between 6 weeks and 6 months postoperatively. There was no significant difference in PF scores after 6 months postoperatively up to 2 years. Furthermore, the mean PROMIS PF score of patients 2 years after recovery was approximately one standard deviation below the population average. This information is helpful in counseling patients and setting expectations for recovery after pilon fractures.

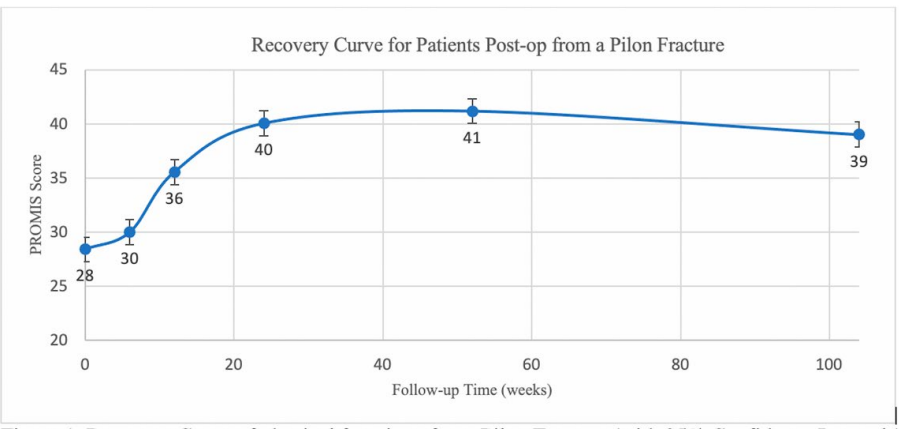

Figure 1: Recovery Curve of physical function after a Pilon Fracture (with 95% Confidence Intervals)

Syndesmotic Injury in Tibial Plafond Fractures Is Associated with Worse Patient Outcomes

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Purpose: Syndesmosis or syndesmotic equivalent injuries occur in 15% of tibial plafond injuries. In rotational ankle fractures, patients with associated syndesmosis disruption are reported to have inferior clinical outcomes compared to ankle fracture patients without syndesmosis disruption. The purpose of this study was to compare postoperative complications and patient-reported outcomes between tibial plafond fracture patients with and without syndesmotic injury.

Methods: All skeletally mature patients with a tibial plafond fracture (OTA 43-B and OTA 43-C) treated at an academic Level I trauma center from 2010-2019 with a minimum of 12 months of follow-up were retrospectively reviewed. Syndesmotic injury was based on a positive intraoperative manual stress examination and evidence of reduction and fixation of the syndesmosis at the time of injury. Patients completed Patient-Reported Outcomes Measurement Information System (PROMIS) physical function (PF) and pain interference (PI) outcome measures at final follow-up. Statistical analysis was performed using $\chi 2$ for categorical variables and Wilcoxon rank sum test for continuous variables.

Results: 174 patients met study criteria, including 46 patients with a syndesmotic injury and 128 patients without a syndesmotic injury. Mean follow-up was 63 months (range, 12-125 months). Demographics including gender, tobacco use, body mass index, and follow-up were similar between cohorts. The cohort with syndesmotic injury had significantly older patients (48 years vs 41 years, $P = 0.01$) and more open fractures (17 of 46 fractures vs 19 of 128 fractures, $P = 0.001$). Patients with syndesmotic injury had higher rates of postoperative infection (syndesmosis injury = 15.2%, no syndesmosis injury = 8.6%, $P = 0.2$) and nonunion (syndesmosis injury = 13.0%, no syndesmosis injury = 10.2%, $P = 0.59$), but these were not statistically significant in this cohort size. Patients with syndesmotic injury had significantly more ankle fusions (10 of 46, 22%) than patients without syndesmotic injury (11 of 128, 8.6%) ($P = 0.02$). Patients with syndesmotic injury had significantly worse PROMIS PF scores (44.3, standard deviation [SD] = 7.78) as compared to patients without syndesmotic injury (47.4, SD = 9.52) ($P = 0.04$). There was no difference in PROMIS PI scores between patients with syndesmotic injury (53.4, SD = 8.87) compared to those without syndesmotic injury (52.8, SD = 9.41) ($P = 0.61$).

Conclusion: Patients with a tibial plafond fracture and syndesmotic injury had significantly more ankle fusions and had worse PROMIS PF scores. A syndesmotic injury in the setting of a tibial plafond fracture may be an indicator of high-energy injury and seems to portend worse patient outcomes.

Posterior Talar Dome Accessibility: Comparing Posteromedial Approaches

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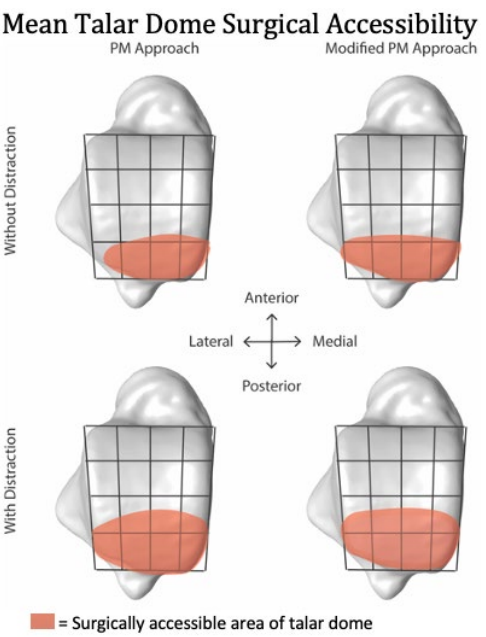
Purpose: Posterior talar body fractures are rare injuries without a consensus surgical approach. This study evaluates the accessible area of the talar dome through two posteromedial approach intervals (posteromedial, PM; and modified posteromedial, mPM) both with and without distraction.

Methods: Ten male cadaveric legs (5 matched pairs) were included. A PM approach, between flexor hallucis longus (FHL) and tibial neurovascular bundle, and a mPM approach, between FHL and Achilles tendon, was performed on each pair. 5 mm of distraction through the tibiotalar joint was applied via an external fixator with the foot held in neutral flexion. Accessible dome surface area (DSA) was outlined by drilling with a 1.6-mm Kirschner wire with and without distraction. Specimens were explanted and analyzed by micro-CT with 3-dimensional reconstruction. Primary outcomes were total accessible DSA and sagittal plane access at predetermined intervals.

Results: The PM approach allowed access to 19.1% of the talar DSA without distraction and 33.1% of the talar dome with distraction ($P<0.001$). The mPM approach provided access to 20.4% and 35.6% of the talar DSA without and with distraction ($P<0.001$) (Fig. 1). The PM approach allowed similar access to the talar dome as did the mPM approach both with ($P = 0.39$) and without distraction ($P = 0.55$). Both approaches demonstrated similar sagittal plane access at all intervals except the lateral border of the talus, where the mPM approach provided greater access both without distraction (20.5% vs 4.38%, $P = 0.001$) and with distraction (34.3% vs 17.8%, $P = 0.02$).

Conclusion: The mPM approach provides equivalent access to the posterior talar body relative to the PM approach. The mPM interval provides the advantage of avoiding dissection of the tibial nerve or posterior tibial artery and should be utilized based on the current data. Using an external fixator for distraction can be used to improve talar dome visualization by greater than 70%.



Direct Versus Indirect Fixation of the Posterior Malleolus in Trimalleolar Ankle Fractures: A Multicenter Cohort Comparison Study

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Purpose: The purpose of this paper is to examine the differences in functional outcomes between direct versus indirect surgical fixation methods of the posterior malleolus in the setting of trimalleolar fractures and identify any variables that affect patient satisfaction.

Methods: This was a multicenter retrospective cohort study of patients who underwent open reduction and internal fixation for a diagnosis of trimalleolar ankle fracture. Direct fixation of the posterior fragment was compared to indirect fixation. The primary outcome was PROMIS (Patient-Reported Outcomes Measurement Information System) scores for total pain and total function postoperatively. 117 patients were identified. The final study cohort consisted of 40 patients in the direct fixation group (D) and 77 in the indirect fixation group (I). The groups did not differ in terms of age or gender ($P = 0.12$ and $P = 0.12$) but did differ in terms of body mass index (BMI) and presence of comorbidities ($P = 0.03$ and $P = 0.03$). To compare between groups, continuous variables were analyzed using independent t tests for parametric variables and Mann-Whitney U test for nonparametric variables. Categorical variables were analyzed using a $\chi 2$ test. Statistical significance was set at $P<0.05$. A univariate and multivariate linear regression model was performed to analyze which factors might affect the outcomes of Total Pain and Total Function.

Results: There was no difference in total pain between groups (D = 47.9, I = 48.7, $P = 0.65$) or total function D=47.0 I=44.5, $p=0.19$. On univariate linear regression model for total pain, BMI, incidence of complication, tobacco use, and open injury all were significant. These factors increased pain levels with open injuries providing the greatest amount of additional pain (coefficient [c] = 11.8, $P = 0.01$). Variables that qualified for multivariate analysis included Workers› Compensation, diabetes, and tourniquet time ($P<0.2$). On multivariate analysis BMI (c = 0.27, $P = 0.02$), incidence of complication (c = 3.92, $P = 0.05$), open injury (c = 13.22, $P = 0.003$), and tourniquet time (c = 0.05, $P = 0.008$) were all significant. For total function, univariate analysis showed age (c = –0.15, $P = 0.006$), BMI (c = –0.30, $P = 0.04$), incidence of complication (c = –6.28, $P = 0.02$), diabetes (c = –6.14, $P = 0.04$), use of external fixator (c = 5.48, $P = 0.02$), and tourniquet time (c = 0.06, $P = 0.001$) all were significant. Factors that qualified for multivariate analysis included sex, open injury, and presence of comorbidity. In the multivariate model, increased BMI (c = –0.31, $P = 0.03$), open injuries (c = –12.62, $P = 0.02$), and increasing tourniquet time (c = –0.06, $P = 0.005$) all decreased postoperative function while use of an external fixator increased postoperative function (c = 6.91, $P = 0.003$). Fixation type was not statistically significant for pain or function scores in our regression.

Conclusion: This study showed no difference in total pain and function utilizing the PROMIS outcome scores when comparing direct versus indirect fixation under uni- and multivariate models.

Treatment of Complex Hindfoot Trauma With Hindfoot Nail

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Purpose: Our objective was to assess outcomes associated with complex hindfoot trauma acutely treated with hindfoot nailing.

Methods: A case series at a Level I trauma center was performed to identify trauma patients with complex hindfoot fractures who underwent hindfoot nailing as definitive treatment after initial external fixation between 2012 and 2020. Indications included a combination of patient comorbidities, fracture severity, and soft-tissue injury. Exclusion criteria included follow-up less than 3 months. Postoperative radiographs were interpreted by a fellowship-trained foot and ankle surgeon. Primary outcome measures included unplanned reoperation/revision and deep infection. Deep infection was defined as any patient requiring surgical debridement after definitive fixation with positive cultures or the presence of positive cultures at the time of planned surgery. Fractures were classified using the AO/OTA classification and injury characteristics and postoperative complications were recorded via chart review.

Results: 26 of 29 of identified patients met inclusion criteria. The most common AO/OTA classification was 43C (62%). The average age was 55 years (range, 31-94) and the most common mechanism of injury was motor vehicle crash (38%). 13 fractures (50%) were open, with Gustilo Anderson grade IIIA fractures being the most common (38%). The overall deep infection rate was 15% with 50% of cases positive for a history of diabetes mellitus or smoking. Unplanned reoperations occurred in 7 cases (27%). Among these, a total of 4 (57%) occurred due to the development of deep infection, 2 (29%) were nonunions, and 1 (14%) was indicated for hardware failure. Below-the-knee amputation occurred in one patient with nonunion (4%), which was a grade IIIA open pilon fracture with significant bone loss. Union was achieved in the majority of patients (92%).

Conclusion: Treatment of complex hindfoot trauma with intramedullary nailing has a high union rate as a salvage procedure in a poor host. Surgeons should consider this treatment in patients who are not candidates for standard open reduction and internal fixation techniques.

Complications and Outcomes After High-Energy Lisfranc Injuries

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Purpose: Lisfranc tarsometatarsal fractures and dislocations are uncommon injuries, most resulting from high-energy trauma. Reduction and fixation are recommended to restore alignment and to promote function. The purpose of this study was to evaluate patient and injury features and to describe potential associations with early and late complications and secondary operations.

Methods: 160 consecutive adults with tarsometatarsal fractures and dislocations at a single Level I trauma center from 2000 to 2018 were identified from a fracture registry. Reduction and fixation were performed using standard techniques of rigid medial fixation and flexible lateral fixation. Complications included infections, wound healing problems, nonunion, malunion, and posttraumatic arthrosis (PTA). Secondary unplanned procedures were documented.

Results: 129 patients with mean age of 39.6 years (range, 18-73) and 74% (n = 96) male were included. Comorbidities included obesity (n = 45, 34%), diabetes mellitus (n = 12, 9.3%), and tobacco use (n = 67, 52%). The majority occurred via high-energy mechanisms, including motor vehicle collisions (30%), motorcycle crash (21%), falls from height (18%), and crush injuries (13%); only 8.7% occurred via ground level fall. 30 (23%) were open injuries, all Gustilo and Anderson type 3: (3A = 6, 3B = 18, 3C = 6), and concomitant forefoot injuries were present in 47% and hindfoot injuries in 12%. 13 patients (10%) underwent amputation acutely due to unsalvageable injury. Unplanned secondary procedures were performed on 30 of the remaining 116 patients (27%), most often for removal of painful or prominent implants (15%), infectious debridement (8.0%), and amputation due to late infection or wound healing complications (5.3%). A total of 70 complications occurred in 44 patients (38.9%), with PTA occurring most frequently (34.8%). Deep infections occurred in 7.8% of patients and superficial wound infections occurred in 3.4% of patients. Nine patients went on to malunion, while 3 failed to achieve union. Deep wound infections occurred more frequently with open injuries (33.3% vs 3.2%, $P<0.001$).

Conclusion: Midfoot fracture dislocation injuries are most often the result of high-energy mechanisms. Open and/or unsalvageable injuries requiring amputation are common. Modest rates of postoperative infection and wound healing complications are seen with these injuries. Secondary procedures were most often performed for pain relief and the most common late complication was PTA, warranting counseling of patients about the long-term sequelae of their injury.

Avulsion Fractures of the Calcaneal Tuberosity: A Single-Center Review of Outcomes and Complications

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Purpose: The purpose of this investigation was to determine the incidence of complications and reoperation after calcaneal tuberosity avulsion fractures, to describe experience with different fixation constructs, and to compare reoperation rates between tuberosity and tongue-type fractures of the calcaneus.

Methods: This was a retrospective study at a single Level I trauma center between 2001 and 2019, including patients with calcaneal tuberosity avulsion fractures compared to patients with calcaneal tongue-type fractures.

Results: 29 tuberosity fractures (23 operative and 6 nonoperative) and 37 tongue-type fractures (29 operative and 8 nonoperative) were treated during the study period. Treatment failure was more common in the tuberosity group (26% vs 7%, $P = 0.013$), as was secondary loss of reduction not requiring revision surgery (17% vs 0%, $P = 0.009$). Initial soft-tissue compromise was a risk factor for reoperation, but fragment size and displacement were not associated with reoperation in the tuberosity group. Elective removal of implant was more common in the tongue-type group (34% vs 9%, $P = 0.002$). Overall complication rate was similar between groups ($P = 0.082$).

Conclusion: Calcaneal tuberosity fractures have a significantly higher rate of revision surgery and loss of reduction compared to tongue-type calcaneal fractures, with similar rates of overall complication.

Comparison of Major Complications

	Tuberosity	Tongue	p
Overall Reoperation	48%	55%	0.663
Treatment Failure	26%	7%	**0.013**
Soft Tissue Complication Only	13%	7%	**0.028**
Catastrophic Loss of Fixation	13%	0%	**0.045**
Secondary Loss of Reduction	17%	0%	**0.009**
Elective Removal of Hardware	9%	34%	**0.002**
Planned Staged Surgery	13%	14%	0.105

Patients with Anterior Impaction Tibial Plafond Injuries May Have Inferior Outcomes

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Purpose: Recent literature has suggested an additional subtype of tibial plafond fracture, the "anterior impaction" (AI) injury. The purpose of this study was to compare the outcomes of patients with AI pilon fractures to those with non-AI pilon fractures.

Methods: Patients who underwent operative fixation of intra-articular distal tibia fractures over a 7-year period at an academic Level I trauma center were retrospectively reviewed. AI injuries were categorized based on previously published criteria, namely involvement of at least 10% of the anterior plafond with associated talar subluxation. Patients were reviewed on CT and radiographs. Kellgren-Lawrence (KL) grade was used to determine posttraumatic osteoarthritis (PTOA) grade at final follow up. $\chi 2$, t test, simple logistic regression, and multiple logistic regression were used; significance was set at $P<0.05$.

Results: This study included 108 patients (26 female) for final analysis, 45 (41.8%) of whom had anterior impaction plafond fractures. Average age, body mass index (BMI), and follow-up were 42.4 ± 13.7 years, 29.3 ± 6.42 kg/m2, and 422 ± 361 days, respectively. There were no statistically significant differences between groups with respect to patient age, sex, BMI, smoking status, fracture status (open vs closed), or follow-up duration between groups ($P>0.05$ for all). Similarly, there were no statistically significant differences when comparing mechanisms of injury between groups; $P = 0.61$. There was no statistically significant difference between groups with respect to proportions of OTA 43-B/C fractures with 16 (36.6%) 43-Bs in the anterior crush cohort and 26 (41.3%) in the non-crush cohort; $P = 0.69$. 41 (91.1%) of the anterior crush fractures were staged with external fixators, a significantly higher proportion than their non-crush counterparts (38, 60.3%; $P<0.001$). $\chi 2$ test demonstrated that AI patients were more likely to undergo reoperation than their non-AI counterparts (31% vs 13%; $P = 0.028$). They were also more likely to undergo subsequent arthrodesis relative to non-AI injuries(13% vs 3%; $P = 0.047$). Similarly, these patients had worse PTOA (KL grade 3-4) at final follow up when compared to their non-AI plafond counterparts (89% vs 46%; $P<0.001$).

Conclusion: AI pilon injuries have inferior outcomes (higher rates of reoperation, progression to arthrodesis, and worse PTOA) than those without these injuries.

Super Diabetes: Complications of Significantly Elevated HbA1c in Ankle Fracture

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Purpose: Our objective was to investigate what threshold of hemoglobin A1C (HbA1c) is associated with increased risks of postoperative complications in patients who carry a diagnosis of diabetes mellitus and who underwent open reduction and internal fixation for ankle fractures.

Methods: This retrospective review of an IRB-approved database of 175 patients with ankle fractures demonstrated 36 (20.6%) who sustained an ankle fracture and who had a HbA1c of above 6.5 upon admission to the hospital. Data collected on patients included demographics, past medical history, fracture classification, surgical fixation, and clinical outcomes including wound healing, surgical site infection, and reoperation. Patients were divided into two cohorts with HbA1c of 8.5 serving as the cut-off. Patients were then divided into three groups with a medium HbA1c group less than 8.5, high HbA1c group 8.6 to 12.9, and very high HbA1c group >13. $\chi 2$ tests of homogeneity and binomial logistic regressions were completed using IBM SPSS to compare outcomes between the cohorts.

Results: The average HbA1c within the total cohort was 9.0 ± 2.3. Increasing HbA1c levels were correlated with increased likelihood of developing wound complications, including both superficial and deep wound infections. Patients with HbA1c levels >8.5 were 6.6 times more likely to develop wound complications than patients with HbA1c levels of ≤8.5 (P = 0.011). When the cohort was divided into three subgroups patients were 5.0 times as likely to develop wound complications (P = 0.011) and, specifically, 4.5 times as likely to develop deep infections (P = 0.022) as their HbA1c transitioned from group 1 to group 3. There were no significant differences in patient demographics, injury characteristics, 90-day hospital readmission, or reoperations among cohorts (Table 1).

Conclusion: Increasing HbA1c is associated with increased complications after ankle fracture fixation with 8.5 as the cut-off. The risk of complications incrementally increases as HbA1c increases above 6.6.

Demographic, Injury, and Outcome Characteristics with HbA1c 8.5 as Cutoff			
	HbA1c ≤ 8.5 (N=20)	**HbA1c > 8.5 (N=16)**	***p*-value**
Mean Age, yrs (±SD)	60.5 (±11.1)	54.9 (±11.8)	0.165
Mean BMI (±SD)	31.6 (±5.9)	30.5 (±5.3)	0.582
Mean CCI, yrs (±SD)	1.7 (±1.0)	1.7 (±1.6)	0.355
Mean Glucose Level on Admission (±SD)	149.9 (±34.7)	205.5 (±98.4)	0.029
Open Wound Status	5 (25.0%)	6 (37.5%)	0.418
Wound Complication	5 (25.0%)	11 (68.8%)	0.009
Superficial Infection	4 (20.0%)	6 (37.5%)	0.049
Deep Infection	2 (10.0%)	5 (31.3%)	0.439
90-Day Hospital Readmission	4 (20.0%)	7 (43.8%)	0.124
Reoperation	4 (20.0%)	8 (50.0%)	0.058

The Impact Two Opioid Prescription Protocols Had on Provider Prescription Patterns Following Ankle Fracture Repair Surgeries

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Purpose: This study aims to evaluate the impact that an urban multicenter trauma department's previous narcotic prescription protocols have had on provider opioid prescription patterns and the effect a change in protocol will have. This study will also determine an optimal postoperative opioid prescription duration for lateral malleolus fracture repair surgery. We will evaluate the opioid prescribing pattern first before any protocol was in place, followed by the first opioid protocol implemented in January 2018. Lastly, we will assess the trends of the current 4-week taper protocol implemented in January 2020.

Methods: Data were collected retrospectively. CPT codes were used to identify subjects who had undergone ankle fracture repair surgery. Patient data were separated by the respective year of their repair surgery from January 2016 to October 2020. PROMIS (Patient-Reported Outcomes Measurement Information System) survey results and visual analog scale (VAS) pain scores were collected in the hospital's electronic medical record system. Continuous data were presented as a mean, and significance was determined by an independent t test between two groups and a one-way analysis of variance test for three groups. The data were collected from January 1, 2016, to October 2, 2020.

Results: A total of 288 patients were enrolled in the study. The years were demographically similar. The mean morphine milligram equivalent (MME) per prescription decreased each year from 483.35 (2016), 417.04 (2017), 283.16 (2018), 248.22 (2019), to 145.51 (2020). The mean prescription duration also decreased each year from 103.19 days (2016), 90.12 (2017), 65.20 (2018), 30.65 (2019), to 20.74 days (2020). The number of prescriptions per patient and the number of pills prescribed per patient decreased each year as well. The rate of oxycodone-acetaminophen, tramadol, and acetaminophen-codeine prescriptions decreased over the years, while hydrocodone-acetaminophen prescription rates were not affected. Interestingly, the 1 month postoperative VAS pain score had a slight increase almost each year over the 5-year period, from 3.62 (2016), 3.68 (2017), 3.93 (2018), 4.52 (2019), to 4.09 (2020) with no statistically significant differences between any of the years. The 1-month postoperative physical function PROMIS scores decreased significantly from 2018 to 2019 ($P<0.05$). Several factors were found to correlate with prescription patterns such as smoking, ethnicity, anxiety, arthritis, history of opioid use, insurance status, and type of opioid.

Conclusion: This study demonstrates that an opioid prescription protocol established in an orthopaedic trauma clinic can lead to decreased opioid prescription rates, decreased MME per prescription, and decreased opioid prescription duration. Interestingly, although overall MME significantly decreased from 2016 to 2020, there was also a minor trend toward increased pain perception. Several demographic and socioeconomic factors were shown to correlate with prescription patterns.

Patients Value Their Own Pain Over Braking Safety When Deciding When to Return to Driving: A Discrete Choice Experiment on Lower-Extremity Injuries

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Purpose: A common concern for patients sustaining lower-extremity orthopaedic injuries is when they can return to driving. Surgeons currently lack guidelines to assist in this decision. We hypothesized that patients would have strong preferences for an early return to driving over various driving-associated risks.

Methods: We consented and enrolled adult, English-speaking patients with an operative lower-extremity fracture from a Level I trauma center. Each participant completed a Discrete Choice Experiment (DCE) survey consisting of 12 hypothetical return-to-driving scenarios with varied attributes. DCEs are a well-validated technique used to quantify attributes that go into decision-making. Based on the survey responses, we calculated patient preferences for time to return to driving (range, 1-6 months) compared to the risk of hardware failure (range, 1%-12%), pain upon returning to driving (range, none to severe), and driving safety measured by braking distance (range, 0-40 feet at 60 mph) using hierarchical Bayesian modeling. Patient preferences were calculated as the median utility (subjective value) with interquartile range (IQR). The relative importance of each attribute is reported on a scale of 0% to 100%. Hierarchical cluster analysis was performed to identify subgroups with differing preferences. The analysis included 96 patients (mean age, 41 years [standard deviation: 15]; 56% male).

Results: Patients most valued a reduced pain level when resuming driving (62%), distantly followed by the risk of hardware failure (17%), time to return to driving (13%), and braking safety (8%). Patients were indifferent to returning to driving at 1 month (median utility: 28, IQR –31 to 80) or 2 months (median utility: 59, IQR: 41 to 91) postinjury. We identified 2 distinct clusters of patients that differed in their preferences. Cluster 1 members (42% of sample) were more likely to be male (68% vs 48%) and had lower educational attainment (college degree: 28% vs 43%). The preferences of Cluster 1 members placed increased importance on returning to driving sooner (relative importance: 29% vs 9%), and a compromised reaction time (18% vs 6%). Cluster 2 members (58% of sample) were predominantly concerned with an increased pain level attributable to driving (61% vs 36%) and were willing to delay their return to driving to avoid a pain increase.

Conclusion: Patients with lower-extremity orthopaedic trauma demonstrated a strong willingness to forgo earlier return to driving for a decrease in their pain level. Furthermore, patients are least concerned about their driving safety and the risk this may place upon society, and place a greater value on their own pain level and chance of hardware failure over proper braking function. The findings of this study are the first to rigorously quantify patient preferences toward a return to driving, as well as heterogeneity in patient preferences, in an area of ongoing clinical importance.

Complications of Hardware Removal

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Purpose: While hardware removal (HR) may improve patient symptoms, any surgery carries risks of unexpected outcomes. Despite being one of the most commonly performed orthopaedic procedures, scant attention has been given to the prevalence and complication profile from HR in orthopaedic surgery. The use of the American Board of Orthopaedic Surgery (ABOS) de-identified database of Part II surgical cases has been employed for numerous orthopaedic interventions to understand trends and complications of such interventions.

Methods: The ABOS de-identified database of Part II surgical case lists from 2013-2019 was queried for Current Procedural Terminology (CPT) code 20680 Removal of implant; deep], and other implant removal codes (20670, 22850, 22852, 22855, 26320). Only HR cases that were performed without any other concurrent procedure were included and examined for associated complications. For the generic complications that required further definition, questionable or ambiguous complications were reviewed by two authors for relevance. The complications were categorized and analyzed by region of the body.

Results: In the years analyzed, isolated hardware removal was performed in 13,089 of the 609,150 (2.1%) of cases, making it the most common reported CPT code for Part II examinees. A complication was reported to have occurred in 1256 of 13,089 (9.6%) of these procedures, including 1151 with surgical complications (8.8%) and 196 (1.5%) with medical/anesthetic complications. The most commonly reported complications were wound-healing delay/failure (2.1%), infection (1.6%), and uncontrolled postoperative pain (1.5%) but other serious events were reported: unexpected reoperations (2.5%), unexpected readmissions (1.6%), continuing pain (1.2%), nerve injury (0.6%), bone fracture (0.5%), and life-threatening complications (intraoperative or immediate postoperative arrhythmia, cerebral vascular accident, congestive heart failure, myocardial infarction, patient expired, pulmonary embolism, respiratory failure, etc) (0.4%). Complication by anatomic region did not significantly differ, except for complications of pelvis/hip (14.8%) (P<0.001) compared to the hand/fingers (8.7%) and femur/knee (8.9%) regions.

Conclusion: Hardware removal is one of the most commonly performed orthopaedic procedures and was associated with a 9.6% overall complication rate in an early U.S. orthopaedic surgeon's practice. Although specific complications like infection, refractures, and nerve damage were reported to each have relatively low rates of occurrence, and associated life-threatening complications are rare, surgeons and patients should be aware that HR carries risk that should be considered when considering intervention.

Delays in Debridement of Open Femoral and Tibial Fractures Increase Risk of Infection

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Purpose: Infection remains a costly, devastating complication following treatment of open fractures. The appropriate timing of debridement is controversial, and available evidence is conflicting.

Methods: This study is a retrospective analysis of the SIGN Online Surgical Database (SOSD), a prospective registry of fracture cases in predominantly low-resource settings. Skeletally mature patients (age ≥16 years) who returned for follow-up after medullary nailing of an open femoral (OTA 32) or tibial (OTA 42) fracture were included. Patients were excluded if they had delays in debridement exceeding 7 days from injury. The primary outcome was infection. The exposure variable was early debridement, defined as a delay from initial injury to wound debridement of 24 hours or less. Confounders including patient demographics, injury details, and country resource availability were adjusted for with propensity scores. Interaction by bone and injury severity were analyzed using the Mantel-Haenszel test for heterogeneity.

Results: 28% of patients met the eligibility criteria and returned for follow-up, with a total of 10,791 fractures from 61 countries included. Overall, the propensity score-adjusted relative risk of early versus late treatment was 0.65, 95% confidence interval (CI) 0.49-0.86. Stratified analysis demonstrated a greater relative risk reduction associated with high-grade open fractures (Gustilo-Anderson [GA] III 0.57 [CI 0.45-0.73] vs GAI/II 0.76 [CI 0.58-0.99]; *P* value for heterogeneity = 0.11) and femoral shaft fractures (femur 0.47 [CI 0.33-0.65] vs tibia 0.72 [CI 0.59-0.89]; *P* value for heterogeneity = 0.03).

Conclusion: Delays in debridement of >24 hours increase risk of infection in open femoral and tibial fractures. This effect is stronger for more severe injuries and femoral fractures. The size and international nature of this cohort make these findings uniquely generalizable to nearly all environments where such injuries are treated.

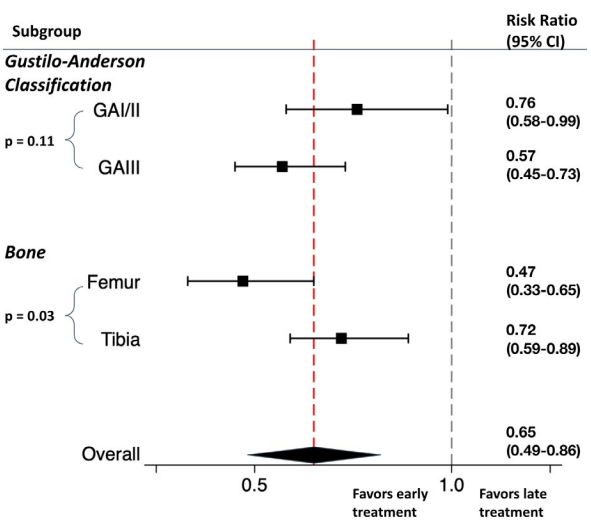

Figure 1: Propensity-adjusted Relative Risk of Developing Infection with Early Debridement, stratified by injury severity and bone. M-H p-value is the Mantel-Haenszel test for heterogeneity.

Utility of Serum Biomarkers in Diagnosing Fracture-Related Infections: A Pilot Study

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Purpose: Fracture related infections (FRIs) are a potential devastating outcome for patients and costly for society. "Classic" inflammatory markers (white blood cell count, erythrocyte sedimentation rate, and C-reactive protein [CRP]) are not sufficient for confirmatory diagnosis, and improved diagnostic biomarkers are needed. The purpose of this pilot study was to compare a large panel of serum-based inflammatory biomarkers in patients with confirmed FRI to patients without infection.

Methods: This is a single center, comparative diagnostic Level III study. The recently proposed FRI definition was used as the "gold standard" for assigning cases as infected. 13 patients meeting the confirmatory FRI criteria were matched to 13 controls based on age, time after surgery, and fracture region. Serum was assessed using the Milliplex human cytokine magnetic bead panel immunology 47-plex immunoassay, as well as hospital laboratory CRP measurements. Group differences were assessed by matched t tests, and receiver operating characteristic (ROC) curve analyses were used to determine optimum cut-points for each biomarker.

Results: CRP, interleukin (IL-6), platelet-derived growth factor (PDGF)-AB BB, and vascular endothelial growth factor (VEGF)-A levels were significantly different when comparing the FRI and matched control groups (all $P<0.05$). Cut-points optimizing the ROC curve analyses were 7.8, 10,443, and 77.5 pg/mL for IL-6, PDGF-AB BB, and VEGF-A, respectfully, and 2.8 mg/dL for CRP. Table 1 shows the sensitivity, specificity, and area under the ROC curve for these cut-points. Having all 4 of the biomarkers below the cut-point was 100% specific for FRI.

Conclusion: This pilot study demonstrates the feasibility of undertaking a larger study to look at the utility of serum biomarkers for establishing the diagnosis of FRI. The data suggest that having multiple biomarkers measuring below a threshold may reliably identify no infection. This should be further investigated in a cohort of patients who meet suggestive FRI criteria.

	Sensitivity	Specificity	AUC
Il-6	53.9	84.6	0.692
PDGF-AB BB	61.5	84.6	0.731
VEGF-A	38.5	92.3	0.654
CRP	46.2	92.3	0.692

Δ OTA Grant

Percent of Normal: A Pragmatic Patient-Reported Outcome Measure for the Orthopaedic Trauma Clinic

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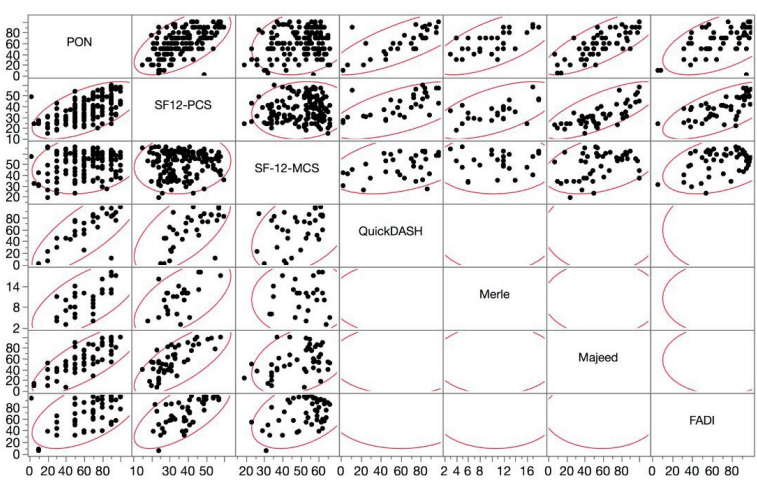
Purpose: The purpose of this study was to compare a single numerical patient-reported outcome measure (PROM) to general health and injury-specific PROMs.

Methods: A prospectively gathered orthopaedic trauma PROMs registry was retrospectively reviewed to identify patients with humerus, pelvis, acetabular, and ankle fractures who successfully completed PROMs during a 9-month period. Patients were administered 3 PROMs: the 12-item Short Form (SF-12), an injury-specific PROM (QuickDASH [an abbreviated version of the Disabilities of the Arm, Shoulder and Hand questionnaire] - humerus; Majeed Pelvic Outcome Score (Majeed) - pelvis; modified Merle d'Aubigne score (Merle) - acetabular; Foot and Ankle Disability Index (FADI) - ankle), and the Percent of Normal (PON) PROM, a single numerical PROM that asked, "How would you rate yourself, if 100% is back to normal?" Floor/ceiling effect, convergent validity, and responsiveness of PROMs were assessed.

Results: 175 patients with 34 humerus, 54 pelvis, 31 acetabular, and 56 ankle fractures were included. None of the PROMs demonstrated a floor effect. The Merle was the only PROM with a ceiling effect (19%). The PON had a strong correlation with the QuickDASH (r = 0.78) and Majeed (r = 0.78), a moderate association with the SF-12 physical component summary score (PCS) (r = 0.63), Merle (r = 0.67), and FADI (r = 0.55), and a weak association with the SF-12 mental component summary score (MCS) (r = 0.22). The regression coefficient for change in PROM over time, a measure of responsiveness, was greater for the PON, compared to the SF-12 PCS/MCS, Majeed, Merle, and FADI, but not the QuickDASH.

Conclusion: The PON is a pragmatic PROM that can be easily administered in clinic by the physician to quickly assess and manage a variety of fractures, avoiding the disadvantages of non-relative general or region-specific PROMs.



Did You Think You Would Die? Patient-Reported Fear of Death and its Impact on the Development of Posttraumatic Stress Disorder After Traumatic Injury

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Purpose: Posttraumatic stress disorder (PTSD) is prevalent following traumatic injury and may hinder recovery. Patient-specific factors may influence PTSD development post-injury and warrant further examination. This study investigates the potential association between patient-reported fear of death at time of injury and development of PTSD.

Methods: Over a 35-month study period, 855 patients who visited the emergency department were prospectively identified. Of these, 250 patients (29%) were screened for PTSD at their first post-hospitalization orthopaedic, trauma, or burn clinic visit and were asked "Did you think you were going to die from this injury?" (yes or no). PTSD screening was conducted using the PTSD checklist for Diagnostic and Statistical Manual for Mental Disorders, Fifth Edition (DSM-5) (PCL-5) questionnaire. A score of 33 (range, 0-80) was considered clinically positive for PTSD and patients were offered ancillary psychiatric services. Retrospectively, medical records were reviewed for baseline demographics and injury information.

Results: 43 patients (17% of 250) indicated a fear of death. The average age was 46 years, with patients who feared death being considerably younger (36 vs 48, $P<0.001$) and 62% were male. The most common mechanisms of injury were motor vehicle or motorcycle collisions (30%) and ground level falls (21%). Gunshot wounds (GSWs) were more common among patients who feared death from trauma (44% vs 7%, $P<0.001$). PTSD questionnaires were completed a median of 26 days after injury, with an average score of 12.6 (standard deviation [SD] = 16.9). PTSD scores were significantly higher for patients with a fear of death from trauma (32.7 vs 8.5) and they required more acute interventions (47% vs 7%), both $P<0.001$. Following multivariable logistic regression, patients who thought they would die from their trauma had >13-times higher odds of developing PTSD (odds ratio [OR]: 13.42, $P<0.0001$). Apart from positive psychiatric history (OR: 5.46, $P = 0.001$), there were no other factors (age, sex, mechanism of injury, or any injury or treatment characteristics) that were predictive of positive PTSD scores on regression.

Conclusion: Patients who reported fear of death at time of injury were 13 times more likely to develop PTSD. Simply asking patients if they believed they would die at time of their injury may be an efficacious means of prospectively assessing PTSD risk.

Do Patients Need Routine Follow-up? Using Patient-Reported Outcomes (PROs) to Limit Unnecessary Clinic Visits

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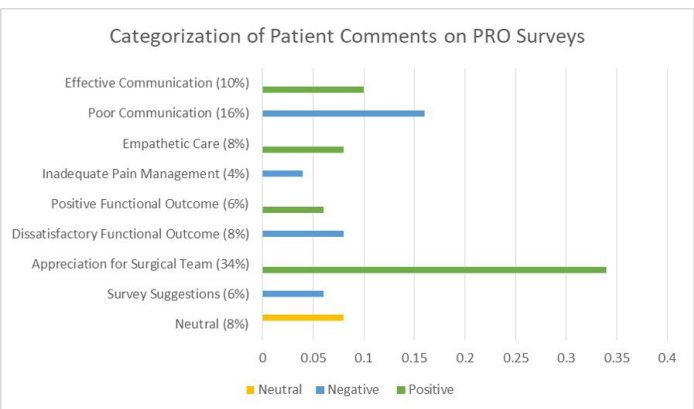
Purpose: Traumatic injuries are costly to patients and society. Following the acute treatment phase, many patients lack the means for long-term follow-up. Utilizing electronic out-of-office patient-reported outcomes (ePROs), providers can gauge patient progress, thus providing the means to optimize the number of follow-up clinic visits while maintaining the quality of care.

Methods: 103 operatively treated ankle fractures were included. ePRO data were regularly collected at intervals of 6 weeks, 12 weeks, 6 months, and 1 year for the Foot and Ankle Ability Measure (FAAM) and Patient-Reported Outcomes Measurement Information System Global-10 (PROMIS-10). Patient-reported satisfaction was queried separately on a Likert scale. The recovery curves for FAAM and PROMIS were plotted to visualize the longitudinal patient progression. Average patient self-reported satisfaction was determined for each colored area.

Results: Patients requiring high attention were between the 5th and 25th percentile, urgent need for follow-up, designated in red. Patients requiring moderate attention, encouraged need for follow-up, were between the 26th and 50th percentile, designated in yellow. Patients requiring low attention, limited need for follow-up, were between the 51st and 95th percentile, designated in green. Patients in the green area reported satisfaction rates of 88% for FAAM and 93% for PROMIS. Patients in the yellow area reported satisfaction rates of 51% for FAAM and 50% for PROMIS. Patients in the red area reported satisfaction rates of 23% for FAAM and 14% for PROMIS.

Conclusion: PROs are the gold standard in evaluating the longitudinal outcomes of patient care. This study proposes an innovative way to monitor patients with ePROs and limit the need for clinic follow-up. This system could improve access to care, decrease total cost of care, and result in more convenient care for patients.



The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

The Impact of Education Level, Access to Transportation, and the Home Environment on Patient-Reported Outcomes After Orthopaedic Trauma Surgery

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Purpose: Social determinants of health impact a variety of health outcomes. Of these determinants, it remains unclear how education level, access to transportation, and the home environment influence patient-reported outcomes following orthopaedic trauma surgery. The aim of this study is to correlate patient-reported outcomes with specific social determinants of health (educational level, transportation access, and home environment) in urban orthopaedic trauma surgical patients.

Methods: A cross-sectional survey was conducted at an urban Level I trauma center to collect data on demographics, education level, access to transportation, and the home environment from 120 patients who underwent fracture repair surgery. This data was correlated with Patient-Reported Outcomes Measurement Information System (PROMIS) scores (global mental health, global physical health, pain interference, and physical function) and parametric statistical analyses were employed to assess significant associations.

Results: Patients with lower education levels reported better physical function up to 6 weeks postoperatively ($P = 0.015$). Patients with limited access to transportation reported worse physical function ($P = 0.037$) and mental health ($P \leq 0.001$) at 3 months while those who relied on others for transportation reported worse physical function at 6 months ($P = 0.003$). Patients with stairs in their homes reported more pain interference up to 6 weeks ($P = 0.043$). Those who faced no difficulty accessing the toilet or shower reported less pain interference at 2 weeks ($P = 0.04$) and 6 months ($P = 0.032$), better physical function up to 6 weeks ($P = 0.004$), and better global physical health at 6 months ($P = 0.038$).

Conclusion: This study found that social determinants of health including education level, access to transportation, and the home environment influence patient-reported outcomes after orthopaedic trauma surgery.

Cefazolin-Only Protocol Decreases Time to Antibiotic Administration in Open Fractures

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Purpose: Open fractures have a well-documented increased risk of infection. Time to antibiotics in patients with open fractures have been shown to affect outcomes. Currently, the Trauma Quality Improvement Program guidelines recommend that patients with open fractures receive antibiotics within 1 hour of arrival to the emergency department (ED). Our facility instituted a single antibiotic agent, cefazolin-only protocol in an effort to decrease the time to antibiotic prophylaxis in open fractures. This study was designed to determine the effect on time to antibiotics and incidence of infection after implementation of a single antibiotic agent protocol.

Methods: A retrospective review of all patients arriving to a Level I trauma center with an open long bone fracture (humerus, ulna, radius, femur, tibia, fibula) from April 2016 to March 2020 were included. Patients transferred in from other hospitals and those who died in the ED were excluded. Prior to April 2018, our institution administered gram-positive antibiotics for Gustilo type I and II open fractures, with the addition of gram-negative coverage for type III fractures. Beginning in April 2018, all patients with open fractures, regardless of the Gustilo classification, were to receive 2 g cefazolin on arrival, with necessary changes made by the orthopaedic service after consultation. Patients with a documented penicillin allergy received 900 mg clindamycin. Patients arriving prior to the protocol change (April 2016-March 2018) were compared to those arriving after the change (April 2018-March 2020) on demographics, injuries, time to antibiotics, and postoperative complications. A subgroup analysis of patients with type III fractures was performed, as this would be the population most affected by the change and most susceptible to complications.

Results: A total of 684 patients were included in analysis: 354 arrived prior to the protocol change and 330 arrived after. Demographics were similar between groups. Patients arriving after the protocol change had a decreased time to antibiotic initiation (56 vs 133 minutes; $P<0.001$). Nonunion rates were lower (5% vs 9%; $P = 0.049$) in the post-protocol group. Surgical site infections and returns to the operating room were comparable between the two groups (10% vs 10%, $P = 0.95$; 12% vs 16%, $P = 0.13$, respectively). When comparing only type III fractures, time to antibiotics was decreased by 56 minutes (104 vs 48 min; $P<0.001$) with no increase in nonunion, returns to the operating room, or surgical site infections.

Conclusion: Use of a single gram-positive agent as the initial antibiotic in patients with open fractures reduces the time to antibiotic administration and does not lead to an increase in infection-related complications.

Screening and Behavioral Health Integration in an Orthopaedic Trauma Clinic

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Purpose: Depression is a common comorbid condition in patients with orthopaedic injuries and is associated with worsened outcomes such as pain, opioid use, complications, and length of stay. We report our experiences implementing a behavioral health integration pathway, including a validated depression screening and referral to care, in a single surgeon's orthopaedic trauma clinic over the course of 1 year from January to December 2019.

Methods: We piloted the usage of Patient Health Questionnaire (PHQ)-2 and PHQ-9 screening for all patients presenting to a single surgeon's orthopaedic trauma clinic. The present study is a retrospective case series of the results of screening in that clinic from January 2019 to December 2019. An evidence-based, real-time treatment protocol embedded in the electronic health record was designed by a psychiatrist at our institution for appropriate psychiatric management triggered when a patient screens positive for depression.

Results: A total of 573 patients had an outpatient visit in the study clinic in 2019. Of these, 476 (83.1%) received the PHQ-2 screening. Of the 97 patients who did not receive the PHQ2 screening, 80 were not screened because they had a current (within 1 year) PHQ screening in their medical record. Ultimately, only 17 patients (3.0%) were not screened. Based on the results of the PHQ-2, 172 patients (36.1%) required completion of the full PHQ-9 questionnaire; of those, 60 (34.9% of patients screened with full PHQ-9, 12.6% of patients screened) screened positive for depression. 50 of these patients were referred to behavioral health via the electronic health record–based pathway, and 8 of these patients enrolled in the formal behavioral health treatment program.

Conclusion: This case series demonstrates the feasibility of screening patients for depression and making referrals to necessary behavioral health treatment in an orthopaedic trauma clinic. Depression is common in this patient population and is also a risk factor for worsened patient-reported outcomes, complication rates, and quality metrics. We were able to identify 50 patients with depression and appropriately triage them for further care in our community without requiring any additional staffing at our clinic or increasing the amount of time spent per visit.

Gender-Based Analysis of Participation in the OTA Annual Meeting From 2016 to 2020

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Purpose: Gender inequality in orthopaedic surgery persists despite improvement efforts and has been the subject of recent research efforts. Prior studies have analyzed gender differences in orthopaedics more broadly, but we sought to report on gender differences with various presentation modes at a single subspecialty society's annual meeting. The purpose of this study was to report on the number and type of presentations by female authors or speakers at the OTA Annual Meeting over the past 5 years.

Methods: Data were collected regarding total presentations by type (podium, poster, or symposium/breakout session moderator) from the OTA Annual Meeting during the years 2016 to 2020. This was further broken down by gender and female participation for each presentation type was reported as both an absolute value as well as a percentage of total presentations. Available OTA membership data for active members was obtained from the online member directory at the time of this writing.

Results: The current estimate of total female active membership in the OTA is 8%. The percentage of total poster presentations given by females showed a modest 3.7% increase over the 5-year study period (13.4%, 15.9%, 14.5%, 15.6%, 17.1%). Female podium presentations at the meeting increased by 8.1% over the study period (11.9%, 14.6%, 16.4%, 12.8%, 20.0%), with the 2020 Annual Meeting having the highest percentage of female presenters of any year studied. Absolute numbers of female breakout session/symposium moderators remained stable over the study period, but as a percentage of total presentations, they increased in 2020 by nearly three times as compared to prior years (8.6%, 10.6%, 2.1%, 6.5%, 21%).

Conclusion: The percentage of female participants in the OTA Annual Meeting has increased over the last 5 years in all three presentation categories. The 2020 Annual Meeting had the highest percentage of female presentations of any year studied. Possible reasons for this include the virtual format and/or increasing submission rate. It should be noted there was over a 50% decrease in the number of symposia/breakout sessions for the virtual meeting. Current membership estimates show a percentage of roughly 8% for females within the OTA and the discrepancy between membership rate and presentation rate can only be speculated. It is important to recognize and track how this trend may positively impact OTA membership in the future.

Prospective Observational Study of an Integrated Therapeutic InitiatiVe for Extremities (POSITIVE): Implementation of an Integrated Orthotic and Rehabilitation Program in the Civilian Setting

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Purpose: The Return to Run (RTR) pathway currently utilized in the military has been demonstrated to facilitate return to duty, recreation, and physical activity and decrease pain in high-functioning patients who have sustained high-energy lower-extremity trauma. A recent study also demonstrated that the processes and outcomes are translatable across military settings; however, to date there is no evidence on implementation of this pathway in the civilian setting. We sought to evaluate the feasibility of implementation of a similar, Return to Performance (RTP) pathway at a high-volume, Level I civilian trauma center. RTP combines a custom variable cadence ankle-foot orthosis (VCAFO) with an 8-week exercise program designed to improve performance and reduce pain.

Methods: A prospective observational study was conducted to enroll all patients eligible for the VCAFO. Patients were followed from initial referral through 1 year. A large, national prosthetic and orthotic company was utilized for brace manufacture and fitting. Physical therapy services were provided in the outpatient setting.

Results: The RTP pathway has been fully operational for 5 years. There was an initial 2-year run-in period for initial training of therapists and prosthetists and logistic implementation at our institution. 58 patients participated in the full RTP pathway, and 21 received RTP via remote rehabilitation delivered through a manual. An additional 6 patients met with the lead physical therapist for at least 1 visit. All expenses for prostheses as well as therapy sessions have been covered by insurance. 32 prosthetists have been trained locally in the fabrication of the brace with an additional 70 trained at the brace manufacturer›s most recent national meeting. 13 physical therapists have been trained to perform functional rehabilitation through the RTP pathway.

Conclusion: Implementation of the RTP pathway can be translated and scaled to the civilian setting. The study has successfully replicated the brace fabrication necessary for optimal outcome in the RTR pathway, although there are remaining questions about scaling of physical therapy. This provides evidence that the process can be decentralized and the benefits of dynamic bracing in high-functioning patients following lower-extremity trauma can be translated to the civilian population.

Integration of Life Care Specialists Into Orthopaedic Trauma Care: A Pilot Study

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Purpose: Orthopaedic trauma patients are frequently prescribed opioids, leaving them at risk for ongoing opioid use and developing opioid use disorder. To date, post-trauma pain management has placed little emphasis on individualized risk assessment and non-pharmacologic approaches. Therefore, we assessed the feasibility of integrating a Life Care Specialist (LCS) into orthopaedic trauma care.

Methods: The LCS is a hybrid between a behavior-based "pain coach" and substance use disorder counselor, offering evidenced-pain management education, opioid risk assessment, coordinated care management, and harm-reduction strategies (Narcan education), with an emphasis on mental wellness using models developed by the Trauma Resource Institute. Selected patients (>18 years) received supplemental care by an LCS at a Level I trauma center. The Opioid Risk Tool (ORT), Patient Health Questionnaire 2-item (PHQ-2), and social determinants of health and substance use (SDOH) survey were completed prior to LCS intervention. Daily morphine milligram equivalents (MME) during inpatient hospitalization, opioid use at 2 weeks postoperatively, and patient satisfaction were recorded.

Results: 122 patients (60% male, mean age: 37.3 ± 13.3) were enrolled. The mean MME/day was 41.7 ± 36.9. Patients met criteria for moderate to severe risk of opioid misuse (39%) and probable depression (11.5%) during initial hospitalization. On average, 1.7 LCS pain management interventions were utilized (most frequently used: progressive muscle relaxation [37.7%], sound therapy [31.1%]). Postoperative outcomes indicated that prescription opioid utilization was low (12.5% of participants) and that opioid-related overdose was infrequent (1.6%). 99% of patients agreed that the LCS was helpful in managing pain.

Conclusion: The findings indicate feasibility of integrating an LCS into orthopaedic trauma care. Compared to previous work in the institution, the average MME/day was approximately 20% lower during the initial trauma hospitalization with LCS intervention. Future randomized controlled trials are needed to cultivate this patient-centered care approach to pain management and opioid-related risk mitigation.

Treatment for Septic Nonunion Is Associated with Disproportionately High Health Care Utilization and Hospital Costs Compared to Aseptic Nonunion

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Purpose: Fracture-related infections are a devastating complication, amplifying the complexity of treatment when comorbid with nonunion. Cost data are needed to quantify the burden of disease and justify the development of better preventative, diagnostic, and treatment algorithms for these complicated problems. The purpose of this study was to quantify the impact of septic nonunion on overall cost of fracture care.

Methods: This was a retrospective review of all adult patients undergoing operative treatment of AO/OTA 31, 32, 33, 41, 42, and 43 fractures between 2012 and 2020 at a single Level II trauma center. Eligible patients were identified by CPT code and classified into primary uncomplicated fracture repair, aseptic nonunion, and septic nonunions on the basis of ICD-9 and -10 codes, operative report review, and microbiology reports. Exclusion criteria included pathologic fractures, patients with a healed fracture presenting with infection, and less than 1-year follow-up. The primary outcome was the total cost of treatment for all hospital-based episodes of care associated with the fracture, including direct and indirect costs.

Results: 117 patients with uncomplicated fracture healing, 82 with aseptic nonunion, and 44 with septic nonunion were included. The median cost of treatment for hospital episodes of care associated with treatment of septic nonunion was $148,318 (interquartile range [IQR] 87,241-256,928), $45,230 (IQR 31,510-68,030) for treatment of aseptic nonunion, and $33,991 (IQR 25,609-54,590) for uncomplicated fracture healing. Total days of hospitalization were significantly longer for the septic nonunion group (median 21.5 days, IQR 10-48.5) compared to the aseptic nonunion group (median 3 days, IQR 2-6) and uncomplicated group (median 4 days, IQR 2-6), P<0.001. Total number of procedures performed at our institution was also significantly higher for patients in the septic nonunion group (median 5 procedures, IQR 2-5 [excluding original fracture treatment]) compared to the aseptic nonunion group (median 1, IQR 1-2 [excluding original fracture treatment]) and uncomplicated group (median 1, range 1-4), *P*<0.001. The hospital made a profit on all patients with commercial insurance, but lost money on all patients with Medicare or Medi-Cal insurance, regardless of diagnosis.

Conclusion: Septic nonunion of lower extremity long bone fractures is associated with a fivefold increase in the hospital-associated cost of care compared to treatment for an uncomplicated lower extremity long bone fracture, and far exceeds the additional costs of care associated with aseptic nonunion. These results demonstrate the outsize burden of septic nonunions on the health care system and provide further evidence for the importance of developing improvements in the prevention, diagnosis, and treatment of this adverse complication.

National Databases Give New Insight Into Acute Compartment Syndrome (ACS)

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Purpose: A better understanding of the risk factors, demographics, and relationships with other comorbidities is needed. We have examined new information from multiple publicly collated databases available to investigators as well as published results from large studies with the methodology of systematic review. Annual data from the American College of Surgeons Trauma Quality Program (TQP) were obtained. Previously published papers and recent study data from the Major Extremity Trauma Research Consortium (METRC) were compared to the large comprehensive database from TQP. We hypothesize that there are misconceptions in the actual incidence and risk factors of ACS currently accepted in the literature.

Methods: We screened 2,880,390 trauma cases available in the 3 national databases and selected 195,164 tibial fractures. Other databases used for comparison were previously published prospectively, including the PACS (picture archiving and communication system) data and patient charts taken from a Level I trauma center data registry.

Results: New incidences and risk factors were noted, different from other smaller database studies and prospective cohorts. New ACS predictors include: proximal (P<0.0001) and midshaft tibial fractures (P<0.0001), open fractures (although a weaker association than thought previously), complex fracture (P<0.0001), substance abuse disorder (P<0.0001), cirrhosis (P = 0.002), or being a smoker (P<0.0001). We also noted that male subjects were 67% (odds ratio [OR] = 1.58-1.78, P<0.0001) more likely to develop ACS than females and that every additional year of age decrease the likelihood of ACS by 1% (OR = 0.99-0.993, P<0.0001). The ACS rate was consistent across the trauma center levels with an expected slight decrease in Level III trauma centers. The fasciotomy rate as well as the ACS rates were lower in the database cohort than any reported prospective study, and probably our reporting should reflect that new number: 9.5% of fasciotomy cases and 17.8% of ACS cases developing muscle necrosis. A multiple logistic regression model identified 4 major factors that increase the risk of muscle necrosis. Open fractures (OR = 1.03-1.40, P = 0.023) regardless of the tibial fracture location and complexity, being male, proximal tibia fractures, and comorbidities like cirrhosis were significantly associated with necrosis (P<0.0001). However, substance abuse disorder did not show a strong effect on necrosis (P = 0.14).

Conclusion: With the large number of patients in trauma registries we can shed new light on risk factors and the reasons for ACS. Several new risk factors have been found from examination through big data statistical analysis. Important questions are raised on whether large retrospective cohorts and prospective trials report on the same disease processes or can be used exclusively in scientific reporting.

Where Are All the Superbugs? Intrawound Powdered Antibiotic Prophylaxis in Open Fracture Care Does Not Drive Patterns of Resistance

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Purpose: Our objective was to determine the consequence of intrawound powdered antibiotic (IPA) prophylaxis at the time of operative fracture care on bacteriology in open fracture cases complicated by surgical site infection (SSI).

Methods: Operative fracture cases were reviewed (Level I, academic, 2018-2020), capturing patient and fracture characteristics, IPA dosing (vancomycin/tobramycin), and SSI details. Fellowship-trained traumatologists used IPAs at their discretion. Cases with <1-month follow-up were excluded.

Results: 713 patients received fracture care for 759 fractures. 144 (19%) were open fractures; 88 (61%) received prophylactic IPAs during surgery. In the open fracture group, there were 16 total SSIs (SSI rate: 10.2% IPA group, 12.5% no IPA group). No patients developed multidrug resistant isolates. There was no statistically significant difference in antibiotic susceptibility profiles of bacterial isolates from either group. No resistant strains of Streptococcus, Enterococcus, gram-negative enterics, Pseudomonas, or Cutibacterium species developed. Two isolates of methicillin-resistant Staphylococcus aureus (MRSA) developed in each group, and a single isolate of resistant coagulase-negative Staphylococcus developed in the IPA group. There were no SSIs in type 1 open fracture cases, with increasing infection rates in type 2 (5.1% IPA group, 8.3% no IPA group) and type 3 (17.5% IPA group, 23.8% no IPA group) open fracture cases. There was no difference in IPA dosing (mean vancomycin/tobramycin: 1.7 g/1.8 g IPA-SSI group, 1.6 g/1.8 g IPA-no SSI group; $P = 0.72$) or Gustilo-Anderson classification ($P = 0.33$).

Conclusion: The use of local antibiotic prophylaxis resulted in no measurable increase in bacterial resistance in operative treatment of open fractures. There was a trend toward decreased rate of SSI requiring operative debridement with the use of IPAs. This is a critical safety finding for the development of drug trials for open fracture prophylaxis with IPAs.

Figure 1: Infection Requiring Operative Debridement – Open Fractures

	IPA Total infections=9 Bacterial isolates=18	No IPA Total infections=7 Bacterial isolates=14
Staphylococcus aureus		
MSSA	3	1
MRSA	2	2
Coagulase negative staphylococcus species		
No resistance	2	1
Oxacillin Resistant	1	0
Streptococcus species	0	1
Enterococcus species	2	2
Cutibacterium (P. acnes)	0	1
Other - Gram positive	1	1
Gram negative enterics (Klebsiella, Enterobacter, E. Coli, Proteus)	3	2
Pseudomonas species	1	1
Other - Gram negative	2	2
Fungal	1	0
Polymicrobial (species represented above)	5	3

No resistant strains of streptococcus, enterococcus, gram negative enterics, pseudomonas, or cutibacterium species

POSTER ABSTRACTS

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

A Mobile Application Improves Health Literacy After Orthopaedic Trauma

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Purpose: Low health literacy has been associated with limited adherence to treatment recommendations and with poor outcomes. The purpose of this study was to evaluate the utility of an educational mobile application (app) for improving orthopaedic trauma health literacy and patient engagement. We hypothesized that app users would be more knowledgeable about their injury and associated treatment recommendations.

Methods: 228 adult patients with lower extremity injuries were approached during their initial presentation following injury. An informational flyer about the app was provided, with the app available for download from either Google Play or the Apple App Store. 183 patients were surveyed prior to app usage and were recorded as control patients. The survey queried knowledge of fracture location, type of treatment, weight-bearing status, healing time, and type of deep vein thrombosis (DVT) prophylaxis. After using the app 45 patients were surveyed at their next outpatient visit.

Results: All patients were stratified according to sex, race, age (<25 years, 25-39 years, 40-60 years, >60 years), and highest level of education. App users were more likely to be female (58% vs 39%, $P = 0.03$) and to have at least a high school education (9.8% vs 0, $P = 0.03$) but were no different regarding age or ethnicity. App users showed stronger health literacy in 3 of 5 categories: knowledge of fracture location (64% vs 38%, $P = 0.001$), weight-bearing status (100% vs 82%, $P = 0.003$), and estimated healing time (53% vs 21%, $P<0.0001$). No differences were noted in knowledge of type of surgery or DVT prophylaxis, but control patients correctly answered >85%, so there was minimal room for improvement. In addition to collecting health literacy measures, the researchers also collected app satisfaction data to improve the app's utility for patients. Regarding content, study patients favored the "My Injury Section" (80%) and suggested more information on exercises (11%) and nutrition (11%).

Conclusion: Trauma app users had better health literacy, particularly pertaining to knowledge of injury type, weight-bearing status, and healing time. Additionally, app users were predominantly female and had at least a high school education. The results of this study support the app to strengthen health literacy and suggest continued investigation to ascertain whether this translates into better adherence to treatment and to better patient-reported outcomes.

Medicare Reimbursement in Orthopaedic Trauma: Decreasing Physician Payment, Despite Increasing Malpractice Coverage

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Purpose: Medicare reimburses physicians based on three additive relative value units (RVUs): work, practice expense, and malpractice coverage. A recent study found that for orthopaedic trauma malpractice cases with plaintiff verdicts, the mean indemnity payment was $3,778,657. As overall expenses continue to rise, it is becoming increasingly relevant to understand how each RVU type is changing over time, particularly regarding malpractice coverage in the increasingly litigious society of today. As such, this study analyzes change to RVU types over time in orthopaedic trauma.

Methods: The Physician Fee Schedule Look-Up Tool from the Centers for Medicare & Medicaid Services was queried for each of the 12 included CPT codes commonly utilized in orthopaedic trauma (23515, 23615, 24515, 24586, 27236, 27248, 26506, 27536, 27758, 27814, 27822, 27828). The mean work, practice expense, and malpractice RVU data were recorded for the years 2000 and 2019. Monetary data was adjusted for inflation to 2019 US dollars (USD) utilizing changes to the United States consumer price index (CPI). The total percent changes in RVUs were calculated based on these adjusted trends for all included procedures.

Results: After adjusting for inflation, total adjusted Medicare reimbursement for all procedures decreased by 32.5% between 2000 and 2019. The average total RVU decreased by 1.4%. The average work RVUs increased by 10.8%, while the practice expense RVUs decreased by 21.5%. The total average work payments decreased by 24.2%, and the total average practice expense payments decreased by 46.3%. Lastly, between 2000 and 2019, the malpractice RVUs increased by 111.6%, and the total average malpractice payment increased by 44.8%.

Conclusion: Medicare reimbursement for common surgical procedures has declined over the last 2 decades and is not keeping up with inflation. This trend is largely driven by the decrease to practice expense RVUs, despite a previous study demonstrating that practice expenses have actually increased by over 60% during this time. Additionally, malpractice payment is the only portion of RVU that has increased. It is likely that Medicare reimbursements are compensating for the increase in malpractice litigation and increasingly steep mean indemnity payments that are common in orthopaedic trauma.

Single Question May Predict Functional Outcome In Orthopaedic Trauma Patients

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Purpose: A complex dynamic exists between patient expectation and clinical outcome. Studies in multiple areas have demonstrated a relationship between patients' anticipated recovery and their functional outcome, but this association has not been investigated in orthopaedic trauma patients. The goal of this study was to investigate the relationship between the patients' expectation of recovery following a surgically fixed fracture and the patient-reported outcome using a single-item question.

Methods: This prospective study was conducted over a 2-year period from 2018 to 2020 at an academic Level I trauma center. All skeletally mature patients with a surgically managed fracture and a complete data set were included. Demographic data and injury characteristics were collected. The PROMIS PF-CAT (Patient-Reported Outcomes Measurement Information System Physical Function computer-adaptive test) was used to assess patient-reported return of physical function. Patient expectations were collected by asking a single question ("SF-1"). The SF-1 asks, "On a scale of 0 to 100, how likely do you believe you are of returning to your previous level of function?" with 0 = no expectation and 100 = full expectation of return to previous level. Both the PF-CAT and SF-1 data were collected at the patients' first postoperative visit within 2 weeks of surgery and at a minimum final follow-up of 3 months. Standard statistical comparisons and regression analysis evaluated the relationship between the SF-1 and PF-CAT.

Results: In total, 410 patients were included in the study with an average age of 55 years (standard deviation [SD]: 17). There were 242 males (59%) and 168 females (41%) in the cohort. Median time of follow-up was 6 months (range, 3-27 months). The average SF-1 score immediately postoperative was 80 (SD: 26) and 82 (SD: 22) at final follow-up. The average PF-CAT immediately postoperative was 32 (SD: 8) and 44 (SD: 9) at final follow-up. There were 129 patients (31%) who reported an SF-1 of 100 at first visit. There was no difference in age, gender, follow-up time, and fracture locations when comparing the patients with an SF-1 score of 100 to all other patients with any response less than 100. However, despite having similar initial PF-CAT scores (32 vs 31, P = 0.27) at first visit, patients who expected full recovery had higher PF-CAT scores at final follow-up (49 vs 41, $P<0.01$) compared to all others. When considering all responses to the SF-1, no association was noted between the SF-1 score and PF-CAT using regression analysis (r2 = 0.08).

Conclusion: These data support the notion that patient expectation of recovery is predictive of functional outcome in orthopaedic trauma patients. While the current study demonstrates that patient expectation cannot directly predict patient-reported outcomes in all subjects, it does for the one-third of all patients who anticipate a full recovery (SF-1 = 100) at the onset of their injury. This study adds to the literature about the importance of optimism and self-efficacy, and may call into question the importance of the treatment/surgeon in the outcome if these are driven by intrinsic patient factors.

A Multidisciplinary Protocol Reduces the Time to Surgery and In-House Mortality for Hip Fracture Patients

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Purpose: Many recent studies have shown that early definitive stabilization of hip fracture in the geriatric population improves outcomes in terms of reduced mortality, length of stay, and incidence of complications. However, multiple administrative, resource, and cultural barriers hinder attempts to reduce time to surgery in most institutions. At one Level II trauma center with a high volume of geriatric hip fractures, we went through a year-long process involving all stakeholders to develop a protocol for prompt treatment of these injuries. The protocol directed emergency department (ED) physicians to identify which patients needed cardiac evaluation and to initiate that process based on Metabolic Equivalent of Task (MET) and Revised Cardiac Risk Index (RCRI) scores. Patients who did not meet specific criteria for delay were immediately posted for surgery, and taken from the ED to the operating room (OR) whenever possible.

Methods: Utilizing the trauma center's American College of Surgeons Trauma Quality Improvement Program database we prospectively reviewed the time to surgery as well as outcome variables before and after institution of a protocol developed by a multidisciplinary team of physicians, staff, and administration.

Results: In the first year after institution of the protocol, we were able to reduce the time to surgery from a median value of 31.7 hours to 24.9 hours, and increase the percentage of patients treated within 24 hours from 45% to 64%. Over that same time period, the in-hospital mortality for these patients dropped from 2.95% to 0.51%. In the second year of the protocol, the time to surgery dropped further, to 21 hours; the percentage treated within 24 hours rose to 90%, and the in-house mortality dropped to 0%.

Conclusion: In our Level II trauma center, a multidisciplinary protocol involving the ED, the OR, the orthopaedic team, and consultant medical services, and managed by the trauma team, was able to substantially reduce the time from admission to definitive stabilization for hip fracture patients with concurrent significant reductions in mortality. This reflected an improvement in a habitual care culture that required buy-in from all physician specialties involved in the care of these patients.

Administration of Prophylactic Enoxaparin on the Morning of Surgery Does Not Increase Risk of Blood Transfusion or Wound Drainage Following Internal Fixation of Geriatric Femur Fractures

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Purpose: Despite standard use of chemoprophylaxis, 30-day incidence of deep venous thrombosis (DVT) or pulmonary embolism (PE) following geriatric hip fracture surgery is reported as high as 7.5%. Missing even a single dose of enoxaparin has been proven to be an independent risk factor for developing DVT in trauma patients. At many institutions it is commonplace to hold preoperative chemoprophylaxis the morning of surgery due to concern for intraoperative bleeding. We sought to determine whether administration of enoxaparin on the morning of surgery resulted in increased rate of blood transfusion or wound drainage in geriatric femur fractures.

Methods: We retrospectively reviewed patients over age 60 years who underwent surgical treatment of an isolated femur fracture (femoral neck, intertrochanteric, femoral shaft, or distal femur) via internal fixation at 3 affiliated academic hospitals. Medical records, hospital billing data, and radiographs were reviewed to determine patient characteristics, Charlson Comorbidity Index (CCI), administration of enoxaparin on the morning of surgery, packed red blood cell (PRBC) transfusion, and utilization of closed incision negative pressure wound therapy (ciNPWT) for persistent drainage. 30-day mortality served as the secondary outcome measure.

Results: 602 patients were included in final analysis. 167 patients (27.7%) received enoxaparin on the morning of their surgery, whereas 435 (72.3%) of patients did not. Rate of blood transfusion was 29% in each group and was not affected by the administration of enoxaparin. Older age and fracture of the distal femur were statistically significantly associated with increased risk of transfusion. There was no significant difference in use of ciNPWT for wound drainage between groups. There was no difference in 30-day mortality between groups.

Conclusion: Administration of prophylactic enoxaparin on the morning of surgery for geriatric femur fractures does not appear to increase rate of postoperative blood transfusion or wound drainage.

Tables

Table 1: Demographic Data of Patient Population

	All Patients (n = 602)	AM Enoxaparin (n = 167)	No AM Enoxaparin (n = 435)	p
Age (years)	77.6 +/- 10.2	75.7 +/- 10.3	78.2 +/- 10.2	0.007
Percent Female	73%	72%	73%	ns
BMI	27 +/- 7.4	28.1 +/- 7.4	26.6 +/- 7.3	0.04
Charlson Comorbidity Index	5.92 +/- 2.8	5.4 +/- 2.6	6.1 +/- 2.9	0.005

Table 2: Administration of AM Enoxaparin by Fixation Type

Type of Fixation	Number of Patients	AM Enoxaparin	No AM Enoxaparin
Cephalomedullary Nail	385	98 (25%)	287 (75%)
Dynamic Hip Screw	58	12 (21%)	46 (79%)
Screws Alone	33	8 (24%)	25 (76%)
Distal Femoral Locking Plate	126	49 (39%)	77 (61%)
Total	602	167 (28%)	435 (72%)

Table 3: Need for pRBC transfusion by Fixation Type

Type of Fixation	AM Enoxaparin requiring PRBC transfusion	No AM Enoxaparin requiring PRBC transfusion	p
Cephalomedullary Nail	24/98 (25%)	67/287 (23%)	0.65
Dynamic Hip Screw	1/12 (8%)	7/46 (15%)	0.42
Screws Alone	1/8 (13%)	8/25 (32%)	0.22
Distal Femoral Locking Plate	23/49 (47%)	43/77 (56%)	0.65
Total	49/167 (29%)	125/435 (29%)	0.88

Table 4: Primary and Secondary Outcomes based on Administration of AM Enoxapain Dose

	AM Enoxaparin (n = 167)	No AM Enoxaparin (n = 435)	p
Number requiring PRBC transfusion	49/167 (29%)	125/435 (29%)	0.88
Incisional Wound VAC placement for drainage	7 (4.2%)	12 (2.8%)	0.37
30-day Mortality	4 (2.4%)	12 (2.7%)	0.8

Mobilization After Hip Fractures on Day of Surgery Associated with Decreased Length of Stay: A Prospective Study

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Purpose: At present, there is limited evidence to guide the optimal timing, venue, or specific type of rehabilitation after hip fracture surgery. Furthermore, there is currently minimal literature quantifying the effects of immediate ambulation or mobilization of patients with these fractures. As efforts to improve treatment expands to include multidisciplinary teams, attention is focused on care processes that are easiest to modify and directly linked to outcomes. The purpose of this study is to determine if evaluation/treatment by physical therapy on the day of surgery impacts length of stay in elderly patients with intra- and extracapsular fractures of the hip.

Methods: Adult patients admitted for hip fracture requiring surgery were included over a 22-month period (May 2017- February 2019). Pathological fractures were excluded in this analysis. Multiple surgeons operated on hip fractures (n = 528) during this time period within one institution. A mobilization protocol was put into place to initiate mobilization of hip fracture patients on day of surgery with the nursing or therapy team. Patients were prospectively monitored thereafter.

Results: Of these 528 surgical cases, 259 (49.05%) were mobilized on day of surgery, while 269 did not mobilize with therapy on postoperative day 0). The median (interquartile range) length of stay of mobilized patients was 4.0 (3-6) days, versus 5.0 (4-6) days in the nonmobilized patients ($P = 0.0158$). The mobilized and nonmobilized cohorts were subcategorized based on their likelihood of discharging home versus a facility. Of the 259 mobilized on day of surgery, 64 (24.71%) were discharged home, versus 48 discharged home (17.84%) in nonmobilized cohort ($P = 0.0434$). Patients were followed postoperatively, with no statistically significant increased rates of readmission between the two cohorts ($P = 0.45$).

Conclusion: Mobilization on day of surgery is a safe method of intervention that reduced inpatient length of stay by 1 day, with a higher percentage of patients being discharged home as opposed to a rehabilitation facility.

Table 1. Summary of data by mobilization

	All Patients (n = 528)	Patients Mobilized		p-value
		Yes (n = 259)	No (n = 269)	
Age (years), mean ± sd	75.2 ± 14.6	75.0 ± 13.9	75.4 ± 15.2	0.77[a]
Length of Stay (days), median (IQR)	5 (3-6)	4 (3-6)	5 (4-6)	**0.02**[b]
ER to OR Time (hours), median (IQR)	19.2 (12.3-27.6)	18.6 (13-26.3)	19.4 (11.1-28.3)	0.80[b]
Patient Readmitted?, n (%)				0.58[c]
Yes	23 (4.4%)	10 (3.9%)	13 (4.8%)	
No	505 (95.6%)	249 (96.1%)	256 (95.2%)	
Disposition, n (%)				**0.04**[c]
Home	111 (21.0%)	64 (24.7%)	47 (17.4%)	
Other	417 (79.0%)	195 (75.3%)	222 (82.6%)	
Completed Nutrition Assessment, n (%)				0.36[c]
Yes	497 (94.1%)	241 (93.1%)	256 (95.2%)	
No	26 (4.9%)	15 (5.8%)	11 (4.1%)	
Missing	5 (1.0%)	3 (1.2%)	2 (0.7%)	

[a] Comparison made using Student's t-test. [b] Comparison made using Wilcoxon Mann-Whitney test.
[c] Comparison made using Chi-Square test.

Table 2. Summary of Logistic and Poisson Regression for Readmission

Predictor	OR (95% CI)	p-value
Age (years)	1.02 (0.99-1.05)	0.2839
Patient Mobilized (Yes vs No)	1.05 (0.44-2.49)	0.58

Table 3. Summary of Poisson Regression for Length of Stay

Predictor	Estimate (95% CI)	p-value
Patient Mobilized (Yes)	1.5 (1.23-1.76)	<0.01
Age (years)	0 (0-0.01)	0.21

Results of Retrograde Intramedullary Nailing Versus Locked Plating for Extreme Distal Periprosthetic Supracondylar Femur Fractures

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Purpose: This study was undertaken to compare clinical and radiographic outcomes following locked plating (LP) versus retrograde intramedullary nailing (rIMN) in extreme distal periprosthetic femur fractures, defined as fractures at or distal to the anterior flange (Su 2 or 3).

Methods: A retrospective review of all patients treated for a Su 2 or 3 periprosthetic distal femur fracture at a single Level I trauma center and minimum 3-month follow-up were reviewed. The primary outcome was reoperation for fixation failure or nonunion. Secondary outcomes included infection, delayed union, overall reoperation rate, postoperative lateral and anterior distal femoral angles (LDFA and ADFA), and change in distal femoral alignment. Outcomes were compared between patients treated with rIMN versus LP.

Results: 33 patients met inclusion criteria, including 7 patients treated with rIMN and 26 patients treated with LP. Average follow-up was 55 weeks (interquartile range [IQR] 18-69 weeks). Demographic data and fracture characteristics are shown in Table 1. The LP group had more points of fixation in the distal segment (nails: 2.9 ± 0.4; plates: 5.5 ± 0.5, $P<0.0001$) and fewer patients who were allowed to weight-bear as tolerated immediately (rIMN: 71%; LP: 12%, $P = 0.001$). There were no reoperations or delayed unions in the rIMN group. In the LP group, 6 of 26 patients (23%) underwent reoperation: 2 for nonunion, 1 for early fixation failure, 2 for infection, and 1 for symptomatic implants. 2 (8%) of the 26 plated fractures had a delayed union that did not require further surgery. None of these complications were statistically significant when compared to the nail group (Table 1). There were no differences in distal femoral alignment or alignment change between groups.

Table 1: Patient Demographics, Fracture Characteristics and Complications

	rIMN (n = 7)	% or SDEV	plate (n = 26)	% or SDEV	All (n = 33)	% or SDEV	P
Age (years)	78.2	10.4	75.6	13.1	76.1	12.5	0.633
BMI	31.0	6.5	30.4	8.9	30.5	8.3	0.872
Follow Up (weeks)	26.3	24.0	63.1	72.8	55.3	67.0	**0.031**
Gender							
Male	1	14%	7	27%	8	24%	Ref
Female	6	86%	19	73%	25	76%	0.652
Smoking							
No	7	100%	24	92%	31	97%	Ref
Yes	0	0%	1	4%	1	3%	>0.999
Laterality							
Left	6	86%	17	65%	23	70%	Ref
Right	1	14%	9	35%	10	30%	0.397
Mechanism							
GLF	4	57%	25	96%	29	88%	Ref
Medium energy (ie bike)	2	29%	0	0%	2	6%	**0.032**
High energy (ie MVC)	1	14%	1	4%	2	6%	0.301
Open							
No	6	86%	24	92%	30	91%	Ref
Yes	1	14%	2	8%	3	9%	0.524
Su Class							
2	0	0%	6	23%	6	18%	Ref
3	7	100%	20	77%	27	82%	0.301
Comminution							
No	1	14%	9	35%	10	30%	Ref
Yes	6	86%	17	65%	23	70%	0.397
Distal Fixation Points	2.9	0.4	5.5	0.5	5.0	1.2	**<0.0001**
Weight-Bearing RX							
NWB	0	0%	17	65%	17	52%	Ref
Protected WB	2	29%	6	23%	8	24%	0.093
WBAT	5	71%	3	12%	8	24%	**0.001**
Post-op Alignment							
LDFA	83.2	2.9	83.9	3.7	83.8	3.6	0.771
ADFA	84.9	8.4	91.3	7.0	90.1	7.6	0.06
Final Alignment							
ΔLDFA	1.9	1.3	2.4	1.7	2.3	1.6	0.798
ΔADFA	4.6	2.4	2.9	2.4	3.3	2.5	0.067
Complications							
Nonunion	0	0	2	8%	2	6%	>0.999
Delayed Union	0	0	2	8%	2	6%	0.559
Fixation Failure	0	0	1	4%	1	3%	>0.999
Infection	0	0	2	8%	2	6%	>0.999
Any Reoperation	0	0	6	23%	6	18%	0.301

Conclusion: Retrograde intramedullary nailing of extreme distal periprosthetic femur fractures appears safe and effective. Surgeons treating these fractures should consider this treatment strategy, even in the most distal fractures.

Patient Outcomes After Combined Open Reduction and Internal Fixation and Acute Total Hip Arthroplasty for Acetabular Fractures

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Purpose: Due to poor bone quality, significant marginal impaction, and preexisting arthritis, geriatric acetabular fractures are sometimes managed with combined open reduction and internal fixation (ORIF) and acute total hip arthroplasty (THA) despite reports that there may be higher complication and revision rates. Recent review articles offer no conclusions on the efficacy of this treatment, and little is available on patient outcomes. The purpose of this study was to evaluate postoperative outcomes and complication rates of a combined approach for acetabular fractures compared to ORIF alone. Our hypothesis is that elderly patients treated with the combined approach will have better overall outcomes / satisfaction with lower secondary procedures than those treated with ORIF alone.

Methods: After IRB approval, a retrospective medical record review identified patients who underwent ORIF / acute THA for acetabular fracture over a 10-year period. This initial search identified 341 patients. Patients undergoing ORIF and later conversion to THA or ORIF without arthroplasty were excluded; 28 patients remained. Demographic data, fracture type, complications, and length of follow-up were collected. Patients were contacted and given a questionnaire via telephone to determine current function, satisfaction, and secondary surgeries. Hip Disability and Osteoarthritis Outcome Score, Joint Replacement (HOOS, JR) and Patient-Reported Outcomes Measurement Information System (PROMIS)-Physical Function scores were obtained.

Results: Major reoperations occurred in 4 (16.7%) of 24 patients at an average of 1.45 years. Infection was the most common complication, seen in 3 patients (12.5%). Two patients (8.3%) have undergone component removal / antibiotic spacer placement and are currently awaiting reimplantation. One patient (4.2%) has completed two-stage revision. The remaining revision (4.2%; 1 of 24) was performed for recurrent instability. Of the 28 patients, 18 (10 men and 8 women) completed the survey. Six were deceased; however, no failures were seen at a mean time to death of 1.4 years. Three patients could not be reached, and 1 declined. Mean age was 70.2 years. Mean clinical follow-up was 363 days and mean phone follow-up was 1612 days (4.4 years). Patients reported their mean overall satisfaction score as 3.78 (1 = unsatisfied, 5 = very satisfied). Women were more satisfied (4.1) than men (3.5). Mean HOOS, JR interval hip score was 47.2%. Mean HOOS, JR interval hip scores between male (48.9%) and female (45.1%) were not significantly different. Mean PROMIS-Physical Function score was 27.9 and was not significantly different between sexes.

Conclusion: ORIF and acute THA is a reasonable option for complex geriatric acetabular fractures. Previous studies have demonstrated reoperation rates of at least 20% for elderly patients treated with ORIF alone, and conversion rates to THA of up to 50%. Our study demonstrated a similar yet slightly lower reoperation rate (16.7%) as previous studies, with acceptable outcome scores at 4.4 years. A combined approach should be considered in complex, elderly acetabular fractures.

Mortality Rates Following Nonoperative Geriatric Hip Fracture Treatment: A Matched Cohort Analysis

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Purpose: Relatively few studies have investigated outcomes following nonoperative treatment of geriatric hip fractures. The purpose of this study was to determine 30-day, 90-day, and 1-year mortality rates in a large cohort of nonoperatively treated geriatric hip fracture patients and to compare these mortality rates with a matched cohort of patients who underwent operative treatment.

Methods: We identified all patients 60 years and older with a fracture of the proximal femur treated at a single academic medical center over a 10-year period using ICD-9 codes for femoral neck, intertrochanteric, or subtrochanteric fractures. Medical records were reviewed to collect demographic information, hospital length of stay (LOS), medical comorbidities, current living status, and date of death, if deceased. Patients treated nonoperatively were matched in a 2:1 ratio with operatively treated patients based on Charlson Comorbidity Index (CCI) and American Society of Anesthesiologists (ASA) scores.

Results: We identified 171 patients treated nonoperatively. 501 operatively treated patients were identified for the matching algorithm. After applying the matching algorithm, including demographics, CCI, and ASA scores, a total of 128 nonoperative and 239 operative patients were included in the final statistical analysis. There were no significant differences in age, sex, CCI, or ASA status score between groups. After matching, patients treated nonoperatively had significantly higher 1-year mortality compared to patients treated operatively (46.1% vs 18.0%, odds ratio [95% confidence interval]: 3.85 [2.34, 6.41], $P<0.001$). As shown in Table 1, mortality rates at 30 days, 90 days, 1 year, and at present were all significantly higher in the nonoperative cohort.

Conclusion: Geriatric patients who underwent nonoperative management of their hip fractures had a 1-year mortality rate of 46.1%, significantly higher than that observed in a matched cohort of patients treated operatively (18.0%).

Table 1

Mortality	Non-operative (n=128)	Operative (n=239)	P value
30 days	31.2%	2.9%	<0.001
90 days	38.3%	6.7%	<0.001
1 year	46.1%	18.0%	<0.001
At Present	61.7%	36.0%	<0.001

Proximal Femoral Canal-Diameter Ratio Is a Predictor of Fractured Neck of Femur in Osteoporotic Patients

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Purpose: Osteoporosis is an independent risk factor for fragility fractures, especially of the neck of femur (NOF). Dual energy x-ray absorptiometry (DEXA) is the gold standard for diagnosing osteoporosis. This is not always readily available or accessible and requires specially trained personnel. Also, poor bone mineral density (BMD) will not necessarily predict the risk of fragility fracture. We have assessed a simpler radiological method that correlates well with BMD scores, to be used along with clinical assessment to pre-empt medical treatment. The proximal femoral canal-diameter ratio (CDR) has been described previously, but this has not been correlated against DEXA scores of patients with or without NOF fractures. The purpose of the study was to ascertain the correlation of CDR in this select group of patients, against DEXA scan results.

Methods: A retrospective, observational, case-control study was conducted collecting data from electronic radiographs and DEXA scan results of patients treated in our institution. 110 patients with NOF fractures who had DEXA scans within a year of the injury were included. The unaffected femur was used to measure CDR in patients with NOF fracture, using annotation tools on a standard AP radiograph of the pelvis. Patients with intracapsular fractures and extracapsular fractures were subgrouped into A and B respectively. 54 patients with no proximal femoral fracture were included as subgroup C. DEXA scan results were interpreted as normal, osteopenia, osteoporosis, and severe osteoporosis. Pearson's correlation coefficient was calculated to identify correlation between CDR values and the DEXA results within a group and Student's unpaired t test to compare the groups.

Results: There was no statistically significant difference in the CDR measurements between groups A and B or between male and female patients within any group, but there was an extremely significant statistical difference ($P<0.0001$) when both fracture groups were compared with group C (Table 1). Pearson's correlation coefficient was 0.465, when the CDR measurements were compared to DEXA results in patients with NOF fracture (moderate positive correlation) and 0.651 in patients without fracture (strong positive correlation). The odds ratio was 6.55 (95% confidence interval: 21.5 to 19.9) if the CDR value 0.61 was taken as a cut-off, to identify abnormal (osteopenic and osteoporotic) in the proximal femur ($P = 0.009$). Table 1. Statistical analysis of CDR data GROUPS Mean CDR values CDR Mean Std Dev Std Error of Mean Numbers in females in males A & B 0.62 (F=77) 0.60 (M=33) 0.61 0.0638 0.0061 110 (53+57) C 0.55 (F=42) 0.57 (M=12) 0.55 0.0752 0.0102 54

Conclusion: Simple and methodical radiological measurement of the CDR of the subtrochanteric region gives a reliable estimate of patient's BMD. There is a significant difference in the CDR of patients who had an NOF fracture when compared with patients who did not. The study supports and reinforces the use of CDR as a surrogate marker of abnormal BMD to easily identify patients at risk of developing NOF fracture, if the CDR is >0.61.

Δ Machine Learning Algorithms Exceed Comorbidity Indices in Prediction of Short-Term Complications Following Hip Fracture Surgery

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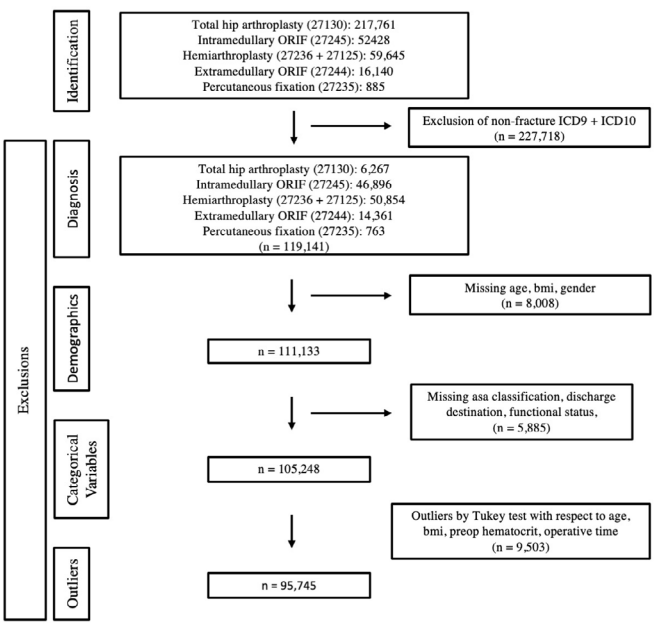
Purpose: The purpose of the present study is to determine the reliability of assessing operative risk following hip fracture through machine learning algorithms.

Methods: The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) was queried from 2011-2018 and the ACS-NSQIP hip fracture targeted dataset was queried from 2016-2018 for all patients undergoing operative fixation for a diagnosis of an acute primary hip fracture. The dataset was randomly split into training (80%) and testing (20%) sets. Three machine learning algorithms were utilized to train models in the prediction of extended hospital length of stay (LOS) >13 days, death, readmissions, home discharge, transfusion, and any medical complication. Testing sets were assessed by receiver operating characteristic curve, positive predictive value (PPV), and negative predictive value (NPV) and were compared to models constructed from legacy comorbidity indices (American Society of Anesthesiology score [ASA] modified Charlson Comorbidity Index [mCCI], frailty index [FI], and Nottingham Hip Score [NFHS]).

Results: Following inclusion/exclusion criteria, 95,745 cases were available in the overall dataset and 22,344 in the targeted dataset. Machine learning models outperformed comorbidity indices for each complication by AUC (area under the receiver operating characteristic curve) analysis (P<0.01 for each): medical complications (AUC = 0.65, PPV = 67.5, NPV = 71.7), death (AUC = 0.80, PPV = 46.7, NPV = 94.9), extended LOS (AUC = 0.69, PPV = 71.4, NPV = 94.1), transfusion (AUC = 0.79, PPV = 64.2, NPV = 77.4), readmissions (AUC = 0.63, PPV = 0, NPV = 96.8), and home discharge (AUC = 0.74, PPV = 65.9, NPV = 76.7).

Conclusion: Machine learning algorithms offer an improved method to holistically calculate preoperative risk of patient morbidity, mortality, and discharge destination. Through continued validation, risk calculators utilizing these algorithms may inform medical decision-making to providers and payers.



Δ OTA Grant

Dual Plating of Periprosthetic Distal Femur Fractures

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Purpose: Periprosthetic distal femur fractures are increasing in incidence as the number of total knee arthroplasties performed rises. Multiple fixation strategies have arisen including lateral locked plating, intramedullary nailing (IMN), dual implant with lateral locked plating/IMN, and dual medial and lateral locked plating. Historically, lateral locked plating has led to high rates of nonunion. IMN alone has been reported to have higher rates of union but increased incidences of malunion, particularly given the more posterior entry due to the femoral component box as well as a short distal segment for fixation. Dual plating has become an attractive option that allows the patient to weight-bear immediately postoperatively and we hypothesize leads to union rates comparable to IMN as well as near-anatomic coronal plane reduction.

Methods: We retrospectively reviewed all patients at a Level I tertiary care center from 2018 to 2020. Patients were included if they sustained a periprosthetic distal femur fracture treated with dual plate fixation at the institution during this time frame. Primary outcomes evaluated were fracture union, complications, revision surgery, and coronal plane alignment.

Results: 31 patients underwent dual plating between 2018 and 2020 with average age of 78.8 years. Five patients were lost to follow-up. 25 (96.2%) of 26 patients went on to achieve radiographic and clinical union at last follow-up. The most common complication was painful implants. Two patients required a repeat operation (7.7%): one underwent deep implant removal for painful hardware (single screw removal), and the second patient went on to atrophic nonunion but sustained no implant failure. The average lateral distal femoral angle was 83°, which remains within the margin of error of anatomic alignment.

Conclusion: Periprosthetic distal femur fractures remain a challenging problem in orthopaedics and have become an increasing component of geriatric trauma. Dual plating of periprosthetic distal femur fractures has several advantages including immediate postoperative weight bearing, improved coronal plane alignment, high union rates, and low incidence of complications/repeat operations. Additionally, biomechanical studies have shown that dual plating constructs impart stronger fixation than both lateral locked plating and lateral plate/IMN combinations. Dual plating obviates the need to determine what total knee implants are in place and what intramedullary nail the femoral component box can accommodate. This can be challenging, particularly with older implants no longer in use and avoids possible contamination of the prosthesis by avoiding a knee arthrotomy. Because of these advantages, dual plating should be added to the surgeon's armamentarium for treatment of these fractures.

Geriatric Fracture Patients/Families Have Poor Health Literacy and Long Length of Stay in Post-Acute Care Facilities: A Prospective Study

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Purpose: Health literacy (HL) includes a patient's comprehension of their medical condition and treatment plan. Geriatric patients with low HL can have poor outcomes. Geriatric fracture patients are often discharged to post-acute care (PAC) facilities (inpatient rehabilitation facilities = IRF, skilled nursing facilities = SNF). PAC is associated with high expenditures but no evidence of better outcomes. Medicare mandates that a care plan must be communicated ≤8 days of admission to PAC. However, many patients/families present to their first orthopaedic follow-up (2-3 weeks post-injury) with no knowledge of their PAC plan. Our objective was to investigate patients'/families' HL of their PAC and evaluate the influence of intervention at hospital discharge by the treating orthopaedic team on HL and length of stay (LOS).

Methods: Patients >65 years of age treated for fracture at a Level I trauma center from April 2018-November 2020 then discharged to PAC were prospectively enrolled at their first orthopaedic clinic visit. Patients with dementia were included only with family present, and family was encouraged to participate for all patients. Participants completed a survey asking: (1) facility name, (2) physician, (3) social worker, (4) discharge goals (activity, equipment, care, etc), and (5) discharge date. Beginning January 2019, patients/families were given verbal/written orthopaedic instruction prior to hospital discharge detailing important questions to ask on arrival to PAC. Bivariate comparisons were performed with Fisher exact test, t test, and Wilcoxon rank sum.

Results: 207 patients were enrolled (Control: n = 106; Intervention: n = 101), with mean age 79 years. The mean HL score for all patients/families was 2.4 out of 5. 93.7% were able to identify the facility, 44.9% could name their physician› and 28.0% could name their social worker. Only 37.2% could identify goals for discharge, and only 35.7% were aware of their anticipated discharge date. There was no significant difference in HL scores (2.4 vs 2.3, P = 0.49) or median LOS (22 vs 28 days, $P = 0.14$) comparing the Control and Intervention groups. Family involvement (68%) did slightly improve HL score (2.6 vs 1.9, $P<0.001$), but did not impact LOS (median 24 vs 35 days, $P = 0.21$). Patients discharged to IRF had better HL scores (3.4 vs 2.2, $P<0.001$), shorter LOS (median 15 vs 30 days, $P<0.001$), and trended toward improved knowledge of discharge goals (48.1% vs 35.6%, $P = 0.2$) than those in SNF.

Conclusion: Geriatric fracture patients and families discharged to PAC have poor overall HL of their care plans (mean 2.4 out of 5) and long LOS (median 26 days). Family involvement and discharge to IRF can improve HL and LOS, but orthopaedic intervention at hospital discharge had no significant effect. Systemic changes are necessary to improve geriatric HL and PAC.

Increased Complications and Cost Associated with Hip Arthroplasty for Femoral Neck Fracture: Evaluation of 576,119 Medicare Patients Treated with Hip Arthroplasty

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Purpose: Multiple studies have shown the benefits of arthroplasty for treatment of femoral neck fractures (FNFs) in geriatric populations. Patients undergoing hip arthroplasty for the treatment of FNF are a significantly different population than elective hip arthroplasty patients. We compare perioperative complications and cost of total hip arthroplasty (THA) for treatment of osteoarthritis (OA) to hemiarthroplasty (HA) and THA for treatment of FNF.

Methods: Data from the Centers for Medicare & Medicaid Services (CMS) were used to identify all patients 65 years of age and older undergoing primary hip arthroplasty between 2013 and 2017. Patients were identified using diagnosis-related group codes 469 and 470, then divided into three cohorts: primary THA for OA (n = 326,313), HA for FNF (n = 223,811), and THA for FNF (n = 25,995). Generalized regressions were used to compare mortality, 90-day readmission, thromboembolic events, and 90-day costs, controlling for age, sex, race, and comorbidity.

Results: Compared to patients treated for OA, FNF patients were older, more likely to be female, and had significantly more comorbidities (all $P<0.001$). Even among the youngest cohort (65-69 years) without comorbidity, FNF was associated with a greater risk of mortality at 90 days (THA-FNF odds ratio [OR] 9.34, HA-FNF OR 27.02; $P<0.001$), 1 year (THA-FNF OR 7.75, HA-FNF OR 19.02; $P<0.001$), and 5 years (THA-FNF HR 4.54, HA-FNF HR 9.965; $P<0.001$), as well as a higher risk for thromboembolic events (THA-FNF OR 1.42, HA-FNF OR 1.36; $P<0.001$) and readmission at 90 days (THA-FNF OR 2.10, HA-FNF OR 2.59; $P<0.001$). Mortality and complications only increased when stratified by age and comorbidities with the 85 years and older age group demonstrating 3.7% 1-year mortality in the THA-OA age group compared to 26% ($P<0.001$) 1-year mortality in the THA-FNF group and a 31.8% ($P<0.001$) 1-year mortality in the HA-FNF cohort. Cases with treatment of FNF were associated with significantly greater direct cost ($P<0.001$). The mean 90-day episode cost for the THA-OA cohort was $25,296 (95% confidence interval [CI] $24,997, $25,595) compared to $37,720 (95% CI $38,970, $39,553; $P<0.001$) for the THA-FNF group and $39,261 (95% CI $37,260, $38,179; $P<0.001$) for the HA-FNF group.

Conclusion: Among CMS hip arthroplasty patients, those with an FNF had significantly higher rates of mortality, thromboembolic events, readmission, and greater direct cost. Reimbursement models for arthroplasty should account for differences among FNF patients who have distinctly different perioperative complication profiles from patients undergoing THA for OA. Bundling these heterogenous groups of patients together in an alternative payment system could disadvantage those centers that care for a higher proportion of FNF patients. Furthermore, this information can be used for counseling FNF patients and families in the perioperative setting regarding risks and complications.

The Focus on Quality Has Driven Down Hospital Stay and Complications Despite No Change in Mortality Following Surgical Treatment of Hip Fractures

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Purpose: The incidence of hip fractures is expected to continue rising globally to coincide with the growing geriatric population. The purpose of this study was to compare developments in the treatments and outcomes for both femoral neck (FN) and intertrochanteric (IT) fractures from 2007 to 2016 using a large-scale database.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried for patients over 65 years of age treated for FN or IT fractures between 2007 and 2016. Linear regression analyses were conducted for continuous variables and Cochran-Armitage trend tests were completed for categorical variables. Statistical significance was defined as $P<0.05$.

Results: 73,008 patients identified as having had a FN or IT fracture met the inclusion criteria for our analyses. Between 2007 and 2016, the mean age increased (76 to 77 years old, $P = 0.003$), body mass index increased (24.7 to 24.8, $P = 0.009$), American Society of Anesthesiologists class increased (2.94 to 3.02, $P = 0.001$), and modified Charlson Comorbidity Index scores decreased (3.2 to 2.9, $P<0.001$) for this cohort. No statistically significant difference in the incidence ratio of FN versus IT fractures per year was observed. Between 2007 and 2016, two trends in fracture management were identified. The use of total hip arthroplasty for FN fractures increased from 22.2% to 28.8% ($P = 0.004$). The shift from plates and screws to intramedullary nails for the treatment of IT fractures also continued to increase from 64.7% to 79.4% ($P<0.001$). Inpatient length of stay decreased from 2007 through 2016 (7.2 days to 6.7 days, respectively, $P<0.001$), any complication decreased from 2011 through 2016 (41.1% to 29.9%, respectively, $P<0.001$), and time from admission to operation decreased from 2007 through 2016 (1.38 days to 1.28 days, respectively, $P<0.001$). No statistically significant difference was found for home discharge or mortality.

Conclusion: Government payor focus on quality measures has led to important improvements in hip fracture care. Decreases in inpatient length of stay, complications, and time to the operating room no doubt lower cost to the health-care system. However, despite these advancements, no differences in home discharge or mortality were identified over this study period. Future work will need to focus on uncovering other modifiable patient-centered factors to continue improving outcomes after FN and IT fractures.

Use of Short Cephalomedullary Nails for Geriatric Hip Fractures Reduces Blood Loss and Need for Transfusion: A Multicenter Retrospective Analysis

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Purpose: Among the growing global burden of geriatric hip fractures, the extracapsular majority are commonly treated with cephalomedullary nails (CMNs) with short and long versions demonstrating contrasting benefits that remain controversial. The important measure of perioperative blood loss has been inaccurately reported using estimated blood loss in the literature, thereby clouding the decision-making process between short and long. Hypothesizing that use of a short CMN would confer a decrease in true blood loss, we sought to assess whether the more accurate «calculated blood loss» (CBL) based on hematocrit dilution would be lower for patients treated with short rather than long CMNs.

Methods: A retrospective comparative cohort analysis was conducted of 1442 cases of CMN fixation of geriatric (ages 60-105 years) extracapsular hip fractures (AO/OTA 31A , 31B3, and 32 fractures within 5 cm of the lesser trochanter) at two Level I trauma centers between January 1, 2009 and December 31, 2018. Patients undergoing multiple simultaneous or revision surgeries were excluded. Blood loss was calculated as previously described based on the volume required to produce the observed change in hemoglobin between pre- and postoperative measurements. Univariate comparisons between long and short nail cohorts were performed using Barnard's exact and Wilcoxon rank-sum tests, and multivariate linear regression analysis was conducted with propensity score weighting.

Results: Use of a short rather than long CMN was associated with approximately a 30% reduction in CBL and a reduction in mean operative time from 66 to 42 minutes. The absolute reduction in transfusion risk was 21%, yielding a number needed to treat of 4.8 (with a short nail to prevent one transfusion). No statistically significant difference in reoperation, periprosthetic fracture, or mortality was noted between groups.

Conclusion: Use of short compared to long CMNs for geriatric extracapsular hip fractures confers markedly reduced blood loss, need for transfusion, and operative time. In concert with prior literature demonstrating a 226% increased risk of surgical site infection following blood transfusion, our data further imply that 1 in 14 patients treated with a long nail develop a surgical site infection that would be avoided with a short nail.

Δ Early Discharge Following Hip Fracture Surgery Is Associated with Decreased Hypercoagulability and Venous Thromboembolism Risk

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Purpose: Prolonged bedrest in hospitalized patients is a risk factor for venous thromboembolism (VTE), especially in high-risk patients with hip fracture. Thromboelastography (TEG) is a whole blood test with evidence that an elevated maximal amplitude (MA), a measure of clot strength, is predictive of VTE in trauma patients. This study compared MA from TEG analysis between hip fracture patients who were discharged from hospital early to hip fracture patients with reduced mobility.

Methods: Serial TEG analysis was performed in hip fracture patients every 24 hours from admission until postoperative day (POD) 5, then at 2 and 6 weeks. Hypercoagulability was defined by MA >65. Patients were divided into an early (within 5 days) and late (after 5 days) discharge group, inpatient at 2 weeks group, and discharge to musculoskeletal (MSK) rehabilitation (MSK rehab), and long-term care (LTC) groups. Two-sample t test was used to analyze differences in MA between the early discharge and less mobile groups.

Results: 121 patients with a median age of 81.0 years were included. Patients in the early discharge group (n = 15) were younger (median age 64.0 years) and more likely to ambulate without gait aids preinjury (86.7%) compared to patients in the late discharge group (n = 105), inpatients at 2 weeks (n = 48), discharged to MSK rehab (n = 30), and LTC (n = 20). At 2 weeks postoperative, the early discharge group was significantly less hypercoagulable (MA = 68.9, standard deviation 3.0) compared to patients in the other four groups (Fig. 1). At 6 weeks postoperative, the early discharge group was the only group to demonstrate a trend toward mean MA below the MA >65 hypercoagulable threshold (MA = 64.4, $P = 0.45$).

Conclusion: Results from this study suggest that patients with hip fracture who are able to mobilize independently immediately after surgery are less hypercoagulable and haveashorterduration of hypercoagulable state compared to patients who are less mobile after hip fracture surgery.

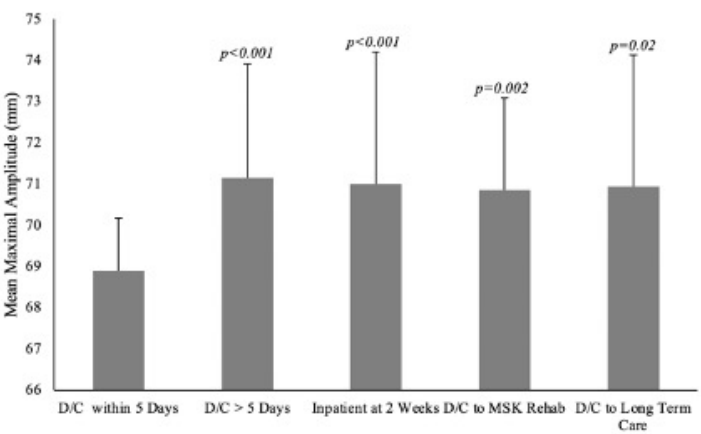

Figure 1. Mean MA and standard deviation of patients with hip fracture in the "early discharge group" and less mobile groups. Two-sample t-test was used to analyze for significant differences in MA between the early discharge group and other four groups.

Δ OTA Grant

Early Clinical and Radiographic Outcomes of the Femoral Neck System in Comparison to Closed Reduction and Percutaneous Pinning for the Treatment of Hip Fractures

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Purpose: Although common, treatment of femoral neck fractures with cannulated screws (closed reduction and percutaneous pinning [CRPP]) is not without limitations. Recent studies have demonstrated that non-nion and subsequent reoperation can occur at a rate of nearly 15% to 20%. A new implant for treatment of these fractures called the Femoral Neck System (FNS) has emerged; however, it is still novel and published literature is scant. In this study, we aim to analyze the reoperation and complication rates of the novel FNS in comparison to CRPP for treating femoral neck fractures.

Methods: This study was a retrospective chart review of the patients treated by our practice from January 2019 (the FNS was released in 2019) to the present time. All adult patients treated with the FNS or CRPP were included in this analysis. Data collection was conducted in a retrospective manner from the patient charts at our practice. Patient follow-up was conducted at 4, 8, 12, and 16 weeks following surgery. Data such as patient demographics, union, comorbidities, and complications/hardware failure were extracted. Statistical analysis was conducted using comprehensive meta-analysis software.

Results: Since the start of 2019 we have adequate follow-up to assess the outcomes of 37 patients treated with the FNS and 49 patients treated with CRPP. The average age of each cohort was 70.1 and 71.9 years, respectively. In the FNS group there were 27 Garden 1 (55.1%), 9 Garden 2 (33.3%), and 1 Garden 3 (2.04%), whereas in the CRPP cohort there were 42 Garden 1 (85.71%) and 7 Garden 2 (14.29%). The rate of revision surgery for the FNS cohort was 1 of 37 (2.70%) compared to 12 of 49 (24.48%) for the CRPP cohort (P = 0.021). The reason for the revision surgery (occurring 5 weeks after initial surgery) in the FNS cohort was hardware failure, and the reasons in the CRPP group (average of 19.9 weeks following initial surgery) were prominent/painful/loosening hardware (7), nonunion (3), hardware failure (1), and osteonecrosis (1). The rate of nonunion in the FNS cohort was 2 of 37 (5.40%), and 7 of 49 (14.28%) for the CRPP group ($P = 0.199$). Lifestyle factors such as diabetes, smoking, and illicit drug use did not increase the odds of complications in a statistically significant manner. 9 of 37 patients (24.3 %) in the FNS cohort reported pain associated with their surgery/hardware whereas 24 of 49 (49.0%) reported pain in the CRPP cohort ($P = 0.022$).

Conclusion: Based on our results from hip fractures treated by the FNS and CRPP during the same time period in our practice, the FNS was associated with a statistically significant decrease in reoperation rate and postoperative pain at the surgical site. It appears the utility of the FNS for treating femoral neck fractures is promising. The additional costs of the FNS may be cost-effective due to the smaller incidence of reoperation found among the patients in our study. Prospective studies and cost analyses are necessary to elucidate this information.

Outcomes for Type C Proximal Humerus Fractures in the Geriatric Population: Comparison of Nonoperative Treatment, Locked Plate Fixation, and Reverse Shoulder Arthroplasty

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Purpose: This study compares patient-reported outcomes (PROs) and range of motion (ROM) between patients managed nonoperatively, with open reduction and internal fixation (ORIF), and with reverse shoulder arthroplasty (RSA).

Methods: This was a retrospective cohort study of patients >55 years old treated with nonoperative management, ORIF, or RSA for AO/OTA Type 11C proximal humerus fractures from 2015 to 2018. Visual analog scale (VAS) pain scores, Patient-Reported Outcomes Measurement Information System (PROMIS) scores, ROM values, and complication and reoperation rates were compared using analysis of variance for continuous variables and $\chi 2$ analysis for categorical variables.

Results: A total of 94 patients were included: 46 nonoperative, 24 ORIF, and 24 RSA. No significant differences in patient characteristics were identified ($P>0.05$). All results are reported in Table 1. At 2-week follow-up ORIF and RSA showed lower VAS scores, and better ROM and PROMIS scores ($P<0.05$) compared to nonoperative treatment. At 6-week follow-up, ORIF and RSA had lower VAS scores, and better ROM and PROMIS scores ($P<0.05$) compared to nonoperative treatment. At 3-month follow-up ORIF and RSA showed decreased VAS scores, and better ROM and PROMIS scores ($P<0.05$) compared to nonoperative treatment. At 6-month follow-up ORIF and RSA showed similar VAS scores ($P>0.05$), but better ROM and PROMIS scores ($P<0.05$) compared to nonoperative treatment. The RSA group had a significantly lower reoperation rate ($P<0.05$).

Table 1. Outcomes Type C Fractures*

	Nonoperative (N=46)	ORIF (N=24)	RSA (N=24)	†p-value
Complications (n)ǂ	**80.4% (37)**	**54.2% (13)**	**0.0% (0)**	**<0.001**
Varus Malunion	54.4% (25)	37.5% (9)	--	0.181
Nonunion	4.4% (2)	4.2% (1)	--	--
HS Translation	2.2% (1)	4.2% (1)	--	--
AVN	4.4% (2)	12.5% (3)	--	--
Reoperation (n)§	**4.4% (2)**	**33.3% (8)**	**0.0% (0)**	**<0.001**
Range of Motion (Mean ± SD, °)				
Active Forward Flexion				
2-week follow up	0 ± 0	0 ± 0	0 ± 0	--
6-week follow up	**16.4 ± 28.1**	**32.6 ± 31.8**	**57.1 ± 50.8**	**<0.001**
3-month follow up	**56.4 ± 47.0**	**80.6 ± 41.1**	**125.1 ± 20.4**	**<0.001**
6-month follow up	**93.6 ± 29.9**	**104.0 ± 28.2**	**133.0 ± 22.5**	**<0.001**
Passive Forward Flexion				
2-week follow up	**0 ± 0**	**11.7 ± 28.6**	**46.5 ± 47.7**	**<0.001**
6-week follow up	**48.4 ± 40.8**	**59.9 ± 41.5**	**114.1 ± 31.5**	**<0.001**
3-month follow up	**68.7 ± 53.4**	**100.4 ± 46.5**	**137.5 ± 21.2**	**<0.001**
6-month follow up	**117.1 ± 22.4**	**125.4 ± 14.8**	**147.9 ± 15.1**	**<0.001**
External Rotation				
2-week follow up	**0 ± 0**	**0.5 ± 1.5**	**3.3 ± 6.1**	**<0.001**
6-week follow up	**12.3 ± 14.7**	**14.7 ± 14.5**	**23.4 ± 13.8**	**0.005**
3-month follow up	**22.3 ± 23.4**	**29.1 ± 21.8**	**37.3 ± 21.3**	**0.013**
6-month follow up	36.6 ± 20.0	35.9 ± 20.7	44.1 ± 19.4	0.233
Patient Reported Outcomes (Mean ± SD)				
VAS Pain Score				
2-week follow up	**6.2 ± 3.3**	**2.6 ± 2.4**	**2.7 ± 2.6**	**<0.001**
6-week follow up	**3.7 ± 3.0**	**2.1 ± 2.4**	**1.1 ± 1.7**	**<0.001**
3-month follow up	**2.4 ± 2.6**	**1.8 ± 2.1**	**1.1 ± 2.0**	**0.047**
6-month follow up	1.8 ± 2.4	1.5 ± 2.3	0.8 ± 1.6	0.085
PROMIS Depression				
2-week follow up	58.3 ± 8.9	54.0 ± 9.6	55.8 ± 7.0	0.285
6-week follow up	53.1 ± 9.4	52.7 ± 8.1	52.8 ± 7.3	0.882
3-month follow up	51.5 ± 8.7	48.8 ± 8.5	49.3 ± 10.2	0.409
6-month follow up	52.5 ± 11.2	47.2 ± 11.3	46.8 ± 10.6	0.117
PROMIS Pain Interference				
2-week follow up	**69.9 ± 6.3**	**64.5 ± 7.2**	**63.8 ± 6.9**	**0.003**
6-week follow up	**61.5 ± 5.9**	**58.1 ± 5.3**	**57.4 ± 5.7**	**0.012**
3-month follow up	**60.0 ± 6.2**	**55.8 ± 6.7**	**50.0 ± 7.3**	**<0.001**
6-month follow up	**58.9 ± 9.6**	**53.5 ± 8.0**	**53.3 ± 6.0**	**0.042**
PROMIS Physical Function				
2-week follow up	28.1 ± 6.7	31.0 ± 5.9	28.3 ± 4.8	0.763
6-week follow up	**30.6 ± 4.7**	**35.8 ± 5.3**	**33.8 ± 4.4**	**0.016**
3-month follow up	35.4 ± 8.5	40.4 ± 5.7	39.0 ± 4.3	0.076
6-month follow up	**36.7 ± 8.9**	**44.3 ± 5.6**	**42.2 ± 5.2**	**0.021**

SD = Standard deviation; ORIF = Open reduction internal fixation; RSA = Reverse shoulder arthroplasty; HS = Head-shaft; AVN = Avascular necrosis; VAS = Visual analog scale; PROMIS = Patient reported outcomes measurement information system
***Boldface** indicates statistical significance.
†p-values calculated using analysis of variance and chi square analysis for continuous and categorical variables, respectively
ǂ Additional complications: Nonoperative – valgus malunion (9); ORIF – screw cutout (2), hardware failure (2), adhesive capsulitis (1), symptomatic hardware (1)
§ Reoperations: Nonoperative – conversion to arthroplasty (2); ORIF – conversion to arthroplasty (3), revision fixation (2), removal of hardware (2), lysis of adhesions (1)

Conclusion: The management of geriatric AO/OTA type 11C proximal humerus fractures with RSA or ORIF led to early decreased pain, and improved physical function and ROM compared to nonoperative management.

Association of Age, Sex, and Race with Prescription of Bone Protective Medications Following Low-Energy Hip Fracture

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Purpose: Patients who suffer a low-energy hip fracture are at an imminent increased risk for future fragility fractures. Initiation of bone protective medications after hip fracture has been reported to lower the risk of subsequent fragility fractures, thereby decreasing morbidity and mortality. Despite current clinical practice guidelines, historical biases of targeting fracture prevention toward certain groups may result in persistent disparities in prescribing of bone protective medication. Our objective was to identify the association of patient age, sex, and race with prescription of bone protective medication following low-energy hip fractures.

Methods: A registry-based cohort of patients ≥50 years with a low-energy hip fracture requiring surgical fixation between 2016 and 2018 was assembled from the American College of Surgeons National Surgical Quality Improvement Program registry. Patients on bone protective medications prior to admission were excluded. Multivariable logistic regression was used to determine adjusted associations between patient age, sex, and race and their interactions with prescription of bone protective medications within 30 days of surgery, after accounting for relevant covariates (comorbidity, injury factors, and treatment factors).

Results: In total, 17,006 patients with a hip fracture who were not previously taking bone protective medications were identified. Their median age was 82 years (interquartile range [IQR]: 73-87), and 66% were female (n = 11,250). Thirty days after surgery, 32% (n = 5409) of patients had been prescribed bone protective medication. Following adjustment for covariates, a significant interaction between age and sex with bone protective medication prescription was observed (P = 0.03). Male sex among patients in their 50s (odds ratio [OR]: 0.73, 95% confidence interval [CI]: 0.61-0.87), 60s (OR: 0.78, 95% CI: 0.69-0.88), 70s (OR: 0.85, 95% CI: 0.78-0.91), and 80s (OR: 0.91, 95% CI: 0.84-0.99) was associated with a lower odds of bone protective medication prescription compared to female patients of the same age. Medication prescription did not differ among patients of different racial backgrounds or those over 90 years.

Conclusion: Only 32% of patients were prescribed bone protective medications within 30 days of surgery for low-energy hip fracture, despite consensus guidelines urging early initiation of secondary prevention treatments in this population. Given that men under 90 years were less likely to receive appropriate therapy, strategies need to be implemented to prevent sex- and age-based disparities in secondary fracture prevention.

Does Construct Stiffness Really Matter in Plated Distal Femur Fractures? Re-Evaluation of a Previously Defined Construct Rigidity Score

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Purpose: Distal femur fractures are a common orthopaedic injury with nonunion as a well-recognized complication that frequently leads to reoperation. Known patient-specific risk factors for nonunion include obesity, open fracture, infection, and smoking. It is proposed that modifiable factors related to construct rigidity may also be related to nonunion. The purpose of this study is to identify risk factors for distal femoral fracture nonunion at our institution as well as apply a previously published lateral locked plating construct rigidity score for external validation.

Methods: This was a single-institution, retrospective case series of adult patients who underwent operative fixation of the distal femur (AO/OTA types 33A and 33C) between 2008 and 2017 at a Level I tertiary referral trauma center. Patient demographics and comorbidities, injury characteristics, and fixation characteristics were gathered by chart review and examination of initial, postoperative, and final follow-up radiographs. Nonunion was defined as the need for a secondary procedure to improve bony healing or lack of radiographic signs of healing at 6 months postoperatively. A construct rigidity score was calculated using the algorithm previously published by Rodriguez et al. Fisher's exact test was used to evaluate categorical variables. The Student t test was used to analyze the relationship of fracture displacement and distance from the articular surface to nonunion. P values were set at <0.05.

Results: We identified 209 patients who underwent operative fixation for distal femur fractures, 147 of whom had minimum 3-months follow-up (70.3%). 12 of the 147 patients (8.2%) underwent reoperation secondary to nonunion. Initial displacement on injury radiographs (sagittal + coronal plane) was significantly associated with nonunion (P <0.001). The use of titanium alloy plates was associated with an increased nonunion rate (21% vs 2.4%, respectively; P <0.003). The use of shorter plates (≤9 proximal holes) resulted in a higher rate of nonunion than the use of longer plates (16.7% vs 2.7%, P <0.02). Flexible constructs (rigidity scores 0-2) had an increased risk of nonunion when compared to stiff constructs (rigidity scores 3-5) (22.2% vs 2.2%, respectively; P <0.007). No nonunions were identified in the cohort of 14 patients with the constructs that were most stiff (rigidity score 5).

Conclusion: In this cohort of 147 patients, we found that initial fracture displacement, titanium material, and shorter plate length are associated with the development of nonunion after operative treatment of distal femur fractures. Contrary to prior reports, this data does not support the notion that increasing construct stiffness leads to higher nonunion rates.

Prior Fragility Fracture Increases Failure Rate After Short Nail for Fixation of Intertrochanteric Fractures

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Purpose: Fixation of intertrochanteric fractures with an intramedullary device has become increasingly common as shown in multiple studies. With the increasing usage of short nails, it is necessary to study the outcomes and failures in a set of cases that were fixed with a short nail. The aim of this study was to determine the failure and revision surgery rate, and associated risk factors, in a set of geriatric hip fractures that were fixed with a short cephalomedullary nail.

Methods: Retrospective chart review was performed of our hip fracture database to identify all geriatric patients who underwent fixation with a short cephalomedullary nail. Data collected included demographics, operative details, imaging, and follow-up data. Radiographs were reviewed to determine AO classification, Dorr classification, and adequacy of reduction on immediate postoperative imaging. History of prior fragility fractures (proximal humerus, distal radius, or contralateral hip) was collected on all patients.

Results: Over a 10-year time period, 92 patients underwent fixation of an intertrochanteric fracture with a short Gamma nail. The overall reoperation rate was 22.7%. 13 patients required revision fixation for a distal periprosthetic fracture at an average of 3.4 years, and 2 patients underwent conversion to arthroplasty after lag screw cutout at an average of 5 months. 2 patients underwent surgery for deep infection. The odds of experiencing a distal femur periprosthetic fracture were 4.3× higher in patients with a history of prior fragility fracture ($P = 0.02$). There was no difference between groups in Charlson comorbidity index or American Society of Anesthesiologists (ASA) score. There was a significantly higher percentage of Dorr C femurs in the non-failed group compared to the failed group ($P = 0.02$).

Conclusion: This study found a high reoperation rate in patients who underwent intertrochanteric fracture fixation with a short cephalomedullary nail, with most revisions due to a distal periprosthetic fracture. Patients who underwent a revision surgery after a short nail due to distal periprosthetic fracture had a significantly higher odds of a prior fragility fracture.

Short-Term Outcomes of Civilian Ballistic Versus Blunt Diaphyseal Femur Fractures

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Purpose: Diaphyseal femur fractures are the most common long bone fractures associated with gunshot wounds. We aim to assess the short-term outcomes of patients treated with an intramedullary nail who sustained diaphyseal femur fractures caused by a low-energy ballistic injury when compared to blunt force trauma.

Methods: A retrospective review of operatively managed diaphyseal femur fractures between January 2015 and April 2020 at a single Level I trauma center was performed. High-energy gunshot wound (GSW) fractures and fractures extending into the articular surface were excluded. Patients demographics, fracture characteristics, treatment information, and outcome measures including complications were recorded.

Results: 96 blunt and 104 gunshot femoral shaft fractures were identified. Patients with GSW fractures had a median length of stay of 2 days shorter than those with fractures from blunt force trauma. Readmission (6.9% vs 0.0%; $P = 0.015$), infection (7.9% vs 1.1%; $P = 0.036$), and reoperation (8.9% vs 3.2%; $P = 0.138$) were significantly more common in diaphyseal femur fractures caused by a ballistic injury than in those caused by blunt force trauma. Loss to follow-up was significantly higher among GSW fracture patients (28%) compared to blunt fractures (20%) ($P = 0.038$).

Conclusion: Short-term complications, particularly infection, readmission, and reoperation, may be relatively high in diaphyseal femur fractures caused by GSWs when compared to those of blunt trauma.

Table 1. Patient Demographics, Fracture Characteristics, and Outcomes

	Blunt n(%)	GSW n (%)	p-value
patients (# fractures)	93 (96)	101 (104)	
Age (mean (SD))	35.6 (15.7)	26.1 (6.6)	<0.001
Male (%)	63 (67.7)	93 (92.1)	<0.001
BMI (mean (SD))	27.36 (5.94)	27.61 (7.19)	0.805
Isolated Injury (%)	32 (34.4)	63 (62.4)	<0.001
ISS (mean (SD))	13.89 (7.38)	12.08 (6.57)	0.261
Fracture Location (%)			<0.001
Distal Third	13 (13.5)	36 (34.6)	
Middle Third	48 (50.0)	30 (28.8)	
Proximal Third	7 (7.3)	10 (9.7)	
Subtrochanteric	28 (29.2)	28 (26.9)	
OTA classification (%)			<0.001
A	43 (46.2)	5 (5.1)	
B	14 (15.1)	0 (0.0)	
C	36 (38.7)	94 (94.9)	
Length of Stay (median [IQR])	7.00 [4.00, 13.00]	5.00 [3.00, 9.00]	0.007
Longest Clinic Follow-up (median [IQR])	3.00 [2.00, 6.00]	2.38 [1.00, 6.00]	0.189
Reoperation (%)	3 (3.2)	9 (8.9)	0.138
30-Day Readmission (%)	0 (0.0)	7 (6.9)	0.015
Non-union (%)	2 (2.2)	1 (1.0)	0.608
Surgical Infection (%)	1 (1.1)	8 (7.9)	0.036

Key: GSW= gunshot wound; BMI= body mass index; ISS= injury severity score; OTA=Orthopaedic Trauma Association; IQR= interquartile range

Smith-Petersen Versus Watson-Jones Approach Does Not Affect Quality of Open Reduction of Femoral Neck Fracture

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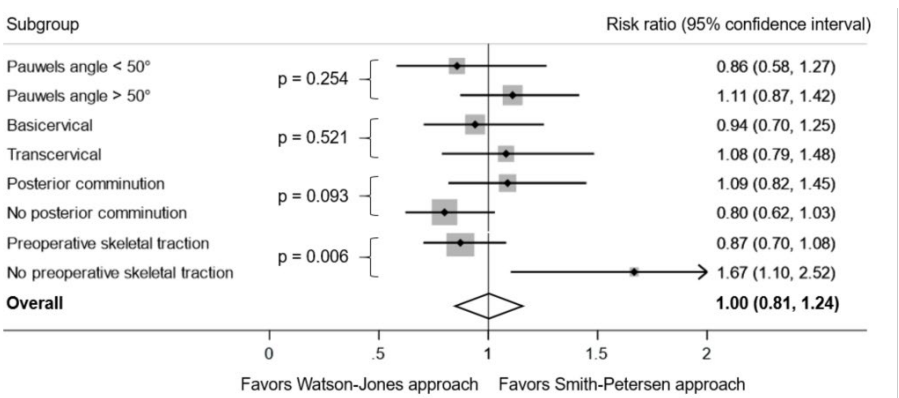
Purpose: This study was undertaken to compare the immediate quality of open reduction of femoral neck fractures by alternative surgical approaches.

Methods: 80 adults aged 18 to 65 years with isolated, displaced OTA / AO type 31-B2 or -B3 femoral neck fractures treated with internal fixation via an open surgical reduction were retrospectively identified from the registries of 12 Level I North American trauma centers. The intervention was the use of a modified Smith-Peterson anterior approach (n = 32) versus Watson-Jones anterolateral approach (n = 48) for open reduction. The main outcome was reduction quality as assessed by 3 senior orthopaedic traumatologists as "acceptable" or "unacceptable" on AP and lateral postoperative radiographs.

Results: 19% of reductions were not acceptable to the panel. No difference was observed in the rate of acceptable reduction by modified Smith-Petersen (81%) versus Watson-Jones (81%) approach (risk difference null, 95% confidence interval [CI] –17.4% to 17.4%, $P = 1.00$) with 90.4% panel agreement (Fleiss' weighted $\kappa = 0.63$, $P<0.01$). Stratified analyses did not identify a significant difference in the rate of acceptable reduction between approaches when stratified by Pauwels angle, basicervical or transcervical fracture location, or posterior comminution. The Smith-Petersen approach afforded a better reduction when preoperative skeletal traction was not applied (RR = 1.67 [95% CI 1.10-2.52] versus RR = 0.87 [95% CI 0.70-1.08], $P = 0.006$).

Conclusion: The quality of open reduction of displaced femoral neck fractures in young adults was not influenced by the choice of a Watson-Jones anterolateral approach versus a modified Smith-Peterson anterior approach when the procedure was performed by a fellowship-trained orthopaedic trauma surgeon.



What Percent of Pediatric Femur Fractures Result from Nonaccidental Trauma?

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Purpose: Fractures are the second most common clinical manifestation of child abuse, with the femur being the most common location for nonaccidental trauma (NAT)-related fractures. The reported proportion of pediatric femur fractures that result from NAT varies drastically in the literature, ranging from 21% to 60%. The purpose of this study is to further assess what ratio of pediatric femur fractures are the result of NAT, and to examine the effect of patient age range on NAT prevalence.

Methods: This was a retrospective review of patients 0 to 36 months old diagnosed with a femur fracture between January 1, 2004 and April 9, 2019 at our institution. Patients with incomplete medical records were excluded. Incomplete medical records were defined as an absence of all femur fracture–related documentation. NAT was defined as a positive workup, meaning NAT was identified via social services, skeletal survey, or ophthalmological examination.

Results: 299 patients were identified; 22 patients were excluded due to incomplete medical records, 37 patients had no mention of an NAT workup entirely, 43 patients did not undergo NAT workup due to lack of suspicion, and 197 patients underwent an NAT workup. 32 of 197 patient femur fractures (16.2%) were determined to be the result of NAT. Of the 32 patients with NAT, 12 were female and 20 were male. The average age at presentation was 0.7 years. Additional injuries were present in 13 patients (40.6%). A significant difference in NAT rates was found between the 0 to 12-month age group and both older age groups; $\chi 2$ (2, N = 277) = 35.1026, P<0.00001.

Conclusion: Over one-fourth (28.9%) of patients seen for femur fractures were not screened for NAT as recommended by the American Academy of Orthopaedic Surgeons guidelines and evidence report. Of the patients who were screened, 16.2% of patient femur fractures (32 of 197) were determined to be the result of NAT.

Race and Ethnicity	No NAT Work Up (n=80)		NAT Work Up (n=197)		Total NAT Patients (n=277)
White Non-Hispanic or Latino/a/x	10	(38.5%)	16	(61.5%)	26
White Hispanic or Latino/a/x	4	(40.0%)	6	(60.0%)	10
Black or African American Non-Hispanic or Latino/a/x	9	(28.1%)	23	(71.9%)	32
Black or African American Hispanic or Latino/a/x	1	(50.0%)	1	(50.0%)	2
Asian Non-Hispanic or Latino/a/x	2	(15.4%)	11	(84.6%)	13
Asian Hispanic or Latino/a/x	0	(0.0%)	1	(100.0%)	1
Hispanic or Latino/a/x	41	(25.5%)	120	(74.5%)	161
Unknown	13	(40.6%)	19	(59.4%)	32

Short Cephalomedullary Nails in Wide Femoral Canals: The Toggle Phenomenon

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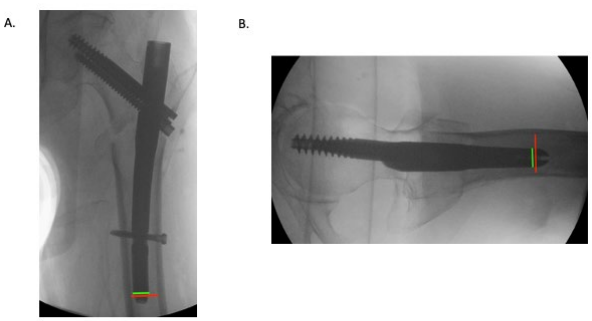
Purpose: In patients with wide femoral canals, a short cephalomedullary nail (CMN) may not provide adequate stability, leading to toggling of the nail around the distal interlocking screw and loss of reduction. The purpose of this study was to define a method for measuring nail toggle and to identify risk factors for nail toggle. A secondary aim was to examine whether increased nail toggle is associated with increased varus collapse and reoperation rate.

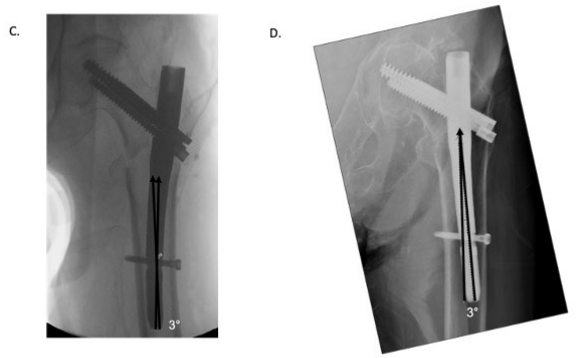
Methods: 71 patients with intertrochanteric femur fractures treated with a short CMN from October 2013 to December 2017 were retrospectively evaluated. The nail/canal ratio was measured on AP and lateral radiographs. Nail toggle and varus collapse were measured on intraoperative and final follow-up radiographs. Risk factors for nail toggle including demographics, fracture classification, quality of reduction, Dorr type, nail/canal ratio, lag screw engaging the lateral cortex, and tip-apex distance (TAD) were recorded.

Results: On univariate regression analysis, Dorr type C ($P = 0.006$), lag screw not engaging the lateral cortex ($P = 0.033$), shorter TAD ($P=0.049$), and smaller nail/canal ratio ($P<0.001$) were found to be associated with increased nail toggle. On multivariate regression analysis, shorter TAD ($P = 0.005$) and smaller nail/canal ratio ($P<0.001$) remained associated with increased nail toggle. Seven patients (10%) sustained nail toggle >4°. They had a smaller nail/canal ratio (0.54 vs 0.74, $P<0.001$), more commonly Dorr C (57% vs 14%, $P = 0.025$), lower incidence of lag screw engaging the lateral cortex (29% vs 73%, $P = 0.026$), shorter TAD (13.4 mm vs 18.5 mm, $P = 0.042$), and greater varus collapse (6.2° vs 1.3°, $P<0.001$) compared to patients with nail toggle <4°. There were two reoperations in the nail toggle >4° group (29% vs 8%, $P = 0.138$).

Conclusion: Lower percentage nail fill of the canal and shorter TAD are risk factors for increased nail toggle. Increased nail toggle was found to be associated with increased varus collapse.



Figures A and B: Example of how nail/canal ratio was measured on intraoperative AP and lateral radiographs. Green line= nail diameter. Red line= femoral canal diameter.



Figures C and D: Example of how nail toggle was measured. (a) Intraoperative AP shows nail in 3 degrees of valgus relative to the femoral axis (b) Final AP radiograph, over 4 years post-op, shows nail in 3 degrees of varus relative to the femoral axis. Nail toggle is 6 degrees of varus.

Effect of Locally Injected Tranexamic Acid on Blood Transfusion and Complications in Fragility Hip Fractures

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Purpose: Fragility hip fracture surgery is associated with significant blood loss, potentially increasing perioperative complications and necessitating blood transfusion at times. There is a paucity of data around interventions to minimize blood loss in this population. Our institution started utilizing locally injected tranexamic acid (TXA) at the time of wound closure with the hypothesis that patients receiving TXA would need fewer blood transfusions and experience no difference in risk of surgical site infection and venous thromboembolism (VTE) compared to a matched historical cohort.

Methods: Patients aged 50 years and over who underwent surgical treatment for a fragility fracture of the femoral neck, intertrochanteric, or subtrochanteric aspect of the proximal femur between March 1, 2018 and February 1, 2020 met inclusion criteria. Fragility hip fracture was defined as occurring after an injury equal to or less than a fall from a standing height. Exclusion criteria include subsequent fracture in the same or contralateral hip, bilateral hip fractures, hip fracture as part of a polytrauma, or high-energy injury. Patients were placed in the study group if they received TXA and were compared to a historical control group of patients who had not received TXA. $\chi 2$ contingency tests were used to assess differences between groups for both complications and blood transfusions. Logistic regression was also used to determine if the use of TXA was associated with a need for transfusion.

Results: 490 patients were included in this study (252 patients received TXA). There was a statistically significant difference in the need for blood transfusions between those who received TXA (33% required transfusions) and those who did not receive TXA (43% required transfusions) ($P = 0.034$). There were no significant differences in 30-day emergency department visits ($P = 0.899$), readmissions ($P = 0.991$), deaths ($P = 0.914$), VTE occurrence ($P = 0.526$), or infection ($P = 0.965$). It is important to note that VTE, infection, and death rates for the entire study cohort were less than 0.5%. Regression analysis indicated that patients receiving TXA were 31.2% less likely to need a transfusion ($P = 0.045$, odds ratio: 0.688 [95% confidence interval: 0.477-0.993]).

Conclusion: Locally injected TXA use in the surgical treatment of fragility hip fractures reduced transfusion needs by 10%. Regression analysis demonstrated that TXA could reduce transfusion needs by up to 31%. Additionally, there was no increased risk of complications in those receiving TXA. Therefore, locally injected TXA seems to be both a safe and effective means of reducing postoperative blood transfusions in patients with fragility hip fractures.

Femoral Shaft Medialization After Intertrochanteric Hip Fracture Fixation: Should We Be Concerned?

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Purpose: Femoral shaft medialization is thought to negatively affect patient outcomes by decreasing the hip abductor moment arm thereby leading to a Trendelenburg gait. This study aims to determine if femoral shaft medialization after intertrochanteric (IT) hip fracture fixation has an effect on patient-reported outcomes at 1-year follow-up.

Methods: An IRB-approved, prospectively collected hip fracture registry at an academic, urban health system was queried for IT fractures treated with sliding hip screws (SHS) and short and long cephalomedullary nails (CMN). Patients were excluded if they did not have a 1-year follow-up evaluation. All patients had radiographic evidence of a healed fracture. Patient demographics, injury characteristics, implant usage, radiographic analysis of femoral shaft medialization, and EuroQol-5 Dimensions (EQ-5D) 1-year functional outcomes were recorded. Univariate analysis of femoral shaft medialization affecting EQ-5D index was performed and multivariate analysis, controlling for age and implant type, was performed using IBM SPSS.

Results: 50 patients with intertrochanteric fractures were identified and met inclusion criteria. Average patient age was 78 years (range, 60-97). Mean femoral shaft medialization with SHS was 0.314 cm (range, 0-0.9) and with CMN it was 0.153 cm (range, 0-0.98). Univariate analysis showed no correlation between shaft medialization and EQ-5D index ($R2 = 0.03$, $P = 0.256$). Multivariate analyses controlling for age and implant type demonstrated that shaft medialization and implant type were not significant factors in determining 1-year functional outcome ($P = 0.411$, $P = 0.230$) and that only age was an independent predictor of outcome ($P = 0.003$).

Conclusion: Femoral shaft medialization is a radiographic finding that can be concerning after fixation of IT fractures with either an SHS or CMN. This study demonstrates that medialization does not significantly impact patient outcomes at 1-year follow-up.

Biplanar Reduction Influences Fracture Collapse and Immediate Postoperative Ambulation in Intertrochanteric Hip Fractures Fixed with a Cephalomedullary Nail

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Purpose: While avoidance of varus malreduction in intertrochanteric hip fractures is supported by substantial evidence, the role of sagittal plane reduction is relatively underappreciated. Although implants allow for controlled collapse, excessive collapse may influence postoperative ambulation. We hypothesized that the quality of biplanar reduction influences fracture collapse throughout healing and postoperative mobilization.

Methods: Low-energy intertrochanteric hip fractures treated with a cephalomedullary nail were identified and those who were ambulatory at baseline and with a minimum of 90-day clinical follow-up were included. Two blinded reviewers independently analyzed injury, operative, midterm follow-up, and most recent radiographs for previously described parameters of reduction (corrected neck shaft angle and Ikuta classification), implant position (femoral head quadrant location and tip-apex distance), and fracture collapse (shortening / sliding). Chart review provided data on immediate postoperative mobilization and clinical outcome. The primary outcome was fracture collapse; secondary outcomes included postoperative ambulation and interval change in ambulatory status.

Results: 139 patients were included with an average age of 80.0 years (standard deviation [SD] = 9.7). Median time to surgery was 1 day and average radiographic follow-up was 497 days. There were 52 radiographically stable and 87 unstable fracture patterns. 31 fractures with a good reduction (ie, a corrected neck shaft angle >135° and Ikuta type N with anterior cortical apposition on the sagittal plane) slid 5.0 mm (SD = 3.3); 62 acceptably reduced fractures meeting one of these two criteria slid 7.5 mm (SD = 6.1), and 44 poorly reduced fractures slid 7.5 mm (SD = 4.9, $P = 0.045$). Neither of these reduction criteria independently predicted slide, nor did fracture pattern stability. However, the amount of shortening was significantly influenced by the quality of the implant position. Optimally placed implants (in the middle tip position in coronal and sagittal planes and a tip-apex distance <25mm) collapsed an average 6.3 mm (n = 97, SD = 3.4) compared to 8.5 mm (n = 40, SD 7.4) in suboptimally placed implants ($P = 0.011$). Patients with a good or acceptable reduction were more likely to ambulate in the first 3 days following surgery ($P = 0.026$).

Conclusion: Biplanar reduction quality significantly influenced both fracture collapse and mobilization in the acute postoperative period. Additionally, the femoral head screw position affected the amount of fracture collapse. These data suggests that to achieve early mobilization, these fractures should not only be fixed early, but with good biplanar reduction and optimized implant placement.

Validation of Orthopaedic Hip Fracture Data From the National Surgical Quality Improvement Program Database

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Purpose: The use of clinical registry data is integral to patient care and predicting outcomes, but is dependent on the accuracy of the data. This study examined the validity of the National Surgical Quality Improvement Program (NSQIP) database collected on all adult hip fracture patients at a single Level I trauma institution.

Methods: A retrospective study of adult patients who underwent surgery for hip fracture at a single Level I trauma center between April 2016 and April 2018 was performed. CPT coding and 30-day complications reported in the NSQIP database were validated for accuracy against the medical records.

Results: 156 patients were identified in the NSQIP database who underwent surgery for femoral neck fractures, including hemiarthroplasty, plate/screw type implants, and intramedullary implants. 29.5% of these procedures were incorrectly coded (Table 1). Additionally, 31 (19.9%) of NSQIP cases had missing complications. In total, there were 36 missing complications—9 bleeding complications requiring transfusions, 14 renal complications, 7 urinary tract infections, 3 infections, 2 respiratory complications, and 1 death.

Conclusion: Validation of the NSQIP database for adult hip fractures at a single institution detected improper coding for 29.5% of cases and missing complications for 19.9% of cases. These discrepancies suggest a need to improve NSQIP data reporting and account for erroneous information when utilizing the database.

Table 1. Accuracy of NSQIP CPT coding for hip fracture surgeries

Initial CPT Code	Description	Number of cases	Number of incorrectly coded cases	Correct CPT code
27125	Hemiarthroplasty, hip	28	26 (92.9%)	27236
27236	Open treatment of femoral fracture, proximal end, neck, internal fixation or prosthetic replacement	29	4 (13.8%)	27235 27244 27245
27244	Treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture; with plate/screw type implant	13	10 (76.9%)	27245 27235
27245	Treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture; with intramedullary implant	86	6 (6.98%)	27236 27235 27495
27235	Percutaneous skeletal fixation of femoral fracture, proximal end, neck	0	N/A	N/A
27495	Prophylactic treatment (nailing, pinning, plating, or wiring) with or without methylmethacrylate, femur	0	N/A	N/A

Basicervical Femoral Neck Fractures (OTA 31B3): Does Implant Choice Matter?

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Purpose: This study was undertaken to compare the efficacy of short cephalomedullary nails (CMNs) with a single lag screw to sliding hip screws (SHSs) with or without a derotation screw for the treatment of basicervical femoral neck fractures (OTA/AO 31B3).

Methods: A consecutive series of patients who presented with a basicervical femoral neck fracture (OTA/AO 31B3) treated with a CMN or SHS was identified. Demographic, clinical, quality, radiographic, and cost data were obtained for each patient. A validated risk predictive tool (Score for Trauma Triage in Geriatric and Middle-Aged Patients [STTGMA]) was calculated for each patient. Patients were excluded if they did not have adequate follow-up demonstrating healing, failure of the implant, or if they did not have aforementioned fixation constructs. Mann-Whitney U, independent t test, and Fisher's exact tests were used to compare outcomes using R software.

Results: 65 basicervical fracture (OTA 31B3) patients were identified. 41 patients were treated with a short CMN compared to 24 patients treated with an SHS. The cost of treatment with a short CMN ($8999.10) was about $1500 higher than that of an SHS ($7524.59) ($P = 0.03$). All fractures went on to unite in the SHS group, while 1 (2.4%) progressed to nonunion in the CMN group ($P = 1.00$). Mean time to radiographic healing was 142 days for a CMN versus 132 days for an SHS ($P = 0.92$). There was 1 lag screw cutout in the SHS group (4.2%) and none in the CMN group ($P = 1.00$). There was 1 fixation failure in each group (2.4% CMN, 4.2% SHS, $P = 1.00$). One hip was converted to arthroplasty in the CMN group (2.4%) compared to 2 in the SHS group (8.3%) ($P = 0.55$). No differences were seen with regard to length of stay, blood loss, complications, readmissions, or mortality rates.

Table 1: Outcomes of basicervical hip fracture patients by treatment.

	Short CMN (n=41)	Sliding Hip Screw (n=24)	Total (n=65)	P Value
Inpatient Mortality, n (%)	0 (0.0%)	1 (4.2%)	1 (1.5%)	0.369
30 day Mortality, n (%)	0 (0.0%)	1 (5.0%)	1 (1.9%)	0.370
1 year Mortality, n (%)	2 (6.9%)	1 (5.6%)	3 (6.4%)	1.000
Operative Time, mean ± SD, minutes	49.59 ± 16.54	72.92 ± 19.21	58.20 ± 20.79	< 0.001
Length of Stay, mean ± SD, days	6.29 ± 3.39	7.17 ± 4.01	6.62 ± 3.62	0.236
Need for ICU, n (%)	5 (12.2%)	3 (12.5%)	8 (12.3%)	1.000
Urinary Tract Infection, n (%)	5 (12.2%)	3 (12.5%)	8 (12.3%)	1.000
Acute Kidney Injury, n (%)	4 (9.8%)	1 (4.2%)	5 (7.7%)	0.644
Transfusion, n (%)	11 (26.8%)	7 (29.2%)	18 (27.7%)	1.000
Major complications, n (%)	3 (7.3%)	1 (4.2%)	4 (6.2%)	1.000
Sepsis or Septic Shock, n (%)	1 (2.4%)	1 (4.2%)	2 (3.1%)	1.000
Pneumonia, n (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Acute Respiratory Failure, n (%)	0 (0.0%)	1 (4.2%)	1 (1.5%)	0.369
Stroke, n (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Myocardial Infarction, n (%)	1 (2.4%)	0 (0.0%)	1 (1.5%)	1.000
Cardiac Arrest, n (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
DVT/PE, n (%)	1 (2.4%)	0 (0.0%)	1 (1.5%)	1.000
Discharge Location, n (%)				0.079
Acute Rehab Facility	6 (14.6%)	1 (4.2%)	7 (10.8%)	
Deceased	0 (0.0%)	1 (4.2%)	1 (1.5%)	
Home with Health Services	3 (7.3%)	6 (25.0%)	9 (13.8%)	
Home	4 (9.8%)	4 (16.7%)	8 (12.3%)	
Skilled Nursing Facility	28 (68.3%)	12 (50.0%)	40 (61.5%)	
30 day readmission, n (%)	1 (2.4%)	0 (0.0%)	1 (1.6%)	1.000
90 day readmission, n (%)	4 (9.8%)	1 (4.3%)	5 (7.8%)	0.646
Procedure Costs, mean ± SD, USD	$8,999.10 ± $3,330.80	$6,326.54 ± $3070.81	$7,524.59 ± $3,411.16	0.033
Total Cost of Admission, mean ± SD, USD	$19,862.76 ± $4,942.74	17900.06 ± $10,341.32	18779.89 ± $8,291.44	0.203
Time to Radiographic Healing, mean ± SD, days	142.33 ± 100.10	131.82 ± 83.04	138.72 ± 93.35	0.921
Time to Last Follow-up, mean ± SD, days	162.79 ± 247.98	439.23 ± 402.46	240.91 ± 320.56	0.061
Progressed to Nonunion, n (%)	1 (2.4%)	0 (0.0%)	1 (1.5%)	1.000
Screw Cut Out, n (%)	0 (0.0%)	1 (4.2%)	1 (1.5%)	0.369
Fixation Failure, n (%)	1 (2.4%)	1 (4.2%)	2 (3.1%)	1.000
Conversion to Arthroplasty, n (%)	1 (2.4%)	2 (8.3%)	3 (4.6%)	0.549

Conclusion: Based on these results, there is no difference in the efficacy of implant choice in the treatment of basicervical femoral neck fractures. Factors outside of radiographic, clinical, and quality outcomes, such as cost and surgeon familiarity, should drive implant choice for OTA 31B3 fractures.

Diagnostic Validity of the CT Capsular Sign for the Detection of Ipsilateral Femoral Neck Fractures Associated with Femoral Shaft Fractures

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Purpose: Missed ipsilateral femoral neck fractures (IFNFs) in patients with femoral shaft fractures can lead to substantial dysfunction. Multiple methods of analyzing the bony anatomy have been described to diagnose these injuries. More recently the "CT capsular sign" that evaluates capsular distention of the hip in the axial soft-tissue window has been reported. We sought to independently evaluate this diagnostic tool to describe its effectiveness.

Methods: 1244 consecutive femoral shaft fractures treated at 7 Level I trauma centers were identified for evaluation. We excluded age <18 years (n = 60), associated acetabular or femoral head fracture (n = 93), prior femoral head / neck fracture or surgery (n = 58), no or low-quality preoperative CT of bilateral hips (n = 80), low-energy or gunshot wound mechanism (n = 186), <6-week follow-up (n = 172), and Kellgren-Lawrence arthritis ≥grade 3 (n = 8). Preoperative radiographs and CT scans of the pelvis were independently reviewed by surgeons blinded to treatment and IFNF diagnosis. Capsular distention was measured as per Park et al, with a side-to-side difference >1 mm considered to be a positive finding. IFNF was defined as femoral necks treated with fixation for suspicion of IFNF by the operative attending (based on operative notes) or subsequent fracture identified during the first 6 weeks postoperatively for those not fixed.

Results: 587 femoral shaft fractures were evaluated. 71% of patients were male and 77% of the fractures were closed. Mechanisms of injury were motor vehicle collision (59%), motorcyle crash (22%), and other high-energy mechanism (19%). 69 patients (12%) had IFNFs. Using multiple evaluators to add data for statistical power, a total of 1034 measurements were made. A positive CT capsular sign had a sensitivity, specificity, positive (PPV), and negative predictive value (NPV) of 0.72 (range, 0.64-0.80), 0.84 (0.81-0.86), 0.39 (0.34-0.43), and 0.96 (0.94-0.97), respectively. Of the 69 femoral neck fractures, 9 were diagnosed intraoperatively after nailing (2) or postoperatively (7). Seven of these 9 had a positive CT capsular sign.

Conclusion: Although not perfect, the CT capsular sign is a useful diagnostic tool to rule out ipsilateral femoral neck fractures in patients with high-energy femoral shaft fractures with an NPV of 0.96.

Outcomes of Vancouver C Periprosthetic Femur Fractures

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Purpose: Periprosthetic femur fractures (PFFs) that occur distal to a total hip arthroplasty (THA), Vancouver C fractures, are challenging to treat. While much has been written about Vancouver B PFFs, there are limited data on Vancouver C fractures. We aimed to report patient mortality, reoperations, and complications following Vancouver C PFFs in a contemporary cohort all treated with a laterally based locking plate.

Methods: We retrospectively identified 42 consecutive Vancouver C PFFs in 41 patients between 2004 and 2018. There was a high prevalence of comorbidities, including 9 patients with neurologic conditions, 9 with a history of cancer, 8 diabetics, and 8 using chronic anticoagulation. Fractures occurred following primary THA in 74%, and revision THA in 26%. Mean time from THA to PFF was 6 years (range, 1 month to 25 years). All fractures were treated with a laterally based locking plate. Fixation bypassed the femoral component in 98% of cases and extended as proximal as the lesser trochanter in 27%. Kaplan-Meier survival was used for patient mortality, and a competing risk model was used to analyze survivorship free of reoperation and nonunion. Mean follow-up was 2 years.

Results: Patient mortality rate was 5% at 90 days and 31% at 2 years. Cumulative incidence of reoperation was 13% at 2 years. There were 5 reoperations including revision osteosynthesis for nonunion and/or hardware failure (2); irrigation, debridement, and hardware removal for infection (2); and removal of hardware and total knee arthroplasty for posttraumatic arthritis (1). Cumulative incidence of nonunion was 10% at 2 years.

Conclusion: Patients who sustained a Vancouver C PFF had a high mortality rate (31%) at 2 years. Moreover, 13% of patients required a reoperation within 2 years, most commonly for infection or nonunion.

Hospital Transfer and Delayed Reduction of Traumatic Hip Dislocations

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Purpose: Delay in reduction of hip dislocations is a known risk factor for the development of osteonecrosis (ON) of the femoral head. The purpose of this retrospective study was to investigate the effect of transfer from an outside hospital on time to reduction of traumatic hip dislocations. We hypothesized that transferred patients experience a delay in hip reduction and subsequently experience higher rates of ON, posttraumatic arthritis (PTA), and secondary hip surgery.

Methods: All traumatic hip dislocations from a Level I trauma center from 2007 to 2020 were retrospectively reviewed. Of 300 patients reviewed, 50 met inclusion criteria. Exclusion criteria included less than 6 months of radiographic follow-up, prosthetic hip dislocations, skeletal immaturity, and recurrent dislocations.

Results: The average age of the cohort was 44 years (standard deviation = 14.8) of age. Patients had an average of 20.5 months of clinical follow-up. There were 48 posterior and 2 anterior dislocations. Dislocations were associated with 39 acetabulum-only fractures, 3 femoral head-only fractures, and 5 had fractures of both the head and acetabulum. Three dislocations had no associated fracture. Of the 50 patients, 37 were transferred from an outside hospital (OSH). Only 3 arrived with a reduced hip joint, and only 7 attempts at reduction were made at OSHs. The average time to reduction in transferred patients was 15:04 (hrs:min) compared with 6:33 for those presenting directly to our tertiary care center ($P = 0.07$). Seven patients (13.7%) developed ON at an average of 10 months following their injuries, 6 of whom were transferred from OSH. Patients who developed ON had an average time to reduction of 40:46 in comparison with 8:19 in patients who did not go on to develop ON ($P = 0.001$). Patients who developed PTA had an average time to reduction of 16:23 compared to 8:22 in patients who did not ($P = 0.22$). Of 28 patients who developed PTA, 24 (86%) were transferred from an OSH. 12 secondary surgeries were required after the index operation, including 9 total hip arthroplasties (THAs). Ten of these patients requiring a second surgery were transferred from OSHs. Patients requiring a secondary surgery had a time to reduction of 23:58 in comparison with 9:21 ($P = 0.43$).

Conclusion: Patients sustaining traumatic hip dislocations who were transferred to our Level I trauma center from an OSH experienced a delay in hip reduction. Delay in time to reduction was associated with a higher risk of ON. Patients with PTA of the hip and a need for secondary surgery experienced delay in reduction; however the sample size of these subsets limits the ability to make conclusions in these groups. A protocol for treatment and transfer of traumatic hip dislocations at transferring centers may be warranted to improve patient outcomes.

Impact of Anesthesia Selection on Postoperative Pain Management in Operatively Treated Hip Fractures

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Purpose: Postoperative pain control for patients with hip fracture is challenged by desire to avoid opioids, minimize delirium, and prevent subsequent falls. We hypothesized that patients getting either local or regional anesthetic would have decreased opioid usage as compared to patients who received neither and that patients receiving local or regional anesthetic would have lower complications rates postoperatively. Finally, we sought to identify whether patient-related factors (fracture type, mechanism of injury, length of stay, patient age) contributed to differences in pain scores and use of opioid medications in the early postoperative period.

Methods: A retrospective review was conducted of patients surgically treated for AO/OTA 31A and 31B fractures at two Level I trauma centers. Outcome variables of receipt of any opioids at 24 and 48 hours, any complication (compartment syndrome, delirium, fall, infection, nonunion, hardware failure) as well as visual analog scale (VAS) pain scores (severe, moderate, mild/none) were analyzed. Univariate and multivariable logistic or multinomial logistic regression were conducted to determine if there was a relation between type of anesthesia administered, patient factors, and outcomes. Odds ratios (ORs) and adjusted odds ratios (aORs) were reported.

Results: Among the patient variables considered, sex, mechanism of injury, and AO/OTA fracture classification did not affect opioid administration at 24 or 48 hours. Use of regional anesthetic was associated with less opioid use in the first 24 hours compared to neither (aOR: 0.42, 95% confidence interval [CI]: 0.24-0.73). Patients with length of stay (LOS) of 10+ days had 3 times the odds of using opioids in both the first 24 hours (aOR: 3.21, 95% CI: 1.10-9.34) and 48 hours (aOR: 2.91, 95% CI: 1.35-6.25) compared to patients with shorter LOS. Patients receiving regional anesthesia were more likely to experience any complication (aOR 1.90, 95% CI: 1.10-3.30), the most common being delirium and postoperative falls. By postoperative day 2, patients who ≥65 years of age were less likely to report severe pain relative to mild/none (aOR: 0.16, 95% CI: 0.06-0.40).

Conclusion: This constellation of findings suggest that age may affect subjective pain scoring postoperatively and supports the use of regional anesthesia to decrease postoperative opioids in hip fracture patients. The increased complication rate in regional anesthetic patients is a subject of further study. Patients with LOS greater than 10 days had 3 times the odds of using opioids in the first 24 and 48 hours, further supporting attempts at minimizing opioid use in these patients.

Soft-Tissue Injury Should Guide Management in Open Fractures of the Femoral Shaft

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Purpose: Current literature dictates that low-grade open femur fractures can be safely treated with primary intramedullary nailing with temporary external fixation and delayed intramedullary nailing reserved for more severe fractures. However, evidence regarding fixation timing and risk for infection is limited. The purpose of this study was to evaluate how degree of injury and treatment course can impact infection after open mid-shaft and subtrochanteric femur fractures.

Methods: An institutional database was used to identify patients with open femur (AO/OTA 32) fractures from blunt trauma who presented to a Level I trauma center between 2012 and 2020. Patients were excluded for incomplete records, lack of 90-day outcome data, gunshot-related injuries, or traumatic amputation. Deep infection within 90 days was the primary outcome defined by criteria from the Centers for Disease Control and Prevention. Medical records were used to collect days to wound coverage, OTA open fracture classification, time to definitive and temporary (if applicable) fixation, time to antibiotics, age, smoking, and diabetes. Student t tests and multivariable logistic regression were used to identify significant associations between the aforementioned variables and the primary outcome.

Results: 90 patients were identified, of whom 10 (11.1%) went on to develop deep infection. Age, smoking, diabetes, ISS, first surgical debridement after 6 hours, antibiotics after 1 hour, and wound coverage past 5 days were not associated with infection on univariate analysis. Multivariable analysis found a higher OTA skin score (requiring flap/graft coverage or degloving) (AR = 53%, odds ratio [OR] = 9.17, $P \leq 0.001$) and delayed definitive fixation (AR = 32%, OR = 15, $P = 0.04$) were independently associated with the development of deep infection. Only 3 of 68 patients (4.4%) who were treated with primary intramedullary fixation went on to develop deep infection, all of whom required supplemental wound coverage or had degloving injuries.

Conclusion: To our knowledge, this is the first study to specifically examine how timing of antibiotics, debridement, and treatment is related to the development of infection after femur fracture. Delayed definitive fixation and higher degree of skin injury were independently associated with the development of deep infection. While we advocate for early debridement and antibiotics in all patients, in patients with severe skin injury where delayed fixation will be required, clinicians should be mindful of the association with infection and perform several serial debridements before final soft-tissue reconstruction.

Management of Low Periprosthetic Distal Femoral Fractures: Plate Fixation Versus Distal Femoral Endoprosthesis

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Purpose: Debate continues regarding the optimum management of periprosthetic distal femoral fractures (PDFFs) at the level of well-fixed femoral components. This study aims to determine which operative treatment strategy is associated with the least perioperative morbidity and mortality when treating low (Su type II and III) PDFFs: lateral locking plate fixation (LLP-ORIF [open reduction and internal fixation]) or distal femoral replacement (DFR).

Methods: This was a retrospective cohort study of 60 consecutive unilateral PDFFs of Su types II (40) and III (20) in patients ≥60 years old: 33 underwent LLP-ORIF (mean age 81.3 ± 10.5, body mass index [BMI] 26.7 ± 5.5; 29 female), and 27 underwent DFR (mean age 78.8 ± 8.3; BMI 26.7 ± 6.6; 19 female). The primary outcome measure was reoperation. Secondary outcomes included perioperative complications, calculated blood loss, transfusion requirements, functional mobility status, length of acute hospital stay, discharge destination, and mortality. Kaplan-Meier survival analysis was performed. Cox multivariable regression analysis was performed to identify risk factors for reoperation after LLP-ORIF.

Results: PDFFs occurred at mean 9.5 ± 5.2 years after primary total knee arthroplasty. The mean length of follow-up was 3.8 years (range, 1.0-10.4). One-year mortality was 13% (8 of 60). Reoperation was more common following LLP-ORIF: 7 of 33 vs 0 of 27 ($P = 0.008$). Five-year survival for reoperation was significantly better following DFR: 100% compared to 70.8% (51.8-89.8 95% confidence interval) ($P = 0.006$). There was no difference for the end point mechanical failure (including radiographic loosening): ORIF 74.5% (56.3-92.7); DFR 78.2% (52.3-100); $P = 0.182$. Reoperation following LLP-ORIF was independently associated with medial comminution: hazard ratio (HR) 10.7 (1.45-79.5, $P = 0.020$). Anatomic reduction was protective against reoperation: HR 0.11 (0.013-0.96, $P = 0.046$). When inadequately fixed fractures were excluded there was no difference in 5-year survival for either reoperation ($P = 0.156$) or mechanical failure ($P = 0.453$).

Conclusion: Absolute reoperation rates are higher following LLP fixation of low PDFFs compared to DFR. Where LLP-ORIF was well performed with augmentation of medial comminution, there was no difference in survival compared to DFR. Although necessary in very low fractures, DFR should be used with caution in patients with a life expectancy exceeding 5 years.

Are BNP Levels at Time of Injury Predictive of Short and/or Long-Term Morbidity and Mortality After Surgically Treated Hip Fractures?

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Purpose: The purpose of this study is to determine if elevated initial B-type natriuretic peptide (BNP) (BNPi) levels or a percent change from baseline BNP (BNPB) at time of injury predicts short-term and/or long-term morbidity and mortality after geriatric hip fracture surgery, which may subsequently be used as a surrogate marker to predict prognosis. A secondary aim of this study was to analyze the effect of postoperative complications on mortality risk.

Methods: This was a retrospective chart review of all operatively treated hip fractures (femoral neck, intertrochanteric femur fracture, and subtrochanteric femur fractures) in patients ≥60 years old between February 2014 and July 2018. Patients were included if they had a BNP level drawn within 48 hours of injury (BNPi) within a single institution's electronic medical records. Perioperative, 30-day, 1-year, and 2-year postoperative complications were recorded. BNPi was analyzed against specific complications to determine if higher BNPi values were associated with greater morbidity and/or mortality. Complications were also analyzed to determine their effect on mortality.

Results: Elevated BNPi values were statistically associated with an increase in morbidity in the perioperative, 30-day, and 1-year postoperative groups. The 1-year postoperative group was found to have an association with increased mortality with increasing BNPi. There were no associations in morbidity or mortality in the 2-year postoperative groups. There were no significant findings in the percent change from baseline BNP value analysis. Univariate analysis further associated death with several complications. Notably, cardiac failure/exacerbation and altered mental status were associated with an increased mortality in all groups and respiratory failure was associated with death in all groups except the 2-year postoperative group.

Conclusion: Patient with lower BNPi levels who sustain hip fractures are possibly less likely to develop complications up to 1 year postoperatively and several complications are associated with increased mortality. Potential inpatient treatment approaches to lower BNP levels following a hip fracture may mitigate certain perioperative and postoperative complications, including mortality. However, the threshold BNP level in which morbidity and mortality increases is unknown and warrants further study. Considering the information ascertained from this study the authors suggest obtaining a BNP level in all hip fracture patients at time of injury. The data obtained can be used for providers in conjunction with the internal medicine physicians to decide which patients could benefit from further medical optimization. Future studies may better define a threshold BNP level.

Δ Treatment of Infected Bone Defects with Endothelial Progenitor Cells (EPCs) ± Local Antibiotics

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Purpose: Infection continues to present a major challenge in bone defect and nonunion management. It has previously been shown that EPCs can reliably heal critical-sized bone defects in a sterile animal model. However, the treatment effect of EPCs or EPCs plus local antibiotics on infection outcomes is unknown. Given their positive effects on bone healing and blood vessel formation, we hypothesized that EPCs would aid in the eradication of infection and that adding local antibiotics would further facilitate this outcome.

Methods: 24 animals underwent surgery to establish a critical-sized defect in the right femur and receive a low-dose inoculation of Staphylococcus epidermidis (103 CFU [colony-forming units]) at the defect site. Two weeks later, a second surgery was performed and animals were randomized to the following treatments: control/no treatment (n = 6), EPCs (n = 6), local vancomycin and rifampin (V+R) (n = 6), or EPCs plus local V+R (n = 6). Animals were sacrificed 2 weeks later. Our primary outcome was infection status based on intraoperative culture at the time of sacrifice (2 weeks post-treatment). Secondary outcomes included radiographic scoring for infection and serum inflammatory biomarker (α-2 macroglobulin) measurement. We did not assess bone healing in this study due to the short follow-up interval.

Results: Results for our primary outcome were as follows: rates of positive culture were 5 of 6 animals (83%) for controls, 4 of 6 (67%) for EPC treatment, 3 of 6 (50%) for local V+R treatment, and 2 of 6 (33%) for EPCs plus local V+R treatment. Differences between culture outcomes were not significant ($P = 0.52$). There were also no significant differences between groups on radiographic scores for infection. Serum α-2 macroglobulin analysis demonstrated that EPCs ($P<0.01$), local V+R ($P<0.01$), and EPCs plus local V+R ($P<0.01$) all significantly decreased inflammatory levels relative to controls at 2 weeks post-treatment.

Conclusion: We were unable to demonstrate a statistically significant effect of either EPCs, local antibiotics, or EPCs plus local antibiotics on infection outcomes in an infected bone defect model. However, we did observe trends towards increasing levels of infection eradication with both local antibiotics and the combination of local antibiotics and EPCs (50% and 67% rates of infection eradication, respectively). Inflammatory biomarker analysis also demonstrated that all 3 treatments reduced inflammation 2 weeks after treatment; however, it is unclear if the inflammation is solely due to infection and thereby a reliable indicator of infection status. These results support further investigation of the impact of EPCs ± local antibiotics on both infection and bone healing outcomes in the treatment of infected bone defects, with both larger group numbers and longer follow-up times.

Δ OTA Grant

Rates of Revision Fixation Between Synthes Trochanteric Fixation Nail (TFN) and Trochanteric Fixation Nail Advanced (TFNA) in a U.S. Hip Fracture Database: Analysis of 7979 Cases

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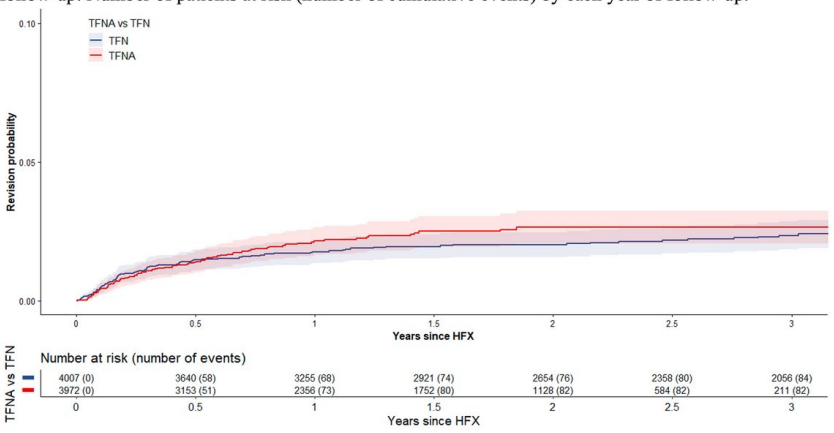
Purpose: Cephalomedullary nails (CMNs) are frequently used to achieve stable fixation of extracapsular hip fractures. Prior reports of the Synthes Trochanteric Fixation Nail Advanced (TFNA) revealed a potential mode of fatigue failure at the proximal screw aperture. However, the incidence of revision surgery of the TFNA has not been described. The purpose of this study was to compare all-cause revision rates between the TFNA and its prior generation forebear, the trochanteric fixation nail (TFN), in the treatment of hip fractures.

Methods: A retrospective cohort study was performed from a U.S. integrated health-care system's hip fracture registry. The study sample comprised patients who underwent CMN fixation of hip fractures from 2014 to 2019 with TFN (N = 4007) or TFNA (N = 3972). Exclusions included pathologic fractures, bilateral fractures, metastatic cancer, and missing implant data. Multivariable Cox proportional hazard regression was used to evaluate all-cause revision risk with adjustment for age, sex, body mass index, American Society of Anesthesiologists classification, smoking, anesthetic type, and Elixhauser comorbidities.

Results: At 3-year follow-up, the cumulative revision probability was 2.35% for TFNs and 2.64% for TFNAs (Fig. 1). After adjustment for covariates no difference was observed in revision risk for TFNA (hazard ratio [HR] 1.21, 95% confidence interval [CI] = 0.89-1.65) when compared to TFN. Reasons for revision included fixation/implant failure (51.8%), nonunion (27.7%), and periprosthetic fracture (14.7%).

Conclusion: In a large cohort from a U.S. hip fracture registry, TFNA had comparable revision rates to the earlier TFN. Subsequent analyses will determine if the TFNA is indeed associated with idiosyncratic modesoffailure, and if there are predisposing injury patterns or vulnerable populations.

Figure 1: Cumulative revision probability (solid line) and 95% confidence limits (shaded area) during follow-up. Number of patients at risk (number of cumulative events) by each year of follow-up.



Demographic and Clinical Profile of Patients Treated with Proximal Femoral Nails: A 10-Year Analysis of More Than 40,000 Cases

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Purpose: Hip fractures can lead to loss of function and are potentially life-threatening. These fractures are commonly treated with cephalomedullary nails. Changes from 2010 to 2019 in patient presentation, comorbidities, implant choice, as well as length of stay and discharge status, are analyzed herein for patients treated with one of the following devices: the Natural Nail System, the Gamma3 System, the TFNAdvanced proximal femoral nailing system (TFNA), or the Titanium Trochanteric Fixation Nail System (TFN). This analysis us es patient cohorts identified previously in a published safety study that demonstrated sim ilar nail breakage rates across all devices.

Methods: The Premier hospital billing database was queried for this analysis. Cohorts included all patients >21 years treated with a Gamma3, TFNA, TFN, or Natural Nail System (NNS) from 2010 to quarter 4 2019 (to avoid the acute pandemic COVID-19 era), with diagnoses for proximal femoral fractures. The date of surgical fixation was the index date. Bilateral cases and patients deceased during index were excluded. Patients were categorized by fracture type (subtrochanteric vs pertrochanteric [including intertrochanteric] vs intracapsular vs shaft), comorbidities at time of index (31 disease states of Elixhauser index [EI]). Patient demographics and provider characteristics were also queried. Descriptive analytics were performed on all outcomes. Planned analyses include generalized linear model and logistic regression analyses to understand the impact of surgical choices on length of hospital stay and discharge status.

Results: The cohort included 14,319 TFNA, 17,262 TFN, 10,495 Gamma3, and 1867 NNS-implanted patients. From 2010 to 2019, patient comorbidities increased significantly (average 2010 EI: 4.62 [standard deviation (SD): 3.02]; average 2019 EI: 5.12 [SD: 3.22], $P<0.0001$). Despite increasing comorbidities, the average length of stay declined significantly from 6.1 (SD: 4.2) days to 5.68 (SD: 4.28) days ($P = 0.0008$). Pertrochanteric, subtrochanteric, intracapsular, and femoral shaft fractures remained fairly constant, affecting 79.9%, 10.5%, 3.8%, and 2.4% patients, respectively; 5.3% of patients presented with multiple fracture types. Pathological fractures, however, increased significantly, from 2.6% of all patients in 2010 to 6.9% in 2019. Long nails were increasingly used, from 39.0% in 2010 to 44.5% in 2019; the increase was particularly noticeable for treatment of pathological fractures (representing 4% of total cohort in 2010 and 10.2% in 2019).

Conclusion: Increasing comorbidities in patients with hip fractures present significant challenges and are met with changes in surgical practice. Ongoing statistical analyses are evaluating the impact of surgical choices on patient outcomes.

Risk Factors for Nonunion Following Locked Plating of Distal Femur Fractures

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Purpose: Nonunion is common following locked plating of distal femur fractures. The purposes of this study were to investigate risk factors for nonunion following locked plating of distal femur fractures and to compare clinical and radiographic union using the Radiographic Union Scale for Tibial Fractures (RUST) and modified RUST scores, which have previously been validated in metadiaphyseal fractures.

Methods: We performed a 10-year retrospective review of all distal femur fractures treated with locked platingat an academic Level I trauma center. Fisher's exact test was used to assess the impact of variables including weight-bearing status and rigidity score on rates of nonunion. RUST and modified RUST scores were calculated at final follow-up or non-union diagnosis. Associations between nonunion and RUST/modified RUST scores were investigated using two-sample t tests.

Results: 78 of 90 patients (87%) achieved clinical union, for an overall nonunion rate of 13%. Rigidity score wassignificantly associated with risk of nonunion ($P = 0.002$, Table 1). No significant association was detected between nonunion and postoperative weight-bearing status ($P = 0.76$) or other previously identified risk factors. Patients who achieved fracture union had significantly higher mean RUST (10.67 vs 6.53, $P<0.001$) and modified RUST (13.47 vs 6.94, $P<0.001$) scores than patients who developed nonunion. Classification analyses identified a RUST score threshold of 9 for diagnosing clinical union (sensitivity [Sn] 93.6% and specificity [Sp] 91.7%) and a modified RUST score threshold of 8 (Sn 93.6%, Sp 91.7%).

Conclusion: Immediate postoperative weight-bearing status did not appear to impact nonunion rates in our cohort of distal femur fractures treated with lateral locked plating. We observed a statistically significant association between rigidity score and nonunion. This study supports the utility of the RUST and modified RUST scores for determining clinically relevant union in patients with distal femur fractures treated with locked plating.

Table 1: Impact of postoperative weight bearing, implant rigidity score, and other risk factors on nonunion rates

	Healed (n=85)	Non-Union (n=12)	p-value¥
Post-op Weight bearing			
WBAT	7 (100%)	0	0.76
50%	4 (100%)	0	
TDWB or NWB	74 (86%)	12 (14%)	
Obese			
Yes	48 (86%)	8 (14%)	0.76
No	33 (89%)	4 (11%)	
Fracture Type			
Open	5 (71%)	2 (29%)	0.21
Closed	80 (89%)	10 (11%)	
Infection			
Yes	2 (100%)	0	0.99
No	83 (87%)	12 (13%)	
Plate Type			
Stainless Steel	66 (87%)	10 (13%)	0.69
Titanium	17 (94%)	1 (6%)	
Mean Rigidity Score (SD)	2.62 (1.27)	2.83 (0.94)	0.58
Median Rigidity Score (IQR)	3 [1,4]	3 [2, 3.5]	0.89
Rigidity Score			
0	1 (100%)	0	0.002
1	28 (97%)	1 (3%)	
2	0 (0%)	3 (100%)	
3	29 (85%)	5 (15%)	
4	27 (90%)	3 (10%)	
5	0	0	

¥: Fisher Exact Test used for all categorical analyses due to small expected cell-counts. WBAT: weightbearing as tolerated; TDWB: touch-down weightbearing; NWB: non-weightbearing; SD: standard deviation; IQR: interquartile range

Development and Validation of a Postoperative Nonunion Risk Score for Subtrochanteric Femur Fractures

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Purpose: The purpose of this study was to develop and validate a postoperative scoring system predicting progression of subtrochanteric fractures to nonunion.

Methods: Following IRB approval, 316 consecutive patients presenting to our institution (85 nonunions; 26.9%) with a fracture involving the subtrochanteric region and fulfilling the inclusion criteria were retrospectively identified. To identify potential unadjusted associations with progression to nonunion, simple logistic regression models were used. A revised adjusted model of multiple logistic regression to predict progression to nonunion was then used, removing covariates in a stepwise fashion according to their likelihood-ratio $\chi 2$ *P* value. For the development of the nonunion scoring system, all factors identified by the logistic regression model were considered, with a highest score of 100.

Results: Having established the risk factors for nonunion, the coefficients were used to produce a risk score for predicting nonunion. In an attempt to identify the high-risk patients in the immediate postoperative period, self-dynamization was excluded. The revised scoring system was the sum of the following: diabetes (6), deep wound infection (35), simple or severe comminution (13), presence of an atypical fracture (14), lateral cortex gap size ≥5 mm (11), varus malreduction 5 to 10° (9), and varus malreduction >10° (20). On the ROC (receiver operating characteristic) curve, the area under the curve (0.790) demonstrated very good discriminatory capability of the scoring system, with good calibration (Hosmer-Lemeshow test; $P = 0.291$). Moreover, 5-fold cross-validation confirmed good fit of the model and internal validity (accuracy 0.806; κ 0.416). The cut-point determined by Youden›s formula was calculated as 18.

Conclusion: This study demonstrates that the risk of nonunion can be reliably estimated in patients presenting with a subtrochanteric fracture, from the immediate postoperative period. The resulting nonunion risk score can be used not only to identify the high-risk patients early, offering them appropriate consultation and in some cases surgical intervention, but also inform surgeons of the modifiable surgery-related factors that contribute to this risk.

Deep Infection After Hip Hemiarthroplasty: Risk Factors and Outcomes After DAIR

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Purpose: Deep surgical site infection (SSI) remains an unsolved problem after hip hemiarthroplasty. Debridement, antibiotic, and implant retention (DAIR) has become a mainstream treatment in elective total joint infection. Evidence for DAIR after infected hip hemiarthroplaty is lacking.

Methods: Patients who underwent a hip hemiarthroplasty at our institution between March 2007 and August 2018 were identified. Case notes, microbiology reports, and radiographs were reviewed up to 1 year post-surgery. SSI was diagnosed using the Centers for Disease Control and Prevention criteria. Multivariable logistic regression was performed to risk factors for SSI and to identify patient characteristics predicting a successful DAIR. The primary outcome for a successful DAIR was a functioning implant in a living patient at 1 year post-surgery.

Results: 3966 patients underwent a hip hemiarthroplasty during the study period. The overall rate of SSI within the cohort was 1.7%; 52 patients (1.3%) were diagnosed with a deep infection, while 17 (0.4%) were treated for a superficial wound infection. 50 underwent revision surgery for deep infection (43 underwent DAIR, 7 excision arthroplasty, and 2 died before surgery). After adjustment for other variables, only concurrent urinary tract infection (odds ratio [OR] 2.78, 95% confidence interval [CI] 1.57 to 4.92, $P<0.001$) and increasing delay to theater post-fracture (OR 1.31 per day, 95% CI 1.12 to 1.52, $P = 0.01$) were predictors of developing an SSI, while a cemented arthroplasty was protective (OR 0.54, 95% CI 0.31 to 0.96, $P = 0.031$). 43 underwent a planned DAIR as their first surgery for infection, of whom 9 patients (20.9%) were alive at 1 year with a functioning hemiarthroplasty. Most patients required multiple surgical debridements. 18 were converted to an excision arthroplasty due to persistent infection, with 6 alive at 1 year. Of these patients, 3 underwent eventual reimplantation of a prosthesis (2 total hip replacement [THR], 1 hemiarthroplasty). 7 patients underwent a removal of their prosthesis as their initial treatment; 2 (28.7%) were alive at 1 year compared to 34.9% of patients after a DAIR. The causative organism appeared to influence success of DAIR; no cases of DAIR were successful with methicillin-resistant Staphlycoccus aureus (MRSA) or Pseudomonas infection. The presence of any gram-negative organism reduced rates of success to 12.5%. Favorable organisms included Citrobacter, Proteus, and Cornybacterium; all had success rates of 60% to 100%. We were unable to identify a statistically significant patient factor influencing success of DAIR.

Conclusion: Preventing SSI remains a vital requirement in hip fracture care. Treating concurent urinary tract infections and avoiding delays to theater may reduce deep SSI. Deep infection after hip hemiarthroplasty is a devastating complication, with high mortality, regardless of the treatment strategy employed. Success rate of DAIR is poor compared to elective THR and should be reserved for favorable organisms and in patients felt to be able to tolerate multiple surgeries.

Civilian Ballistic Femur Shaft Fractures Compared with Blunt Femur Shaft Fractures: Open or Closed?

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Purpose: Civilian ballistic femur fractures are treated commonly in urban trauma centers but there is limited information on outcomes due to difficulty in long-term follow-up. The purpose of this study is to assess ballistic femur shaft fracture outcomes and compare them to closed and open femur shaft fractures sustained via blunt mechanisms. We hypothesized that ballistic femur shaft fractures would have similar outcomes to blunt open fractures.

Methods: A retrospective cohort study at a Level I trauma center was performed to identify ballistic femur shaft fractures treated with intramedullary nailing (IMN) between 2018 and 2020. Exclusion criteria were age less than 16 years or follow-up less than 3 months. Three distinct groups were formed: a ballistic fracture group, a blunt closed fracture group, and a blunt open fracture group. Main outcome measures included unplanned reoperations, deep infection, need for soft-tissue reconstruction, nonunion, malunion, hardware failure, and compartment syndrome. Deep infection was defined as any patient requiring surgical debridement after definitive fixation with positive cultures or the presence of positive cultures at the time of nonunion surgery.

Results: A total of 471 femur shaft fractures were identified. A group of 56 ballistic fractures and comparison groups of all femur shaft fractures sustained via blunt mechanisms and treated with IMN were included in the analysis. Among the two subgroups of nonballistic injuries, 253 were blunt closed fractures and 162 were blunt open fractures. Compartment syndrome only occurred in the ballistic fracture group. In comparison of the blunt closed and ballistic fractures, there were no differences in the rate of compartment syndrome (7.1% vs 0%, $P = 0.13$) or nonunion (3.6% vs 5.1%, $P = 0.67$). The ballistic group required fewer reoperations compared with the blunt closed group (10.7% vs 13.4%, $P<0.001$). The ballistic group had a higher incidence of deep infection than the closed fracture group (8.9% vs 3.6%, $P = 0.041$). Soft-tissue reconstruction was higher in the ballistic group compared to the closed fracture group (4% vs 0.4%, $P = 0.02$). There were no significant differences between the ballistic group and the open blunt group in deep infections (8.9% vs 6.2%, $P = 0.49$), soft-tissue reconstructions (3.6% vs 0.62%, $P = 0.72$), reoperations (10.7% vs 9.9%, $P = 0.85$), and compartment syndrome (7.1% vs 0%, $P = 0.13$). The proportion of nonunion was 3.6% in the ballistic group and 6.3% in the blunt open fracture group ($P = 0.49$).

Conclusion: Ballistic femur fractures do not perfectly fit with blunt closed or open femoral fractures, but their outcomes more closely resemble those of blunt open fractures. A high index of suspicion for the development of compartment syndrome should be maintained in ballistic femur fractures. The overall rates of nonunion were similar between all groups, but the deep infection rate was significantly higher in the ballistic group than the closed blunt group.

Outcomes of Low-Velocity Ballistic Femoral Shaft Fracture

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Purpose: Ballistic femur fractures are a common injury treated at urban, civilian trauma centers in the United States. This study investigates the outcomes of these injuries by comparing the rate of infection, nonunion, secondary operations, and associated injuries from low-velocity gunshot wound (GSW) injuries with closed fractures sustained by blunt trauma.

Methods: A retrospective review of 345 patients with femoral shaft fractures treated at a single Level I trauma center from 2011 to 2020 was conducted. Operative injuries were managed by fellowship-trained orthopaedic surgeons utilizing standard techniques. Patients were categorized by mechanism of injury, and the following outcomes were examined: superficial and deep infection, compartment syndrome, nonunion, malunion, associated injuries, and secondary operations.

Results: Over 9 years, 148 patients in the GSW group and 197 patients who sustained closed fracture from blunt trauma were included. The rates of deep infection were similar between GSW and blunt trauma femur fractures at 1.35% and 1.52% respectively ($P = 0.64$). Nonunions occurred in 8 blunt trauma patients (4.1%), while no GSW patients experienced nonunions ($P = 0.08$). The rate of compartment syndrome was higher in the GSW group (n = 9, 6.08%; $P<0.001$) versus none after blunt trauma. Associated arterial injury requiring repair after GSW occurred in 9% ($P<0.001$), while no blunt injuries had arterial injury requiring repair. Finally, the rate of secondary operation was nearly equivalent between the GSW and blunt trauma groups at 8.1% and 8.12%, respectively ($P = 0.93$).

Conclusion: Ballistic femoral shaft fractures are often equated with open injuries; however, our data indicate rates of infection, nonunion, and secondary operations closely mirror those of closed injuries resulting from blunt force trauma. Compartment syndrome and arterial injury are more common after low-velocity GSW and warrant careful clinical examination.

Outcomes of Proximally Locked Versus Unlocked Cephalomedullary Nail Use in Low-Energy Intertrochanteric Femur Fractures

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Purpose: Intertrochanteric femur fractures are common and are treated with a variety of implants, based on surgeon preference. Despite the frequent use of cephalomedullary nail (CMN) fixation, limited prior work has been done to compare nuances of proximal fixation technique. Whether to lock the proximal fixation into place and whether to compress the fracture via the implant are two options with no evidence to guide decision-making. This study compares the outcomes of different proximal fixation techniques in patients with low-energy intertrochanteric hip fractures.

Methods: Retrospective review was performed of all adult patients with low-energy (from standing height or equivalent) intertrochanteric hip fractures (AO/OTA Fracture Classification 31A1 [n = 44], 31A2 [n = 118]) treated with CMNs at a Level I trauma center between 2014 and 2020. 162 patients, 71% females, with mean age 76 years (range, 24-98) were included. The same implant was used in all patients. The type of proximal fixation, ie, blade (n = 149, 92%) versus screw (n = 13, 8%), unlocked (n = 75, 46%) versus locked (n = 87, 54%), compression using the implant (n = 72, 44%), and other technical details were recorded. Radiographic complications were documented including: varus collapse, implant penetration, and nonunion.

Results: Mean follow-up was 5.3 months and 30% of patients (n = 48) developed complications related to their CMN. Lateralization of the blade / screw (>10 mm) was higher in the unlocked group (42% vs 11.5%, $P<0.001$), with the majority (75.6%) of all cases of lateralization occurring in the unlocked group. Varus collapse was similarly observed more often in the unlocked group (10.7% vs 2.3%, $P = 0.027$). All cases of medial migration occurred in the absence of intraoperative compression ($P = 0.042$). Neither choice of blade versus screw, nor long versus short nail, was associated with complications or outcomes. No associations were found between unstable / stable fracture patterns, age, or sex, and the complications studied.

Conclusion: Cephalomedullary screw / blade lateralization and varus collapse were associated with a nonlocked proximal construct. Compressing through the device was associated with lower risk of screw / blade medialization. These data suggest that routine locking proximally to create a fixed-angle construct and compressing through the device may decrease the risk of complications.

How Does Internal Fixation Compared to Arthroplasty Impact Quality of Life for Patients Who Have Suffered Femoral Neck Fractures?

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Purpose: A multicenter randomized controlled trial of 298 patients aged ≥60 years with a displaced subcapital hip fracture found that participants allocated to fixation experienced worse functional outcomes than those who underwent arthroplasty. Moreover, 39% of patients in the fixation group required reoperation, compared to 5% in the hemiarthroplasty (HA) group and 9% in the total hip arthroplasty (THA) group. Since the completion of that trial in 2005, there have been two larger, multicenter randomized controlled trials conducted to evaluate the success of internal fixation and arthroplasty methods, separately, for treatment of femoral neck fractures in patients ≥50 years. We aimed to compare functional outcomes among participants from these trials who did not undergo reoperation.

Methods: Participants from the trial treated with internal fixation were more likely to be younger and healthier than those in the trial who underwent arthroplasty. We built an inverse probability treatment weighting model to balance covariates among the participants from both trials. We then performed two propensity score weighted linear regression models, using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) and 12-item Short Form Health Survey (SF-12) physical component summary (PCS) scores measured at 24 months as dependent variables. Propensity score weights and the respective preinjury functional scores were included as adjustment variables in each model. A subgroup analysis was performed, including only those participants aged ≤70 years.

Results: Data from 716 arthroplasty and 549 internal fixation patients were included in our propensity score weighting model. Internal fixation patients had higher WOMAC stiffness scores, indicating worse stiffness, at 24 months, as compared to THA patients (adjusted mean difference [AMD] 0.42 points, 99% confidence interval [CI] 0.09 to 0.75; $P<0.001$) and HA patients (AMD 0.39 points, 99% CI 0.04 to 0.74; $P = 0.004$). However, this statistically significant difference did not cross the 7-point threshold for a minimal clinically important difference. No statistically significant differences were found in the other WOMAC scales, nor with the SF-12 PCS. In participants aged ≤70 years, no difference was found in any of the functional outcomes.

Conclusion: Our results show similar findings to the earlier trial, in that functional outcomes, particularly stiffness, may be worse in femoral neck fracture patients undergoing internal fixation versus arthroplasty. These results, however, may not be applicable to a younger, more active hip fracture population.

What Are the Odds of Sustaining a Second Hip Fracture Within 2 Years of a First Hip Fracture?

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Purpose: Our objectives were (1) to develop a simple-to-use model that predicts short-term (2-year) risk of a second contralateral hip fracture in a cohort of first-time hip fracture patients and (2) to identify targets for preventative/prophylactic interventions.

Methods: 913 patients treated for unilateral hip fractures at an urban, academic medical center between September 2015 and December 2019 were identified. Using occurrence of a second contralateral hip fracture as the dependent variable, different logistic regression models were created using variables that comprise the FRAX score as the independent variables. These models were compared to the original FRAX score and the simplest model with the greatest predictive capacity (area under the curve [AUC]) was retained and rates of second hip fractures were compared across binned age quartiles.

Results: 39 patients (4.3%) sustained a contralateral hip fracture at a mean of 383 ± 320 days. The final model found only age (83-89 age cohort [odds ratio (OR) = 5.07, $P = 0.011$], 89-103 age cohort [OR = 5.83, $P = 0.006$]) and secondary osteoporosis (OR = 2.50, $P = 0.022$) to be independent predictors of second hip fracture in the short-term period. The predictive capacity of this model was no different than the FRAX score (AUC: 0.691 vs 0.668, $P = 0.345$). Of note, patients >83 years old had a 6.1% and 15.6% risk of second hip fracture occurring within 2 years (new model) and 10 years (FRAX).

Conclusion: This study demonstrates that age and presence of secondary osteoporosis (simple measurements) are equivalent to the more complex FRAX score with regard to predicting short-term odds of sustaining a second contralateral hip fracture. This risk is greatest in patients >83 years old and these patients should be targeted with preventative and/or prophylactic interventions.

Table 1: Subsequent Contralateral Hip Fracture Incidence and 10-Year FRAX Hip Fracture Risk Stratified by Age Group.

	Age 41 - 74 (n=253)	Age 74 - 83 (n=266)	Age 83 - 89 (n=254)	Age 89 - 103 (n=222)	Total (n=995)	P Value
Subsequent Contralateral Fracture, n (%)	3 (1.2%)	7 (2.6%)	15 (5.9%)	14 (6.3%)	39 (3.9%)	< 0.01
Subsequent Contralateral Fracture Within 1 Year, n (%)	0 (0.0%)	6 (2.3%)	7 (2.8%)	9 (4.1%)	22 (2.2%)	< 0.01
Time to Subsequent Fracture Surgery, mean ± SD, days	797 ± 246	292 ± 415	398 ± 325	325 ± 220	383 ± 320	0.07
FRAX 10-Year Hip Fracture Probability, mean ± SD	5.0% ± 4.4%	12.5% ± 6.7%	15.8% ± 7.3%	15.2% ± 6.5%	12.1% ± 7.6%	< 0.01

Comparing Medicare Reimbursement to Physicians and to Hospitals for Hip Fracture From 2012 to 2017

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Purpose: Medicare reimbursement for hip fracture remains a continual target of reform. The purpose of this study was to evaluate trends in reimbursement to both hospitals and physicians as well as assess charges for hip fracture episodes of care billed to Medicare.

Methods: The Inpatient Utilization and Payment Public Use File from the Centers for Medicare & Medicaid Services was queried for all hip fracture procedures (Diagnosis-Related Group 480-482) from 2012 to 2017. This database contains all hip fracture admissions billed to Medicare during these years. Extracted hospital data included hospital charges and amount paid by Medicare for each procedure. For physician payment, the Physician and Supplier Public Use File was utilized to collect physician charge and Medicare physician payment for all fee-for-service physician payments for hip fracture procedures(CPT codes 27235, 27236, 27244, 27245). All monetary data were adjusted for inflation to year 2017 dollars.

Results: From 2012 to 2017, Medicare paid physicians for 763,864 hip fracture repairs, totaling over $580 million in direct fee-for service payments to surgeons. Meanwhile, from 2012 to 2017 Medicare paid hospitals under the Inpatient Prospective Payment System over $10.2 billion in payments for these admissions. The mean amount charged by physicians increased from $3817.16 to $4,136.94 (+$319.78, +8.4%), while the mean payment to physicians decreased from $871.49 to $815.31 (–$56.18, –6.4%) per procedure. The mean amount charged by hospitals increased from $50,879.50 to $69,509.26 ($18,629.76, +36.6%), while the mean payment to hospitals per episode of care increased from $12,238.29 to $13,321.58 (+$1,083.29, +8.9%). The difference in percent change in mean reimbursement between hospitals and physicians was statistically significant ($P<0.01$).

Conclusion: Although mean charges for hip fractures billed to Medicare has increased for both physicians and hospitals from 2012 to 2017, mean adjusted Medicare reimbursement for hip fractures to physicians has decreased, while mean adjusted reimbursement to hospitals for hip fracture episodes of care increased during this time. These data suggest the government may be targeting the providers over the hospitals in efforts to reduce cost in hip fracture care.

Recovery Curve for Patients Suffering an Intertrochanteric Hip Fracture Using Patient-Reported Outcomes Show Pace of Recovery and Significant Long-Term Deficits

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Purpose: The morbidity and mortality of intertrochanteric (IT) hip fractures has been well elucidated. However, the time frame over which patients recover from IT fractures is less clear. The goal of this study was to evaluate Patient-Reported Outcomes Measurement Information System (PROMIS) physical function (PF) scores to better understand the trajectory of patient recovery following IT hip fractures.

Methods: A retrospective review of all patients suffering an IT fracture treated with either an intramedullary nail or sliding hip screw were identified by ICD-9 and -10 codes over a 5-year period. PROMIS PF scores were pulled for each patient identified. Scores were then grouped based on follow-up: immediately postoperative, 6 weeks, 3 months, 6 months, 12 months, and 24 months after surgery. Scores were averaged and 95% confidence intervals (CIs) were calculated to create a recovery curve.

Results: The patient breakdown at the predetermined time points was as follows: immediate (n = 161 patients), 6 weeks (n = 176), 3 months (n = 154), 6 months (n = 114), 1 year (n = 121), and 2 years (n = 68). The average age was 66 years (standard deviation 18.5). The average PROMIS PF immediately postoperatively was 28 (95% CI ± 1.4), 6 weeks was 31 (1.0), 3 months was 35 (1.6), 6 months was 37 (1.8), 1 year was 37 (1.8), and 2 years was 38 (2.8) (Fig. 1).

Conclusion: IT fracture patients show improvement postoperatively up to 6 months. After 6 months, there is no improvement in PF out to 2 years, with mean scores greater than one standard deviation below population norms, albeit it in a largely elderly population. This information is helpful for surgeons to provide prognostic information to patients while highlighting that most functional improvement after IT hip fracture is made in the first 6 months.

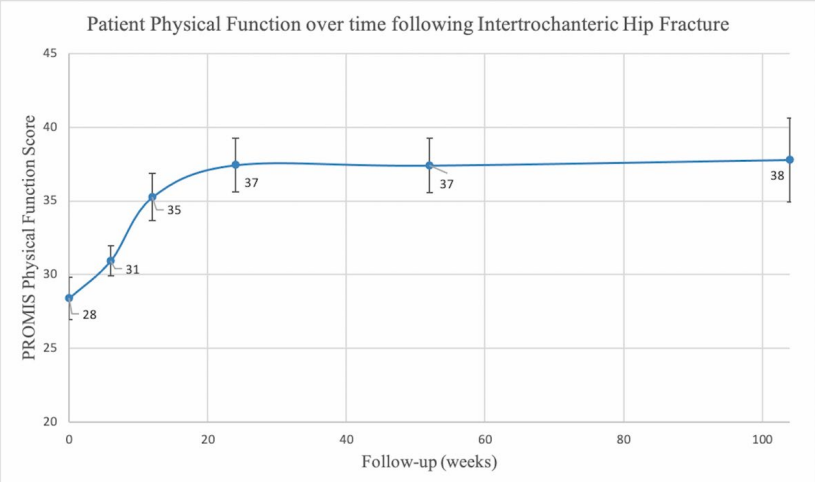

Figure 1: Recovery Curve of physical function after an IT Hip Fracture (with 95% Confidence Intervals)

Short Versus Long Cephalomedullary Nails for Reverse Obliquity Intertrochanteric Hip Fractures

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Purpose: Cephalomedullary nail (CMN) fixation for reverse obliquity hip fractures is considered the standard in orthopaedic trauma surgery. However, little data and no consensus on nail length have been reported for treatment of this fracture pattern. The purpose of this study is to evaluate the safety and efficacy of short CMN implants compared to long CMN implants for the treatment of reverse obliquity fractures.

Methods: A hip trauma registry was queried for radiographically confirmed AO/OTA 31A3.1, 31A3.2, and 31A3.3 reverse obliquity intertrochanteric fractures. Patient demographics, surgical details, and hospital quality measures such as length of stay, complication rates, and mortality rates during admission, at 30 days, and 1 year were queried. Radiographic and clinical outcomes including healing time, and hardware complications were assessed. Statistical analysis was performed using independent t tests, Mann-Whitney U, and Fisher's exact tests using IBM SPSS software.

Results: 98 consecutive patients with a mean age 81.5 ± 10.1 years with reverse obliquity intertrochanteric fractures were identified. 57 patients were treated with a long CMN and 41 patients with a short CMN. No differences in age, sex, body mass index, Charlson Comorbidity Index, ambulation status, or OTA classification existed between the groups at baseline (P>0.05). No patients in either cohort underwent reoperation, experienced screw cutout, broken hardware, peri-implant fracture, or infection.

Conclusion: CMN length does not affect short or long-term outcomes in patients with a reverse obliquity hip fractures. Patients in both cohorts had similar rates of healing and postoperative complications.

Table 1. Outcomes of reverse obliquity hip fracture patients. Categorial variables reported as count (percent). Numerical values reported as mean (SD).

	Long IMN (N=57)	Short IMN (N=41)	Total (N=98)	p value
Inpatient mortality	1 (1.8%)	2 (4.9%)	3 (3.1%)	0.376
30 day mortality	3 (5.5%)	3 (7.5%)	6 (6.3%)	0.686
1 year mortality	7 (15.2%)	8 (23.5%)	15 (18.8%)	0.346
Length of stay	7.68 (4.77)	7.34 (4.59)	7.54 (4.67)	0.800
Need for ICU	9 (15.8%)	7 (17.1%)	16 (16.3%)	0.865
UTI	3 (5.3%)	2 (4.9%)	5 (5.1%)	0.932
AKI	2 (3.5%)	4 (9.8%)	6 (6.1%)	0.203
Anemia	28 (49.1%)	18 (43.9%)	46 (46.9%)	0.609
Major complications	4 (7.0%)	7 (17.1%)	11 (11.2%)	0.120
Sepsis or Septic Shock	1 (1.8%)	0 (0.0%)	1 (1.0%)	0.394
Pneumonia	1 (1.8%)	3 (7.3%)	4 (4.1%)	0.170
Acute Respiratory Failure	1 (1.8%)	0 (0.0%)	1 (1.0%)	0.394
Stroke	0 (0.0%)	0 (0.0%)	0 (0.0%)	
MI	1 (1.8%)	1 (2.4%)	2 (2.0%)	0.813
Cardiac Arrest	0 (0.0%)	2 (4.9%)	2 (2.0%)	0.092
DVT/PE	1 (1.8%)	1 (2.4%)	2 (2.0%)	0.813
Discharge location				0.134
ARF	11 (19.3%)	4 (9.8%)	15 (15.3%)	
Deceased	0 (0.0%)	2 (4.9%)	2 (2.0%)	
HHS	5 (8.8%)	3 (7.3%)	8 (8.2%)	
Home	4 (7.0%)	0 (0.0%)	4 (4.1%)	
Hospice	1 (1.8%)	0 (0.0%)	1 (1.0%)	
SNF	36 (63.2%)	31 (75.6%)	67 (68.4%)	
Transfer	0 (0.0%)	1 (2.4%)	1 (1.0%)	
30 day readmission	6 (10.7%)	5 (12.8%)	11 (11.6%)	0.752
90 day readmission	9 (16.1%)	6 (15.4%)	15 (15.8%)	0.928
Total cost of admission	$27,123.99 ($11,906.04)	$23,016.11 ($12,113.15)	$24,987.89 ($12,070.49)	0.236

Mechanical Failure in Distal Femur Fractures with 3 Generations of Precontoured Locking Plates: Analysis of 105 Patients Treated at 8 Trauma Centers

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Purpose: Distal femur fractures remain challenging injuries to treat, with complication rates of 20% to 35%, including failed fixation, nonunion, and malunion. Fixation with distal femur locking plates (DFLPs) has become the most common technique used. Over the past 3 decades, implant manufacturers have developed (and subsequently modified) a number of DFLPs in an effort to improve clinical results and address surgeon user needs, including the use of different materials (stainless steel [SS] versus titanium [Ti]) and the incorporation of fixed angle (FA) or variable angle (VA) locking screws. The aim of this study was to evaluate treatment failure in a large patient cohort with distal femur fractures treated with a DFLP.

Methods: This retrospective case-control series evaluated mechanical treatment failures in 1187 patients with OTA 33-A and C distal femur fractures treated with DFLPs at 8 Level I trauma centers from 2010 to 2017. 152 patients (12.8%) experienced treatment failure with 43 being strictly biologic (nonunion without mechanical fixation failure) and 105 involving mechanical failure. Of the mechanical failures, 11 distal femurs were treated with a Ti-FA, unicortical screw DFLP system designed for minimally invasive application ("Less-Invasive Stabilization System" or "Ti-LISS", DePuy Synthes); 24 with an SS-FA DFLP ("Periloc", Smith & Nephew), 12 with an SS-FA DFLP ("Locking Condylar Plate®" or "FA-LCP", DePuy Synthes, West Chester, PA); 44 with a SS-VA DFLP ("VA-LCP", Synthes), and 14 "other" DFLPs. DFLP details, modes of failure, and time to failure were studied.

Results: Of 105 mechanical failures, only 11 DFLPs failed by screw cut-out from the condyles and most failures (80%) occurred at the level of the femoral shaft and / or fracture site. Failures occurred in a number of different manners, depending on the DFLP and its properties. 33 of 104 SS plates (33%) failed by bending or breaking at the level of the fracture while no Ti plates failed at this location ($P<0.05$). 11 of 12 failures with Ti-LISS (92%) occurred via shaft fixation, mostly by screw loosening (91%). 16 of 44 VA-LCP failures (36%) occurred at the distal plate-screw junction, while only 5 of 61 other DFLPs (8%) failed in that way ($P<0.05$). Distal failures occurred on average at 23.7 weeks compared to femoral shaft and fracture site failures that occurred at 38.0 and 38.9 weeks, respectively ($P<0.05$). VA-LCP distal screw-plate junction failures occurred on average at 21.4 weeks.

Conclusion: Mechanical failure occurred in 9% of patients with a distal femur fracture treated with a DFLP. The mode, location, and timing of failure varied depending on the characteristics of DFLP and relatively few (<10%) failed by cut-out from the distal condylar segment. This information should be used to optimize implant usage and design to prolong the period of stable fixation before potential implant failures occur in patients with a prolonged time to union.

Roadside Evaluation of Distracted Driving: Driver Limitations in Recognizing Traffic Light Transitions (REDD – LIGHT)

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Purpose: Distracted driving is a global epidemic and is responsible for thousands of injuries every year. As most injuries occur at or near intersections, the purpose of the REDD – LIGHT study was to examine the prevalence of distracted driving at traffic lights. Our secondary goals were to determine the specific distractions and their effect on reactions to traffic light transition.

Methods: Drivers stopped at a red traffic light were observed covertly for distracted driving behaviors. We separated the observational variables into demographic variables (age, sex), driving distractions (in-vehicle, outer-vehicle, and mobile phones), and reaction to traffic light transition (delayed vs not delayed). We considered a driver delayed if they failed to proceed for more than 2 seconds when the light transitioned to green or when the vehicle fell behind another proceeding vehicle by a full car-length. Following the National Highway Traffic Safety Association observation protocol, mobile phone distractions were grouped into three subcategories: talking on a handheld device, talking using a visible headset on, and visibly manipulating a handheld device. We performed regression analyses to determine associations on demographics, distracted driving, and delayed driver reactions.

Results: Out of the 1008 drivers we observed, 608 (60.3%) were distracted while stopped at the red light. In-vehicle distractions (44.8%) were most prevalent, and distractions involving mobile phones were seen in 75 drivers (7.4%). We recorded 126 drivers (12.5%) as delayed at the light transition, 111 (88.1%) of whom were distracted. Drivers between 30 and 50 years old were more likely to be distracted (odds ratio [OR] = 1.3, $P = 0.050$). There were seven specific distractions significantly associated with a delayed reaction (talking on or manipulating a handheld device, in-vehicle devices [air-conditioning controls, navigation], eating/drinking, reaching, nonspecific and specific outer-vehicle distractions). Mobile phone distractions had the highest risk for a delay at the traffic light (talking while holding a phone [OR = 8.2, $P = 0.043$] and manipulating a handheld phone [OR = 2.9, $P = 0.002$]). Delayed reactions were not associated with talking to a passenger and talking on a hands-free device.

Conclusion: Distracted driving is exceedingly prevalent, as the majority of drivers stopped at traffic lights engaged in distracting behaviors. One in eight drivers had delayed reactions, and 88% of them were distracted. This demonstrates how distractions negatively affect drivers› situational awareness. The fact that we observed drivers at a single red light along their trip further emphasizes the gravity of these numbers. These data can be applied toward driver education, action plans, and policy development aimed at injury prevention due to distracted driving.

Risk of Acute Kidney Injury After Antibiotic Prophylaxis with Piperacillin and Tazobactam

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Purpose: Kidney dysfunction is known to cause significantly worse outcomes and increase mortality in critically injured patients. Current guidelines recommend gram-negative coverage for high-grade open fractures, and aminoglyocosides have historically been the most commonly used despite the growing evidence that these drugs are associated with acute kidney injury (AKI). Piperacillin / tazobactam (PT) has been proposed as an alternative broad-spectrum antibiotic; however, some evidence in the critical care literature has shown PT and vancomycin in combination increase rates of AKI. The aim of this study is to evaluate if PT was associated with increased rate of inpatient AKI in patients with open fractures.

Methods: A retrospective cohort study was performed on Gustilo-Anderson type II and III open fractures that presented to a single Level I trauma center over a 5- year period (2015-2019). All patients received open fracture prophylactic antibiotics upon arrival to the hospital. In the initial 2 years of the study period, antibiotics protocols were not standardized but included cefazolin for type II open fractures and the addition of gram-negative coverage in type III open fractures. In the second 2 years the protocol was standardized and consisted of cefazolin for type II open fractures and PT for type III open fractures. Due to the low interobserver agreement in Gustilo classification there were a large number of type II open fractures that received PT (68 patients) and these patients were included. Adequate laboratory values during the patients' hospital stay (including basic metabolic panel [BMP] preoperatively and postoperatively) were required for inclusion. Two groups were created: a PT group consisting of any patient who received PT for open fracture antibiotic prophylaxis, and a control group consisting of any patient with an open fracture who received any other antibiotic for open fracture prophylaxis. Patient demographics, number of contrasted studies performed, fracture characteristics, rates of AKI, and fracture-related infection (FRI) rates were assessed. AKI was defined as an increase in creatinine greater by than 50% during the patient's admission compared to the initial admission creatinine.

Results: The PT group contained 191 patients and the control group contained 213 patients. Between groups, there were no differences in age, sex, race, body mass index, American Society of Anesthesiologists class, smoking status, or number of contrasted studies. There was no difference in the rate of AKI between the PT and control groups (4.6% vs 3.9%, $P = 0.79$). There was no difference in rate of AKI between the PT and control groups when substratified by Gustilo-Anderson fracture type (type II: 8.3% vs 3.3%, $P = 0.27$; type III: 2.2% vs 4.4, $P = 0.38$).

Conclusion: The use of PT in prophylactic antibiotic treatment of type II and III open fractures does not affect the rate of AKI in patients and can be used as monotherapy without increased risk of renal injury.

Proximal Tibia Fracture Dislocations: Management and Outcomes of an Underrecognized Injury

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Purpose: Proximal tibia fracture dislocations (PTFDs) are a subset of plateau fractures, with little in the literature since description by Hohl (1967) and classification by Moore (1981). We sought to evaluate reliability in diagnosis of fracture-dislocations by traumatologists and to compare their outcomes with bicondylar tibial plateau fractures (BTPFs).

Methods: This was a retrospective cohort study at 14 Level I trauma centers throughout North America. In all, 4771 proximal tibia fractures were reviewed by sites and 278 possible PTFDs were identified using the Moore classification. These were reviewed by an adjudication board of 3 traumatologists to obtain consensus. Outcomes included interrater reliability of PTFD diagnosis, wound complications, malunion, range of motion (ROM), and knee pain limiting function. These were compared to BTPF data from a previous study.

Results: Of 278 submitted cases, 187 were deemed PTFDs, representing 4% of all proximal tibia fractures reviewed and 67% of those submitted. Interrater agreement by the adjudication board was good (83%). 61 PTFDs (33%) were unicondylar. 11 (6%) had ligamentous repair and 72 (39%) had meniscal repair. Two required vascular repair. Infection was more common among PTFDs than BTPFs (14% vs 9%, $P = 0.038$). Malunion occurred in 25% of PTFDs. ROM was worse among PTFDs, although likely not clinically significant. Knee pain limited function at final follow-up in 24% of both cohorts.

Conclusion: PTFDs represent 4% of proximal tibia fractures. They are often unicondylar and may go unrecognized. Malunion is common, and PTFD outcomes may be worse than bicondylar fractures.

	PTFD (n=187*)	Bicondylar Plateau Fracture (n=1297*)	p-value†
Age at injury in years, mean (SD)	48 (16)	50 (14)	0.056
Sex, n (%) Female Male	 82 (44) 105 (56)	 541 (46) 647 (54)	0.186
Body mass index, mean (SD)	29 (7)	30 (7)	0.914
Injury Severity Score, mean (SD)	10.3 (6.8)	10.5 (7.0)	0.508
Mechanism of injury, n (%) Fall from height Fall from standing MVC MCC Pedestrian vs auto Other	 73 (39) 12 (6) 31 (17) 29 (16) 10 (5) 32 (17)	 418 (32) 205 (16) 230 (18) 255 (20) 94 (7) 80 (6)	**<0.001**
Laterality, n (%) Left Right	 98 (52) 89 (48)	 662 (51) 634 (49)	0.115
Open fractures, n (%)	7 (4)	123 (9)	**0.009**
Compartment syndrome, n (%)	18 (10)	166 (13)	0.255
Ipsilateral bony injury, n (%)	24 (13)	245 (19)	**0.042**
Temporary ex-fix used, n (%)	149 (80)	813 (63)	**<0.001**
Plating, n (%) Medial only Lateral only Dual plating	 57 (31) 35 (19) 89 (49)	 129 (10) 457 (37) 648 (53)	**<0.001**
Wound dehiscence, n (%)	17 (9)	72 (6)	0.070
Wound infection, n (%)	26 (14)	118 (9)	**0.038**
Time to radiographic union in months, mean (SD)	6 (7)	6 (8)	0.671
Malunion, n (%) Articular Metaphyseal	 27 (14) 3 (2)	 92 (7) 34 (3)	**0.001** 0.404
Range of motion at last follow-up, mean (SD) Extension Flexion	 3 (5) 112 (19)	 2 (4) 116 (39)	**<0.001** **0.017**
Time to return to work in months, mean (SD)	7 (7)	9 (14)	0.195
Knee limiting function at last follow-up, n (%)	39 (24)	277 (24)	0.851

*Missing data in some cells, percents reflect individual denominators
†Chi-squared test for categorical variables, Wilcoxon rank sum (Mann-Whitney U) test for continuous variables

Table 1. Comparison of proximal tibia fracture dislocations (PTFDs) with bicondylar tibial plateau fractures

Treatment and Health Services Outcomes in Older Patella Fracture Patients in Ontario, Canada: A Population-Based, Retrospective Cohort

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Purpose: There remains a substantial lack of knowledge and evidence regarding treatment and health services outcomes following operative and nonoperative patellar fracture management in older patients. Factors predicting readmission and treatment length of stay (LOS) have not been previously reported. Additionally, reoperation rates for this patient subset have not been investigated. We conducted a retrospective study of patella fracture treatment outcomes in a large cohort of older patients using a provincial health database. The purpose of this study was to evaluate treatment and health services outcomes in older (≥66 years) patella fracture patients.

Methods: Data from the Canadian Institute for Health Information was used to identify patients ≥66 years who had sustained a patella fracture between April 1, 2004 and March 31, 2016, from a linkable dataset. Intervention codes from the Discharge Abstract Database (DAD) were used to categorize patients into operative and nonoperative groups at baseline. We identified rates of reoperation up to 2 years after initial treatment (including revision fixation, hardware removal, joint replacement, and irrigation and debridement). Ambulatory care reporting databases were used to identify frequency and cause of emergency department (ED) readmission within 30 days of treatment discharge, and DAD was used to identify treatment LOS. We used a Cox proportional hazard model followed by cumulative incidence analysis to evaluate the rate of reoperation. A multivariate logistic regression and multivariate linear regression were used to assess ED readmission and treatment LOS, respectively.

Results: A total of 6258 patients were identified in the database, 72% of whom received nonoperative treatment at baseline. 74% of patients were female, and the average time to surgery was 7 days. Approximately 20% of operatively treated patients underwent reoperation, mostly related to hardware removal within 2 years of initial treatment. ED readmission was high (15.2%), but generally unrelated to the patella fracture. Falls represented 11% of readmissions, with the majority of cases presenting in the nonoperative group. Male sex, rural residence, and baseline dementia were all significant predictors of ED readmission. Furthermore, treatment LOS following operative management averaged 7 days. Finally, net costs were higher following operative intervention, despite the nonoperative group having higher baseline costs.

Conclusion: Our study revealed that most older patella fracture patients are treated nonoperatively. In those treated operatively, there are high rates of reoperation. ED readmissions are also common in this population, but generally unrelated to the patella fracture. These results suggest that managing patella fractures in older patients is complex, and complications are prominent. Further investigation with prospective studies is warranted.

Staged Fixation Strategy of Tibial Plateau Fracture with Acute Compartment Syndrome

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Purpose: High-energy tibial plateau fractures often accompany acute compartment syndrome, and are usually treated by fasciotomy with external fixation followed by secondary plating after open reduction. Initial soft-tissue injury may influence the bony union. Fasciotomy wound or pin site of external fixator may provoke wound infection and exert adverse effect on lower limb function. We tried to assess the result of staged open reduction and plating for tibial plateau fracture with acute compartment syndrome.

Methods: 30 patients with tibial plateau fractures in company with acute compartment syndrome were enrolled. There were 23 men and 7 women, with a mean age of 59.7 years (range, 37-82). The mechanism of injury was motor vehicle accidents in 19, fall from a height in 7, and direct injury in 4. According to the AO/OTA classification, 2 were C1, 5 were C2, and 23 were C3 fractures, including 2 cases of open fractures (I: 1, IIIC: 1, Gustilo-Anderson classification). In Schatzker fracture classification, 12 were type V and 18 were type VI. Immediate fasciotomy was performed once acute compartment syndrome was diagnosed, and stabilization of fracture was followed with external fixation. After the soft-tissue condition normalized and the fasciotomy wound was closed, the internal conversion was done in an average of 31 days (range, 9-55 days) after index trauma. At the time of internal conversion, the external fixator pin site grades were 0 in 2 cases, 1 in 12 cases, 2 in 9 cases, and 3 in 7 cases, as described by Dahl. Radiologic assessment with bony union and alignment, functional assessment using Knee Society Score and American Orthopaedic Foot & Ankle Society (AOFAS) score were carried out. The average follow-up period was 33.2 months (range, 12-85 months).

Results: 29 cases achieved primary bony union (96.7%) at an average of 20.7 weeks (range, 12-35) after internal conversion. One case of nonunion healed after autogenous bone grafting and additional plate augmentation. The mean Knee Society Score and AOFAS score were 92.5 (range, 65-100) and 95.5 (range, 74-100), respectively, at the latest follow-up. Complications included 2 cases of deep infection (6.7%) and 3 cases of posttraumatic arthritis caused by severe articular comminution. The presence of an open fracture, fracture classification, and duration of external fixation and fasciotomy were not related to the occurrence of infection. However, the grade 3 pin site of the external fixator at the time of internal conversion had a significant risk of deep infection (Fisher exact test, $P = 0.048$).

Conclusion: Staged fixation for tibial plateau fracture with acute compartment syndrome may achieve satisfactory osseous union and functional results while decreasing deep infection and soft-tissue complications. Attention should be paid to manage the pin site of the external fixator to avoid deep infection.

Clinical Depression (Major Depressive Disorder) Does Not Affect Functional Outcomes in Patients with Tibial Plateau Fractures

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Purpose: Prior studies have demonstrated that Major Depressive Disorder (clinical depression: Diagnostic and Statistical Manual of Mental Disorders, 4th ed [DSM-4]) is not associated with poorer functional outcomes following hip and ankle fractures, but leads to worse outcomes following elective procedures such as total joint arthroplasty surgery. The purpose of this study is to determine if depression is associated with poorer functional outcomes in patients who sustain tibia plateau fractures.

Methods: Patients with a tibia plateau fracture were prospectively enrolled in a registry. Demographic data, medical history, and injury information were collected at time of enrollment. Functional status was assessed using the Short Musculoskeletal Function Assessment (SMFA) at baseline (preinjury), 3 months, 6 months, and 1 year post injury. Any wound complications and reoperations were recorded at each follow-up visit. Injury fracture site depression (mm) and postoperative residual articular incongruity (mm) were obtained from injury and follow-up radiographs. Records were reviewed to identify patients with a diagnosis of clinical depression and who were taking antidepressant medications at the time of their injury. SMFA scores, injury fracture site depression, postoperative residual articular incongruity, complications, and reoperations were compared between patients with and without clinical depression using Mann Whitney U tests or $\chi 2$ tests.

Results: There were 420 patients enrolled in the registry and the mean age was 50.8 ± 15.6 years. 42 (10%) were being treated for depression at the time of their tibia plateau fracture, of whom 34 (81.0%) were treated operatively. Of the 378 patients in the non-depressed cohort, 316 (83.6%) were treated operatively. Depressed patients were older (55.5 ± 12.7 vs 50.3 ± 15.8, $P = 0.05$) and were more likely female (73.8% vs 47.6%, $P<0.01$). There were no differences in injury mechanism or Schatzker classification. At baseline, the clinical depression cohort had worse SMFA scores compared to the non-depressed cohort (5.90 ± 14.41 vs 2.69 ± 8.35, $P<0.01$). There were no differences in total SMFA score or any SMFA subscores at 3, 6, and 12 months. Clinically depressed patients had similar initial fracture site depression and residual articular incongruity as compared to non-depressed patients. 36.3% of operative patients and 28.2% of nonoperative patients had residual articular incongruity. The incidence of wound complications, reoperations, and healing also did not differ between the cohorts.

Conclusion: Despite patients with clinical depression reporting higher (poorer) SMFA scores at baseline, clinical depression was not associated with worse injuries, diminished clinical, or poorer functional outcomes following tibia plateau fractures.

Long-Term Outcomes of Multiligament Knee Injuries

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Purpose: Multiligament knee injuries (MLKIs) can be challenging to treat and may result in lifelong functional impairment. However, there are very little data regarding long-term outcomes of MLKIs. Our hypothesis was that MLKIs would have poor long-term outcomes.

Methods: This was a retrospective clinical follow-up study of a previously published series of 106 MLKIs (102 patients) treated at a single Level I trauma center between March 2000 and December 2008. Six patients had died, 4 had amputations, and 1 had a total knee replacement. Remaining patients were solicited, and 20 knees (18 patients) were evaluated at a mean follow-up of 13.1 years (range, 11-15 years) with patient-reported outcome measures (PROs). The mean age at follow-up was 44 years (range, 29-62) and 14 were male. The primary outcome measure was the Internal Knee Documentation Committee (IKDC) score. 16 knees (14 patients) also had physical examination and bilateral knee radiographs assessed with the Kellgren-Lawrence (KL) arthritis score. Data were analyzed with Wilcoxon signed-rank test using JMP Pro v13.

Results: The mean IKDC score was 56, which was significantly worse than the age-matched normative value of 77 ($P = 0.004$) and exceeds the minimum clinically important difference of 12. Secondary mean PRO scores were significantly worse than normative population values, including Lysholm knee score (61 vs 94, $P<0.001$), Tegner activity score (3.8 vs 5.7, $P = 0.001$), Marx activity score, (2.6 vs 12.2, $P<0.001$), PROMIS (Patient-Reported Outcomes Management Information System) Physical Function (48 vs 59.7, $P<0.001$) and PROMIS Pain Interference (52.7 vs 43.6, $P = 0.002$). Mean knee extension was 1.7° of flexion and mean flexion was 106°. Arthritis was present in all MLKIs that had radiographs (six KL2, seven KL3, and three KL4 knees). Comparing the MLKI to noninvolved knee in the 12 patients with unilateral injury, KL scores were significantly worse in the MLKI (1.6 vs 2.9, $P = 0.04$). Comparing those MLKIs that underwent ligament repair/reconstruction (n = 11) to those that did not (n = 9), there was no statistically significant differences in physical examination, imaging, or PROs except for better Short Form-36 Social Functioning (89 vs 63, $P = 0.02$) and Tegner activity score (4.5 vs 2.9, $P = 0.05$) in the surgical group.

Conclusion: This study is the first to report the average long-term outcomes of MLKIs and demonstrates that outcomes are generally poor even with modern treatment techniques. Posttraumatic arthritis appears to be universal. Clinicians should be aware of these results when counseling patients.

"Working" for Better Outcomes: Do Unemployed Patients Have Worse Outcomes Following Tibial Plateau Fracture?

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Purpose: While many studies have examined predictors for patient return to work following orthopedic trauma, to our knowledge, none have studied how pre-injury employment status can affect patient outcomes following orthopaedic trauma. This study seeks to compare patient outcomes after tibial plateau fracture between employed and unemployed patients to elucidate if employment status has an effect on patient recovery.

Methods: A consecutive series of 347 patients with 350 tibial plateau fractures with a known employment status treated by 1 of 3 orthopaedic traumatologists was prospectively collected at our academic medical center. Initially, patient demographics and injury characteristics were recorded. Patient outcomes were recorded at all follow-up visits. Patients were excluded if they had less than 1 year of follow-up, if they were disabled from occupation prior to the time of injury, if they were retired, or if they were receiving Workers' Compensation. Patients who reported their employment status as "full time student" were included in the employed group. Functional and patient-reported outcomes between employed and unemployed patients were compared using binary logistic regression and multiple linear regression analysis while controlling for demographic and injury characteristics using IBM SPSS.

Results: Of 350 fractures with complete follow-up and known employment status, 265 patients with 268 tibial plateau fractures met inclusion criteria. There were 33 patients (12.5%) with an employment status of "unemployed" at the time of injury. The mean follow-up time was 2.8 years for employed and 2.4 years for unemployed patients. Employed patients had lower pain scores at latest follow-up at a mean of 2.7 on the visual analog scale (VAS), while unemployed patients had a mean score of 4.5 ($P = 0.002$). Additionally, unemployed patients were more likely to report that they were tender to palpation over the surgical site (TTP) on physical examination with 24.2% of this group reporting they were TTP, while only 12.3% of the employed group reported the same ($P = 0.024$). Employed patients also had lower standardized total Short Musculoskeletal Function Assessment (SMFA) scores (mean 14.26) as well as standardized functional SMFA scores (mean 24.20) compared to their unemployed counterparts (mean 22.89, mean 32.52, respectively) ($P = 0.009$, 0.048). With regard to functional outcomes including rates of nonunion, hardware failure, and reoperation, as well as knee extension and flexion at latest follow-up, there were no differences between employed and unemployed groups.

Conclusion: Patient-reported outcomes including VAS pain score and SFMA scores are significantly better at final follow-up in patients who are employed over those who are not. However, clinically recorded functional outcomes including radiographic healing and patient range of motion are not different between these two groups. Thus, unemployed patients appear to perceive their outcomes to be worse, despite comparable clinically recorded functional outcomes.

Use of Incisional Negative Pressure Wound Therapy Does Not Protect Against Postoperative Wound Complications Following Fixation of Bicondylar Tibial Plateau Fractures

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Purpose: To evaluate whether the preemptive use of an incisional negative pressure wound therapy (NPWT) device, also known as an incisional wound vacuum-assisted closure (VAC), is protective against postoperative wound complications following surgical fixation of bicondylar tibial plateau fractures.

Methods: We retrospectively reviewed all patients who underwent open reduction and internal fixation for an acute bicondylar tibial plateau fracture (AO/OTA 41-C) from 2010 to 2020 at a large academic Level I trauma center. All patients underwent primary closure after fixation and received either a traditional sterile dressing (TD) or incisional NPWT device. Patient demographics including sex, age, medical comorbidities, tobacco, illicit drug use, and alcohol abuse were collected. Injury characteristics including mechanism of injury, whether the patient's fracture was open or closed, and polytrauma status were also noted. Postoperative complications including superficial surgical site infection (sSSI), deep SSI (dSSI), wound dehiscence (WD), osteomyelitis, nonunion, and reoperation rates were recorded. Comparisons of baseline characteristics and complications were done using $\chi 2$ tests. Characteristics that significantly differed between groups were placed into a multivariate logistic regression, and associations between variables were identified.

Results: 194 patients were included in the study. 42 patients had an incisional NPWT device placed and 152 were given a TD chosen per surgeon preference. There were 10 sSSIs, 17 dSSIs, 6 WDs, 10 cases of osteomyelitis, and 6 nonunions in this cohort. 19 patients returned to the operating room (OR) for infection-related complications. The NPWT group had significantly more tobacco users ($P = 0.03$) and drug users ($P<0.01$). The percentage of polytraumas was larger in the NPWT group (33% vs 23%), but this difference was not found to be statistically significant ($P = 0.37$). A greater percentage of NPWT patients returned to the OR for infection-related complications (16.7% vs 9.3%, $P = 0.46$), but this was not significant. The NPWT group also had a greater percentage of all complications and a significantly greater percentage of dSSIs (19.5% vs 5.92%, $P = 0.02$). However, a multivariate logistic regression controlling for baseline patient characteristics did not reveal a significant association between use of NPWT and dSSIs ($P = 0.13$). Use of incisional NPWT was not significantly associated with any other complication, and use of TD was also not found to be significantly associated with any complications.

Conclusion: The application of an Incisional NPWT device is often considered for prevention of infectious-related complications and wound dehiscence following surgical fixation of bicondylar tibial plateau fractures. In this study, NPWT was not protective against postoperative wound complications compared to TDs.

Judicious Early Primary Open Reduction and Internal Fixation for Closed AO/OTA 41C (Schatzker VI) Bicondylar Tibial Plateau Fractures Is Not Associated with Increased Risk of Deep Infection or Reoperation

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Purpose: The optimal treatment for complex bicondylar tibial plateau (BTP) fractures remains controversial. Recent evidence suggests that early surgery by experienced orthopaedic trauma surgeons is safe and cost-effective in appropriately selected patients. The primary aim of this study was to compare rates of deep infection and unplanned reoperation following acute (≤48 hours) versus delayed open reduction and internal fixation (ORIF) of closed fractures. The secondary aim was to identify risk factors for deep infection in the entire cohort including open fractures.

Methods: This was a retrospective cohort study of consecutive patients >18 years undergoing ORIF of an AO/OTA 41-C (Schatzker 6) BTP fracture at two Level I trauma centers between 2001 and 2018. Rates of deep infection and reoperation were compared for patients with closed fractures undergoing acute ORIF (aORIF) versus delayed ORIF (dORIF). $\chi 2$ analyses were used for categorical comparisons. Binomial logistic regression controlled for age, gender, open fracture, diabetes, smoking status, alcohol status, and body mass index.

Results: 508 OTA/AO 41C BTP fractures were identified (mean follow-up 3.8 years, standard error [SE] 70.7 days). Patients were between 18 and 98 years of age (mean 52.5 years, SE 0.7). Of the 456 patients (89.8%) with closed fractures, 202 (39.8%) underwent aORIF. Average time from injury to surgery was 1.1 days for aORIF and 8.3 days for dORIF. More patients in the dORIF group were managed initially with an external fixator (49.6% vs 3.9%, $P<0.001$) and more required fasciotomy for compartment syndrome (19.7% vs 12.9%, $P = 0.041$). Infection rate was lower for aORIF compared to dORIF (7.9% vs 19.7%, $P<0.001$). The rate of unplanned reoperation was also lower for aORIF (14.4% vs 23.6%, $P = 0.013$). In binomial logistic regression modeling, open fracture ($P = 0.005$ [odds ratio (OR) 3.5, 95% confidence interval (CI) 1.5-8.5]), current smoking ($P = 0.05$ [OR 2.1, 95% CI 1.0-4.6]), and former smoking ($P = 0.003$ [OR 3.9, 95% CI 1.6-9.7]) were predictors of deep infection for the entire cohort.

Conclusion: Early definitive fixation within 48 hours of injury may be a safe strategy for closed BTP fractures when the timing of surgery is guided by the surgeon's assessment of the soft-tissue envelope. Higher rates of external fixation and compartment syndrome in the dORIF group indicate a tendency to delay more severe injuries. These results must be interpreted with caution due to inherent selection bias, but the findings are consistent with recent literature showing that early ORIF of BTP fractures can be safe in appropriately selected patients.

History of Tobacco Use and Diabetes Are Significantly Associated with Higher Postoperative Complication Rates in Bicondylar Tibial Plateau Fractures

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Purpose: Our objective was to evaluate the effect of baseline patient characteristics on outcomes in bicondylar tibial plateau fractures.

Methods: Adult patients who underwent open reduction and internal fixation of a bicondylar tibial plateau fracture (AO/OTA 41-C) between 2004 and 2020 at a large academic Level I trauma center were retrospectively identified. Postoperative complications including superficial surgical site infection (sSSI), deep SSI (dSSI), wound dehiscence (WD), osteomyelitis, nonunion, and reoperation rates to address wound complications were tallied. Baseline patient characteristics such as sex, smoking history, illicit drug use history, history of alcohol abuse, body mass index (BMI), and medical comorbidities were noted. Injury factors such as mechanism, open versus closed fracture, and polytrauma status were also tallied. A multivariate logistic regression was constructed to evaluate associations between baseline patient characteristics, injury factors, and complication rates.

Results: We identified 247 patients for inclusion in the study. Mean age was 50 ± 15 years, and mean BMI was 27 ± 8. Of these patients, 67 had a history of smoking, 30 had a history of alcohol abuse, 30 had a history of drug abuse, 29 had diabetes, and 41 had a history of peripheral vascular disease. 21 patients presented with an open fracture and 63 presented as a polytrauma. Mean time to surgery was 8 ± 8 days. 13 patients developed an sSSI, 21 developed a dSSI, 9 developed WD, 10 developed nonunion, and 14 developed postoperative osteomyelitis. Univariate logistic regression models relating tobacco to complications and diabetes to complications were significant for associations between tobacco/diabetes and development of sSSI, dSSI, and all complications. A multivariate logistic regression controlling for open fractures, tobacco use, drug abuse, sex, diabetes, polytrauma, and BMI revealed a significant association between tobacco use and dSSI ($P<0.01$). Tobacco use ($P<0.01$), diabetes ($P = 0.046$), sex ($P = 0.027$), and open fracture ($P = 0.03$) were significantly associated with greater risk of developing any soft-tissue infection. Diabetes ($P<0.01$), tobacco use ($P = 0.03$), and open fracture ($P = 0.04$) were all significantly associated with greater risk of all complications.

Conclusion: The unstable fracture pattern in bicondylar tibial plateau fractures and the extensive soft-tissue damage that often occurs in these injuries often results in high postoperative wound complication rates. This study demonstrated that tobacco use and diabetes are significantly associated with increased wound complications following operative management of these fractures. Providers should continue to counsel their patients regarding risk factor management and consider additional preemptive measures in this subset of patients to help improve postoperative outcomes.

Flexible Versus Rigid Intramedullary Nailing of Tibial Shaft Fractures in Skeletally Immature Adolescents

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Purpose: Flexible intramedullary nails are commonly used for definitive operative treatment of tibial shaft fractures in skeletally immature patients. The use of rigid intramedullary nails has been limited in children due to potential physeal arrest with subsequent deformity and/or limb-length discrepancy. This study seeks to compare the outcomes of rigid versus flexible intramedullary nailing (IMN) of tibial shaft fractures in adolescent patients with open physes.

Methods: Chart review included skeletally immature patients between ages 10 and 16 years presenting to a Level I pediatric trauma center between January 2009 to January 2019 with a tibial shaft fracture treated with an intramedullary device. Electronic medical records and radiographic imaging were reviewed. Student t and $\chi 2$ tests were performed.

Results: 55 patients were included, 28 patients underwent rigid IMN and 27 underwent flexible IMN. The average age in the rigid IMN group was 14.7 years versus 12.6 years in the flexible nail group ($P<0.001$). Patients treated with rigid IMN had a significantly decreased time to weightbearing, less time immobilized in a cast, and were less likely to undergo hardware removal. Rigid IMN treatment was associated with a significant radiographic difference in posterior slope. The mean decrease in posterior slope demonstrated by the rigid IMN group was $1.9° \pm 3.1°$. Six patients exhibited proximal tibial physeal arrest in the rigid IMN group while no patients in the flexible nail group displayed this finding ($P = 0.001$).

Conclusion: There was no significant difference in time to union or complications between the flexible and rigid IMN groups, although patients treated with rigid IMN benefited from decreased time to weightbearing, less time immobilized in a cast, and avoided future hardware removal. There was statistically significant increased incidence of physeal arrest in the rigid IMN group with a decrease in posterior slope.

Demographics			
Variable	**Rigid**	**Flexible**	**P-Value**
Total, n	28	27	--
Age at Surgery, yrs	14.7 ± 1.1	12.6 ± 1.4	<0.001*
Skeletal Age, yrs	14.0 ± 1.0	12.6 ± 1.2	<0.001*
Length of Surgery, min	122.3 ± 66.4	119.1 ± 77.8	0.871
Time to WB, mo	0.8 ± 0.9	2.3 ± 1.4	0.002*
Follow-Up, days	399.1 ± 616.8	271.9 ± 145.6	0.301
Union, days	114.6 ± 176.1	82.85 ± 39.1	0.805
Change in Posterior Slope, mm	1.9 ± 3.0	-0.06 ± 4.0	0.041*
Initial CPV	0.06 ± 0.02	0.06 ± 0.03	0.886
Final Coronal Alignment, deg†	-0.84 ± 1.4	-1.82 ± 3.4	0.160
Final Sagittal Alignment, deg††	-0.78 ± 1.8	0.0 ± 6.4	0.533
Open Injury, n	11	11	1.000†
Cast Use, n	6	17	0.005*†
Hardware Removal, n	8	22	<0.001*†
Complications, n	11	11	1.000†
Physeal Arrest, n	6	0	0.003*†

* Statistical significance ($p<0.05$)

† χ^2 test

†Varus alignment indicated by negative number

††Recurvatum

Rate of Reoperation and Readmission After Operative Management of Midshaft Clavicle Fractures in Adolescents

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Purpose: The national rates of reoperation and readmission after operative management of midshaft clavicle fractures in adolescents is unknown. The purpose of this study was to determine the rate of reoperation and readmission after operative management of midshaft clavicle fractures in adolescents. Additionally, this study aimed to evaluate differences between patients who did or did not require a reoperation or readmission.

Methods: Patients 10 to 18 years old with an operatively treated midshaft clavicle fracture from both Florida (2005-2012) and California (2005-2009) were identified using the Healthcare Cost and Utilization Project (HCUP) State Inpatient Database. The number of patients that required reoperation within 2 years or readmission within 90 days of operative management was determined. Differences in demographic factors between patients who did or did not require a reoperation or readmission were also determined. Descriptive, univariate, and multivariate analyses were performed.

Results: There were 334 adolescent midshaft clavicle fractures managed operatively from a cohort of 11,728 patients over the study period. 53 patients (15.87%) underwent a reoperation within 2 years at an average of 209.53 ± 151 days since the index surgery, while 11 patients (3.29%) were readmitted within 90 days to a hospital at an average of 18.91 ± 18 days after discharge. Reasons for reoperation included hardware removal (n = 49) with an average time of 202.39 ± 138 days, and revision open reduction and internal fixation (ORIF) (n <10) with an average time of 297 ± 289 days. The odds of reoperation were higher for female patients (P<0.01) and patients who had an outpatient surgery (P<0.01), while the odds of reoperation were lower for patients who underwent surgery in California (P = 0.02) The most common reason for readmission was a postoperative infection (n <10).

Conclusion: There is a high rate of reoperation and readmission after ORIF for midshaft clavicle fractures in adolescents. The majority of reoperations are performed for removal of hardware and factors associated with reoperation include female sex, outpatient surgery, and geographic location. The most common reasons for readmission was postoperative infection. Additional research is needed to investigate reasons for reoperation and readmission, variability in these rates, and ultimately decrease the risk of reoperation and readmission after operative management of midshaft clavicle fractures in adolescents.

Unicolumnar Pin Fixation of Type III Supracondylar Humeral Fractures Is Associated with a Greater Than Three Times Higher Odds of Lost Reduction

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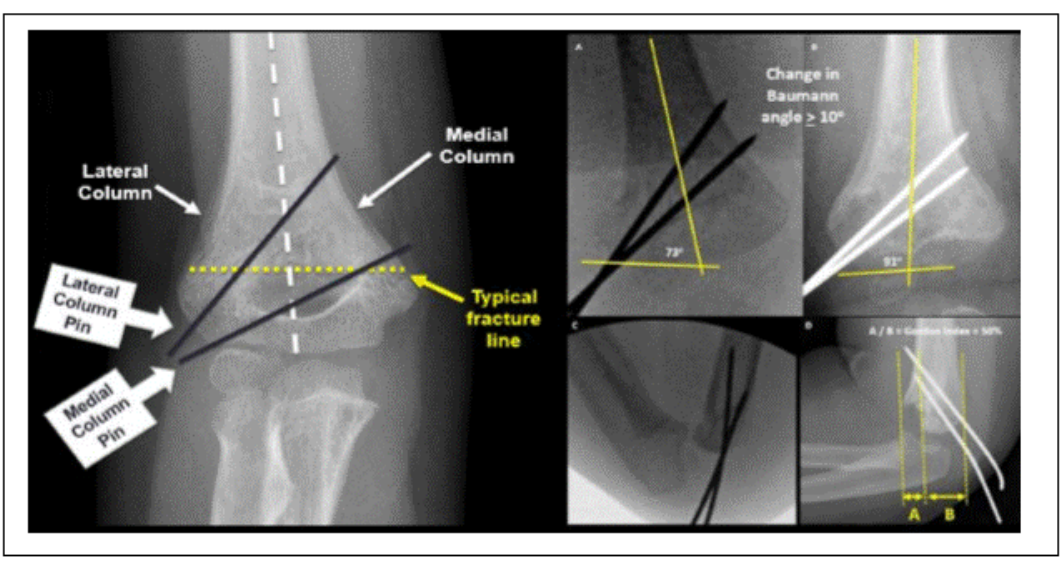
Purpose: Our aim was to compare the rate of loss of reduction between two groups of type III supracondylar humeral fracture patients: a unicolumnar fixation group versus a bicolumnar fixation group.

Methods: Patients with type III supracondylar humeral fractures were identified from surgical billing records. Pin placement was categorized as unicolumnar fixation (lateral column only) or bicolumnar fixation (lateral and medial column). The status of reduction and fixation at time of fluoroscopy was identified by assessing the Baumann angle, the Gordon index, and anterior humeral line (AHL). Loss of reduction was assessed at time of healing and defined as a Baumann angle change ≥10 and Gordon index of ≥0.5, and failure of AHL to intersect the capitellum. Statistical analysis was performed using the Fisher exact test and logistic regression.

Results: There were 257 patients included in the study (mean age 5.8 years; range 2-14). Of these patients, 183 had bicolumnar fixation, with 6% (11) demonstrating loss of reduction. 74 patients had unicolumnar fixation with 18% (13) showing loss of reduction. These two rates were significantly different ($P = 0.008$) with a 3.3-times higher odds (95% confidence interval = 1.3, 8.6) of loss of reduction with unicolumnar fixation. Multivariate analysis showed statistical significance of unicolumnar versus bicolumnar fixation ($P = 0.007$) and showed a trend toward higher loss of reduction with increased fluoroscopy time ($P = 0.07$).

Conclusion: There is a statistically significant increase in the rate of supracondylar fracture loss of reduction for patients with unicolumnar fixation when compared to bicolumnar fixation.



Comparative Effectiveness of Nonoperative Versus Operative Treatment for Completely Displaced Clavicle Shaft Fractures in Children

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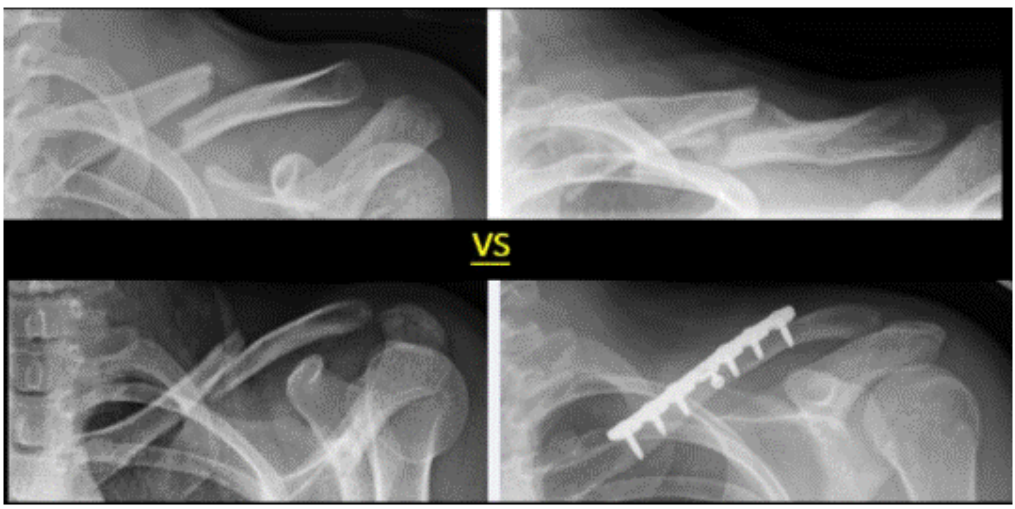
Purpose: Our aim was to compare the outcomes among children treated nonoperatively versus operatively for completely displaced clavicle fractures.

Methods: A retrospective cohort study of 110 pediatric patients with completely displaced clavicle shaft fractures was undertaken, 55 treated nonoperatively and 55 treated operatively (plate and screws). Outcome measures included time to return to activities, complications, and QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand [DASH] questionnaire) scores. Data were collected via chart review and telemedicine follow-up. Regarding statistical analysis, the Fisher exact test was used for categorical variables and Student two-tailed t test for continuous variables.

Results: The nonoperative group had an average age of 11.6 years (range, 8-14) while the operative group average was 14.3 years (range, 9-17). No significant difference ($P = 0.941$) between the groups was identified regarding average time to return to full unrestricted activities (90.4 days for nonoperative group and 89.7 days for operative group). Significant ($P = 0.031$) differences in refracture rate were detected: 22% (12 of 55) nonoperative patients versus 7% (4 of 55) in the operative group. There was a 27% rate (15 of 55) of plate and screw removal in the operative group. A subset of each group provided QuickDASH data and no significant differences ($P = 0.329$) were noted; 77% (17 of 22) nonoperative patients reported no disability versus 88% (22 of 25) in the operative group.

Conclusion: Prior comparative studies in this age group have documented a faster return to unrestricted activities. Our study did not confirm this. We also found a surprisingly high 22% refracture rate in the nonoperative group and an annoyingly high 27% rate of plate and screw removal in the operative group.



Complications with Surgical Treatment of Pediatric Supracondylar Humerus Fractures: Does Surgeon Training Matter?

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Purpose: National trends reveal increased transfers to referral hospitals for surgical management of pediatric supracondylar humerus (SCH) fractures. This is partially due to the belief that pediatric orthopaedic surgeons (POs) will have better outcomes compared to non-pediatric orthopaedic surgeons (NPOs). We compared outcomes of operatively treated SCH fractures between POs and NPOs at a single tertiary care center where both groups cover primary call for pediatric fractures.

Methods: Patients age 3 to 10 years undergoing operative treatment of SCH fractures from 2014 to 2020 were included. Patient demographics and perioperative details were recorded. Radiographs at surgery and short-term follow-up assessed quality and maintenance of reduction. Primary outcomes were major loss of reduction (MLOR) and iatrogenic nerve injury (INI). Secondary outcomes included overall complications, reoperation, quality of pin construct, need for open reduction, and surgical time.

Results: 311 fractures were reviewed, including 103 Gartland type 2, 170 type 3, 28 modified Gartland type 4, and 10 flexion type. POs performed 132 cases, and NPOs performed 179 cases. The rate of MLOR was 1.5% among POs and 2.2% among NPOs ($P = 1$). The rate of INI was 0% among POs and 3.4% among NPOs ($P = 0.041$). All nerve palsies resolved at mean 13.1 weeks postoperatively. Rates of reoperation, infection, and readmission were not significantly different among PO and NPO groups. Rates of open reduction were also similar (3.8% vs 4.5%). Operative times were decreased with POs compared to NPOs (38.1 vs 44.6 minutes; $P = 0.030$). Pin constructs were graded as higher quality in the PO group, having a higher mean pin spread ratio ($P = 0.029$), a lower rate of "C" grade (only 1 column engaged with pins; $P = 0.010$), and less frequent crossed-pin technique (9.8% vs 32.4%; $P<0.001$). The NPO group took significantly more cases to the operating room overnight (21.2%) compared to the PO group (3.8%) ($P<0.001$). Multivariate analysis revealed positive associations for operative time with MLOR (odds ratio [OR] = 1.021; $P = 0.005$) and INI (OR = 1.048; $P = 0.009$).

Conclusion: Postsurgical outcomes between POs and NPOs were similar in this study. The rate of MLOR was not different between groups, despite differences in pin constructs. The NPO group experienced a statistically higher rate of INI (3.4%), although this association is likely confounded by longer operative time, which serves as a proxy for fracture complexity. The rate of other complications was similar between groups and universally low. These findings support the assertion that pediatric subspecialty training is not a prerequisite for safely and successfully treating these common injuries.

Is the Iliac Cortical Density Similarly Positioned in the Developing Pelvis?

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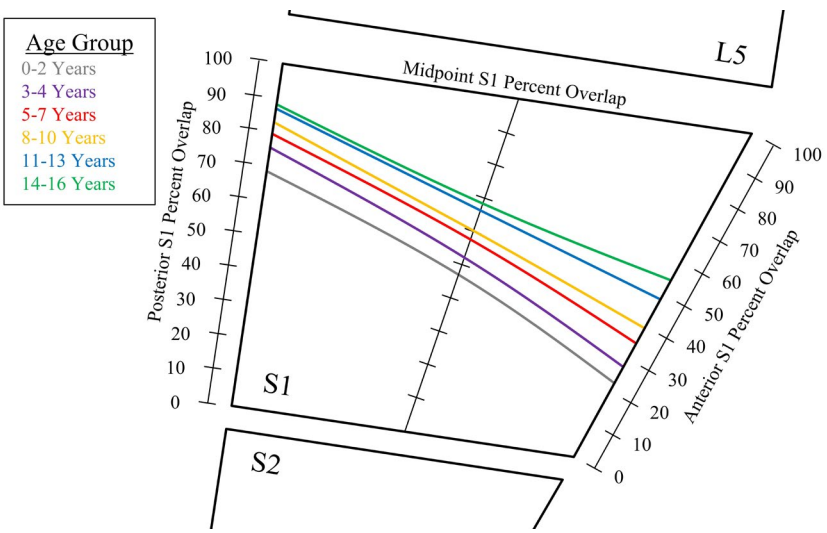
Purpose: The iliac cortical density (ICD) is a critical fluoroscopic landmark for pelvic percutaneous screw placement. It is unclear whether the classic ICD landmark is located similarly in the developing pelvis. Our purpose was to evaluate the ICD in pediatrics, and quantify the diameter of osseous pathways for three screw trajectories: iliosacral (IS) at S1 and transiliac-transsacral (TSTI) at S1 and S2 with respect to age and pelvic dysmorphism.

Methods: 267 consecutive pelvic CT scans in children aged 0-16 years were analyzed. ICD and S1 vertebral heights were measured at multiple regions along S1. Their height and corresponding ratios, as well as osseous screw corridor dimensions, were compared between age groups and by dysmorphic status.

Results: In the non-dysmorphic pelvises, S1 height, ICD height, and the ICD to S1 height ratio increased across age groups for all locations (P<0.001) (Fig. 1). All three screw pathway diameters increased with age (P<0.001). In the dysmorphic group, there was no increase in ICD to S1 height ratio with age. Except for the age 0-2 group, the ICD to S1 height ratios were significantly larger in the non-dysmorphic group. In the dysmorphic group, S1 TSTI pathway remained narrow with age while IS at S1 and TSTI at S2 had a significant increased diameter with age (P<0.001).

Conclusion: The ICD is a useful fluoroscopic landmark for percutaneous screw placement in the pediatric pelvis. For non-dysmorphic pelvises, the ICD to S1 height ratio, as well as osseous corridors for IS, TSTI at S1, and TSTI at S2 screw trajectories increase significantly with age. In dysmorphic pelvises, there is no significant improvement in the S1 TSTI corridor despite increased age and growth. The margin for safe screw placement in S1 is smaller for younger and dysmorphic pelvises.



The CORE-KIDS Core Outcome Set for Childhood Limb Fractures

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Purpose: There is considerable variability in the measurement and reporting of outcomes during trials relating to childhood fractures. This is limiting synthesis of results and pooling of studies into effective meta-analyses that influence practice around the world. This could be addressed with a core outcome set, an agreed set of outcomes to be measured in all trials of childhood fractures. The aim of this study is to develop a core set of outcome domains that should be measured and reported in all future trials of childhood limb fractures.

Methods: The study was reviewed by the North London–Hampstead research ethics committee (HRA/REC IRAS number 262503). A four-phase study was conducted to agree a core set of outcome domains. Outcomes relevant to professionals were identified through systematic review of trials, and outcomes relevant to families were identified through semi-structured interviews with 20 families (parent-child dyads). Outcome domains were prioritized using an international three-round Delphi survey with 205 panelists and then condensed into a core outcome set through a consensus workshop with 31 stakeholders including surgeons, therapists, nurses, and patients.

Results: The systematic review and interviews identified 85 outcome domains as relevant to professionals or families. The Delphi survey prioritized 30 upper and 29 lower limb outcomes at first round, an additional 17 upper and 18 lower limb outcomes at second round, and 4 additional outcomes for upper and lower limb at the third round as important outcomes. At the consensus workshop, the core outcome domains was agreed as: (1) pain and discomfort, (2) return to physical and recreational activities, (3) emotional and psychosocial well-being, (4) complications from the injury and treatment, (5) return to baseline activities daily living, (6) participation in learning, (7) appearance and deformity, and (8) time to union. (9a) Recovery of mobility and (9b) recovery of manual dexterity were recommended as core outcomes for lower and upper limb fractures, respectively.

Conclusion: This set of core outcome domains are recommended as a minimum set of outcomes to be reported in all trials. It is not an exhaustive set and further work is required to identify what outcome tools should be used to measure each of these outcomes. Adoption of this outcome set will improve the consistency of research for these children that can be combined for more meaningful meta-analyses and policy development. Further work is required to identify and validate outcome instruments (including patient-reported outcomes) that can be used to measure these domains. This core outcome set has been endorsed by the British Society of Children's Orthopaedic Surgeons, the Orthopaedic Trauma Society, and the Nederlandse Orthopaedische Vereniging as the reporting standard for clinical studies of childhood limb fractures.

The Effects of Sacroiliac Joint Fixation on the L5/S1 Facet Joint: A Cadaveric Study

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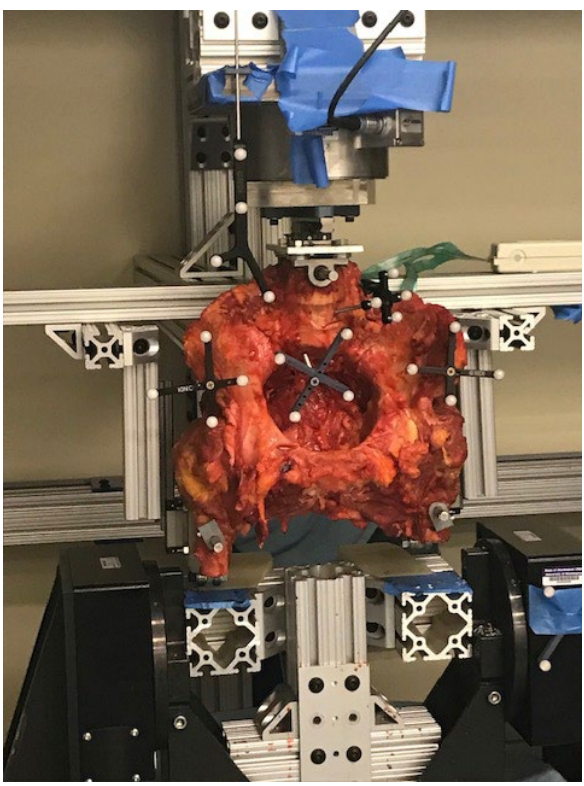
Purpose: Injuries to the posterior pelvic ring are often stabilized with fixation across the sacroiliac joint (SIJ). However, the compensatory changes at the neighboring L5/S1 facet joint are unknown. The objective of this study was to determine the change in pelvic kinematics and contact forces at the L5/S1 facet joint after SIJ fixation using a cadaveric biomechanical model.

Methods: Five fresh-frozen cadaveric pelvis specimens were dissected to remove all nonstructural soft tissue. Retroreflective marker clusters were fixed to the L5 vertebral body, S1 body, and bilateral anterior superior iliac spines (ASISs) to represent the motion of L5, S1, and the ilium, respectively. Flexible pressure sensors were inserted in both L5/S1 facet joints. Biomechanical testing was performed using a hexapod robotic system that applied axial load individually to each side of the pelvis. Biomechanical testing was performed prior to SIJ fixation, after unilateral fixation with a 7.0-mm iliosacral screw, and after bilateral SIJ fixation.

Results: Contact force at the L5/S1 facet joint significantly increased from 65.4 ± 40 N to 128 ± 122 N following unilateral fixation ($P = 0.0161$) and to 144 ± 154 N ($P = 0.0038$) after bilateral fixation. Significantly more motion in multiple planes occurred at L5/S1 facet joint after fixation of the SIJ. Unilateral SIJ fixation increased flexion of the ilium relative to L5 from 1.25° to 2.04° ($P = 0.01$) and increased axial rotation of L5 relative to S1 from 2.81° to 3.23° ($P = 0.001$). Bilateral fixation increased flexion of the ilium relative to L5 to 1.8° from 1.25° prior to fixation ($P = 0.001$), increased axial rotation of L5 relative to S1 to 3.6° from 2.81° prior to fixation ($P = 0.002$), and increased flexion of L5 relative to S1 to 3.7° from 3.1° prior to fixation ($P = 0.04$).



Conclusion: The L5/S1 facet joint experiences compensatory increased motion under increased contact force after unilateral and bilateral SIJ fixation, possibly predisposing it to adjacent segment arthritis.

POSTER ABSTRACTS

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

AP Pelvis Radiograph Has Poor Sensitivity Compared to CT as Screening Test for Unstable Sacral Fractures

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Purpose: The orthopaedic surgeon taking general call will encounter patients who have sustained pelvic ring injuries. We investigated the sensitivity of the AP pelvis radiograph as a screening test for clinically serious unstable sacral fractures that merit consultation with an orthopaedic trauma specialist and possibly transfer to a higher level of care.

Methods: A retrospective clinical cohort of consecutive patients with unstable sacral fractures presenting to a regional Level I trauma center from 2006 to 2019 was identified from a trauma registry. Fractures were confirmed by review of pelvis CT and documentation and classified by the AOSpine Sacral Fracture Classification. The sensitivity of the initial AP pelvis radiograph for a new diagnosis of pelvic ring injury was determined using the transcribed attending radiology report. Report reference to concomitant or outside hospital pretransfer imaging was grounds for exclusion. Three fellowship-trained orthopaedic traumatologists blinded to the study purpose then interpreted the AP pelvis radiograph set for «any pelvic ring injury» on a picture archivind and communication system workstation using ImageJ software (National Institutes of Health, Bethesda, MD). The sensitivity of the AP pelvis radiograph as interpreted by radiologists on duty versus the orthopaedic traumatology panel was compared for disruptions of the pelvic ring. Interrater agreement was assessed by Fleiss' unweighted κ. Predictors of missed diagnosis were explored by multivariable regression.

Results: 114 unstable U/Y/H-pattern sacral fractures were identified from 29,917 trauma activations (incidence 0.4%). 63 patients were included (24 U, 23 Y, and 16 H-pattern sacral fractures) after exclusion of 51 radiograph reports referencing antecedent pelvis CT results. The visualization of 94% of sacra on the AP pelvis radiograph was obscured by artifact. On-duty radiologists identified 54% of complete sacral fractures and 2% of unstable U/Y/H-type sacral fractures. The orthopaedic traumatologist panel identified 63% of complete sacral fractures (range 43%-75%, $\kappa = 0.27$) and 12% of unstable U/Y/H-type sacral fractures (range 5%-27%, $\kappa = 0.11$). The presence of a pelvic binder was significantly associated with failure to detect a complete sacral fracture, while sacral dysmorphism, anterior pelvic ring disruption, extrasacral posterior pelvic ring disruption, and the presence of "stepladder" disruption of the sacral neural foramina were each independently associated with greater likelihood of identifying a complete sacral fracture.

Conclusion: The AP pelvis radiograph demonstrates poor sensitivity and poor agreement for complete and unstable sacral fractures, whether interpreted by radiologists or orthopaedic traumatologists. Pelvis CT should be considered when radiography is negative but clinical concern for a pelvic ring injury remains.

Erectile Dysfunction Following Acetabular Fracture

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Purpose: The aim of this study was to determine the rate of erectile dysfunction in male patients who sustained an acetabular fracture with no previously identified urogenital injury.

Methods: All males between the ages of 18 and 70 years who were treated for traumatic injury to the acetabulum without urogenital injury were identified using an institutional trauma database and invited to participate in an online cross-sectional survey. As part of the survey, the International Index of Erectile Function (IIEF), a validated patient-reported outcome measure for male sexual function, was administered. Patients were asked to complete the IIEF score for both pre-injury and current sexual function, and the erectile function (EF) domain was utilized to quantify the degree of erectile dysfunction. Fractures were classified according the OTA/AO classification schema and Letournel fracture classification. ISS, race, and treatment details including surgical approach were collected from the database. Descriptive statistics were used to evaluate demographic data. The Student t test was used to compare means. Multiple linear regression was used to analyze predictors of erectile dysfunction after acetabular fracture.

Results: 93 men with acetabular fractures, without previously diagnosed urogenital injury, responded to the survey at a minimum of 12 months (mean 43.0 ± 20.8 months) post-injury. The mean age was 52.5 ± 14.8 years. The mean EF domain score decreased 5.02 ± 1.73 points after injury, which is greater than the minimal clinically important difference of 4. Moderate to severe erectile dysfunction developed in 26.8% of patients after injury, and 34.1% decreased a minimum of 4 points on the EF domain score. Increased ISS was predictive of decreased EF score.

Conclusion: Patients with acetabular fractures have an increased rate of erectile dysfunction at intermediate-term follow-up. The orthopaedic trauma surgeon treating these injuries should be aware of this as a potential associated injury, ask their patients about their function, and make appropriate referrals.

Table 3 Crosstabulation

		Post Injury EF					Total
	Pre-Injury	< 10	11-16	17-21	22-25	26-30	
Severe ED	< 10	5	0	0	0	0	5
Moderate ED	10-16	3	4	1	0	1	9
Mild to moderate	17-21	0	2	1	0	0	3
mild ED	22-25	1	6	2	4	1	14
no ED	26-30	9	4	3	6	37	59
	Total	18	16	7	10	39	90

Anterior Pelvic Ring Fracture Pattern Predicts Displacement in Complete and Incomplete Sacral Fractures Associated with Lateral Compression Injuries

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Purpose: Predicting stability of lateral compression (LC) pelvic ring injuries on static imaging can be difficult and may require an examination under anesthesia (EUA) to determine management. Previous studies show higher rates of instability with complete sacral fractures associated with bilateral pubic rami fractures. This study aims to establish anterior pelvic ring injury patterns that are particularly susceptible to displacement to help guide management.

Methods: This was a retrospective study of patients treated for LC pelvic ring injuries between 2014 and 2019. Radiographic imaging was used to characterize the anterior fracture location (parasymphyseal, pubic body, Nakatani region of pubic rami, or root) and pattern (comminuted, oblique, segmental, or transverse). Primary outcome measures were displacement at follow-up and instability on EUA requiring operative stabilization. On the side of the pelvis with more significant fracture pattern, analysis was performed by calculating each pattern's absolute risk (AR) of displacement and using Fisher's exact test with significance of $P<0.05$. Sacral fracture type was accounted for by using bivariate analysis with significance of $P<0.05$.

Results: 116 patients were eligible for inclusion. 73 patients (63%) had incomplete sacral fractures; 61 patients (53%) displaced, and 55 (47%) had no displacement. Univariate analysis showed that displaced patients were more likely to be older (53 vs 45 years, $P = 0.062$) and female (55%, $P<0.01$). If at least one of the inferior or superior ramus fracture patterns was transverse or unfractured, the risk of subsequent displacement was 0% ($P<0.01$). Bivariate analysis revealed that comminuted (AR 79%, $P<0.05$) and oblique (AR 83%, $P<0.05$) Nakatani 1 (medial) superior pubic rami fractures were associated with increased risk of displacement for both complete and incomplete sacral fractures.

Conclusion: Based on this analysis, displacement of both complete and incomplete LC sacral fractures was more likely in older patients, females, and presence of comminuted or oblique Nakatani 1 (medial) superior pubic rami fracture. If a superior or inferior ramus was transverse, nondisplaced, or not fractured, the risk of displacement was 0%. This information will help disclose patients that may benefit from nonoperative management and identify those who should proceed with EUA or surgical fixation.

What Is the Probability That External Beam Irradiation Is the Most Effective Modality to Prevent Heterotopic Ossification After Acetabular Surgery? A Bayesian Analysis

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Purpose: Despite the high incidence of heterotopic ossification (HO) after surgical fixation of acetabular fractures, HO prophylaxis treatment pathways remain controversial. Although external beam irradiation (XRT) has been shown to be effective against HO formation in smaller observational studies, there are no adequately powered standalone randomized controlled trials (RCTs) to support its use compared to placebo. We performed a Bayesian network meta-analysis to determine the probability that XRT is the most effective HO prophylaxis treatment strategy.

Methods: In this Bayesian network meta-analysis, RCTs (N = 4) and observational studies (N = 6) were separately analyzed. The primary outcome measure was overall HO formation and significant HO formation (Brooker classification 3 and 4). We compared outcomes between HO prophylaxis type— XRT, indomethacin, or no prophylaxis. For each study outcome, we fit fixed effects and random effects models, and selected the reported model based on optimizing model fit characteristics.

Results: Among RCTs, the average incidence of overall HO formation was 24% for patients who received XRT, compared to 41% in patients who received indomethacin and 60% in patients who received no prophylaxis. Compared to the no prophylaxis control group, patients who received XRT were 45% less likely to develop HO (risk ratio [RR] 0.55, 95% credible interval (CrI) 0.31-0.98) and patients who received indomethacin were 26% less likely to develop HO (RR 0.74, 95% CrI 0.59-0.93). Based on RCT data, the probability that XRT was the most effective treatment strategy to prevent HO formation was 88%. By comparison, indomethacin had a 12% probability of being the most effective strategy but an 87% chance of being the second best strategy. Similarly, among RCT data, the probability that XRT was the most effective treatment strategy to prevent significant HO (Brooker 3 and 4) was 92%. Among observational studies, patients who underwent XRT were 42% less likely develop HO (RR 0.58, 95% CrI 0.30-0.99) compared to the no prophylaxis subgroup. Patients who received indomethacin were 22% less likely to develop HO compared to the control group but this did not reach statistical significance (RR 0.78, 95% CrI 0.31-1.39).

Conclusion: Among the best data available in the literature, we determined that there is ~90% probability that XRT is the most effective treatment strategy to prevent HO after acetabular surgery. Drawbacks to XRT include high cost and resource utilization, risk of radiation-induced sarcoma, and possible increased rates of non-infectious wound healing problems. Given these risks, our data are critical to inform treating surgeons on the relative effectiveness of XRT to better assist discussions and shared treatment decisions with patients.

Peripheral Nerve Injury in Operatively Managed Pelvic Ring Injuries: Is Pelvic Angiography a Predictor of Neurologic Deficit?

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Purpose: A detailed neurologic examination can be difficult to perform in the polytraumatized patient. However, the identification of such deficits are important to recognize acutely in order to address durable medical equipment and rehabilitation needs to optimize prognosis and outcomes. The aim of the current study was to identify risk factors associated with peripheral nerve injury in patients with pelvic ring fractures.

Methods: The current study presents on 274 consecutive patients that presented to a single Level I academic trauma hospital for surgical fixation of a pelvic ring injury. Peripheral nerve injury was classified as positive when the patient was unable to perform anti-gravity motor strength (<3/5 muscle strength grading) with associated sensory deficits in the corresponding dermatome. Pelvic ring fractures were classified according to the Young and Burgess and OTA classification systems. Associated injuries and demographic information was obtained from patient records. Logistic regression analyses were performed and reported in odds ratios (ORs) and 95% confidence intervals (CIs).

Results: Of the 274 patients with pelvic ring injuries included in this study, 35 patients (13%) had an associated peripheral nerve injury. Of these patients with a nerve injury, 32 (91%) had a sciatic nerve injury and 3 (9%) had a femoral nerve injury. Patients who required pelvic angiography were significantly more likely to have an associated nerve injury; there was a 34% (14 of 41) nerve injury rate in the angiography group compared to 9% (21 of 233) in the no angiography group ($P<0.001$). Patients who underwent angiography were over 5 times as likely to have an associated nerve injury (OR 5.2, 95% CI 2.4-11.5; $P<0.001$). Of those who underwent angiography (N = 41), 33 patients (80%) had embolization with gel foam or a coil. Patients who underwent angiography without embolization were almost 8 times as likely to have an associated nerve injury (OR 7.6, 95% CI 1.8-31.9; $P = 0.006$). Patients with an associated acetabular fracture were almost 4 times as likely to have an associated nerve injury (OR 3.8, 95% CI 1.8-7.8; $P<0.001$). There was no association between fracture pattern and nerve injury. There was also no association between age, sex, or body mass index between patients who did and not have an associated nerve injury.

Conclusion: We identified pelvic angiography and an associated acetabular fracture as significant factors associated with concomitant peripheral nerve injury in patients with pelvic ring fractures. Interestingly, patients who underwent pelvic angiography without embolization had the highest odds (almost 8×) of an associated nerve injury, perhaps related to venous bleeding and local compression. These data will help more acutely identify patients at high risk of nerve injury, which will both assist surgeons in counseling patients but also potentially help with earlier intervention strategies such as bracing and therapy.

What Is the Minimum S1 Transsacral Corridor Width for Transsacral Screw Fixation After Pelvic Ring Injuries?

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Purpose: Sacral dysmorphism is pragmatically defined as sacral anatomy resulting in narrowing of the S1 transsacral (TS) corridor that precludes safe TS screw placement. The degree of narrowing defining sacral dysmorphism remains controversial, ranging from 7 to 10 mm in the literature with 10 mm being the commonly accepted cut-off precluding S1 TS screw fixation. The purpose of this study was to determine what corridor width prevented screw placement and if TS screws could be placed in corridors less than 10 mm safely.

Methods: Patients with operative pelvic fractures and preoperative CT scans were included. On the preoperative CT scan, the width of the S1 TS corridor on axial reformatted images (parallel with the S1 body) and the coronal reformatted images (perpendicular to the S1 body) were measured. S1 axial and coronal angles were measured and used to calculate a sacral dysmorphism score. Patients with a postoperative CT scan who underwent S1 TS screw fixation were reviewed to determine if screw placement was intraosseous or extraosseous. Screw breaches through the neural foramen or anterior sacral cortex were documented along with any resulting iatrogenic nerve injury.

Results: 290 patients with pelvic ring injuries were identified. 51 (18%) fixation constructs included an S1 TS screw. No S1 TS screws were placed in a corridor with a width <8 mm. The S1 TS corridor width ranged from 8 to 23 mm and 8 to 21 mm in the axial and coronal planes, respectively. Of the 290 patients, 114 (39%) had S1 corridors <8 mm. Patients with S1 corridor width <8 mm were younger (33 vs 43 years; median difference [MD]: 8, 95% confidence interval [CI]: 2 to 18, P =0.01), had a greater S1 axial angle (27° vs 0°; MD: –27, 95% CI: –28 to –25, P<0.0001), a greater coronal angle (22° vs 20°; MD: 27, 95% CI –27 to –25, P<0.0001), and a greater dysmorphic score (65 vs 58; MD: –81, 95% CI: –86 to –76, P<0.001). There were no significant differences in sex, body mass index, or ethnicity between patients with an S1 TS corridor <8 mm and >8 mm. 6 screws were placed in corridors <10 mm in width. The number of extraosseous screws between S1 TS screws placed in corridors <10 mm versus >10 mm was not significantly different (2 of 6 [33%] vs 18 of 27; proportional difference 6%, 95% CI –33% to 39%, P = 1.0). Only one of these extraosseous screws, placed in a corridor >10 mm, resulted in a nerve injury. None of the extraosseous screws placed in corridors <10 mm resulted in nerve injuries.

Conclusion: S1 TS corridor narrowing that prohibits TS screw fixation is commonly used to define sacral dysmorphism but the actual corridor width used in the literature varies. Our study revealed that no S1 TS screws were placed in corridors less than 8 mm in width and that screw placement in corridors between 8 and 10 mm was possible with the same risk of cortical breach. The 8-mm cut-off observed in this cohort may help to standardize literature on sacral dysmorphism.

Comparison of 3D Printing-Assisted Transrectus Abdominis Lateral Incision and Traditional Ilioinguinal Approach in the Treatment of Pelvic Fracture

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Purpose: We sought to compare the clinical effects of 3-dimensional (3D) printing-assisted transrectus abdominis lateral incision and traditional ilioinguinal approach in the treatment of pelvic fracture.

Methods: From June 2017 to July 2020, 46 patients with pelvic fracture who were treated in the orthopaedic department in our hospital were selected as research subjects; they were randomly divided into the experimental group and the control group, with 23 patients each. The control group was given traditional ilioinguinal approach surgery, while the experimental group was given 3D printing-assisted transrectus abdominis lateral incision surgery. The hip function, pain visual analog scale score, operation time, postoperative drainage volume, hospital stay, length of incision, and complications were compared between the two groups.

Results: After 6-month follow-up, the excellent and good rate of hip function in the experimental group was significantly higher than that in the control group, with statistical significance ($P<0.05$); the hip function score in the experimental group was significantly higher than that in the control group, and the visual analog scale pain score was significantly lower than that in the control group, both with statistical significance ($P<0.05$). The operation time and hospital stay in the experimental group were significantly shorter than those in the control group, the postoperative drainage volume was significantly less than that in the control group, and the length of incision in the experimental group was significantly shorter than that in the control group, with statistical significance for all ($P<0.05$); the total incidence of complications in the experimental group was significantly lower than that in the control group, with statistical significance ($P<0.05$).

Conclusion: Compared with the traditional ilioinguinal approach, the 3D printing-assisted transrectus abdominis lateral incision approach in the treatment of patients with pelvic fractures can shorten the recovery time of hip function and receive more significant effect.

Outcomes of Acetabular Fracture Fixation with a Minimum 5 Years Follow-up: A Retrospective Study of 87 Cases in a Single Center

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Purpose: Successful outcome from acetabular fracture fixation is multifactorial. Long-term results are not frequently reported. The aims of the study to evaluate the long-term results of open reduction and internal fixation in a large series of acetabular fractures with a minimum 5-year follow-up and to identify the risk factors associated with a poor outcome.

Methods: We analyzed 190 displaced acetabular fractures managed surgically between 1998 and 2014 in an orthopaedic trauma unit. Patients were followed for a minimum of 5 years; those who had associated pelvic ring injury, had developed infection, needed revisional surgery, and were lost to follow-up were excluded from the study, leaving 87 patients with a mean of 124 months (range, 60-261) for the follow-up period. The primary outcomes are survivorship of hip joint as posttraumatic osteoarthritis using the Matta scoring system and divided into success and failure groups for identifying the affected risk factors. The other assessments evaluated were general demographics, the status of fractures, postoperative Matta radiological outcome grading, and other complications.

Results: Overall, the rate of secondary osteoarthritis (defined as fair and poor score according to the Matta scoring system) was 28.7% (25 out of 87 patients). When comparing successful and failed groups, significant independent negative predictors were high age at the time of injury, presence of acetabular impaction and hip dislocation, severe initial displacement of the articular surface, and poor reduction of Matta's radiological outcome grading. The presence of preoperative intra-articular fragments and femoral head fracture had no statistical effect on the difference between the two groups.

Conclusion: When analyzing patients who could be followed up for more than 5 years, open reduction and internal fixation of displaced acetabular fractures were able to successfully prevent posttraumatic osteoarthritis in 71.3%. The results represent comparative data for any future and past studies on the outcome of surgical fixation of acetabular fractures.

Lumbopelvic Fixation in the Treatment of Spinopelvic Dissociation: Union, Complications and Neurologic Outcomes of a 20-Year Case Series

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Purpose: Spinopelvic dissociation is a rare injury characterized by acute discontinuity of the spine from the pelvis and often presents with significant instability, neurologic injury, and traumatized posterior soft tissues. In patients with significant displacement, neurologic compromise, and/or inadequate pathways for percutaneous fixation, open lumbopelvic fixation may be indicated. Previous literature has reported reliable union and maintenance of alignment with a significant incidence of wound complication. We sought to review the outcomes following lumbopelvic fixation over a 20-year period at our busy Level I trauma center.

Methods: We reviewed all cases spinopelvic dissociation over a 20-year period and isolated patients who underwent open lumbopelvic fixation. We collected demographic data, associated injuries, pre- and postoperative neurologic status, pre- and postoperative kyphosis, and classified all injuries using the Roy-Camille and AO schema. Minimum follow-up was 3 months. Outcomes were collected through chart review and included radiographic and clinical union, incidence of hardware or wound complication, and need for reoperation. Patients who underwent adjunctive percutaneous fixation were also included.

Results: We identified 44 cases of spinopelvic dissociation treated with open lumbopelvic fixation from an initial cohort of 156 patients with U-, H-, Y-, or lambda-type sacral fractures. From this cohort, 33 patients fulfilled inclusion criteria with a mean follow-up of 399 days. Ten patients from this cohort were repaired with a combination of percutaneous iliosacral and open lumbopelvic techniques. The average preoperative kyphosis in this cohort was 25° and the average postoperative kyphosis was 23°. 17 patients (51%) had a documented neurologic deficit preoperatively and 7 (21%) were unknown or unable to be assessed. In patients presenting with bowel or bladder dysfunction (n = 10), all underwent laminectomy at the time of surgery and 3 patients (30%) continued to have dysfunction at last follow-up. There were 4 cases (12%) of surgical site infection and 3 (8%) wound complications treated without surgery. Three patients required hardware removal secondary to a painful implant. All cases went on to union.

Conclusion: This is the largest reported series of spinopelvic discontinuity repaired using open lumbopelvic fixation in the literature. We found open lumbopelvic fixation yielded a high union rate without any cases of hardware failure or pseudoarthrosis. Approximately one in five patients had a wound complication, with the majority of these being surgical site infections. Bowel and bladder dysfunction at presentation was common and 70% of cases had resolution at final follow-up when treated with decompression and stable fixation.

Are Pelvic Binders an Effective Prehospital Intervention?

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Purpose: Widespread adoption of prehospital pelvic circumferential compression devices (PCCDs) by Emergency Medical Services (EMS) systems has been slow and variable across the US. We sought to determine how often EMS providers identified unstable pelvic ring injuries and how frequently a PCCD was placed prehospital. Secondarily, we hypothesized that prehospital PCCD use would improve early hemorrhagic shock outcomes.

Methods: We conducted a single center retrospective cohort study of unstable pelvic ring injuries (lateral compression [LC]3, anterior-posterior compression [APC]2-3, combined mechanical injury [CMI], and vertical shear [VS] patterns). We included all patients who were transported directly to our center by EMS, received a PCCD during their resuscitation (prehospital or emergency department), and were treated between the years 2011 and 2020. PCCDs were defined as any commercial pelvic binder or modified circumferential splint (eg, linen sheet). Prehospital treatment details were obtained from the EMS medical record. The primary outcome was the proportion of patients who received a PCCD by EMS before hospital arrival. Secondarily, we explored factors associated with receiving a prehospital PCCD, and its association with changes in vital signs, blood transfusion, and mortality.

Results: Of the 161 patients included in this study, 85 (52.8%) were suspected by EMS providers of having a pelvic ring fracture and 52 (32.2%) received a prehospital PCCD. Wide variation in prehospital PCCD use was observed based on patient characteristics, geographic location, and EMS provider level. Helicopter flight paramedics applied a prehospital PCCD in 46% of the study patients they transported (n = 38 of 83); in contrast, the EMS organizations geographically closest to our hospital applied a PCCD in ≤5% of cases (n = 2 of 47). Other predictors associated with receiving a prehospital PCCD included lower body mass index ($P = 0.005$), longer time interval from 911 call to patient hospital arrival ($P = 0.001$), and lower ISS ($P<0.05$). We were unable to identify any improvements in clinical outcomes associated with prehospital PCCD, including early vital signs, number of blood transfusions within 24 hours, or mortality during admission ($P>0.05$).

Conclusion: There is wide practice variation in the application of prehospital PCCDs. While disparate PCCD application across the state is likely explained by differences across EMS organizations and provider levels, our study was unable to identify any clinical benefits to the prehospital use of PCCDs. It is possible that the benefits of a prehospital PCCD can only be observed in the most displaced fracture patterns with the greatest early hemodynamic instability. Our study highlights opportunities for increased standardization of EMS protocols and further evaluation of prehospital PCCD efficacy.

Reformatting of CT Scans Parallel to the S1 End Plate Increases Visualization of Transiliac Transsacral (TITS) Pathway in the First Sacral Segment, Especially with Dysmorphism

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Purpose: Percutaneous posterior pelvic ring fixation for fractures has increased significantly in the last 2 decades. Decisions regarding the ability to place screws percutaneously are made based upon evaluation of CT scans historically obtained with axial cuts oriented perpendicular to the axis of the body but usually oblique to the lumbosacral spinal elements. Prior work has demonstrated that when the axial image is formatted in relation to the plane of the sacrum, a larger safe zone for transsacral screw placement in the first sacral corridor can be appreciated. The purpose of this study was to investigate the change in understanding of safe corridors when using axial CT images in the plane of the sacrum as compared to the traditional axial CT images perpendicular to the body.

Methods: 50 pelvis CT scans without evidence of osseous pelvic injuries were deidentified and randomly placed on different PowerPoint slides. Each slide included a video of the axial CT along with the corresponding sagittal CT image. The axial CT included either an image created via traditional means (cuts perpendicular to the axis of the body) or through a reformat (cuts parallel to the S1 superior end plate). Both fellowship-trained orthopaedic trauma surgeons and orthopaedic residents reviewed each scan to determine whether a TITS screw could be placed in the first sacral segment safely. Patients were then grouped based on markers of sacral dysplasia. A conversion was defined as a patient deemed unable to have safe passage for a TITS screw on traditional axial cuts but safe with reformatted axial cuts.

Results: CT scans were reviewed by 9 attending surgeons and 5 residents. Overall, 58% of the patients were felt to have a safe corridor in the first sacral segment using traditional axial cuts whereas 68% were felt to have a safe corridor with the reformatted axial cuts. Attending surgeons felt 58% had a safe corridor on the axial scan and 67% on the reformats, while residents felt 58% and 70% had safe corridors, respectively. When grouped by dysplasia, those without signs of sacral dysplasia (n = 28) had a safe corridor 93% of the time on original scans and 93% of the time with reformatted CT scans. However, of those who had dysplasia (n = 22), only 12% were felt to have a safe corridor on original scans but 35% were felt to have a safe corridor on reformatted scans. The average conversion rate was 34% (range, 18%-75%) for attendings and 35% (range, 18%-50%) for residents.

Conclusion: Reformatting of CT scans parallel to the superior end plate of the S1 body increases the likelihood of identifying a safe corridor for a TITS screw, especially in patients with evidence of sacral dysplasia. We would recommend the routine use of reformatting CT scans in this manner to provide better understanding of the osseous fixation pathways of the upper sacral segment.

Acetabular Fractures Treated with Open Reduction and Internal Fixation and Acute Total Hip Arthroplasty: Follow-up of 42 Patients After 1 to 20 Years

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Purpose: Geriatric acetabular fractures are associated with substantial joint impaction and comminution, features previously shown to be prognostic of a poor result. Thus, a combined procedure of open reduction and internal fixation (ORIF) and acute total hip arthroplasty (THA) can be a good option when the joint cannot be adequately reconstructed. We report short- to medium-term outcome of the results of patients treated with this combined procedure at Oslo University Hospital Ullevaal.

Methods: 56 cases treated with ORIF and acute THA from January 1, 2000 to December 31, 2019 were identified. Seven cases treated for periprosthetic fractures were excluded. One patient was a foreign citizen and one was treated with only THA; both were excluded. Five patients died within 3 months after surgery, leaving 42 cases treated for an acute acetabular fracture available for follow-up. Mean age was 68 years (range, 37-87). There were 36 men and 11 women. Mean follow-up was 2.8 years (range, 1-16). The majority of fractures involved the anterior column. The most common mechanisms of injury were fall from standing height (n = 36) and motor vehicle accidents (n = 11). Six were polytrauma cases. Medical comorbidities were common.

Results: Of the 48 cases treated for a nonreconstructable acetabular fracture, 42 had their implant intact at follow-up. Six patients were deceased within 3 months after surgery, all of whom were categorized as American Society of Anesthesiologists (ASA) class 4 by an anesthesiologist preoperatively. Four cases developed postoperative infections within 3 months after surgery; all four were ASA 4 patients. Two were treated with soft-tissue debridement and retained the implant; 2 needed multiple revisions and removal of the THA. One dislocation was treated with closed reduction with no further revision required. All four cases treated for postoperative infection were deceased within 3 months. At the latest follow-up, 28 patients were ambulatory without a walking aid. Harris Hip Score (HHS) at follow-up was available for 36 patients. Median HHS was 82 (range, 51-100).

Conclusion: ORIF and acute THA for select geriatric acetabular fractures can be performed with good results. In this cohort, mean HHS was 82 at latest follow-up. ASA class 4 patients are at high risk for severe complications and death, and other treatment options should be preferred in this group.

Does Subcutaneous Internal Fixation (INFIX) Perform Similarly Radiographically to Other Methods of Anterior Pelvic Fixation for Pelvic Ring Injury?

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Purpose: Optimal treatment for high-energy pelvic ring injuries remains a challenge for orthopaedic surgeons. Particularly, anterior pelvic ring fixation remains controversial. Many techniques have been described, including open reduction and internal fixation (ORIF), percutaneous cannulated screw fixation, subcutaneous internal fixation (INFIX), and external fixation. Despite a variety of fixation techniques, there is scarce literature investigating direct comparisons between common methods of anterior pelvic fixation. We hypothesize that INFIX will not show a significant difference in pelvic deformity or pubic symphysis reduction when compared to ORIF and external fixation methods in the setting of pelvic ring injury.

Methods: We retrospectively reviewed orthopedic trauma patients from 2011 to 2015 who sustained high-energy pelvic ring injuries treated with ORIF, external fixation, or INFIX. Reduction assessment included pelvic deformity index and pubic symphysis widening measured from pre- and postoperative AP pelvis radiographs. Interrater reliability of radiographic measurements was calculated between two independent reviewers. Comparison between fixation techniques was analyzed using t test with significance as $P<0.005$.

Results: 37 patients were included, average age 45.4 years. Anterior-posterior compression (APC)3 injuries were seen in 29.7%, and lateral compression (LC)3 injuries in 21.6% patients. In more severely displaced injuries, INFIX was used in 42.1% of patients, ORIF in 36.8%, and external fixation in 21.1%. 15 patients underwent INFIX, 11 underwent ORIF of pubic symphysis or innominate bone, 6 underwent external fixation, and 5 underwent isolated sacroiliac screw placement. Average pelvic deformity index reduction with INFIX was 35.9% versus 38.1% with external fixation ($P = 0.71$), and 51.4% with ORIF ($P = 0.78$). Average reduction of pubic diastasis with INFIX was 52.1% versus 41.4% with external fixation ($P = 0.34$), and 72.5% with ORIF ($P = 0.002$). Interrater reliability of pre- and postoperative measurements was 0.93 and 0.91, respectively. Full weight bearing with INFIX averaged 10.9 weeks, 12 weeks with external fixation, and 15.9 weeks with ORIF. Complications included 23 cases of lateral femoral cutaneous nerve (LCFN) neuritis (9 in INFIX patients), 2 cases of heterotopic ossification, 1 case of deep infection, and 1 case of hardware failure. Average follow-up was 1.2 years.

Conclusion: INFIX radiological reduction outcomes were comparable to traditional methods of anterior pelvic fixation. Consistent with prior anatomic and case series, a higher incidence of LCFN neuritis was reported in those patients with INFIX. In the cases of more severe injury, INFIX and ORIF were preferentially used over external fixation.

Anterior Pelvic Ring Fixation Techniques: A Retrospective Assessment of Reduction Quality and Reduction Maintenance After Unstable Pelvic Ring Disruptions

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Purpose: We sought to compare reduction quality, reduction maintenance, and postoperative complications of anterior pelvic ring injuries stabilized with either anterior pelvic external fixation (APEF), anterior subcutaneous internal pelvic fixation (INFIX), or medullary ramus screw fixation (RSF) with the hypothesis that RSF results in comparable reduction quality and maintenance with fewer postoperative complications, as compared to APEF or INFIX.

Methods: A retrospective review was performed for 115 patients with unstable anterior and posterior pelvic ring disruptions (OTA / AO 61B2-61C3). All patients were treated with combined anterior and posterior fixation. Patients were grouped based on the method of anterior ring fixation utilized: APEF (n = 48), INFIX (n = 39), or RSF (n = 28). Reductions of the pelvic ring were evaluated using the pelvic deformity index (PDI) and pelvic asymmetry value (PAV), calculated from postoperative pelvic radiograph measurements. Reduction maintenance was evaluated based on the change in PDI and PAV from the initial postoperative radiograph to the radiograph at final follow-up. Complications were tabulated, including surgical site infections, lateral femoral cutaneous nerve injuries, symptomatic heterotopic ossification, and unplanned reoperations.

Results: Reduction quality was similar among the three groups with no significant differences in PDI ($P = 0.297$) or PAV ($P = 0.189$). RSF demonstrated superior reduction maintenance with less change in PDI ($P = 0.019$) and less change in PAV ($P = 0.017$) than APEF or INFIX. Average follow-up was 6.53 months with no significant differences in follow-up time among the groups ($P = 0.542$). The groups also did not differ significantly in demographic characteristics (age, gender, and body mass index). Complications were seen more frequently in the INFIX (51.3%) and APEF (35.4%) groups than the RSF group (14.3%) ($P = 0.008$). Surgical site infections were most common in the APEF group ($P = 0.038$). Lateral femoral cutaneous nerve (LFCN) injuries were seen in 13 INFIX patients (33.3%), 6 APEF patients (12.5%), and 3 RSF patients (10.7%). LFCN injuries in the RSF group were seen only in patients who sustained combined anterior ring disruption with symphysis diastasis and / or acetabular fracture injury patterns, which necessitated an open reduction. No patients in the RSF group who underwent closed reduction reported an LFCN injury.

Conclusion: The quality of pelvic ring reduction was not significantly different between APEF, INFIX, or RSF. RSF demonstrated the greatest ability to maintain the reduction at final follow-up. Overall complications were least in the RSF group and highest in the INFIX group.

Should We Perform Acute Total Hip Arthroplasty for all Patients Over 45 Years Old with an Acetabular Fracture Dislocation?

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Purpose: Femoral head osteonecrosis (ON) after acetabular surgery is associated with poor outcomes and often requires conversion to total hip arthroplasty (THA). Hip dislocation is often cited as the primary risk factor for femoral head ON. However, there is a large subset of patients who suffer a dislocation but do not go on to develop ON. The aim of this study was to focus on the subset of patients that present with an acetabular fracture dislocation and determine what the primary risk factors are for femoral head ON.

Methods: We report on 103 consecutive patients who presented to a single Level I trauma center over a 5-year period who underwent surgical fixation of acetabular fracture dislocation via a Kocher-Langenbeck surgical approach. All patients sustained a hip dislocation in association with the index acetabular fracture. The primary outcome was femoral head ON and conversion to THA. Fractures were classified according to the Judet and Letournel classification system. $\chi 2$ and logistic regression analyses were performed and odds ratios (ORs) reported with 95% confidence intervals (CIs).

Results: Of the 103 patients included, 15 patients (15%) went on to develop femoral head ON with conversion to THA. The mean age of the patients who developed ON was 47 years compared to 38 years for those who did not ($P = 0.019$). Patients over the age of 45 years were over 3 times more likely to develop ON and require THA (OR 3.2 [95% CI 1.1-9.9]; $P = 0.040$). Among the entire cohort, 17 patients (17%) were treated with a greater trochanteric osteotomy at time of index surgical fixation; this is typically used at our center for wall fractures that extend more superiorly and anteriorly. The ON rate for patients who underwent trochanteric osteotomy was 30% compared to 12% for those who did not receive an osteotomy ($P = 0.058$). Patients who were over 45 years old and also required a trochanteric osteotomy were over 5 times more likely to develop postoperative ON and require THA (OR 5.3 [95% CI 1.0-26.4]; $P = 0.044$). There was no association between acetabular fracture subtype and development of ON. Associated fracture patterns as a group were also no more likely to develop ON than elementary patterns ($P = 0.380$). Finally, the presence or absence of an associated posterior wall fracture was not associated with the development of ON ($P = 0.983$).

Conclusion: For patients who present with an acetabular fracture dislocation, age over 45 years is associated with an increased risk for subsequent femoral head ON and THA conversion. Additionally, if such patients require a trochanteric osteotomy, the risk is synergistic and the likelihood of THA conversion is increased over 5-fold. These data support consideration of an acute THA in patients over the age of 45 years who present with an acetabular fracture dislocation, and particularly in the smaller subset of patients who present with a cranial and/or anterior wall that would require a trochanteric osteotomy.

Malreduction, Not Fixation Technique, Is Associated with Increased Complications and Worse Functional Outcomes in High-Energy Posterior Pelvic Ring Injuries

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Purpose: Our objective was to evaluate the effect of transsacral screw technique and quality of reduction on loss of reduction, complications, and outcomes of operatively treated high-energy pelvic ring injuries.

Methods: An institutional database was used to identify skeletally mature, nongeriatric patients with traumatic sacral fractures presenting to a Level I trauma center from 2011 to 2018. All patients were treated with percutaneous transsacral screws for the posterior pelvic ring injury. Preoperative radiographs and CT were analyzed for fracture pattern, characteristics, and associated sacroiliac joint diastasis. All patients underwent routine postoperative CT scans as part of an institutional protocol that were reviewed for quality of reduction, number of screws, screw station (S1 or S2), screw diameter, thread length, cortical perforation of screw head / washer, and number of cortices engaged. Postoperative follow-up radiographs were assessed for loss of reduction and fixation failure. Chart review was used determine patient demographics, body mass index, ISS, removal of implants, postoperative nerve injury, and functional outcomes using Majeed, Iowa, and Short Form-12 outcome measures.

Results: 63 patients, of the 258 evaluated, with complete radiographic and clinical follow-up as well as functional outcome scores were included in this analysis. With respect to transsacral screw technique, number of screws, screw station, thread length, engaged cortices, cortical breach, and presence of washer were not associated with functional outcomes, complications, malunion, or change in implant position over time—regardless of injury pattern. However, malreduction of greater than 5 mm, as noted on postoperative CT, was associated with worse functional outcome ($P = 0.09$), an increased incidence of neurological injury ($P = 0.02$), and a higher rate of fixation failure ($P = 0.02$).

Conclusion: Measurable and quantifiable characteristics of transsacral screw technique do not seem to have a demonstrable effect on complications, loss of reduction, or functional outcomes in the treatment of high-energy pelvic ring injuries. However, malreduction leads to significantly higher rates of complications, malunion, and worse functional outcomes. With the increasing popularity and focus on percutaneous fixation techniques, more attention needs to be paid to achieving better quality reductions to improve outcomes and decrease complication rates.

Quantifying Blood Loss in Acetabular ORIF:
Fracture Pattern, Surgical Approach, and Delay to Surgery

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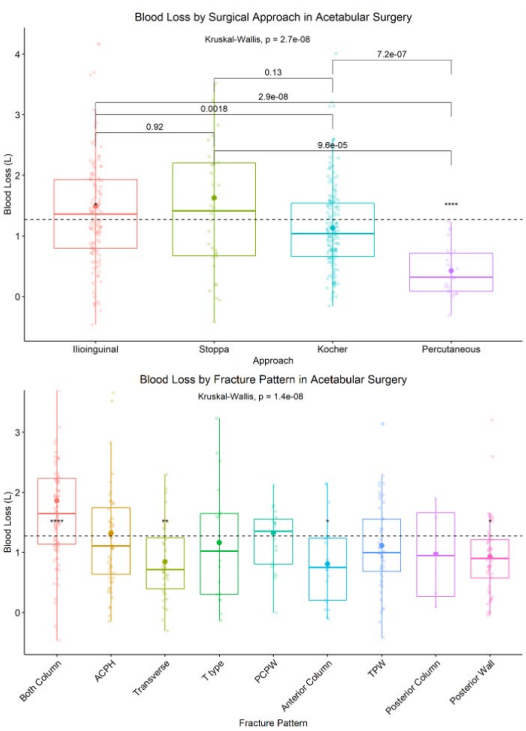
Purpose: The purpose of this study was to investigate factors impacting perioperative blood loss (BL) in acetabular open reduction and internal fixation (ORIF), using a quantitative, formulaic approach to minimize error and bias.

Methods: Adult patients receiving unilateral acetabular ORIF (academic, Level I, 2008-2018) were reviewed for demographics, injury patterns, surgical outcomes, and perioperative laboratory data. BL was calculated using a hemoglobin mass-loss formula (International Council: Standardization in Haematology), which adjusts for change in total blood volume by height, age, weight and gender. Key inputs included pre- and postoperative hemoglobin, transfusions, and fluids delivered including cell-saver. A multivariate model was created using a backwards stepwise multivariate linear regression.

Results: 345 patients with complete data were included (median BL 1001 mL; interquartile range [IQR] 700-1700). Our model identified male sex (+391 ± 112 mL, $P<0.01$), time to surgery, surgical approach, and fracture pattern as significant factors. Approaches: Patients receiving a Stoppa only or an ilioinguinal approach did not bleed differently (median 1.41 L vs 1.36 L, $P = 0.92$) but lost significantly more than Kocher approaches (median 1.04 L, $P<0.01$). Percutaneous surgery resulted in the least BL (median 0.32 L, IQR 0.09-0.71; $P<0.01$, all 3 comparisons). Fracture Pattern: Associated both-column fractures bled the most (median 1.65 L, IQR 1.13-2.23; $P<0.01$) while transverse fractures bled the least (median 0.72 L, IQR 0.39-1.24); posterior wall injury was also a low BL pattern ($P<0.01$) in the model. Surgical delay resulted in 80 ± 1.6 mL less BL/day ($P<0.01$). While formula-driven BL highly correlated to surgeon-estimated BL, surgeons underestimated relative to objective measures (0.88 ± 0.05 L, $P<0.01$).



Conclusion: Blood loss in acetabular ORIF is influenced by male sex, time to surgery, surgical approach, and fracture pattern. Use of quantitative measures should be considered for adoption in BL analysis in orthopaedic trauma.

Heritable Thrombophilia Is Associated with Venous Thromboembolism After Pelvic and Acetabular Trauma Despite Appropriate Prophylaxis

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Purpose: Venous thromboembolism (VTE) events continue to be a significant cause of morbidity and mortality in orthopaedic trauma despite the standardized use of prophylaxis. Patients presenting with pelvic and acetabular fracture, injuries that are associated with life-threatening hemorrhage acutely and VTE subacutely, are not routinely screened for the presence of heritable coagulopathy disorders. The purpose of this study was to examine the incidence of heritable thrombophilia in the setting of acute pelvic and acetabular fracture and to determine if its presence is associated with increased risk of VTE events.

Methods: Skeletally mature patients admitted to two Level I trauma centers for isolated operative pelvic and/or acetabulum fractures were enrolled over 4 years in a prospective study. On admission, patients had blood drawn for PT (prothrombin time)/INR (international normalized ratio) in addition to markers for heritable thrombophilia (hyper-homocysteinemia, factor II and V deficiency, protein C deficiency or resistance, protein S deficiency, antithrombin III deficiency, and lupus anticoagulant). Medical records were reviewed for age, sex, smoking status, body mass index (BMI), and occurrence of VTE events. All patients were treated with 6 weeks of VTE prophylaxis using twice-daily subcutaneous enoxaparin (30 mg or 40 mg bid depending on weight) starting on admission and not held for surgery. Kruskal-Wallis with post hoc pairwise Dunn testing was used to evaluate the association of heritable thrombophilia with VTE. One-way analysis of variance and $\chi 2$ tests were used to compare the demographic variables of patients with and without markers of heritable thrombophilia.

Results: 146 patients with isolated pelvic and/or acetabular fractures were enrolled in this study. 49% of patients (n = 71) had no markers, 26% (n = 38) had one marker, and 25% of patients (n = 37) had more than one marker for heritable thrombophilia. Smoking status, age, BMI, and gender were not significantly different among the three groups. At an average of 85 weeks (range, 6-200) of follow-up VTE had occurred in 6.8% of patients (n = 10). Six of those ten patients had more than one marker for heritable thrombophilia. Patients who had more than one marker of heritable thrombophilia were associated with a higher incidence of VTE compared to patients with no markers ($P = 0.02$) and one marker ($P = 0.006$).

Conclusion: To our knowledge, this study is the first to specifically examine the incidence of heritable thrombophilia in the setting of acute trauma with pelvic and/or acetabular fracture and determine its significance on VTE. The incidence of heritable thrombophilia in this population of patients with isolated, acute pelvic and acetabular fractures is 51%. Greater than one marker of heritable thrombophilia is associated with an increased risk of VTE despite standard prophylaxis. Clinicians should consider screening patients with pelvic and/or acetabular fracture for heritable thrombophilia to mitigate the risk of VTE.

Risk Factors for Deep Infection and Total Hip Arthroplasty After Combined Pelvic Ring and Acetabular Fractures

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Purpose: The purpose of this study is to describe the risk factors for deep infection and conversion to total hip arthroplasty (THA) after operative management of combined pelvic ring and acetabular fractures.

Methods: A retrospective review of all combined pelvic ring and acetabular fractures was performed at a single Level I trauma center over a 5-year period (2014-2019). Inclusion criteria included operative management of both injuries and skeletal maturity. Primary outcomes included conversion to THA and deep infection as defined by positive cultures at the time of a secondary debridement or conversion to THA. A minimum of 3-month follow-up was included for infection analysis, while a minimum of 1-year follow-up was required for conversion to THA analysis. Demographic factors, injury characteristics, and surgical choices were assessed between those who developed a deep infection and those who remained infection-free.

Results: A total of 189 patients were identified from billing data. 149 patients had 3-month follow-up. Patients who developed a deep infection had significantly higher body mass index (36.1 vs 30.5 kg/m2; $P = 0.009$), higher estimated blood loss (1262 cc vs 561 cc; $P<0.001$), higher rates of hip dislocation (64.7% vs 40.8%, $P = 0.037$), and a higher rate of intraoperative transfusion (76.5% vs 48.8%, $P = 0.03$). There were no significant differences in age, sex, tobacco use, abdominal or genitourinary organ injury, pelvic artery embolization, length of stay, or discharge disposition (home vs facility). 83 patients had 1-year follow-up. Patients who underwent conversion to THA were significantly older (42.8 vs 36, $P = 0.03$), had higher rate of posterior wall involvement (87.5% vs 46.6%, $P<0.001$), higher rates of hip dislocation (52.5% vs 36.7%, $P = 0.031$), marginal impaction (45.8% vs 23.3%, $P = 0.042$), posterior wall comminution (66.7% vs 30.5%, $P = 0.002$), and higher estimated blood loss (913 mL vs 620 mL, $P = 0.02$), and longer operative time (324 min vs 256 min, $P<0.001$). There were no differences in type of pelvic ring injury (Young-Burgess) or acetabular fracture classification (Letournel), ISS, ICU stay, or tobacco or illicit drug use. There was no difference between the THA/no THA groups in the order of fixation (posterior ring fixation first vs acetabular fixation first).

Conclusion: Management of patients with combined injuries of the acetabulum and pelvic ring is particularly challenging. Higher body mass index, higher-complexity surgery (higher estimated blood loss and higher rates of transfusion), and hip dislocation were associated with infection. Hip survivorship is negatively associated with older age, and fracture characteristics like posterior wall involvement, wall comminution, and marginal impaction, but was not associated with pelvic ring injury type or acetabular fracture type. The order of pelvic ring versus acetabular fixation did not affect conversion to THA at 1 year.

Trauma Index of Mortality: A Real-time Predictive Model for Polytrauma Patients

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Purpose: Vital signs and laboratory values are routinely used to guide clinical decision-making for polytrauma patients. These objective measures guide decisions to use damage control techniques in lieu of early definitive fracture fixation. We previously reported development of a dynamic model that captures evolving physiologic changes during a trauma patient's hospital course. We now report the results of use of the model for 1 year.

Methods: The Trauma Index of Mortality (TIM) is a machine-learning algorithm that uses electronic medical record (EMR) data to predict mortality within subsequent 48 hours of scoring during the first 3 days of hospitalization. The model updates every hour, recalculating as the patient's physiology dynamically changes in response to trauma and resuscitation. The model's development was reported previously. The algorithm was introduced into the clinical setting at our center starting August 5, 2019, and data were collected through August 4, 2020. Area under the receiver operating characteristic (ROC) curve (AUC), sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), and positive and negative likelihood ratios (LRs) were used to evaluate model performance.

Results: During the first year of clinical application, from August 5, 2019 through August 4, 2020, the model was used for 776 trauma patients who arrived at our center as Level I or II trauma activations. The last TIM score accurately predicted mortality within subsequent 48 hours of scoring in 20 of the 23 12-hour time intervals for a sensitivity of 86.9% (95% confidence interval [CI] 73%-100%). The specificity was 94.7% (95% CI 93%-96%), and the PPV was 33.3% (95% CI 21.4%-45%). The model predicted survival for 716 time intervals and was incorrect 3 times, yielding an NPV of 99.6% (95% CI 99.1%-100%). The positive LR was 16.3 (95% CI 11.6 - 23.01) and the negative LR was 0.14 (95% CI 0.07-0.21). The AUC was 0.97.

Conclusion: The primary strength of our model is its discriminative ability. It can group patients into low-risk and high-risk groups. Based on the NPV of our model, if our model predicts survival, then the risk of mortality over the subsequent 48 hours is 0.7%. However, if the model predicts mortality, then the risk mortality within the subsequent 48 hours is over 30%. By continuously adapting with the patient's physiologic response to trauma and relying on EMR data alone, the TIM overcomes many of the limitations of prior mortality risk models. It may be a useful tool to inform clinical decision-making for polytrauma patients early in their hospitalization.

Long-Term Pulmonary Function, Thoracic Pain, and Quality of Life in Patients with 1 or More Rib Fractures

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Purpose: This retrospective cohort study evaluated long-term pulmonary function, thoracic pain, and quality of life in patients admitted with rib fractures.

Methods: All patients admitted with one or more rib fractures between January 1, 2012 and December 1, 2019 were included. During one follow-up visit, pulmonary function was measured using spirometry and patients completed questionnaires on thoracic pain and quality of life. Patients were stratified by chest wall injury severity into one or two rib fractures, multiple rib fractures, or a flail chest. Multivariable analysis was performed to compare outcome after operative treatment with nonoperative treatment in patients with three or more rib fractures.

Results: In total, 300 patients were included. The median follow-up was 39 months (P25-P75, 18-65 months). At follow-up, the corrected forced vital capacity (FVC) returned to 84.7% (P25-P75, 74.3-93.7) and the forced expiratory volume in 1 sec (FEV1) to 86.3% (P25-P75, 75.3-97.0) of the predicted reference values. The median EuroQol 5 Dimensions 5-Level (EQ-5D-5L) utility score (US) was 0.82 (P25-P75, 0.66-0.92) and visual analog scale score was 75 (P25-P75, 70-85). The Short Form-12 version 2 (SF-12v2) physical and mental component summaries (PCS and MCS) were 45 (P25-P75, 38-54) and 53 (P25-P75, 43-60), respectively. This indicated a quality of life within normal population ranges. Moderate to severe thoracic pain, dyspnea in rest or during mild effort, and chest tightness were reported by 64 (21.3%), 70 (23.3%), and 48 (16.0%) patients, respectively. Long-term outcomes were similar for patients with one or two rib fractures, multiple rib fractures, or a flail chest. No difference in long-term outcomes between operative and nonoperative treatment was demonstrated.

Conclusion: While long-term pulmonary function and quality of life recover to normal values, subjective thoracic complaints such as pain and dyspnea remain frequently present in patients following rib fractures. No effect of chest wall injury severity or treatment modality on long-term outcomes was demonstrated.

Risk Factors for Major Thromboembolism in Orthopaedic Combat Casualties

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Purpose: In combat casualty care, tranexamic acid (TXA) is administered as part of the initial resuscitation effort; however, conflicting data exist as to whether TXA contributes to increased risk of venous thromboembolism (VTE). The purpose of this study is to determine (1) What factors increase risk of pulmonary embolism (PE) after combat-related orthopaedic trauma? and (2) Is administration of TXA an independent risk factor for major thromboembolic events?

Methods: We performed a query of the Department of Defense Trauma Registry (DoDTR) for all combat-injured patients who sustained injuries from January 2011 through December 2015 necessitating medical evacuation from forward surgical care in Iraq or Afghanistan to a military trauma center within the United States. We included combat casualties with orthopaedic injuries. In total, 493 patients were identified. We evaluated patient characteristics, injury factors, treatment, and occurrence of major thromboembolic events, which we defined as segmental or greater PE or thromboembolism-associated pulseless electrical activity (PEA).

Results: Regression analysis revealed TXA administration, traumatic amputation, acute kidney failure, and hypertension to be associated with the development of a major thromboembolic event for all models. Injury characteristics independently associated with risk of major VTE were ISS ≥23, traumatic amputation, and vertebral fracture. The best performing model utilized had an area under the receiver operating characteristic curve of 0.84, a sensitivity of 0.72, and a specificity of 0.84.

Conclusion: TXA is an independent risk factor for major VTE after combat-related orthopaedic injury. Injury factors including severe trauma, major extremity amputation, and vertebral fracture should prompt suspicion for increased risk of major thromboembolic events and increased threshold for TXA use if no major hemorrhage is present.

The Contribution of Polytrauma and Hemodynamic Shock on Infection and Reoperation in Tibia and Femur Fractures: A Multivariate Regression Analysis

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Purpose: Tibia and femur fractures often result from high-energy injuries and frequently occur in multiply injured patients. Prior literature suggests polytrauma is a risk factor for delayed healing and nonunion of these fractures. Work in animal models has demonstrated a negative effect of hemorrhage on fracture healing. However, no clinical studies have delineated which components of polytrauma predict delayed healing or nonunion, and it is unknown if hemorrhage or shock at presentation contributes to postoperative complications after operative management of tibia and femur fractures.

Methods: A retrospective review of all tibia and femur fractures treated with an intramedullary nail from 2013-2018 at a single Level I trauma center was performed. Patients age 18-55 years with a tibia fracture or femur fracture below the level of the lesser trochanter treated with intramedullary nailing were eligible. Patients with pathologic fractures, planned revision for bone grafting, and subacute presentation were excluded, leaving 392 tibia and 367 femur fractures included. Patient-specific variables including demographics, American Society of Anesthesiologists class, pH, base deficit, shock index, ISS, open fracture, additional orthopaedic injuries, length of hospital stay, smoking, vascular injury, fasciotomies, use of external fixation, and postoperative weight-bearing status were collected. Fractures were classified using the OTA/AO Classification. All data for reoperations were collected and categorized based on the indication(s) for surgery.

Results: There was no significant effect of ISS, pH, shock index, or base deficit on any of the analyzed outcomes. Multivariate analysis showed open fracture (odds ratio [OR] = 4.85, $P<0.001$), fasciotomies (OR = 2.32, $P = 0.027$), restricted weight bearing (OR = 1.92, $P = 0.013$), and increased age (OR = 1.03, $P = 0.015$) correlated with increased risk of reoperation. Deep infection was predicted by the need for flap coverage (OR = 3.59, $P = 0.050$) and open fracture (OR = 3.12, $P = 0.023$). Predictors of reoperation for aseptic nonunion included open fracture (OR = 2.73, $P<0.001$), smoking (OR = 1.99, $P = 0.018$), number of additional orthopaedic injuries (OR = 1.12, $P = 0.048$), and increased age (OR = 1.03, $P = 0.043$).

Conclusion: These results support previously published literature demonstrating the negative effect of soft-tissue injury around the site of a fracture, but they do not show an effect of shock at presentation on the risk of reoperation, nonunion, or infection. There does not appear to be a clear link between the global magnitude of injury and reoperation. In contrast, a high magnitude of local soft-tissue injury resulting in open fracture, fasciotomies, and a need for flap coverage had a significant effect on reoperation outcomes.

Initial Lactic Acid Level Is Associated with Longer and More Expensive Hospital Stays for Lower Extremity Long Bone Fractures

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Purpose: Lactic acid is well studied in the trauma population, and is frequently used as a laboratory value that correlates with resuscitation status and has thus been associated with patient outcomes. There is no literature that assesses the direct association of initial lactate level with hospital costs. We hypothesized that initial lactate levels would be associated with higher rates of ICU utilization and longer and more expensive hospital stays.

Methods: All trauma activations that underwent operative fixation of their tibia and/or femur at our institution from May 2018 to August 2020 were included. Patients who did not have a lactic acid level drawn at the time of their presentation were excluded. Cohorts were divided based on their initial lactate level into normal (<2.5), intermediate (2.5-4.0), and high (>4.0). Data on surgical timing, hospitalization costs, length of stay, and discharge disposition were collected from the electronic medical record. Patients were further evaluated based on the mechanism of their trauma: ballistic, motor vehicle accident (MVA), or other. Analysis of variance (ANOVA) tests were used to compare between groups, and t tests used for individual cohort comparisons.

Results: 401 patients were included. They averaged 34.1 ± 13.0 years old, remained hospitalized for 8.8 ± 9.5 days, and 35.2% required ICU care during their hospitalization. 31.2% of the injuries resulted from ballistic trauma, and 13.8% had multiple operative fractures of the lower extremity. Patients with high lactic acid levels had significantly higher time to surgery ($P = 0.012$), hospitalization costs ($P<0.001$), and length of stay ($P<0.001$). These trends were consistent when cohorts were subdivided by injury. Lactate levels were higher in the ballistic cohort (4.03 ± 2.42) than in the blunt trauma cohort (3.39 ± 1.85) ($P = 0.004$).

	Length of Stay (Days)	Hospital Costs ($1K)	Time to Surg (Hours)
All Patients (n=401)	**8.82 ± 9.53**	**267 ± 283**	**37.4 ± 56.1**
Normal Lactate (<2.5)	6.95 ± 5.95	204 ± 189	31.9 ± 48.8
Intermediate Lactate (2.5-4.0)	7.76 ± 7.53	230 ± 225	29.3 ± 32.1
High Lactate (>4.0)	11.91 ± 13.12	364 ± 379	51.4 ± 76.8
p-value (ANOVA)	*<0.001*	*<0.001*	*0.002*
Polytrauma (n=55)	**13.8 ± 8.0**	**463 ± 313**	**50.6 ± 60.0**
Normal Lactate (<2.5)	11.57 ± 7.11	358 ± 329	44.1 ± 62.5
Intermediate Lactate (2.5-4.0)	12.62 ± 7.21	408 ± 213	37.1 ± 32.6
High Lactate (>4.0)	16.75 ± 8.76	601 ± 337	68.2 ± 73.9
p-value (ANOVA)	*0.106*	*0.039*	*0.247*
Tibia (n=138)	**8.5 ± 11.7**	**224 ± 235**	**44.0 ± 75.4**
Normal Lactate (<2.5)	6.07 ± 5.64	165 ± 130	35.0 ± 54.8
Intermediate Lactate (2.5-4.0)	7.07 ± 6.73	191 ± 131	29.2 ± 28.3
High Lactate (>4.0)	13.08 ± 18.57	334 ± 358	71.0 ± 116.(
p-value (ANOVA)	*0.009*	*0.001*	*0.021*
Femur (n=208)	**7.7 ± 8.0**	**244 ± 292**	**29.6 ± 36.6**
Normal Lactate (<2.5)	6.46 ± 5.40	194 ± 161	26.3 ± 38.8
Intermediate Lactate (2.5-4.0)	6.92 ± 7.73	223 ± 254	27.8 ± 34.5
High Lactate (>4.0)	9.77 ± 9.49	316 ± 384	34.9 ± 33.2
p-value (high vs normal)	*0.028*	*0.034*	*0.323*

Conclusion: High initial lactate levels are associated with higher hospitalization costs and lengths of stay in orthopaedic trauma patients who underwent fixation for fractures of the lower extremity long bones.

Surgical Fixation of Unstable Chest Wall Injuries:
A Comparison of Locking Versus Non-Locking Plates

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Purpose: There has been a substantial increase in the surgical treatment of unstable chest wall injuries recently. While a variety of fixation methods exist, most surgeons have used plate and screw fixation. Rib-specific locking plate systems are available; however, evidence supporting their use over less-expensive, conventional plate systems (such as pelvic reconstruction plates) is lacking. We sought to address this by comparing outcomes between locking plates and non-locking plates in a cohort of patients from a prior randomized trial who received surgical stabilization of their unstable chest wall injury.

Methods: We used data from the surgical group of a previous multicenter, prospective, randomized controlled trial comparing surgical fixation of acute, unstable chest wall injuries to nonoperative management. In this substudy, our primary outcome was hardware-related complications and reoperation. Secondary outcomes included ventilator free days (VFDs) in the first 28 days following injury, length of ICU and hospital stay, and general health outcomes (Short Form-36 [SF-36]).

Results: From the original cohort of 207 patients, 108 had been treated surgically and had data available on the type of plate construct used. 59 (55%) had received fixation with non-locking plates (primarily 3.5 or 2.7-mm pelvic reconstruction plates) and 49 (45%) had received fixation with locking plates (primarily rib-specific locking plates). There was a 15% rate (9 of 59 patients) of hardware loosening in the non-locking group versus 4% (2 of 49 patients) in the locking group ($P = 0.1$). In addition, the rate of reoperation for hardware complications was 3% in the non-locking group versus 0% in the locking group ($P = 0.5$). No patients in either group required revision fixation for loss of reduction or nonunion. There were no differences between the groups with regard to VFDs, length of stay, or SF-36 scores.

Conclusion: We found no statistically significant differences in outcomes between patients who received surgical stabilization of their unstable chest wall injury when comparing non-locking plates versus locking plates. However, the rate of hardware loosening was nearly 4 times higher in the non-locking plate group and trended toward statistical significance, although reoperation related to this was less frequent. This finding is not surprising, given the inherent challenges of rib fixation including thin bones, comminution, potential osteopenia, and a postoperative environment of constant motion. We believe that the increased cost of locking plate fixation in this setting is likely justifiable given these findings.

The Creation and Validation of a New Rib Fracture-Specific Patient-Reported Outcome Measure: The Outcomes After Chest Trauma Study

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Purpose: Chest wall injury is a common cause of morbidity after blunt-force trauma. The use of patient reported outcome measures (PROMs) in these patients is inconsistent in the current literature, with limited validation of the currently used PROMs in a rib fracture population. No rib fracture-specific PROM existed. This study reports on the generation and subsequent validation of the first disease-specific PROM for chest wall trauma.

Methods: A three-phase multicenter study was performed across 20 hospitals to produce and validate a new PROM, the Chest Trauma Score (CTS). The COSMIN criteria were used throughout to guide the development and the validation of the score. Phase one consisted of a series of focus groups in which the experiences of rib fracture patients were used to generate items for the new PROM. A constructivist grounded theory method was applied to the data and a new conceptual modsel for rib fracture recovery was created. Phase two involved formal cognitive interviews and focus groups with both rib fracture patients and the health-care professionals involved in delivering chest trauma care. Content validity and readability scores were used to judge the overall content validity of the new PROM against two comparative instruments, the Short Form-12 (SF-12) and the EuroQol 5 Dimensions 5-Level (EQ-5D-5L). Phase three was a prospective longitudinal validation of the PROMs at baseline, post-injury, and 90 and 104 days post-injury. The CTS was further refined by a mixture of classic test theory and Rasch analysis. A "global rating of change" score was used as the anchor to calculate the minimum clinically important difference (MCID). Test-retest reliability, internal consistency, the standard error of measurement (SEM), and the smallest detectable change (SDC) were calculated to assess the suitability of the CTS as a potential research outcome measure.

Results: 22 patients attended focus groups to generate items (phase one). 12 patients and 16 health-care professionals underwent cognitive interviews to establish content validity (phase two). 311 patients completed the instrument in phase three. The CTS consists of 32 items assessing pain, mobility, activities, independence, respiratory and psychological health. The CTS obtained greater content validity scores than the EQ-5D and SF-12, which lack questions on respiratory health. The CTS fit the Rasch model well (RMSE = 0.01, IMSNQ 1.05, ZSTD 0.2). Test-retest reliably was excellent (intraclass correlation coefficient = 0.98). Internal consistency was equally high (Cronbach›s $\alpha = 0.94$). The MCID for the CTS was 9; this change was above the SDC (SDC = 6) and so could be detected by the instrument. The total scores for the CTS correlated well with the EQ-5D.

Conclusion: This study provides the first condition-specific and validated PROM for use in chest trauma. Important measurement properties of the CTS have been defined and validated, allowing the CTS to be used in both research and clinical practice.

What Predicts Change in Preoperative to Intraoperative Gustilo Anderson Classification Grade for Open Fractures?

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Purpose: The Gustilo Anderson (GA) classification is a validated assessment tool used to evaluate the severity of an open fracture wound. While the original intent of the GA classification was to be used post debridement, many surgeons use it both preoperatively and intraoperatively. However, it is known that the postoperative classification can be different than the preoperative. Among patients enrolled in a previous trial, we set out to determine what factors may change the initial GA assessment in order to help better predict the postoperative classification and subsequent treatment.

Methods: All patients enrolled in the trial had a GA grade assigned both preoperatively and intraoperatively by their treating surgeon. We determined how frequently the initial GA grade was upgraded or downgraded intraoperatively using descriptive statistics. We then performed a logistic regression with absolute change in preoperative to intraoperative score as the dependent variable. Length of wound, width of wound, bone loss, preoperative GA grade, location of fracture, mechanism of injury, preoperative skin loss, and preoperative muscle loss were included as independent variables in our analysis. Results were presented as odds ratios (ORs), 95% confidence intervals (CIs), and P values. All tests were 2-tailed with alpha = 0.05.

Results: A total of 2415 participants enrolled in the trial were included in our analysis. 315 patients (13.0%) had GA grade upgraded intraoperatively, while 130 patients (5.3%) had GA grade downgraded. Bone loss (OR 1.58, 95% CI 1.22-2.03; $P<0.001$), fractures of the tibia (OR 1.41 vs fractures elsewhere, 95% CI 1.13-1.75; $P = 0.002$), and a GA grade of 1 at presentation (OR 1.70 vs GA grade 2, 95% CI 1.23-2.27; $P = 0.001$, and OR 1.79 vs GA grade 3, 95% CI 1.11-2.85; $P = 0.02$) were associated with increased odds of deviance in GA ranking.

Conclusion: Our results suggest that a large proportion of open fractures are assigned an incorrect GA grade preoperatively. In particular, fractures involving any amount of bone loss, of the tibia, or those assigned a lower preoperative GA grade were more likely to have a deviance in GA grade from preoperative to intraoperative assessments. Treatment recommendations based on preoperative assessments should be interpreted with caution while consideration should be made to tailor treatment made on additional factors other than size of wound alone.

Practice Patterns and Pain Outcomes for Targeted Muscle Reinnervation: An Informed Approach to Targeted Muscle Reinnervation Use in the Acute Amputation Setting

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Purpose: Targeted muscle reinnervation (TMR) and regenerative peripheral nerve interface (RPNI) procedures have been shown to be effective for treatment of symptomatic neuromas and phantom limb pain after amputation; however, the specific indications and comparative outcomes of each are unknown. The primary research questions were: what is the complement of nerves most frequently necessitating secondary pain intervention after conventional amputation, can this information guide focused application of TMR and RPNI to the primary amputation setting, and how do outcomes compare in both settings?

Methods: We performed a retrospective review of records for patients who had undergone lower-extremity TMR and/or RPNI at our institution. 87 procedures (59 for secondary treatment of symptomatic neuroma pain after amputation, 28 for primary prophylaxis during amputation) were performed. We reviewed records for amputation level, TMR and/or RPNI timing, pain scores, patient-reported resolution of nerve-related symptoms, and complications/revisions. We evaluated the relationship between amputation level and the symptomatic nerve addressed on pain symptoms from neurologic intervention.

Results: Mean pain score decreased after delayed TMR/RPNI procedures (4.3 vs 1.7, $P<0.001$) and final pain was 1.0 ± 1.9 at follow-up for acute procedures. Symptom resolution was achieved in 92% of patients. The sciatic nerve most commonly necessitated intervention for symptomatic neuroma above the knee, while the tibial nerve and common/superficial peroneal nerve was most problematic following transtibial amputation. None of our patients necessitated a revision pain procedure after primary TMR/RPNI targeting these commonly symptomatic nerves. Failure to address the tibial nerve during a secondary procedure was associated with increased risk of unsuccessful TMR/RPNI resulting in revision surgery (odds ratio 26, 95% confidence interval 1.8-368, $P = 0.02$).

Conclusion: There is a consistent pattern of symptomatic nerves that require secondary surgical intervention for management of pain after amputation. TMR and RPNI were translated to the primary amputation setting by using this predictable pattern to devise a surgical strategy that prevents symptomatic neuroma pain while also minimizing surgical morbidity.

Gluteal Pillar Iliac Crest Autograft Harvest Using Acetabular Reamer Technique: As Effective as Reamer-Irrigator-Aspirator System

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Purpose: Gluteal pillar iliac crest (GPIC) harvested with acetabular reamer is a method to obtain autograft from the ilium. The powered reamer efficiently harvests large amounts of graft and preservation of the iliac crest architecture may decrease postoperative pain. The purpose of this study is to evaluate nonunions treated with GPIC harvested with the acetabular reamer technique compared to reamer-irrigator-aspirator (RIA). We hypothesized that nonunion treated with GPIC would achieve union rates equivalent to those treated with RIA.

Methods: Patients who underwent nonunion repair with autograft (2015-2020) were retrospectively reviewed. Injury characteristics, operative data, and radiographs were collected and reviewed until final follow-up. Radiographic union was the defined end point. Complications at both the donor and nonunion site were reviewed and analyzed.

Results: 71 patients met inclusion criteria. GPIC and RIA graft were utilized in 48 and 23 patients, respectively. Average follow-up was 49.5 weeks. The overall union rate was 74.6%, with no difference in union rates between the GPIC and RIA groups (79.2%, 73.9% respectively, $P = 0.21$). No difference was found in time to radiographic union between the GPIC and RIA groups (19.7 weeks, 20.4 weeks respectively, $P = 0.46$). 9 patients in the RIA group required a transfusion, compared to 5 patients in the GPIC group ($P = 0.004$). Two GPIC patients had persistent harvest site pain that resolved without treatment by 6 months postoperatively. One patient had a superficial infection at the GPIC harvest site, which resolved with oral antibiotics.

Conclusion: For the treatment of nonunions, autograft harvested from GPIC via the acetabular reamer technique achieves similar union rates and time to union as RIA. Transfusion rates are higher with RIA, while prolonged harvest site pain is a concern after GPIC. This study is the first to validate equivalent union rates of GPIC compared to RIA for the treatment of nonunion. Further clinical study and potential cost-savings analyses of this technique are warranted.

Table 1: Demographics

	GPIC	RIA	p
Total Patients	48	23	
Age (mean)	45.7	55.8	**0.01**
Male	33 (69%)	13 (57%)	0.31
BMI	28.19	28.67	0.39
Smokers	11 (22.9%)	4 (17.4%)	0.59
Mechanism of Injury			
MVA	7	8	
MCC	0	1	
Fall	33	8	
GSW	1	0	
Other	8	6	
Open Injury	13 (27.1%)	10 (43.5%)	0.17

Patient Outcomes Following Conversion Total Hip Arthroplasty: A Propensity Matched Analysis

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Purpose: Conversion total hip arthroplasty (cTHA) is increasingly utilized following failed hip or acetabular fracture fixation and other hip preservation procedures. While primary THA (pTHA) has a high success rate, little is known about outcomes following cTHA. The purpose of this study is to evaluate patient-reported outcomes (PROs) and complication rates following cTHA compared to pTHA.

Methods: Patients who underwent a cTHA or pTHA from 2015-2020 were retrospectively identified. THA patients were propensity matched in a 1:1 fashion by age, body mass index (BMI), and sex. Pain scores and Patient-Reported Outcomes Measurement Information System (PROMIS) physical function (PF), pain interference (PI), and depression (DA) scores, were compared at preoperative and final postoperative follow-up time points using independent t tests. Differences in complication and reoperation rates between cohorts was assessed using $\chi 2$ analysis.

Results: A total of 118 THAs were included in this analysis with an average follow-up of 21.2 months (range, 6-63 months). cTHAs were most commonly performed following hip fracture fixation (50.5%). The conversion cohort had significantly longer length of stay (3.6 days vs 1.9 days, $P<0.01$) compared to pTHA. There was no significant difference in complication rates (conversion: 15.3%, primary: 8.5%, $P = 0.26$), with intraoperative fracture being the most common for both. cTHA and pTHA groups also experienced similar reoperation rates. No significant differences in PF, PI, or DA at final follow-up were identified between groups (Table 1).

Conclusion: In a cohort propensity matched by age, BMI, and sex, conversion and primary THA led to similar complication rates, reoperation rates, and PROs. These results suggest patients undergoing cTHA can expect similar outcomes to pTHA.

Table 1. Outcomes*

	Primary (N=59)	Conversion (N=59)	†p-value
Final Follow Up (Mean ± SD, months)	22.3 ± 14.4	20.1 ± 14.0	0.397
Length of Hospital Stay (Mean ± SD, days)	**1.9 ± 1.2**	**3.6 ± 3.0**	**<0.001**
Discharge Destination (n)			0.066
Home	91.4% (53)	79.3% (46)	
Skilled Nursing Facility	8.6% (5)	20.7% (12)	
Surgical Complications (n)	8.5% (5)	15.3% (9)	0.255
Reoperations (n)	6.8% (4)	5.1% (3)	0.697
PROMIS Physical Function (Mean ± SD)			
Preoperative	36.5 ± 5.5	34.6 ± 6.3	0.087
Final Δ	6.2 + 9.0	6.6 + 8.6	0.788
Final follow up	42.7 ± 9.3	41.3 ± 9.8	0.417
PROMIS Pain Interference (Mean ± SD)			
Preoperative	64.0 + 6.0	64.6 + 6.5	0.590
Final Δ	-8.2 ± 10.8	-7.6 ± 10.4	0.784
Final follow up	55.7 ± 9.6	57.3 ± 10.6	0.388
PROMIS Depression (Mean ± SD)			
Preoperative	51.3 ± 10.8	53.8 ± 10.0	0.194
Final Δ	-4.3 ± 9.0	-3.2 ± 8.4	0.505
Final follow up	46.9 ± 9.0	50.7 ± 11.4	0.052
VAS Pain Score (Mean ± SD)			
Preoperative	5.8 ± 3.1	5.6 ± 3.0	0.756
Final Δ	-3.0 ± 3.7	-3.0 ± 3.6	1.000
Final follow up	2.8 ± 3.1	2.6 ± 3.1	0.760

SD = Standard deviation; PROMIS = Patient reported outcomes measurement information system; VAS = Visual analog scale
Δ = Postoperative score – preoperative score
†p-values calculated using independent t-tests and chi square analysis for continuous and categorical variables, respectively
***Boldface** indicates statistical significance

Treatment of Posttraumatic Osteomyelitis and Infected Nonunions in the Lower Extremity Using a Multi-Staged Induced Membrane Technique: Success Rates of Limb Reconstruction and Risk Factors for Infection Recurrence

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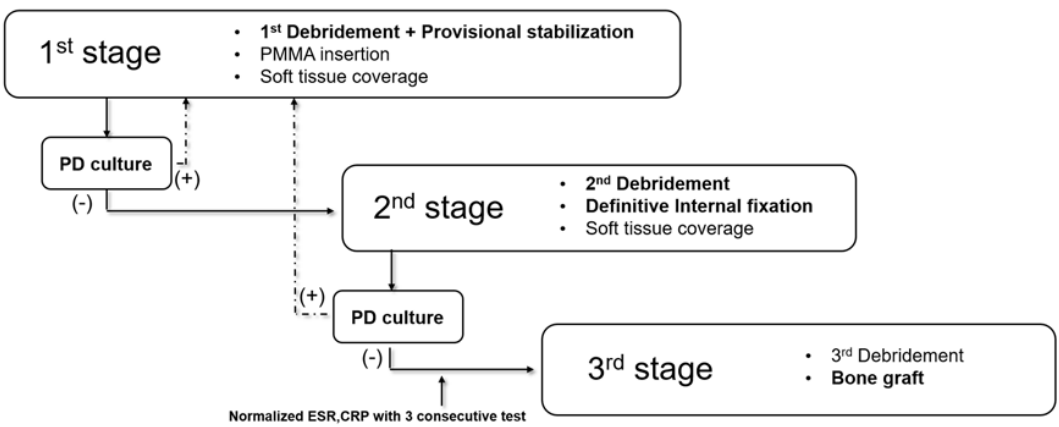
Purpose: There is limited clinical evidence regarding the ability of induced membrane technique (IMT) to treat critical-sized bone defects (CSBDs) due to infected nonunion (IN) or posttraumatic osteomyelitis (PTOM). This study evaluates the success rates of limb reconstruction after treatment with multi-staged IMT for CSBD of the lower extremity due to IN or PTOM.

Methods: A total of 328 patients diagnosed with IN or PTOM based on clinical and radiographic findings were treated with a multi-staged IMT from 2013 to 2018. There were 140 cases of CSBD of the tibia and femur with at least 24-month follow-up after bone grafting. The success rate of limb reconstruction was evaluated as the primary outcome measure. The variables associated with recurrence of infection (ROI) were also analyzed.

Results: CSBDs in 43 femurs and 97 tibias were included. The mean infection duration before initial treatment was 71.1 months. On average, 2.5 operative debridements were performed before final bone grafting based on the result of intraoperative post-debridement culture results. The primary success rate of limb reconstruction was 75% (105 of 140 patients) at a mean follow-up of 45.3 months. There were 35 cases of ROI at a mean of 18.5 months after staged bone grafting. An infected free flap, a surprise positive culture, deviation from our protocol, and an elevated erythrocyte sedimentation rate before bone final grafting were all identified as independent risk factors of infection recurrence.

Conclusion: Treating recalcitrant IN and PTOM of the lower extremity with a systematic staged IMT protocol demonstrates favorable success rates.



Antibiotic Cement-Coated Intramedullary Nails for the Treatment of Infected Nonunion of Long Bones

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Purpose: Antibiotic-impregnated cement nails are used to treat postoperative deep infections after primary intramedullary nailing of long bone fractures. These are often complicated by a nonunion as well. There are limited data on the effectiveness of this treatment on both the eradication of infection and the achievement of union after treatment. We hypothesized that the treatment of long bone–infected nonunion with exchange nailing using an antibiotic-impregnated nail and 6 weeks of culture-specific antibiotics would be a successful treatment.

Methods: This was a retrospective observational cohort study conducted at an urban Level I trauma center. 40 consecutive patients who received an antibiotic cement nail for treatment of intramedullary osteomyelitis were monitored for nonunion status after primary intramedullary nailing. Minimum follow-up was 12 months. Outcomes of interest were eradication of infection and radiographic union.

Results: Antibiotic nailing successfully eradicated infection and resulted in union in 34 patients (85%), while 6 patients (15%) had persistent infection and required further surgical treatment. Of the 6 patients who required further treatment, 5 eventually went on to heal with fracture union and eradication of their infection, while one required a salvage procedure. Of the 5 patients who eventually went on to heal, 4 of them healed with repeat antibiotic or intramedullary nails, while one required segmental resection and bone grafting before healing. The lone patient who did not heal was treated with a plate and an antibiotic nail for his humerus and is functioning with a persistent nonunion but has no evidence of infection.

Conclusion: Our study suggests that antibiotic nailing technique is a viable therapeutic option to eradicate intramedullary osteomyelitis and support fracture union.

Outcomes of patients who failed treatment with antibiotic nailing intramedullary nail

Sex	Age (years)	Fracture type	Infecting organism	Surgical Intervention	Outcome
M	64	Closed	MRSA	Antibiotic nails (2) to resection arthroplasty to external fixator to fusion	Ankle resection arthroplasty & fusion
F	66	Unknown	MSSA	Segmental femur resection with antibiotic spacer placement, intramedullary nailing, and iliac crest bone grafting	Union/Infection Eradication
M	28	IIIC	Proteus Mirabilis	Antibiotic nails (3) to ORIF to Antibiotic nails (2)	Union/Infection Eradication
M	23	Unknown	MRSA	Intramedullary nail (1)*	Union/Infection Eradication
M	29	IIIB	MRSA	Antibiotic nail (1)	Union/Infection Eradication
M	21	IIIB	Citrobacter Koseri	Antibiotic nail (3)	Union/Infection Eradication

Can We Predict When Exchange Nailing Will Fail?

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Purpose: Exchange nailing for long bone nonunion has reported success rates ranging from 54% to 100%. Given the disease burden and variability in failure rates, identifying patient and injury factors that are associated with failure is critical in order to help guide surgeons. The purpose of this study was to identify factors associated with failure of exchange nailing. We hypothesized that cortical contact less than 100% (but greater than 50%), and a foot type appearance (elephant or horse) would be associated with higher rates of failure.

Methods: We performed an IRB-approved, retrospective review of all femur and tibia nonunions treated with exchange nailing at two Level I trauma centers from 2006 to 2019. Septic nonunions and patients whose primary mode of treatment was not exchange nailing were excluded from the analysis. Failure of exchange nailing was defined as either (1) absence of bridging bone on 3 or more cortices on radiographs obtained at least 1 year following exchange nailing, or (2) patient required an additional surgery during the follow-up period to promote union. Treatment method and return to the operating room for secondary procedure was at the treating surgeon's discretion. Demographic data, body mass index (BMI), smoking status, comorbid conditions, injury data, fracture location and characteristics, supplemental fixation, cortical contact, and graft use were recorded. Fisher's exact test and forward logistic regression were utilized to assess confounders.

Results: A total of 138 patients met inclusion criteria, 83% (115) having a minimum of 1-year follow-up or meeting primary outcome, with 63% being femurs and 37% tibias. Average age at exchange nailing was 39 years (95% confidence interval [CI] 37.00-42.50) with 68% being male. Overall union rate was 77%, with 20% (21 of 105) requiring at least one secondary surgery to promote union. Proportion of healed fractures at 6 weeks, 3 months, and 6 months was 9.6%, 36%, and 66.7%, respectively. Foot type was not associated with increased risk of treatment failure (odds ratio [OR]: 1.131, 95% CI 0.335-3.817, $P = 0.843$). Factors associated with success of treatment included oligotrophic type (OR: 3.12, 95% CI 1.15- 8.43). Factors associated with failure included use of graft (auto- or allograft) (OR: 0.262, 95% CI 0.087- 0.780, $P = 0.016$) and less than 100% cortical contact (OR: 0.275, 95% CI 0.074-1.023, $P = 0.054$]. Age, gender, BMI, smoking status, history of diabetes, open/closed fracture, foot type, presence of comminution, and nondiaphyseal location were not associated with failure.

Conclusion: In our series, we demonstrated a 33% failure rate of exchange nailing, which is higher than previously reported in some studies. Bone graft use and lack of 100% cortical contact appear to increase the risk of failure. Morphological features do not appear to increase the risk of failure. Surgeons should utilize caution when considering bone grafting if the primary treatment is exchange nailing. Alternative treatment options may be more successful.

Outcomes Following Operative Reconstruction of Symptomatic Rib Nonunions

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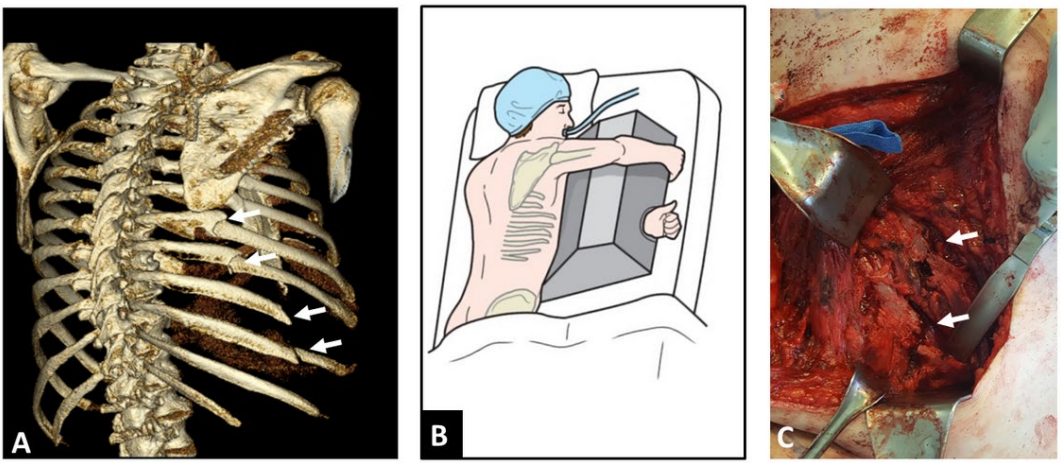
Purpose: The majority of rib fractures can be treated nonoperatively, but a subgroup of patients have been reported to develop symptoms consistent with rib nonunion. There is a paucity of literature on the reconstruction of rib nonunions, and no clear consensus on treatment. The purpose of this study is to assess the outcomes of patients after rib nonunion reconstruction using plate and screw fixation augmented with autogenous iliac crest bone graft.

Methods: Between January 2007 and August 2019, 25 consecutive patients with 51 painful rib nonunions were treated for nonunited rib fractures at a Level I trauma center. Patient characteristics / demographics, mechanism of injury, number of rib nonunions, and postoperative radiographs were recorded and assessed. An author-derived patient outcome questionnaire evaluating satisfaction, patient-reported complications, and return to occupation and activity, as well as validated patient-reported general health measures, were completed.

Results: In 25 patients, 51 painful rib nonunions were treated for nonunited rib fractures. The average length from injury to surgical rib reconstruction was 25.1 months (range, 3-118 months; median = 12 months). Follow-up was obtained in 18 of 25 patients (72%) with a mean of 46.1 months (range, 13-139). All ribs went on to radiographic union at an average of 12.3 weeks (range, 8-24 weeks) after surgery. 16 of 18 patients (89%) reported satisfaction with surgery and 15 (83%) reported mild to no pain at final follow-up. Five patients had complications, of which 3 were major, although resolved after treatment.

Conclusion: Successful treatment of symptomatic rib nonunion is possible with satisfactory patient-reported and radiographic outcomes and with an acceptable rate of complications. Operative fixation with rib plates and bone grafting should be considered the primary treatment method for symptomatic rib nonunions.



Characteristics of Occult Infection With Nonunion Repair in Patients Without Clinical or Laboratory Signs of Infection

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Purpose: Successful treatment of fracture nonunion requires both correct identification of the contributing factors and subsequent selection of appropriate therapy. Recent literature has described occult infections in the setting of nonunion as infections that slow progression of healing but do not present with signs of infection. The purpose of this study is to determine the incidence of occult infection in fracture nonunion, its causative organisms, and associated injury or patient characteristics.

Methods: Patients who presented to a single Level I trauma center with a primary compliant of fracture nonunion from 2014 to 2019 were identified using an institutional database. Patients were excluded for pathologic fractures, nonunion secondary to nonoperative management, and index nonunion repair at an outside hospital. Medical records were reviewed for demographic variables including age at time of nonunion repair, body mass index (BMI), sex, smoking status, diabetes, injury characteristics, culture results, and physical examination and laboratory values at time of presentation. Welch t tests and $\chi 2$ tests were used to compare characteristics between groups.

Results: A total of 327 nonunion patients were identified, 65% (n = 211) of whom had no clinical or laboratory signs of infection at presentation. Following operative intervention, 6% (n = 13) of these patients had positive intraoperative cultures or gross purulence indicating occult infection. The most common organisms causing occult infection were low-virulence coagulase-negative staphylococci (CoNS) and *Propionibacterium acnes*. 35% of patients (n = 116) presented with clinical and/or laboratory signs of infection, with 14% (n = 16) of these patients having negative cultures. The most common organisms in the infected nonunion group were methicillin-resistant *Staphylococcus aureus* (MRSA) and gram-negative rods. There were no significant differences in age, sex, BMI, smoking or diabetes status, or percentage of open fracture between any of the groups. However, patients with occult infection were more likely to be of the upper extremity (62% vs 14%, $P<0.01$) and less likely to involve the tibia (8% vs 64%, $P<0.01$) when compared to those with signs of infection at presentation.

Conclusion: The incidence of infection in patients presenting for nonunion repair without clinical or laboratory findings consistent with infection is 6%. Occult infected nonunion occurs primarily in the upper extremity with pathogenic organisms almost exclusively of low virulence (CoNA and P. acnes). Given the significant incidence of occult infection, it is a prudent rule to obtain specimens for culture and pathology in all patients presenting for nonunion repair.

Morbidity and Mortality Following Operative Management of Octogenarian Tibial Shaft Fractures

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Purpose: As the geriatric population continues to rise, the incidence of geriatric tibial shaft fractures is projected to increase. There is significant variation in the functional and physiological status within this population. The purpose of this study was to compare the complications following operative treatment of tibial shaft fractures for patients who are aged 65 to 79 years compared to patients who are aged 80 to 89 years. We hypothesize that octogenarians experience an increased rate of postoperative complications.

Methods: In this retrospective cohort study, data were collected through the National Surgical Quality Improvement Program database for the years 2006 to 2018. Current Procedural Terminology codes 27758 and 27759 and various International Classification of Diseases, Ninth and Tenth revision codes were used to identify all tibial shaft fractures (AO/OTA 42A, 42B, 42C) that were treated with open reduction and internal fixation (ORIF) or intramedullary nailing (IMN). Patients were divided into a 65 to 79-year-old group and an 80 to 89-year-old group. The primary outcome studied was 30-day mortality. Secondary outcomes included surgical site infections, wound breakdown, pneumonia, unplanned intubation, pulmonary embolism, acute renal failure, urinary tract infection, blood transfusion, myocardial infarction, deep vein thrombosis, sepsis, stroke, extended length of stay, readmission, and reoperation. Univariate and multivariate analyses were performed with a significance set at $P<0.05$.

Results: 434 patients with tibial shaft fractures were included in the study. Of these, 333 were aged 65 to 79 years and 101 were aged 80 to 89 years. On multivariate analysis, 80 to 89-year-old patients did not have higher rates of 30-day mortality or any other postoperative complications than patients 65 to 79 years of age.

Conclusion: After controlling for demographics and comorbidities, age is not independently associated with 30-day mortality or postoperative complications following operative treatment of tibial shaft fractures. In appropriately selected octogenarian patients, operative management of tibial shaft fractures represents a relatively safe treatment modality that may promote early rehabilitation.

Patient Comorbidities Associated with Acute Infection Following Open Tibia Fractures

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Purpose: The purpose of this study was to determine the patient comorbidities associated with increased risk of acute infection following open tibia fractures.

Methods: Using the National Trauma Data Bank data from 2007 to 2015, 147,535 open tibia fractures were identified that underwent debridement and stabilization. Infection was defined as any surgical site infection, superficial or deep, that required subsequent treatment. Patient comorbidities were determined from ICD-9 codes. Comparative statistical analyses between patient groups that did develop infection and those that did not were performed and odds ratios (ORs) determined for each comorbidity.

Results: The rate of infection was 0.27%, with 396 patients developing infection during acute management of an open tibia fracture. Alcohol use (OR 2.26, 95% confidence interval [CI] 1.73-2.96, $P<0.0001$), bleeding disorders (OR 4.50, 95% CI 3.13-6.48, $P<0.0001$), congestive heart failure (OR 3.25, 95% CI 1.97-5.38, $P<0.0001$), diabetes (OR 1.73, 95% CI 1.29-2.32, $P = 0.0002$), psychiatric illness (OR 2.17, 95% CI 1.30-3.63, $P<0.0001$), hypertension (OR 1.56, 95% CI 1.23-1.95, $P<0.0001$), obesity (OR 3.05, 95% CI 2.33-3.99, $P<0.0001$), and chronic obstructive pulmonary disease (COPD) (OR 2.09, 95% CI 1.51-2.91, $P<0.0001$) were all associated with increased infection rates. Smoking (OR 0.957, 95% CI 0.728-1.26, $P = 0.722$) and drug use (OR 1.11, 95% CI 0.579-2.11, $P = 0.7607$) were not associated with any difference in infection rates.

Conclusion: During the acute hospital admission for open tibia fractures, patients with congestive heart failure, bleeding disorders, or obesity are 3 to 4.5 times more likely to develop an infection than patients without those comorbidities. Similarly, patients with diabetes, psychiatric illness, hypertension, or COPD are 1.5 to 2 times more likely to develop subsequent infection compared to patients without those comorbidities. These increased risks can be used during patient counseling and to develop risk models for the infectious complications following acute open tibia fractures. Furthermore, these comorbidities represent a more at-risk patient population for complications and can serve as modifiers when evaluating surgeon/hospital performance.

Risk Factors Associated with Delayed and Aseptic Nonunion Following Tibial Diaphyseal Fractures Managed with Intramedullary Nailing

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Purpose: Tibial diaphyseal fractures are the most common long bone fractures in adults. The majority of these fractures are successfully managed with reamed intramedullary nailing. However, nonunion and delayed union are recognized complications that cause considerable patient morbidity and require significant resources to manage. There remains a paucity of evidence identifying factors that predict a patient's risk of progression to delayed union and nonunion following a tibial shaft fracture. The primary aim of this study was to identify independent predictors of nonunion and delayed union in tibial diaphyseal fractures treated with intramedullary nailing. The secondary aim was to assess the Radiographic Union Scale for Tibial fractures (RUST) score as an early predictor of tibial fracture nonunion.

Methods: A consecutive series of 647 patients who underwent intramedullary nailing for tibial diaphyseal fractures were identified from a trauma database. Demographic data, comorbidities, smoking status, alcohol consumption, use of nonsteroidal anti-inflammatory drugs (NSAIDs), steroid use, details regarding mechanism of injury, fracture classification, complications, and further surgery were recorded. Nonunion was defined as the requirement for revision surgery to achieve union. Delayed union was defined as a RUST score <10 at 6 months postoperatively.

Results: There were 41 nonunions (6.3%), of which 13 were infected (31.7%), and 77 delayed unions (11.9%). There were 127 open fractures (19.6%). Adjusting for confounding variables, NSAID use (odds ratio [OR] 3.50, $P = 0.042$), superficial infection (OR 3.00, $P = 0.026$), open fractures (OR 5.44, $P<0.00001$), and high-energy mechanism (OR 2.51, $P = 0.040$) were independently associated with nonunion. Smoking was associated with nonunion on unadjusted analysis ($P = 0.021$). Smoking (OR 1.76, $P = 0.034$), open fracture (OR 2.82, $P = 0.001$), and high-energy mechanism (OR 1.81 $P = 0.030$) were independently associated with delayed union. The RUST score at 6-week follow-up was reliably predictive of nonunion (sensitivity and specificity of 75%).

Conclusion: NSAID use, high-energy mechanisms, open fractures, and superficial infection were independently associated with nonunion in patients with tibial diaphyseal fractures treated with intramedullary nailing. The 6-week RUST score may be a useful tool to identify patients at risk of nonunion.

Small Residual Fracture Gaps Are Associated with Significant Delays in Healing in Diaphyseal Tibia Fractures Treated with Intramedullary Nailing

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Purpose: Intramedullary nailing of diaphyseal tibial fractures has become the standard of care with excellent union rates. Despite advances in implants and technique, delayed and nonunion remain a difficult problem for both patient and surgeon. The purpose of this study was to investigate whether residual fracture gapping at time of intramedullary nail fixation for tibial shaft fractures is associated with delayed or nonunion.

Methods: The medical records of patients sustaining acute tibial shaft fracture underwent statically locked, reamed intramedullary nailing between 2006-2013. Inclusion criteria included patient age >18 years, definitive treatment within 7 days of injury, no pathologic or stress fracture, no segmental bone defect, and at least 6 months of radiographic follow-up. Baseline demographic, injury, and surgical data were recorded for each patient. Immediate postoperative radiographs were assessed for largest fracture gap on AP and lateral films as well as for angular deformity. Radiographs from each postoperative visit were assessed for healing using the Radiographic Union Scale for Tibial Fractures (RUST) and evaluated for implant failure. Clinic notes and subsequent operative notes were assessed for the diagnosis of nonunion and postoperative infection. Student t tests were used to evaluate significance of fracture gap, translation and other covariates on time to union (TTU). Covariates with P<0.2 in univariate analysis were incorporated into a multivariate logistic regression model to identify factors independently associated with increased TTU.

Results: After applying inclusion and exclusion criteria, we identified 209 patients who underwent intramedullary nailing during the study period and who had adequate follow-up. Fractures with mean AP/lateral gaps of <3 mm, 3.1-5 mm and >5 mm had an average TTU of 5.9, 6.5, and 8.4 months, respectively; fractures with larger residual gap sizes had a significantly longer TTU ($P = 0.008$). Fractures with mean AP/lateral gaps of <3 mm, 3.1-5 mm and >5 mm had a nonunion rate of 2.87%, 3.83%, and 9.57%, respectively; fractures with larger residual gap sizes had a higher nonunion rate ($P<0.001$). In multivariate logistic regression analysis, only larger fracture gap and the presence of postoperative infection were found to significantly correlate with increased TTU ($P<0.001$ and $P<0.001$).

Conclusion: Residual gapping following intramedullary fixation of tibial shaft fractures is associated with an increase in likelihood of nonunion, especially in the setting of an average AP and lateral fracture gap of 5 mm. Surgeons are encouraged to critically evaluate fluoroscopic images and to use additional techniques to optimize intraoperative reduction and fracture site apposition.

Is It Safe to Elevate Flaps for Secondary Bone Grafting After Open Tibia Fractures?

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Purpose: Severe open tibia fractures that require flaps often require subsequent bone grafting for bone gaps or to treat nonunion. Surgeons are typically faced with a choice of elevating the flap or using a fresh surgical approach to access the tibia. Little is known regarding the complications associated with these two surgical tactics. We hypothesized that bone grafting with a flap elevation approach would have significantly more surgical wound complications than a control group of bone grafting with flap-sparing alternate approaches.

Methods: This retrospective cohort study was performed at a Level I trauma center. We included all adult patients with open tibia fractures treated with rotational or free tissue transfers followed by tibia bone grafting between 2006 and 2020. Our primary outcome was postoperative wound dehiscence requiring additional surgery. Secondary outcomes included deep wound infection and amputation after bone grafting. We compared complications proportion with a mixed-effects regression model to account for repeat operations among some patients.

Results: There were 124 study patients (mean age, 40 years; 82% male) who underwent 150 bone grafts. There were no differences between the 2 groups in fracture types or demographics. 58% of the flaps were rotational, and 40% were free flaps. 71 bone grafts (47.7%) were performed with flap elevation, and 78 bone grafts in the control group (52.3%) underwent a flap-sparing alternate approach for the procedure. In only 1 case (1 of 71, 1.4%) did a patient who underwent flap elevation for bone grafting have a postoperative wound dehiscence requiring reoperation. Similarly, there were no cases of surgical dehiscence (0 of 78, 0.0%) in the control group (adjusted risk difference [RD], 0.7%, 95% confidence interval [CI]: –0.3% to 1.8%, $P = 0.14$). Overall, there were also no clinically or statistically significant differences in deep wound infection (flap elevation: 24%, control: 15%, adjusted RD, 3.3%, 95% CI: –2.1 % to 8.7%, $P = 0.23$) or amputation (flap elevation: 6%, control: 3%, adjusted RD, 2.0%, 95% CI: –1.6% to 5.6%, $P = 0.26$) after adjusting for confounders.

Conclusion: We found no evidence that flap elevation during a subsequent bone graft treatment in open tibia fracture patients was associated with elevated risk of a surgical wound dehiscence or other type of complication compared to a control group that did not have flap elevation for the bone graft. As limb salvage efforts for severe open tibia often involve secondary procedures after soft-tissue coverage, surgeons should be aware that tibial flaps can typically be elevated for such procedures when indicated without fear of adverse consequences to the flap.

Type III Open Diaphyseal Tibia Fractures Treated with Single-Stage Immediate Intramedullary Nailing and Primary Closure Yield Low Rates of Flap Coverage

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Purpose: Type III open diaphyseal tibia fractures are associated with significant soft-tissue injury as a result of high-energy trauma. Staged fixation with delayed closure remains common practice due to concern for soft-tissue complications and infection. We hypothesize that type III open high-energy diaphyseal tibia fractures treated with immediate intramedullary nailing and primary closure yield low rates of flap coverage.

Methods: All type III open tibia (OTA 42/43) fractures treated at a single Level I academic trauma center between 2010 and 2020 were queried from a prospective database. The Gustilo-Anderson classification was noted in the index operative report. It is standard practice at this regional referral center to prioritize attempted primary closure of all open fractures without plastic surgery comanagement at the initial debridement using meticulous soft-tissue handling and the modified Allgower Donati suture technique for skin. Included patients sustained high-energy injuries and underwent intramedullary nailing at the initial surgery with at least 3 months of in-person postoperative follow-up. Patients with type IIIB and C injuries were excluded. Secondary procedures for soft-tissue coverage were tabulated as the primary outcome. Descriptive statistics are performed.

Results: There were 255 patients identified (73% type IIIA, 22% type IIIB, 7% type IIIC). A total of 107 patients met inclusion criteria. Average age was 40 years (range, 18-91). There were 28 female patients (26%). A total of 70 patients (65%) sustained polytrauma, 6 patients (6%) had diabetes mellitus, and 31 patients (29%) endorsed active tobacco use. The median follow-up was 10 months (range, 3-125). There were 95 of 107 patients (89%) who healed their soft-tissue envelope uneventfully. Among the patients who failed primary closure, five patients required free tissue transfers, five required local rotational flaps, and two underwent split-thickness skin grafting only.

Conclusion: The results of this study support our hypothesis that immediate intramedullary nailing and primary closure of high-energy type III open diaphyseal tibia fractures yields low rates of flap coverage. The vast majority of primarily closed wounds healed uneventfully. We recommend stable intramedullary fixation and meticulous soft-tissue closure when possible at the index procedure.

Outcomes of Proximal Third Tibial Shaft Fracture Managed with SIGN Intramedullary Nailing in a Resource-Limited Set-up: A Prospective Cohort Study

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Purpose: Proximal one-third tibial shaft fracture is a big challenge to manage due to the deforming forces from the patellar tendon, anterior compartment muscle, and pes anserinus pull. The outcome is variable depending on the techniques used, degree of bone comminution, soft-tissue injury, and implant used. The management option is mainly intramedullary nailing since it preserves the soft tissue and weight-sharing nature. In a resource-limited set-up, there is no polyaxial nail and C-arm; the only option to manage such injury is SIGN (Surgical Instrument Generation Network) locked type of intramedullary nail (IMN). This nail is uniaxial with 7° curve in the proximal end and it lacks the ability to control the deformities that will cause malunion. The aim of this study was to present the clinical, radiological, and patient-reported functional outcome of proximal third tibial shaft fracture managed with SIGN IMN in a resource-limited set-up.

Methods: A 2-year prospective cohort study was undertaken at a tertiary institution among patients with proximal tibial shaft fracture managed with SIGN IMN. All adult patients with extra-articular proximal tibial fracture were included in the study and followed for 6 months to 2 years. Their clinical, radiological, and patient-reported functional outcome (PROM) was recorded at 6 weeks and 3, 6, and 12 months until discharged from follow-up. Clinical infection, pain, time of weight bearing, and difficulty of walking were recorded. Postoperative angular malalignment was measured from Radiant DICOM image of patients› radiographs and the functional outcome was scored with Karistrom-Olerud score.

Results: A total of 178 patients with proximal third tibial shaft fracture were managed with SIGN IMN and included in the study. The mean age was 33.6 years (range, 15-70). Based on AO classification, 7.8% were AO-41 and the rest were AO-42. Majority of the patients (72.2%) were open fracture. Almost all of the proximal tibial fracture was in the typical valgus and apex anterior deformities. Clinically, there were 4 smoker patients (2.2%) who developed wound dehiscence and deep surgical site infections for whom SIGN nail was changed to external fixator. Eight patients (4.5%) were having delayed union and required nail exchange. Based on the Karistrom-Olerud score, functional outcome was determined at 6 and 12 months, which showed 84.3% good to excellent and 16.7% moderate to satisfactory result. There is no record of poor scoring. Radiologically, 14.7% of patients showed mild postoperative malalignment deformities (7°-10°).

Conclusion: Proximal tibial shaft fracture is not uncommon in resource-limited set-up and the management is challenging. Even though managing such fractures is difficult in resource-limited set-up, the clinical, radiological, and patient-reported outcome is satisfactory with SIGN IMN.

Circular Frame Reconstruction for the Definitive Primary Treatment of Severe Tibial Fractures

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Purpose: We conducted a case-series evaluation of the effectiveness of circular frame treatment for severe open fractures. Secondarily, we sought to establish the effectiveness of a simple two-ring construct for the treatment of grade 3 open tibial fractures. Despite widespread use, there are no large series of spatial frames reported in contemporary practice. Two-ring circular frame constructs may have potential advantages over more complex multiple-ring circular frame constructs.

Methods: Institutional registries and routinely collected prospective outcome data from a single center were used to recruit a consecutive series of patients presenting to a Level I center with a complex tibial fracture requiring a circular fixation construct. Inclusion criteria included all patients with tibial fracture treated by circular frame fixation. Subgroup analysis was undertaken for patients presenting with a simple 2-ring construct and patients without prospectively collected outcome data. The subsequent progress of this cohort toward union was assessed.

Results: Overall, 264 patients were identified who had been treated over a 5-year period. Of these, 236 participants were surviving and contactable. A core data set from records review including complications and outcomes were available for all patients. Overall limb salvage rates were 98%, with a third requiring secondary procedures (including transport, bone graft, docking site procedures, and pin/wire replacement). In addition, contemporary patient-reported outcome measures including quality of life (EuroQol 5 Dimensions [EQ5D]) and disability rating scale were available for 26% of participants. As would be expected, a fall in EQ5D VAS (visual analog scale) was seen from 87 pre-injury to 66 post-injury ($P<0.05$). Disability rating profile yielded final post-injury scores of 42 (rising from 17 pre-injury, $P<0.05$). With regard to grade 3 open fractures treated with a two-ring construct, all patients had Gustilo-Anderson grade 3 injuries with 22% type A, 69% type B, and 9% type C. Of the subgroup, a single patient required a secondary amputation and 1 patient died within 90 days. Overall 21 of 23 patients (91%) progressed toward union and 96% were successfully salvaged. The mean frame time was 11.5 months, with 6 patients returning to theater for an unplanned procedure. There were no malunions in this cohort.

Conclusion: The spatial frame construct gives a high limb salvage rate in severe open fractures and overall 91% success rate as a primary treatment in grade 3 open tibial fractures in this cohort. A 2-ring construct offers advantages that may include reduced cost, reduced operative time, and reduced pin and wire requirement without compromising outcomes.

Unreamed Intramedullary Nailing Versus External Fixation for the Treatment of Open Tibial Shaft Fractures in Uganda: A Randomized Clinical Trial

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Purpose: In low-income countries, external fixation is often the standard of care for the definitive treatment of open tibial shaft fractures. In contrast, intramedullary (IM) nailing is the standard in most high-income countries. We performed a parallel-group, randomized clinical trial at a regional hospital in Uganda to compare unreamed IM nailing versus external fixation to treat open tibial shaft fractures.

Methods: We screened all skeletally mature patients presenting with open tibial shaft fractures to the study location. Patients were included if they presented with Gustilo-Anderson type II or IIIA open tibial shaft fracture and received definitive treatment within 24 hours. Our primary outcome was the Function IndeX for Trauma (FIX-IT), measured at 6 weeks, 3 months, 6 months, and 12 months after randomization. Secondary outcomes included quality of life (EuroQol 5 Dimensions 3 Levels [EQ-5D-3L]), malunion, nonunion, and deep surgical site infection. We calculated treatment effects using Bayesian models informed by prior meta-analysis data, which suggest a medium treatment benefit with IM nailing. Bayesian analyses do not produce P values but, rather, calculate the probability of treatment benefit. In these analyses, we estimate if the probability of treatment benefit in our study population continued to favor IM nailing at levels consistent with prior high-income country data.

Results: The trial enrolled 55 patients (n = 31 to IM nailing and n = 24 to external fixation) with a mean age of 39 years (standard deviation [SD]: 12), and 65% were male. IM nailing improved the 1-year average FIX-IT score by 1.4 points (95% credible interval [CrI], 0.7 to 2.1) compared with external fixation. Given these results, the probability of any improvement in the FIX-IT score with IM nailing was 99%, but the probability the difference exceeds previously reported effects was only 38%. IM nailing also increased 1-year quality of life by 0.05 points (95% CrI: 0.00 to 0.10) and decreased rates of malunion (difference, –14%; 95% CrI: –27% to –2%) and nonunion (difference, –5.3%; 95% CrI: –18% to 5%). The probability of treatment benefits with IM nailing exceeding prior estimates of quality of life, malunion, and nonunion were 45%, 73%, and 50%, respectively. The rates of deep infection did not differ between groups (difference, 0%; 95% CrI: –18% to 19%).

Conclusion: Our findings suggest that IM nailing has broad treatment benefits compared with external fixation for the treatment of open tibial shaft fractures in low-resource settings. However, it is unlikely that these treatment benefits exceed the minimal clinically important differences necessary to justify the additional costs and resources required for IM nailing, given the economic constraints in many low-income country hospitals.

The Role of Cultures in Diaphyseal Tibia Nonunions: A Multicenter Study

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Purpose: Routine intraoperative culture of presumed aseptic tibial nonunions remains controversial. We aimed to describe the role of cultures and outcomes among diaphyseal tibia nonunions in both presumed septic and aseptic nonunions.

Methods: Patients from 10 academic Level I trauma centers who sustained a diaphyseal tibia fracture (AO/OTA 42) and underwent nonunion repair were retrospectively identified. Patients with preoperative (within 48 hours of surgery) inflammatory markers (erythrocyte sedimentation rate, C-reactive protein, and white blood-cell count) with or without intraoperative cultures at the time of nonunion surgery were included. Minimum follow-up for inclusion was 6 months after nonunion repair. The rate of complications was the primary outcome. Secondary outcomes included positive cultures and treatment with systemic antibiotics after nonunion repair. Patients with positive screening serum markers were considered presumed septic while those with negative screening markers were considered presumed aseptic. Surprise positive was defined as presumed aseptic with positive intraoperative cultures. $\chi 2$, Fisher exact, and Kruskal-Wallis tests were used for statistical comparisons. A level of significance was set a priori at $P<0.05$.

Results: A total of 191 tibia nonunions with complete preoperative inflammatory makers were included. 136 (71%) of these had intraoperative cultures taken. Average length of follow-up was 19.2 months. 32% of patients (43 of 136) had positive intraoperative cultures. 7% (10 of 136) had negative preoperative inflammatory markers with positive cultures (surprise positive). Patients with positive culture results compared to negative culture results were more likely to have persistent nonunion after repair (37% vs 13%; $P<0.01$), and require readmission for related complications (35% vs 18%; $P = 0.05$). Patients with positive cultures had increased risk of persistent nonunion (odds ratio [OR] 4.0, 95% confidence interval [CI]: 1.7-9.5, $P<0.01$) and readmission (OR 2.4, 95% CI: 1.1-5.4, $P= 0.04$) compared to patients with negative cultures. Patients with surprise positive cultures, even when treated, had similar complications rates to those with no cultures taken with the exception of higher readmission rates than the no culture taken group (40% vs 7.4%; $P = 0.035$). Patients with positive cultures (presumed septic + surprise positive) demonstrated more persistent nonunions (37% vs 7%; $P<0.01$) and increased readmission rates (35% vs 7%; $P<0.01$) compared to the group with no culture taken.

Conclusion: This study further demonstrates the controversy in intraoperative cultures. Prognostic value exists when taken. On the contrary, the clinical course of those patients without cultures was similar or favorable compared to those with surprise positive cultures. More data are needed to define the role of culture in the presumed aseptic nonunion.

Loss of Stabilization in Distal Tibia Shaft Fractures (LOST): How Many Interlocks Are Required?

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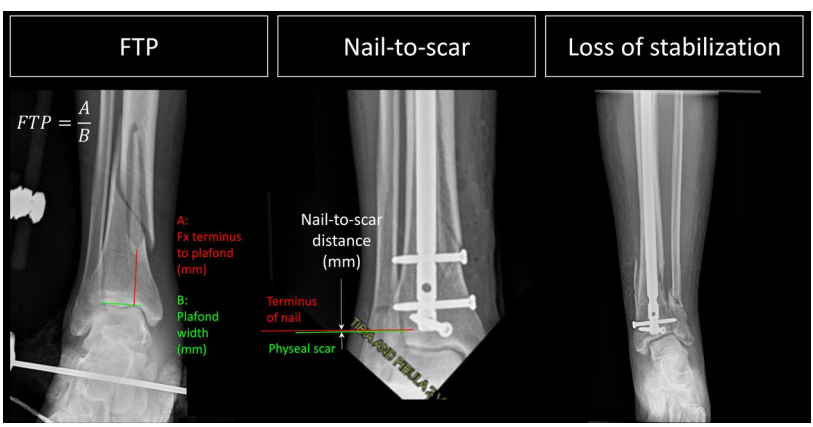
Purpose: Distal tibia shaft fractures represent a treatment challenge. Malreduction is common (10% to 29%), but reasons for loss of reduction are largely uninvestigated. For the very distal tibia fracture, there are a paucity of data regarding the circumstances that may lead to postoperative changes in alignment.

Methods: All tibia fractures treated with locked intramedullary nails at two Level I academic centers over a 12-year study period were reviewed. Only fractures within 3.0 plafond widths of the plafond were included, isolating very distal fractures. Loss of stabilization (LOST) was defined as a change in linear or angular alignment of >4 mm or >4° on an AP or lateral projection between initial and final postoperative radiographs, revision surgery (excluding for infection or symptomatic hardware), or broken hardware.

Results: 1942 tibias were screened, capturing 236 eligible fractures. LOST occurred in 45 tibias (19.1%) with no differences in demographics between groups. Open fractures and the number of medial-to-lateral interlocks (fewer than two) were associated with LOST (P = 0.038 and 0.007, respectively). Oblique distal interlocks were used in more distal fractures, with no change in the incidence of LOST. Greater numbers of medial-to-lateral and oblique interlocks, in total, approached significance for protection against LOST (P = 0.11), but likely remained underpowered for a more complex comparison. Nail size, nail depth, the use of tibial or fibular adjuvant stabilization, tibia and fibula fracture location and shape, and time to full weight bearing were not associated with LOST.

Conclusion: Loss of stabilization in distal tibia fractures is associated with open fracture and the number of distal interlocks used. This data may be used to determine which distal tibia fractures are amenable to nail stabilization. This work characterizes the contribution of interlocks to postoperative stability in far distal tibia fractures.



POSTER ABSTRACTS

Preoperative Serum Inflammatory Markers Do Not Correlate Closely with Cultures in Tibia Nonunions

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Purpose: The accuracy of currently available preoperative inflammatory markers to diagnose septic tibia nonunions remains unclear. Further, controversy remains over obtaining cultures and the interpretation of a positive culture in a setting of low clinical suspicion of infection based on physical findings and negative markers. The purpose of this study is to evaluate the accuracy with which erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and white blood cell (WBC) count can predict positive cultures.

Methods: Patients from ten Level I trauma centers who sustained a diaphyseal tibia fracture (AO/OTA 42) that underwent nonunion repair were identified retrospectively. Patients were included if ESR, CRP, or WBC count laboratory results were obtained within 48 hours prior to nonunion repair. Patients were included only if they had intraoperative culture acquisition at the definitive nonunion surgery. Elevated serum inflammatory markers were defined according to institutional limits. Diagnostic accuracy testing and logistic regression analyses were performed.

Results: In a dataset of 191 tibia nonunions, 55 (29%) had no cultures taken at the time of definitive nonunion surgery. Of the 136 (71%) with cultures (96 open and 40 closed fractures), 43 (32%) had positive cultures at the time of nonunion repair. The ability of serum markers to predict a negative culture result showed sensitivities ranging from 40% (WBC count) to 53% (ESR). Elevated serum inflammatory markers were not associated with higher odds of positive cultures.

Conclusion: The results of this study demonstrate that serum ESR, CRP, and WBC count do not accurately predict culture results at the time of tibia nonunion repair. Surgeon variance in obtaining cultures in presumed low-risk nonunions is also demonstrated with almost 30% having no culture obtained. Further study is warranted on both the predictive value of serum markers and variance in culture acquisition.

Table 1. Diagnostic Accuracy of Serum Inflammatory Markers

	ESR	CRP	WBC
Sensitivity	53.2% (38.1% - 67.9%)	51.1% (36.1% - 65.9%)	40.4% (26.4% - 55.7%)
Specificity	74.2% (63.8% - 82.9%)	70.8% (60.2% - 79.9%)	70.8% (60.2% - 79.9%)
PPV	52.1% (37.2% - 66.7%)	48.0% (33.7% - 62.6%)	40.2% (27.7% - 57.9%)
NPV	75.0% (64.6% - 83.6%)	73.3% (62.6% - 82.2%)	69.2% (58.7% - 78.5%)

* Estimate (95% CI)

Optimal Nail Diameter to Medullary Canal (ND/MCD) Ratio in Diaphyseal Tibia Fractures Treated with Intramedullary Nailing

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Purpose: Up to 17% of diaphyseal tibia fractures result in delayed union. Most patients achieve excellent outcomes with intramedullary nailing and it is unknown why some experience delayed healing. The goal of our study was to assess potential risk factors that may influence fracture healing in these patients with an emphasis on the nail diameter to medullary canal (ND/MCD) ratio.

Methods: 1050 adult patients who underwent operative treatment of tibia fractures between 2006 and 2018 were retrospectively reviewed. Exclusion criteria were inadequate follow-up (<12 months), additional lower extremity fractures, additional hardware, and nondiaphyseal and pathologic fractures. All fractures were classified using AO/OTA and Gustilo-Anderson schemas. Postoperative AP and lateral radiographs were used to calculate the ND/MCD ratio. Regression analyses were used to identify demographic and clinical variables associated with complications. A receiver operating characteristic curve analysis was used to identify the ND/MCD ratio that best differentiated between subjects who developed a nonunion and those who did not.

Results: The majority of patients included in the study presented with 42B fracture type (50 of 95, 53%). 27 patients had open fractures and grade III was the most prevalent injury pattern (11 of 27, 41%). The cumulative incidence of complications was 29.5%. Complications included nonunion, delayed union, infection, valgus deformity, symptomatic hardware, and compartment syndrome. Nonunion was noted in 18 patients (19.0%). In the univariate analysis, prescription medication use (P= 0.0137), open fractures (P<0.0001), and a decrease in the ND/MCD ratio (P= 0.0425) were significantly associated with the development of a complication. The odds of a complication among open fractures were 10.1 times (95% confidence interval [CI]: 3.2 to 32.1, P<0.0001) the odds of a complication among closed fractures. ND/MCD ratio cutoff of 85% was associated with the highest area under the curve value (sensitivity = 44%, specificity = 79%) in an exploratory analysis differentiating between the subjects that developed nonunion and the ones that did not.

Conclusion: A large proportion of patients with tibia fractures smoke (38%) and have comorbidities (54%). Patients who sustain open fractures, use prescription medications, and those with lower ND/MCD ratios are at higher risk for complications. ND/MCD ratio of <85% should be avoided as it may lead to nonunion development.

Longer-Term Outcomes Following a Humeral Shaft Fracture: Results for 291 Patients at a Minimum 1-Year Follow-Up

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Purpose: The primary aim of this study was to assess patient-reported outcomes following a humeral diaphyseal fracture. The secondary aim was to compare the outcomes of patients who achieved union after initial management (nonoperative or operative) with those who achieved union after nonunion surgery.

Methods: From 2008 to 2017, 291 skeletally mature patients with a humeral diaphyseal fracture (mean age, 55 years [range, 17-86], 58% [n = 168] female) were retrospectively identified from a trauma database and available for follow-up at a mean of 5.5 years (range, 1.2-11.0) postinjury. 64 patients (22%) were managed operatively (<12 weeks) and 227 (78%) nonoperatively. Electronic records and radiographs were reviewed to determine fracture union. The primary outcome measure was the abbreviated Disabilities of the Arm, Shoulder and Hand score (QuickDASH). Secondary outcome measures included the EuroQol 5-Dimension (EQ-5D), EQ visual analogue scale (EQ-VAS), and 12-item Short Form health survey (SF-12) scores.

Results: After initial management, 229 patients (79%) united (62 operative, 167 nonoperative) and 62 (21%) developed a nonunion (2 operative, 60 nonoperative; $P<0.001$). 52 (93%) of 56 patients achieved union after nonunion surgery. The overall mean QuickDASH was 20.8, EQ-5D 0.730, EQ-VAS 74, SF-12 physical component summary (PCS) 44.8 and mental component summary (MCS) 50.2. Patients who developed a nonunion but united after nonunion surgery reported a worse functional outcome (mean QuickDASH 27.9 vs 17.6, $P = 0.003$ and health-related quality of life [HRQoL]; mean EQ-5D 0.639 vs 0.766, $P = 0.008$; EQ-VAS 66 vs 76, $P = 0.036$; SF-12 PCS 41.8 vs 46.1, $P = 0.036$) than those who united after primary nonoperative or operative management. When adjusting for confounders, union after nonunion surgery was independently associated with poorer function (difference in QuickDASH 8.1, $P = 0.019$) and HRQoL (difference in EQ-5D –0.102, $P = 0.028$).

Conclusion: Longer-term patient-reported outcomes following a humeral shaft fracture were satisfactory. Patients achieving union after nonunion surgery reported poorer limb-specific function and HRQoL when compared to those who united after initial management, whether this was nonoperative or operative. Strategies to identify and target early operative intervention to patients at risk of nonunion may have an important role, given the potential impact of nonunion on longer-term outcome.

Avoiding Dorsal Soft-Tissue Problems with Olecranon Plating

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Purpose: This study evaluated a cohort of proximal ulna/olecranon fractures suitable for plating. Plates were inserted laterally or medially on the ulna to decrease soft-tissue complications typically associated with dorsally placed implants as well as to enhance the moment of inertia loading of the construct. By not using the standard dorsal plating method, we sought to avoid the soft-tissue concerns of a subcutaneous plate along the dorsal ridge of the ulna. Furthermore, with the plate at approximately 90° to the arc of motion and loading, the moment of inertia of the plate loading is improved.

Methods: This is an method efficacy cohort study with a single surgeon performed at a Level II trauma center. The technique utilized medial or lateral placement of plates along the proximal ulna, placing the plate below the dorsal ridge (not directly under the skin). The same indications for the normal dorsal plating were used. When needed, a small pocket was created under the triceps to accept a bent (blade-like) portion of the plate below the triceps tendon. The technique was used on 33 consecutive patients with a retrospective review. Demographic data used included age, sex, OTA fracture classification, and type of plate. Outcome parameters were postoperative range of motion, healing, infection, associated injuries, use of a hinge fixator, instability, associated morbidity, and removal of hardware.

Results: Of 33 patients (19 male, 14 female) patients, 31 were available for follow-up. Mean age was 50 years (range, 22-92) with a mean follow-up time of 10 months (range, 3-18 mo). Nine fractures were open, none of which required any soft-tissue coverage procedures. Implants used included 3.5-mm reconstruction plates, 3.5-mm locking compression plates and when appropriate mini-fragment plates. Out of 33 patients, 32 went on to fracture union. Range of motion was calculated as mean extension of 14.8° (range, 0°-50°); flexion 119.5° (80°-135°). The one failure was in a patient with an open B1.3 pattern and 30 pack-year history of smoking and noncompliance. He was treated with hardware removal and a spacer and medullary screw. He was subsequently lost to follow-up. Six patients had supplemental hinged external fixation to allow better soft-tissue management and treatment of ligamentous instability. There were no fixator failures, extensor mechanism dysfunctions, neurological lesions, or irritation from the hardware, and none of the patient population requested/required hardware removal.

Conclusion: Medial and lateral placement of proximal ulna plates allows for adequate fracture treatment with the benefit of avoiding the issues noted with dorsal plating. Historically, subcutaneously placed plates and those on the dorsal ulna have had a small but notable need for hardware removal. Medial and lateral plating allowed for adequate fracture fixation without the need for hardware removal. Also, a biomechanical advantage is due to the strongest cross-sectional moment of inertia of the plate being more optimally oriented. We feel that this series demonstrated acceptable performance of plates placed medial or lateral along the proximal ulna.

The Effectiveness of Saline Load Test in Detecting Simulated Traumatic Elbow Arthrotomies: A Cadaveric Investigation

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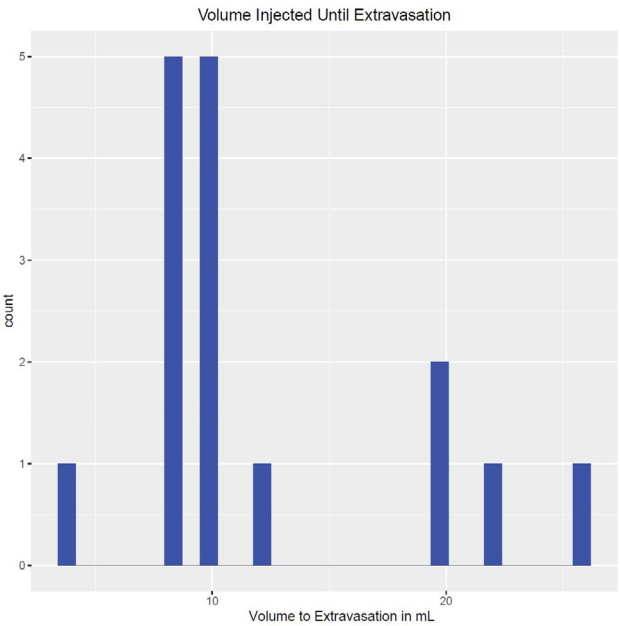
Purpose: Injuries communicating with the elbow joint are essential to detect and treat promptly. While the saline load test to detect traumatic arthrotomy is well studied in other joints, it has not been well explored in the elbow; therefore, the appropriate volume of saline infusion to detect traumatic elbow arthrotomy is not known. This study aimed to determine (1) the saline infusion volume necessary to achieve 90%, 95%, and 99% sensitivity in detecting traumatic elbow arthrotomy; and (2) specimen factors associated with higher saline volume at arthrotomy detection.

Methods: 16 thawed, fresh-frozen forequarter upper extremity amputation cadavers were arthrotomized through the direct lateral arthroscopic portal site using a 4-mm trochar. The intra-articular location of the arthrotomy was confirmed through trapping the trochar in the ulnohumeral joint. An 18-gauge needle was then inserted into the elbow joint, followed by intra-articular saline–methylene blue injection. The preestablished arthrotomy site was monitored for extravasation. The amount of saline required to detect arthrotomy was recorded. All injections were confirmed as intra-articular through direct visualization of joint staining during post-experimentation open exploration.

Results: Mean saline volume required for extravasation was 12.2 mL ± 6.26 (4 mL-26 mL). The volume of saline needed to achieve sensitivities of 90%, 95%, and 99% were 21, 23, and 25.4 mL, respectively (Figure 1). Linear regression demonstrated that increasing age was associated with lower volume to extravasation (odds ratio [OR]: 0.67; 95% confidence interval [CI]: 0.48-0.932; $P = 0.037$), while body mass index ($P = 0.571$) and extremity laterality ($P = 0.747$) did not affect the volume of saline required to achieve extravasation through similar-sized arthrotomies.



Conclusion: Saline infusion volume required to detect an elbow arthrotomy with 99% sensitivity was 25.4 mL. We recommend using at least 26 mL when performing the saline load test to rule out a potential elbow arthrotomy in the traumatic setting.

Comparison of Complications Between Reverse Shoulder Arthroplasty and Open Reduction and Internal Fixation for the Treatment of Proximal Humerus Fractures

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Purpose: While the use of open reduction and internal fixation (ORIF) for the treatment of proximal humerus fractures (PHFs) has remained consistent over the last decade, there has been a significant increase in the use of reverse total shoulder arthroplasty (RTSA). There are numerous considerations when deciding between these treatment options, including potential complications. This study sought to compare the 30-day complication profiles of RTSA to ORIF in a large, validated, retrospective cohort in order to guide surgeons in optimizing their patients prior to surgery.

Methods: Patients who underwent surgical treatment for PHFs (OTA / AO classification 11-A1 / 2 / 3, 11-B1 / 2 / 3 or 11-C1 / 2 / 3) with RTSA or ORIF were identified in a national database (National Surgical Quality Improvement Program) using CPT and ICD codes. Demographics and comorbidities were identified for each cohort of patients. 30-day complications were analyzed with univariate and multivariate analyses using $\chi 2$, Fisher's exact, and analysis of variance testing.

Results: The total number of patients included in this study was 2157, 522 (24.2%) of whom underwent RTSA and 1635 (75.8%) of whom underwent ORIF. Patients undergoing RTSA were older with an average age of 73.52 years compared with 63.84 years in those undergoing ORIF ($P<0.001$). Patients with RTSA were more likely to experience any 30-day complications (15.1% vs 7.3%, $P<0.001$), pulmonary complications (1.7% vs 0.7%, $P=0.029$), extended length of stay >3 days (25.5% vs 15.0%, $P<0.001$), and perioperative transfusion requirement (11.7% vs 4.8%, $P<0.001$) after univariate analysis. After controlling for differences in demographics, perioperative transfusion requirement was found to be significantly more common in the RTSA cohort (odds ratio 1.383, 95% confidence interval 1.080-2.345).

Conclusion: Patients undergoing RTSA were older and at increased risk for any 30-day complication, pulmonary complications, extended length of stay, and perioperative transfusion requirement after univariate analysis. After controlling for demographic variables and comorbidities, RTSA placed patients at increased risk for perioperative blood transfusion. Patients undergoing RTSA should be counseled prior to surgery regarding the risk for transfusion and medically optimized through multidisciplinary care if the surgeon elects to proceed with RTSA versus ORIF for the treatment of PHFs.

There Is No Difference in Long-Term Functional Outcomes Between Open Reduction and Internal Fixation and Radial Head Arthroplasty in Treating Radial Head Fractures

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Purpose: Radial head fractures can be treated with open reduction and internal fixation (ORIF) or radial head arthroplasty (RHA), but there is a paucity of long-term functional outcome data comparing these options. We hypothesized that arthroplasty would have better long-term functional outcomes than ORIF particularly for patients with more than three fracture fragments.

Methods: We recruited adult, English-speaking patients with a radial head fracture treated operatively between 2007 and 2018 with either ORIF or RHA at a Level I trauma center. Functional outcome was assessed using the QuickDASH, an abbreviated version of the Disabilities of Arm, Shoulder and Hand (DASH) questionnaire. 76 patients completed the QuickDASH, including 51 who underwent ORIF and 25 who underwent RHA. Median time between surgery and survey was 94 months (range, 24 to 156 months). Secondary outcomes included complication, reoperation, range of motion, and pain at last follow-up. ORIF patients compared with RHA patients were younger (mean age 45.8 years vs 59.1 years), predominantly male (88% vs 29%), lower body mass index (BMI; 28.2 vs 34.9 kg/m2), had less comminution (29% vs 64%) and less soft-tissue injury (39% vs 68%). Among the 33 participants with fractures with 3 or more fragments, 21 underwent ORIF and 12 underwent RHA.

Results: Long-term functional outcomes were similar for both treatment groups (mean difference = 0.2, 95% confidence interval [CI]: –9.0 to 9.3, $P = 0.97$). On average, the patients in both treatment groups included in this study recovered to a level of function that is within one standard deviation of the general population (10.1 ± 14.68). QuickDASH scores for both ORIF (15.7 ± 18.4) and RHA groups (22.8 ± 18.6) indicated a low level of disability, with higher QuickDASH scores indicating higher disability on a scale of 0 to 100. Similar results were observed for fractures with more than 3 fragments, with mean QuickDASH scores of 18.7 ± 17.2 in ORIF patients (standard deviation = 17.2) and 26.1 ± 19.0 in RHA patients (mean difference = –4.4, 95% CI: –19.0 to 10.2, $P = 0.54$).

Conclusion: In contrast to our hypothesis, we found similar long-term outcomes between ORIF and arthroplasty even in the subgroup of patients with multifragmentary fractures. These data indicate that ORIF and arthroplasty may provide similar long-term functional outcomes even for some of the worst fracture types. Although not statistically significant, RHA patients reported a higher average level of functional disability, which is likely due to demographic and injury factors as RHA patients were older, higher BMI, likely lower demand preoperatively, and had more soft-tissue injury in this cohort.

Anatomic Radial Head Arthroplasty: The Importance of Implant Angle

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Purpose: Multifragmentary radial head and neck fractures not amenable to open reduction and internal fixation are usually treated with radial head arthroplasty (RHA). The optimal implant design is subject to debate. An anatomic radial head implant has the theoretical benefit of mimicking the native radial head and thus the physiologic radiocapitellar and radioulnar joint contact forces. The angle of the radial head stem with respect to the proximal radius shaft (radial stem angle [RSA]) will influence radiocapitellar contact pressures. We hypothesize that variances in the placement leading to increased RSA in an anatomic implants will contribute to failure. The aim of this study is to characterize the risk of RHA failure with respect to the stem angle placement of an anatomic RHA design.

Methods: A retrospective review of patients who underwent RHA for acute fractures between 2006 and 2019 at two academic centers was performed. Adult patients with anatomic implants and a minimum of 6 months of radiographic follow-up were included. Review of the patients' initial postoperative radiograph was conducted to measure the RSA on AP and lateral views. Radiolucency, stress shielding, and radiocapitellar arthritis were also evaluated. Patients were stratified according to whether their implant was intact or had failed at the time of last follow-up. Implant failure was defined as prosthesis removal or revision by the time of review. AP and lateral RSAs were compared using two-sample t tests. Radiolucency, stress shielding, and radiocapitellar arthritis were compared using Fisher exact tests. Binomial regression was used to predict failure—one for angles measured on AP radiograph and one for those measured on lateral radiograph.

Results: 40 patients were identified and included in the analysis. The mean age was 43 years. Of the 40 patients, 19 were female and 21 were male. In 34 elbows (85%), the RHAs were intact and 6 RHAs (15%) had failed. Implant failure was associated with larger lateral RSA when compared to intact implants ($P = 0.01$). Additionally, larger lateral RSA was associated with increased odds of failure (odds ratio [OR] 1.32, 95% confidence interval [CI] 1.11-1.71). There was no difference between the two groups in anterior RSA and no associated increase in the odds of failure with increasing anterior RSA (OR 1.02, 95% CI 0.89-1.17). There was no difference in radiolucency, stress shielding, or radiocapitellar arthritis between the groups.

Conclusion: The significance of stem positioning in RHA remains understudied. RSA in this anatomic design appears to play an important role in implant survival and may act as an independent factor that can lead to implant failure. Further research is warranted to better understand the mechanism of failure seen in anatomic designs with larger RSAs. A comparison study of failure in nonanatomic RHA should also be undertaken to better understand if this finding is consistent across all RHA implant types or limited specifically to anatomic components.

Risk Factors for Revision Surgery Following Uncemented Radial Head Arthroplasty for Unreconstructible Radial Head Fractures: Minimum 3-Year Follow-up

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Purpose: The purposes of this study were to assess the revision rate following radial head arthroplasty (RHA) and to determine risk factors associated with revision surgery.

Methods: A total of 122 patients with 123 RHAs (mean age 50.7 years [range, 18-79]) who underwent RHA for unreconstructible radial head fractures (RHFs) between 1994 and 2014 and were at least 3 years out from surgery were included. Demographic variables, injury- and procedure-related characteristics, radiographic findings, complications, and revision procedures were assessed. Cox regression analysis was performed to identify risk factors that are associated with revision surgery following RHA.

Results: The median follow-up for the study cohort was 7.3 years (interquartile range, 5.1-10.1). All patients had unreconstructible RHFs of which type Mason/Johnston IV were the most prevalent (80; 65.0%). One or more associated osseous or ligamentous injury was seen in 89 elbows (72.4%). The median time to surgery was 7.0 days (interquartile range, 3.0-11.0). Implanted RHAs were categorized as rigidly fixed (65; 52.8%) or loosely fixed (58; 47.2%). A total of 28 elbows (22.8%) underwent revision surgery at a median of 1.1 years (interquartile range, 0.3-3.8) with the majority of patients (17, 60.7%) undergoing revision surgery within the first 2 years. The most common reason for revision surgery was implant loosening (14, 29.2%). Univariate Cox regression suggested that Workers' Compensation claims (hazard ratio [HR]: 5.48, $P<0.001$) and the use of an external fixator (HR: 4.67, $P = 0.007$) were significantly associated with revision surgery. The variable selection based on Cox regression models resulted in a model with Workers' Compensation claims as a single predictor.

Conclusion: Revision rates following RHA for unreconstructible RHFs are high, with the most common cause for revision surgery being painful implant loosening. Revision surgeries are predominantly performed within the first 2 years after implantation and surgeons should be aware that Workers' Compensation claims and the use of an external fixator are associated with revision surgery.

Acute Distal Biceps Tendon Repair Using an Endobutton Technique Results in Excellent Short- and Long-Term Patient Outcomes: A Single-Center Experience of 102 Patients

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Purpose: Acute distal biceps tendon repair is reported to reduce fatigue-related pain and minimizes loss of forearm supination and elbow flexion strength. Despite the growing use of cortical buttons for these injuries, reported outcomes in the literature are limited. We report the short- and long-term outcome following repair using a cortical button technique.

Methods: Between 2010 and 2018, 102 patients (101 males; mean age 43 years) underwent acute (≤6 weeks) distal biceps tendon repair using a cortical button fixation technique. The primary short-term outcome was complications. The primary long-term outcome was the QuickDASH, an abbreviated version of the Disabilities of the Arm, Shoulder and Hand questionnaire. Secondary outcomes included the Oxford Elbow Score (OES), EuroQol 5 Dimensions 3 Levels (EQ-5D), satisfaction, and return to function.

Results: There were 8 patients (7.8%) who had a major complication and 34 patients (33.3%) a minor complication. Major complications included rerupture (n = 3, 2.9%), unrecovered nerve injury (n = 4, 3.9%), and surgery for heterotopic ossification excision (n = 1, 1.0%). Three patients (2.9%) required surgery for a complication. Minor complications included neuropraxia (n = 27, 26.5%) and superficial infection (n = 7, 6.9%). At a mean follow-up of 5 years (range, 1-9.8), outcomes were available for 86 patients (84.3%). The median QuickDASH, OES, EQ-5D, and satisfaction scores were 1.2 (interquartile range [IQR] 0-5.1), 48 (IQR, 46-48), 0.80 (IQR, 0.72-1.0), and 100 of 100 (IQR, 90-100), respectively. A majority of patients returned to sport (82.3%) and employment (97.6%) following surgery. Unrecovered nerve injury was associated with a poor outcome according to the QuickDASH (P<0.001), although rerupture and further surgery were not (P>0.05).

Conclusion: This study is the largest single-center consecutive series in the literature that documents both the short- and long-term outcomes following acute surgical management of patients with an acute distal biceps tendon rupture using a cortical button technique. The results of this study suggest that this procedure yields excellent long-term patient-reported outcomes, health-related quality of life, and patient satisfaction in the majority of cases. Although rare, unrecovered nerve injury adversely affects outcome and must be fully considered when surgeons and patients are considering surgical repair of these injuries.

More Than Just a Rebound Effect: Regional Anesthesia Increases Early and Late Opioid Demand in Proximal Humerus and Humeral Shaft Fracture Surgery

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Purpose: Regional anesthesia (RA) can be used to reduce pain and opioid use in proximal humerus and humeral shaft fracture surgery. However, the real-world impact of these modalities on inpatient opioid consumption and outpatient opioid demand is unclear. The hypothesis of this study was that RA would decrease inpatient and outpatient opioid demand in patients undergoing proximal humerus and humeral shaft fracture surgery.

Methods: Inpatient and outpatient opioid demand was recorded in all patients ages 18 years and older undergoing proximal humerus or humeral shaft fracture surgery at a single, Level I trauma center from July 2013 to July 2018 (n = 380 patients). Inpatient opioid consumption from 0-24, 24-48, and 48-72 hours and outpatient opioid demand from 1 month preoperative to 2 weeks, 6 weeks, and 90 days postoperative were converted to oxycodone 5-mg equivalents (OEs). Unadjusted and adjusted models were constructed to evaluate the impact of RA and other factors on opioid utilization.

Results: Adjusted models demonstrated increases in inpatient opioid consumption in patients with RA from 48 to 72 hours postoperatively (9.1 estimated OEs without RA vs 12.6 estimated OEs with RA from 48 to 72 hours postoperatively, P<0.05) but no significant differences at other time points. Outpatient opioid demand was significantly higher in patients with RA at all time points (114.8 OEs without RA vs 139.5 with RA from 1 month preoperatively to 2 weeks, 127.6 vs 171.2 OEs to 6 weeks, and 140.3 vs 197.7 OEs to 90 days, all *P* values for RA <0.05).

Conclusion: In proximal humerus and humeral shaft fracture surgery, RA was associated with increased inpatient and outpatient opioid demand after adjusting for baseline patient and treatment characteristics.

Table 1: Adjusted inpatient opioid consumption and outpatient opioid demand in oxycodone 5-mg equivalents in patients with and without RA. Red coloring highlights statistical significance. Simulated estimates from multivariable model (95% CI) displayed. Incident rate ratios and p-values from multivariable model.

Timeframe	Oxycodone without RA (95% CI)	Oxycodone with RA (95% CI)	Incident rate ratios (95% CI, p-value)
Inpatient consumption			
0-24 hours post-op	7.4 (5.9, 9.6)	8.7 (6.9, 11.3)	1.17 (1, 1.38; p=0.05)
24-48 hours post-op	11.5 (7.2, 17.3)	13.9 (8.6, 21)	1.21 (0.94, 1.56; p=0.145)
48-72 hours post-op	9.1 (5.4, 14.3)	12.6 (7.4, 20.1)	1.38 (1.04, 1.84; p=0.025)
Outpatient demand			
1-month pre-op to 2 weeks post-op	114.8 (90.5, 143.1)	139.5 (110.3, 173.8)	1.22 (1.04, 1.41; p=0.009)
1-month pre-op to 6 weeks post-op	127.6 (99.6, 163.7)	171.2 (133.6, 219.7)	1.34 (1.15, 1.56; p=<0.001)
1-month pre-op to 90 days post-op	140.3 (110.5, 176.2)	197.7 (155.2, 248.4)	1.41 (1.21, 1.65; p=<0.001)

Radiographic Measurement Reliability of Head Shaft Angle and Greater Tuberosity Position Varies with the Humeral Rotation for Proximal Humerus Fractures

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Purpose: The purpose of this study was to compare the interrater and intrarater reliability of radiographic measurements of the head shaft angle (HSA) and greater tuberosity position, measured using humeral head height (HHH), on postoperative AP shoulder radiographs with the arm in internal rotation (IR), neutral rotation (NR), and external rotation (ER).

Methods: A cross-sectional study of 24 patients with proximal humerus fractures was performed using AP shoulder radiographs with the humerus in NR, in 30° of IR, and in 30° of ER. The intraclass correlation coefficient (ICC) was used to assess interrater and intrarater reliability for HSA and HHH (Fig. 1) in each humeral rotation position. We also evaluated measurement differences between positions using the one-way analysis of variance statistic.

Results: HSA demonstrated good to excellent reliability across all three rotational views, with the highest estimates for both interrater (ICC: 0.85, 95% confidence interval [CI: 0.76-0.94) and intra-rater (ICC: 0.96, 95% CI: 0.93-0.98) reliability achieved in neutral rotation. There were significant differences in the values observed in each rotation with a mean HSA value of 133.1° (+/-13.6°) in ER, and increased valgus in neutral (140.8° ± 14.4°) and IR (159.5° ± 20.4°) views. HHH measurements demonstrated the greatest interrater (ICC: 0.78, 95% CI: 0.62-0.89) and intrarater (ICC: 0.86, 95% CI: 0.76-0.92) reliability in neutral rotation. A significant difference in measurement value was observed with regards to humeral rotation with a mean measurement of 48.5 mm in IR, increasing to 53.1 mm in ER (P<0.001).

Conclusion: This study demonstrates that the reliability for radiographic measurements of proximal humerus fractures varies with humeral rotation on AP radiographs. Future clinical studies should standardize the technique by which AP radiographs and measurements are obtained.

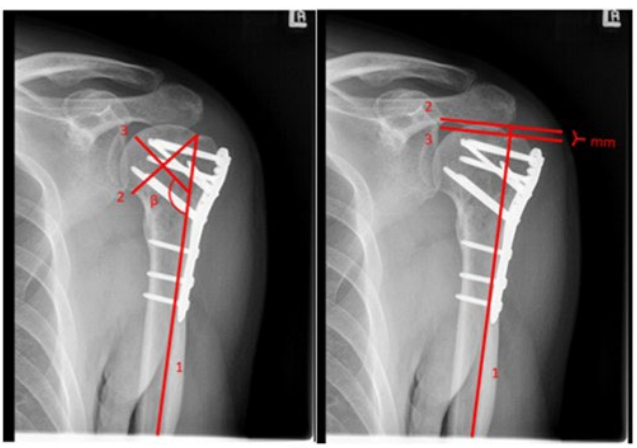

Figure 1. Instructions were provided to the observors to standardize the head shaft angle (a) and greater tuberosity position (b) measures.

POSTER ABSTRACTS

See the meeting app for complete listing of authors' disclosure information. Schedule and presenters subject to change.

Return to Work and Sport After a Humeral Shaft Fracture

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Purpose: The primary aim was to determine the rate of return to work and sport following a humeral diaphyseal fracture. The secondary aim was to identify factors associated with failure to return to work and sport.

Methods: From 2008 to 2017, all patients with a humeral diaphyseal fracture were retrospectively identified from a trauma database. Demographics and injury characteristics were recorded. Details of pre- and postinjury work and sport were obtained via postal survey. The Work Group comprised 177 patients in employment prior to injury (mean age 47.0 years [range, 17.6-78.0], 50.8% female [n = 90]) and the Sport Group comprised 182 patients involved in sport prior to injury (mean age 52.9 years [range, 18.0-85.0], 57.1% female [n = 104]). Receiver operating characteristic curve modeling was used to determine the age cut-off most strongly associated with failure to return to sport.

Results: Mean follow-up for the Work Group was 5.8 years (range, 1.3-11). 85% (n = 151 of 177) returned to work at a mean of 14 weeks postinjury (95% confidence interval [CI] 11.6-16.5; range, 0-104). Of these, 59.9% (n = 106) returned full-time to their previous employment. Female sex (odds ratio [OR] 2.5, $P = 0.042$), alcohol-abstinence (OR 3.0, $P = 0.024$), heavy manual work (OR 5.5, $P = 0.031$), sustaining a right- (OR 2.8, $P = 0.019$) or dominant-sided injury (OR 2.4, $P = 0.044$), and proximal-third fracture (OR 4.6, $P = 0.014$) were associated with failure to return to work. Mean follow-up for the Sport Group was 5.4 years (range, 1.3-11). There was a significant deterioration in the mean University of California, Los Angeles Activity Score, which reduced from 6.9 (95% CI 6.6-7.2; range, 1-10) before injury to 6.1 (95% CI 5.8-6.4; range, 1-10) postinjury ($P<0.001$). 89% (n = 162 of 182) returned to sport, 7.7% (n = 14) within 3 months of injury, 34.1% (n = 62) within 6 months, and 69.8% (n = 127) within 12 months. Patient age ≥60 years ($P = 0.016$), one or more medical comorbidities (OR 4.5, $P = 0.015$), unemployed/retired (OR 4.2, $P = 0.002$), associated radial nerve palsy (OR 4.8, $P = 0.030$), and failing to achieve union (OR 17.9, $P = 0.032$) were associated with failure to return to sport.

Conclusion: The majority of patients successfully return to work and sport following a humeral diaphyseal fracture. Female patients, those in heavy manual jobs, with a dominant- or right-sided injury, or a proximal-third fracture are at increased risk of failure to return to work. Older patients with comorbidities, those not employed at the time of injury, with a concomitant radial nerve palsy, or failing to achieve union are at increased risk of failure to return to sport. These findings may be useful for surgeons counseling patients about expected return to activity after a humeral diaphyseal fracture.

Time to Surgery for Unstable Elbow Fractures Is Not Associated with an Increased Risk for Complications

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Purpose: Some have reported that a delay in time to surgery (TTS) is correlated with a higher risk of complications in the operative treatment of hip fractures and proximal humerus fractures. The aim of this study was to determine if there is a correlation between TTS and complications following repair of unstable elbow fractures.

Methods: 353 patients who sustained an elbow fracture or fracture dislocation, underwent surgical repair, and ≥6 months of postoperative follow-up were identified and were grouped as those who experienced a complication and those who did not. Complications reported included infection, hardware failure, elbow contracture, and fracture nonunion. A Mann-Whitney U test was run to determine if there were differences in TTS between those who experienced a complication and those who did not. A Spearman correlation test was run to determine if TTS was correlated with the patients' range of motion at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year and their Mayo Elbow Performance Index (MEPI) score at their latest follow-up interval. A $\chi 2$ test was run to determine if patients with a TTS ≥2 weeks experienced a greater number of complications than those with a TTS surgery less than 2 weeks.

Results: The median TTS for patients who did not experience a complication was 7 days, whereas the median for patients who did was 6 days and this was not significantly different, U = 9,282, z = –0.723, $P = 0.469$. There were no differences in age, Charlson Comorbidity Index (CCI), or gender between the two groups. The Spearman correlation test determined that TTS was not correlated with 2-week arc of motion (rs = 0.103), 6-week arc of motion (rs = –0.053), 3-month arc of motion (rs = –0.035), 6-month arc of motion (rs = –0.055), 1-year arc of motion (rs = –0.089), or latest MEPI score (rs = –0.103). The $\chi 2$ test of homogeneity found that, of the 39 patients with a TTS ≥2 weeks, 13 (25%) experienced a complication. Of the 244 patients with a TTS <2 weeks, 56 (18.7%) experienced a complication. These differences were not significant ($P = 0.288$).

Conclusion: Surgeons can feel comfortable delaying complex elbow surgery for various reasons and not diminish patient-expected outcomes.

Patient Obesity Only Affects Severity of Proximal Humerus Fractures, Not Outcomes

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Purpose: The prevalence of obesity in adults has increased significantly in the United States and worldwide. It has been extensively reported in the literature to cause not only medical problems, but musculoskeletal issues as well. In addition to being associated with high rates of osteoarthritis as compared to normal weight populations, obese patients have a greater risk of trauma, including minor injuries and fractures. The purpose of this study is to evaluate the effect of the non-modifiable factor of obesity on the outcome of operatively treated proximal humerus fractures.

Methods: Proximal humerus fractures requiring surgery were prospectively followed. Fractures were classified according to the international AO/OTA and Neer classifications to determine their severity. Patients' body mass indexes (BMIs) were calculated and used to identify two groups: BMI ≥30 kg/cm2 (obese) and <30 kg/cm2 (non-obese). Variables such as age, gender, height, weight, Charlson Comorbity Index (CCI), number of complications, latest follow-up shoulder range of motion (ROM), and latest follow-up Disabilities of the Arm, Shoulder and Hand (DASH) survey scores were also recorded. Independent t tests were used for statistical analysis of continuous variables and $\chi 2$ tests for categorical variables. Regression analysis was performed to determine if BMI was a predictor of severity of fracture pattern as determined by the AO classification. Statistical significance was considered as $P \leq 0.05$.

Results: Overall, 198 patients who sustained 200 proximal humerus fractures were analyzed. Patient age at time of injury was 60.0 ± 13.6 years. There were 61 OTA 11-A, 69 OTA 11-B, and 70 OTA 11-C fracture types. 62 patients (31.3%) were obese, while 136 patients (68.7%) were non-obese. No significant differences were seen between groups in regards to age, gender, height, CCI, complication rates, Neer classification, or functional and clinical outcomes as determined by follow-up DASH scores and shoulder ROM, respectively. Statistical analysis also demonstrated that obese patients had greater fracture severity per the AO/ OTA classification ($P = 0.021$).

Conclusion: Based on the results of this study, obesity is associated with more severe fracture pattern of the proximal humerus as determined by the AO/OTA classification. However, there are no differences in outcomes or complication rates between obese patients and non-obese patients. With increasing rates of obesity, this relationship may have important epidemiological implications in the future, including predicting proximal humerus fracture burden and severity in society. Additionally, orthopaedic surgeons should be reassured that performing proximal humerus fixation in obese patients yields similar outcomes and complication rates to non-obese patients.

Healing Rate, Complications, and Patient-Reported Outcome Measures Associated with Plate Fixation and Autologous Bone Grafting for Clavicle Nonunion

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Purpose: Clavicle nonunion is an uncommon yet debilitating complication of acute clavicle fracture and is associated with shoulder dysfunction and pain. Management typically involves open reduction and internal fixation (ORIF) with bone grafting. Although this treatment has been well described, patient-reported outcome measures (PROMs) for this intervention have not been widely studied. The purpose of the current investigation is to evaluate the healing rate, complications, and PROMs among clavicle nonunion patients treated with ORIF and bone grafting.

Methods: Clinical and hospital records were evaluated for 59 consecutive adult patients seen and treated by a single surgeon at a quaternary referral center for management of a clavicle nonunion. Pre- and postoperative outcomes were assessed with the Short Form-12, Brief Pain Inventory, Disabilities of the Arm, Shoulder and Hand (DASH), and Time Trade-off questionnaires and improvement analyzed using repeated-measures analysis of variance.

Results: The case series included 59 adult patients (38 males, 21 females) with an average age at injury of 39.9 years. All initial clavicle fractures were closed and 19 (32%) were comminuted. At presentation to our institution, 44 patients (75%) had been treated nonoperatively for their acute fracture for a mean of 15 months (range, 2-120). To address nonunion, 27 patients (46%) had single plating and 32 (54%) had double plating, all with bone grafting performed by the same surgeon. Treatment was successful in uniting 98% of all clavicle nonunions. One patient (2%) had a persistent nonunion and 3 patients (5%) required more than one procedure to obtain bony union. Three patients (5%) were lost to follow-up. Complications included infection with positive cultures for Propionibacterium acnes in 2 patients (3%) and symptomatic hardware in 6 patients (10%). In 25 patients with both pre- and postoperative PROMs at a mean 7.1 years, there was statistically significant improvement in all functionality scores ($P \leq 0.001$).

Conclusion: Our study demonstrates that plate fixation with autologous bone grafting is a reasonably safe and effective intervention to address nonunion with PROMs, indicating that patients demonstrate significant functional improvement.

Radiographic Outcomes of Humerus Fractures in Low- and Middle-Income Countries

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Purpose: The Surgical Implant Generation Network (SIGN) intramedullary nailing system was developed for use in resource-limited settings to effectively treat femoral, tibial, and humeral fractures. With more than 300,000 nails implanted worldwide since 1995, SIGN has greatly improved the global care of long-bone fractures. While satisfactory clinical and radiographic results following fixation of femoral and tibial shaft fractures with the SIGN nail have been reported in the literature, the efficacy of SIGN nail fixation for humeral shaft fractures has not been investigated in a large-scale study.

Methods: We performed a retrospective analysis of closed humeral fractures treated in low- and middle-income countries using a standard SIGN nail. Humeral fractures were selected at random from the SIGN Online Surgical Database (SOSD). Cases with inadequate orthogonal postoperative radiographs or those involving the proximal or distal humeral metaphysis were excluded. Additional cases were reviewed to achieve the a priori minimum sample size of 500. Fractures were classified according to the AO/OTA classification system. Additional demographic variables available in the SOSD were also recorded. As previously described, a digital onscreen protractor was used to measure deviation from anatomic alignment (DFAA) in the coronal and sagittal planes using the AP and lateral radiographs, respectively.

Results: A total of 906 humeral fractures in the SOSD were reviewed. After application of inclusion and exclusion criteria, 503 humeral fractures with adequate orthogonal postoperative radiographs were included in the final analysis. A sample case is shown in Figure 1. Average coronal plane DFAA was 3.7°, with 76.5% of fractures within 5° of anatomic alignment. Average sagittal plane DFAA was 3.3°, and 81.6% of fractures had a DFAA <5°.

Conclusion: The SIGN nail achieves satisfactory postoperative alignment in humeral fractures in more than 75% of cases. Further investigation of cases with malalignment may further elucidate appropriate surgical indications.

Health Disparities in Adult Clavicle Fracture Management

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Purpose: Disparities and barriers continue to limit patient access to orthopaedic care. Clavicle fractures are common injuries in the adult population and have varying rates of surgical and nonsurgical management. The purpose of this study was to identify if demographic measures of socioeconomic and health-care disparity are associated with different rates of operative versus nonoperative management.

Methods: Claims for adult patients (≥18 years old) diagnosed with an outpatient clavicle fracture were identified from 2011 to 2018 in the New York Statewide Planning and Research Cooperative System (SPARCS) database. Patients were followed for 6 months to identify whether they underwent surgery. Multivariable logistic regression was performed to evaluate the effect of patient demographic factors on the likelihood of patients receiving surgical versus nonsurgical management.

Results: 25,933 patients with clavicle fractures were identified and 2868 underwent surgery (11.1%). Increased age (odds ratio [OR] = 0.98, P≤0.0001), female sex (OR = 0.815, *P*≤0.0001), African-American race (OR = 0.427, *P*≤0.0001), other race (OR = 0.749, *P*<0.0001), Medicare (OR = 0.265, *P*≤0.0001), Medicaid (OR = 0.76, *P* = 0.0001), Workers› Compensation (OR = 0.778, *P* = 0.0429), self-pay (OR = 0.442, *P*≤0.0001), other payer (OR = 0.666, *P* = 0.0349), and those with a higher social deprivation index (SDI) (OR = 0.997, *P* = 0.0002) had a decreased likelihood of undergoing surgery (Table 1).

Conclusion: This study demonstrates that differences in management of clavicle fractures in adults is associated with multiple demographic and socioeconomic factors that suggest disparities in clavicle fracture management. Defining these disparities and promoting physician awareness of these biases may help guide appropriate operative and nonoperative clavicle fracture management.

Table 1: Odds of Receiving Clavicle Fracture Surgery After Initial Diagnosis, Adults

	Rate of Surgery (11.1%)	Odds Ratio (95% CI)	P-value
Age	-	0.98 (0.978 - 0.983)	**<.0001**
Sex			
Males	13.2	-	-
Females*	7.3	0.815 (0.741 - 0.897)	**<.0001**
Race			
White Race	12	-	-
Asian Race$^{\psi}$	10.2	0.841 (0.659 - 1.074)	0.1652
African American Race$^{\psi}$	5.3	0.427 (0.346 - 0.527)	**<.0001**
Other Race$^{\psi}$	9.6	0.749 (0.654 - 0.858)	**<.0001**
Ethnicity			
Non-Hispanic Ethnicity	11.2	-	-
Hispanic Ethnicity$^{\gamma}$	10.2	0.998 (0.863 - 1.154)	0.9777
Primary Insurance			
Private	15.8	-	-
Medicare$^{\delta}$	2.1	0.265 (0.217 - 0.322)	**<.0001**
Medicaid$^{\delta}$	11.8	0.76 (0.661 - 0.873)	**0.0001**
Worker's Compensation$^{\delta}$	12.4	0.778 (0.61 - 0.992)	**0.0429**
Self-Pay$^{\delta}$	7.9	0.442 (0.384 - 0.51)	**<.0001**
Other$^{\delta}$	12.4	0.666 (0.457 - 0.972)	**0.0349**
Charlson Score			
CCI = 0	12.1	-	-
CCI ≥ 1$^{\Phi}$	3	0.452 (0.361 - 0.567)	**<.0001**
SDI	-	0.997 (0.996 - 0.999)	**0.0002**

*compared to males
$^{\psi}$compared to white race
$^{\gamma}$compared to non-Hispanic ethnicity
$^{\delta}$compared to private insurance
$^{\Phi}$compared to CCI = 0

Acute Sternoclavicular Dislocation: Treatment and Outcomes

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Purpose: This study investigates operative and nonoperative management and perioperative outcomes in sternoclavicular dislocations for both anterior and posterior acute dislocations. Also, we sought to elucidate risk factors for postoperative complications and patient-specific adverse outcomes.

Methods: We retrospectively reviewed adult patients treated for sternoclavicular joint dislocation (SCJD) between January 1, 2008, and December 31, 2018, at 8 sites. Data extraction defined demographics, injury characteristics, comorbidities, mechanisms of injury, treatment, complications, and clinical outcomes.

Results: A total of 97 SCJD injuries were included for analysis. 38 patients (39.1%) had an anterior dislocation, and 59 patients (61%) had a posterior dislocation. 30 of 59 posterior dislocations (50.8%) received surgery as the initial management while 14 of 38 (36.8%) of the anterior dislocations received acute surgery. Techniques used for acute repair were percutaneous reduction (4), FiberWire repair (8), dynamic compression plate fixation (8), locking plate fixation (4), suture fixation (7), allograft reconstruction (5), screw fixation (6), and clavicle resection with allograft reconstruction (2). 19 of 53 nonoperative patients (35.8%) had complications after initial treatment. Of those, 9 of 53 patients in the nonoperative group (17%) had persistent joint instability requiring surgery. 4 of 44 (9%) in the acute operative group and 6 of 53 (11.3%) in the nonoperative group had decreased range of motion. 2 of 53 (3.8%) of the non-operative group had symptomatic pain due to the SCJD injury and 3 of 44 (6.8%) in the operative group. 2 of 53 patients (3.8%) in the nonoperative group had a neurovascular injury versus none in the operative group. At final follow-up, 22 of 97 (22.7% of all patients) remain symptomatic. Overall, 70 of 97 patients (72.2%) were able to comfortably resume daily activities: 26 of 44 (59%) in the operative group and 44 of 53 (83%) in the nonoperative group.

Conclusion: Sternoclavicular joint dislocations are rare injuries with no current standard treatment. Usually, operative treatment is indicated for symptomatic unstable injuries or recurrent dislocation. In our study, the majority of patients were treated with closed management. Patients who underwent surgical management had a lower rate of complications. These data indicate that closed management should be considered unless obvious indications for operative treatment are present (ie, symptomatic instability or compression symptoms from posterior dislocations). Patients should be counseled on the risk of persistent symptoms of decreased range of motion, pain, and instability. To the best of our knowledge, this is the largest descriptive series to date of SCJD injuries.

Radiographic Scoring of Humeral Shaft Fractures Helps Identify Patients at Risk of Nonunion

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Purpose: Conservative treatment with a fracture brace is the gold standard for fractures of the humeral shaft. However studies have demonstrated nonunion rates ranging from 5% to 23%. Delayed surgical intervention for humeral nonunions has been associated with poor functional outcomes, suggesting that earlier diagnosis and intervention may be beneficial. Recently, studies have assessed an adaptation of the Radiographic Union Score for Tibial Shaft Fractures (RUST) for the humerus, demonstrating good inter- and intraobserver reliability. This scoring system aims to provide an objective measure of the progression of radiographic union and may aid in early identification of patients at risk of progression to nonunion. This study evaluates the reliability of this radiographic scoring system for conservatively treated humeral shaft fractures and assesses its utility in identifying patients at risk of nonunion.

Methods: A retrospective review of the electronic medical records of a Level I trauma center was conducted to identify patients treated for humeral diaphyseal fractures over 10 years. Patients treated surgically within 6 weeks of injury, age <18 years, follow-up of less than 3 months, and those lacking at least one set of orthogonal radiographs within 3 months of injury were excluded. Radiographs between 2 and 14 weeks post-injury were stratified into 3-week time intervals for comparison and assessed independently in a randomized order by 5 reviewers at various stages of training using the modified RUST (mRUST) scoring system. Radiographs were reassessed a minimum of 4 weeks later. Interobserver reliability was determined using intraclass correlation coefficient (ICC) and intraobserver reliability was measured using ICC and weighted kappa (κw). Statistical analyses were performed using SPSS.

Results: A total of 57 patients with 132 sets of orthogonal radiographs met the study criteria. 8 patients (14%) developed nonunion. Interobserver ICC from both time points was 0.827 (95% confidence interval [CI] 0.788-0.863). ICC from each round of scoring yielded 0.792 (95% CI 0.743-0.837) and 0.845 (95% CI 0.804-0.881) demonstrating a lack of statistically significant difference in interobserver agreement between the two rounds. Intraobserver ICC and κw demonstrated substantial to almost perfect agreement. Patients who failed to progress beyond a score of 8 by 5 to 7 weeks following injury were more than four times as likely to progress to nonunion as those who surpassed this threshold (odds ratio [OR] = 4.27, 95% CI 2.29-7.96, $P<0.001$). Receiver operating characteristic curve demonstrated an area under the curve of 0.714 (95% CI 0.639-0.789), sensitivity = 0.365, specificity = 0.881, positive predictive value = 0.334, and negative predictive value = 0.895.

Conclusion: The results of this study advocate the use of the mRUST for conservatively treated humeral shaft fractures as both a reliable and reproducible objective measure of fracture healing. Additionally, fractures that scored ≤8 at 5 to 7 weeks post-injury should be considered at significantly increased risk of progression to nonunion and given greater consideration for early intervention.

Δ Multiple Closed Reductions Prior to Definitive Fixation Are Detrimental to Patients with Distal Radius Rractures

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Purpose: This study aimed to determine if multiple failed closed reductions (CRs) prior to fixation of a distal radius fracture is associated with the odds of complication-related reoperation up to 2 years post fracture.

Methods: We identified all distal radius fracture patients aged 18 years or older between the 2003 and 2016 in Ontario, Canada from linked administrative databases. We used procedural and fee codes between 8 and 14 days of the fracture to determine which patients underwent primary outpatient surgical fixation as well as those who underwent initial CR(s) followed by secondary definitive fixation. We grouped patients according to the number of CRs they underwent prior to definitive fixation. We used intervention and diagnostic codes to identify reoperations within 2 years of fixation. We used multilevel multivariable logistic regression to compare the association between the number of CRs and reoperation while accounting for clustering at the surgeon level and adjusting for other relevant covariables. We performed an age-stratified analysis to determine if the association between the number of CRs and reoperation differed by patient age.

Results: We identified 5464 patients with distal radius fractures managed with outpatient fixation between 8 and 14 days of their fracture. A total of 1422 patients (26.0%) underwent primary surgical fixation (mean time to fixation 10.6 ± 2.0 days), while 3573 (65.4%) underwent secondary fixation following one failed CR (mean time to fixation 10.1 ± 2.2 days, time to CR 0.3 ± 1.2 days), and 469 (8.6%) underwent fixation following two failed CRs (mean time to fixation 10.8 ± 2.2 days, time to first CR 0.0 ± 0.1 days, time to second CR 4.7 ± 3.0 days). The CR groups had higher proportions of female patients compared to the primary group, and patients who underwent two failed CRs were more likely to be fixed with a plate (vs wires or pins). The unadjusted proportion of reoperations was significantly higher in the group that underwent two failed CRs (7.5%) compared to those who underwent primary fixation (4.4%), and fixation following one failed CR (4.9%). Following covariable adjustment, patients who underwent two failed CRs had a significantly higher odds of reoperation (odds ratio [OR] 1.72 [1.12-2.65]) compared to those who underwent primary fixation. This association appeared to worsen for patients over the age of 60 years (OR 3.93 [1.76-8.77]). We found no significant difference in the odds of reoperation between patients who underwent primary fixation versus secondary fixation following one failed CR.

Conclusion: We found that patients with distal radius fractures who undergo multiple CRs prior to definitive fixation have a significantly higher odds of reoperation compared to those who undergo primary fixation. This suggests that surgeons should offer fixation following a single failed CR rather than attempt multiple closed reductions. Prospective studies are required to confirm these findings.

Δ OTA Grant

Upper Extremity Wood Saw Injuries: Experience at a Single Level I Trauma Center

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Purpose: Saw injuries are common, with over 30,000 injuries occurring annually from table saw use alone. The degree of injury often dictates subsequent management, although management strategies are not universally agreed upon and subsequent outcomes are not well described. The purpose of this study was to identify injury patterns, management strategies, and complications following upper extremity saw injury at our institution.

Methods: 10,721 patients treated for an upper extremity laceration, crush, or amputation at a single Level I trauma center from 2012 to 2019 were reviewed to identify those injured using a wood saw. Mechanism of injury, injury level and severity, primary management, and complications (infection, wound healing issue, neuroma) were subsequently collected.

Results: 283 adult patients with an upper extremity wood saw injury were identified. Mean age was 50.1 years, and most injuries occurred in males (97.5%) and were predominately of White race (78.7%). Only 7.8% of injuries involved a Workers› Compensation claim. Nearly 90% of patients were right-hand dominant, although the nondominant hand was usually injured (70.8%). Nearly half (48.1%) of injuries involved a table saw, and 22.3% involved a circular saw, while miter saws, reciprocating saws, band saws, and hand saws were less commonly involved, with <5% of overall injuries occurring from each saw type. The majority of injuries were to fingers (92.2%), followed by hand (6.4%), wrist (2.5%), and forearm (0.7%). Multiple fingers were involved in 26.1%, and nearly 20% resulted in partial or complete amputation of a digit. No amputations occurred proximal to the finger. The index finger was most often injured (43.8%), followed by the thumb (32.5%), and long finger (31.8%). Bone involvement at the finger level was common, occurring in 41.7%, while vascular and nerve injuries occurred less frequently (10.6% and 14.5%, respectively). 230 cases (81.3%) were managed nonoperatively, with bedside debridement (69.6%), laceration repair (63.6%), and home oral antibiotics (51.6%), while 18.7% were managed operatively, with debridement (12.0%), tendon repair (10.6%), osseous fixation (9.2%), revision amputation (7.8%), and nerve repair (7.1%). Overall complication rates were low (2.5%), with 5 patients developing infection and 2 developing neuroma.

Conclusion: Wood saw injuries are common and may be a source of morbidity, with 20% resulting in amputation of a digit; however, subsequent complications are surprisingly rare, and the majority of these injuries can be managed nonoperatively with local wound care and oral antibiotics.

Is Bony Congruence at the Distal Radioulnar Joint Predictive of Need for Fixation Following Traumatic Wrist Injury?

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Purpose: The distal radioulnar joint (DRUJ) is a complex and inherently unstable articulation that may be disrupted with traumatic injury about the wrist. DRUJ injuries can often lead to pain, instability, and arthritis. Stability of this articulation is conferred, in part, by bony congruency between the sigmoid notch of the distal radius and the ulnar head. Several distinct sigmoid notch morphologies have been described and are theorized to lend varying degrees of stability to the DRUJ. Studies of sigmoid notch morphology, until this point, have been anatomic cadaveric studies and have not been analyzed in the setting of distal radius fracture. The purpose of this study is to report the incidence of the described sigmoid notch morphologies in patients with traumatic wrist injury and assess the impact of these anatomic variations on fracture pattern and DRUJ stability.

Methods: Retrospective institutional database review was performed to identify all distal radius fractures and any associated or isolated DRUJ injuries diagnosed at a single academic medical center from 2015 through 2019. Only patients with CT scans at time of injury were included in this analysis. Exclusion criteria were not having undergone CT scan or skeletal immaturity at time of injury. Demographic information and radiographic parameters were extracted using a predetermined spreadsheet by two independent reviewers. Statistical analysis was performed using $\chi 2$ test and Fisher exact test.

Results: Final analysis included 96 patients, 48 males and 48 females. Mean age at time of injury was 50 years (standard deviation 17). 93 patients had distal radius fractures and 3 had isolated DRUJ injuries. Sigmoid morphology was flat-face in 14 patients (15%), ski-slope in 26 patients (27%), "C" type in 49 patients (51%), and "S" type in 7 patients (5%). Males and females had significant differences in sigmoid morphology ($P<0.05$). Females were more likely to have flat-face notches, while males were more likely to have ski-slope morphologies. No correlation was found between sigmoid morphology and specific fracture patterns, likelihood of requiring supplemental DRUJ fixation, or involvement of the volar or dorsal lunate facet.

Conclusion: Differences in sigmoid notch morphology have been theorized to confer varying degrees of bony stability to the DRUJ. This study finds that while sigmoid notch morphologies are not associated with patterns of injury or DRUJ instability, significant differences are present in the bony morphology of males versus females, with males being significantly more likely to have "ski-slope" morphology. A detailed understanding of this bony morphology and any gender-related variations is important for treating these injuries and restoring optimal function to the hand and wrist.

Distal Radius Fractures: Does the Anesthesia Method Have an Impact on the Post-Reduction Radiographic Measurements? A Comparison Between Hematoma and Bier Block

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Purpose: Displaced distal radius fractures are commonly treated with closed reduction and splinting in the acute care setting and there is no established better anesthesia method regarding quality of the reduction. We hypothesize that radiographic outcomes after closed reduction and splinting of distal radius fractures in the emergency department are dependent on whether regional (Bier block) or local (hematoma block) anesthesia is used.

Methods: In an IRB-approved retrospective study, consecutive adult patients undergoing closed reduction and splinting of a dorsally displaced distal radius fracture in the emergency department at two academic tertiary care institutions between 2014 and 2017 were identified. Patients with previous fracture, OTA B fracture, and reduction performed by non-orthopaedic residents were excluded. Demographic variables, pre- and post-reduction measurements on radiographs (radial height [RH], radial inclination [RI], ulnar variance [UV] and lateral tilt [tilt]), time of procedure, level of training, and OTA classification were collected. Student's t test, $\chi 2$, or Fisher's exact test were used when appropriated. *P* value <0.05 was considered statistically significant.

Results: 83 patients underwent reduction under hematoma block (HB), and 95 patients under Bier block (BB). Both groups were similar in comorbidities, gender, and OTA classification, but HB patients were significantly older than in the BB (60 vs 54 years old, $P = 0.02$). Pre-reduction RH, RI, and tilt were not significantly different between the two groups, but initial UV was less positive in the BB group (1 mm vs 3 mm, $P<0.001$). Post-reduction measurements were significantly different for tilt, with a mean of 3° volar in BB compared to neutral in HB ($P = 0.03$) and UV, with a mean neutral variance in the BB compared to 1 mm in HB ($P<0.001$). Absolute correction (difference between pre and post-reduction measurements) for tilt and UV were similar while RI and RH had significantly bigger values for the HB group. Absolute tilt correction was smaller among the obese patients (21° vs 28°, $P = 0.002$), and post-reduction tilt was also different according to the obesity status (1 dorsal vs 2.5 volar, in degrees, obese vs non-obese, respectively, $P = 0.04$).

Conclusion: Total correction under both anesthesia methods was radiographically similar for tilt and UV. A significantly more volar tilt post-reduction was achieved in the BB, although the clinical impact may not be significant since neutral position was achieved in HB. Obesity was associated with significant differences in radiographic outcomes. While each type of anesthesia has its own set of risks, radiographic parameters following distal radius fracture closed reduction in adult patients may be significantly different depending on the type of anesthesia used and the obesity status.

Which Parameters Predict Delayed Fracture Displacement of Distal Radius Fractures Resulting in Surgical Treatment?

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Purpose: Distal radius fractures (DRFs) are common injuries and represent 17% of all adult upper extremity fractures. Some fractures deemed appropriate for nonsurgical management following closed reduction and casting exhibit delayed secondary displacement (greater than 2 weeks from injury) and require late surgical intervention. This can lead to delayed rehabilitation and functional outcomes. This study aimed to determine which demographic and radiographic features can reliably predict delayed fracture displacement.

Methods: This is a multicenter retrospective case-control study using radiographs extracted from our Analytics Data Integration, Measurement and Reporting (DIMR) database, using diagnostic and therapeutic codes. Skeletally mature patients aged 18 years or older with an isolated DRF treated with surgical intervention between 2 and 4 weeks from initial injury, with two or more follow-up visits prior to surgical intervention, were included. Exclusion criteria were patients with multiple injuries, surgical treatment with fewer than two clinical assessments prior to surgical treatment, or surgical treatment within 2 weeks of injury. The proportion of patients with delayed fracture displacement requiring surgical treatment will be reported as a percentage of all identified DRFs within the study period. A multivariable conditional logistic regression analysis was used to assess case-control comparisons, in order to determine the parameters that are mostly likely to predict delayed fracture displacement leading to surgical management. Intra- and interrater reliability for each radiographic parameter will also be calculated.

Results: A total of 210 case-controlled pairs were identified, with 81% being female and a mean age of 50.2 years (standard deviation = 14.1). Variables assessed in the model included prereduction and postreduction radial height, radial inclination, radial tilt on the lateral radiograph, volar cortical displacement, injury classification, intra-articular step or gap, ulnar variance, radiocarpal alignment, and cast index. Decreased prereduction radial height ($P<0.001$), decreased prereduction radial inclination ($P<0.001$), and increased prereduction volar cortical displacement ($P = 0.046$) were significant predictors of delayed fracture displacement beyond a minimum of 2-week follow-up.

Conclusion: Cast immobilization is not without risks and delayed surgical treatment can result in a prolonged recovery. Therefore, if reliable and reproducible prereduction and immediate postreduction parameters can be identified that predict delayed fracture displacement, this information will aid in counseling patients with DRFs, and may lead to earlier surgical intervention, when indicated.

The Circular Arc Curved Nail for Internal Fixation of Tibio-Talo-Calcaneal Arthrodesis

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Purpose: Normal anatomy demonstrates alignment of the heel, the subtalar facet, the talus, the ankle joint, and the distal tibia on a regular curve. This curve lies on a vertical plane that is slightly angulated inwards in relation to the sagittal plane. Today's hindfoot nails are either straight or bent. The hole that accommodates the implant is always straight and thus does not respect the normal alignment of the hindfoot. This technique may cause a plantar neurapraxia—the nail holds the calcaneus poorly and tends to create a hindfoot varus. The purpose of the study is to optimize the technique to stabilize the hindfoot in anatomical alignment.

Methods: An instrumentation was designed to create a circular arc bore hole crossing the heel, the posterior subtalar facet, the tibiotalar joint, and the distal tibia metaphysis. At the operation, the desired definitive position of the hindfoot is fixed temporarily with Kirschner wires. A guiding frame is fixed to 3 critical spots of the hindfoot to drill the central hole. Using an image amplifier, the hole is bored using a motor-driven end-cutting flexible reamer that is seated within a rigid curved hull. The nail has the same shape as the hull and is impacted up to the distal tibia. A distal locking screw crossing the subtalar joint and a proximal locking screw within the tibia concludes the central fixation. 47 patients (23 women and 24 men aging 30 to 84 years [mean age, 52]) have been treated so far using this technique. The diagnosis was basically primary and posttraumatic arthritis and includes diabetic arthropathies (4 cases) and failed total ankle replacement (3 cases). All patients were treated for 2 weeks postoperatively with a closed circular cast without weight bearing. After 2 weeks, our patients practiced partial weight bearing using a CAM (controlled ankle motion) walker for another 6 weeks.

Results: The mean follow-up time of the patient series is 3 years (range, 16-78 months). 2 patients with diabetic arthropathy died 2 years and 8 months and the other 8 months postoperatively after consolidation of the arthrodesis due to their primary disease. 3 cases sustained a deep infection that required a below-knee amputation in 2 cases and a calcanectomy in another case. Within the remaining 42 cases, 37 consolidated their arthrodesis within 2 months; 5 cases had a delayed union and 2 cases had to be revised for a nonunion—1 in the ankle, the other one in the subtalar joint. Patients with a good bone quality and anatomical hindfoot axes could bear their body weight entirely at 2 months.

Conclusion: The tibio-talo-calcaneal arthrodesis can be successfully treated using a central circular arc curved nail respecting a form-fit interaction between bone and nail. The anatomical osteoarticular alignment of the hindfoot is corrected or preserved. Due to the safe approaches, the technique allows for primary stability and prevents shortcomings such as neurological complications and nonunion. We expect a shorter period between surgical fixation and full weight bearing.

Incidence and Factors Associated with Infection on Patients' SIGN Nail Done for Long Bone Fractures in Tibebe Ghion Specialized Hospital, Bahir Dar, Ethiopia

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Purpose: Our objective was to estimate the incidence and to identify factors associated with surgical site infection after intramedullary nailing of long bone fractures in patients operated with Surgical Implant Generation Network (SIGN) nails in Tibebe Ghion Specialized Hospital.

Methods: The study was conducted using a retrospective cross-sectional study in patients who were admitted and operated with a SIGN nail from January 2018 to September 30, 2020 who fulfill the inclusion criteria. Cases with SIGN nails were reviewed and cases with infection were analyzed in particular. The data were entered and analyzed using SPSS windows version 23 software. Descriptive statistics like frequency tables and descriptive summaries were used to describe the variables. Binary logistic regression model was used to analyze the association between variables. Bivariable and multivariable logistic regression analysis was used and the results were presented in tables and charts. Odds ratios (ORs) were used to compare associations between dependent and independent variables.

Results: The overall incidence of infection was 5.2%. It varies with the nature and severity of injury, which is 10.7% in open fractures and 1.7% in closed fractures. In open injuries, infection rate increases as severity increases, accounting for 1.33%, 2.67%, and 10.67% for grade I, grade II and grade IIIA fractures, respectively.

Conclusion: The present study showed overall incidence of infection is comparable to lower middle-income countries but higher than developed countries. Time from injury to surgery, nature of fracture, pattern of fracture, and previous use of external fixator were found to be significantly associated with occurrence of surgical site infection. We recommend that more attention should be given to patients on SIGN nails for complaints around the surgical wound. Open and complex fractures are at risk of infection and we need to have appropriate measures to prevent infection. It is good to be cautious and look at predisposing factors for infection while doing nailing early and using external fixation.

Hip Fracture Care in the Elderly During the COVID-19 Pandemic: Is There an Association Between Confinement and Mortality in SARS-CoV-2–Negative Patients?

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Purpose: The SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) outbreak put unprecedented pressure on the healthcare system. At the same time, a "stay-at-home" indication was imposed. The lockdown generated a reduction in high-energy trauma, but patients with hip fractures continued to be referred to the emergency department. We analyzed hospital morbidity, mortality, and readmission rates at 30 days in COVID-19–negative hip fracture patients treated during the global pandemic and report on their outcomes.

Methods: We performed a retrospective cohort study of 77 recent and 470 historical hip fracture patients. Patients with hip fractures occurring between April 1, 2020 and June 30, 2020 or between April 1 and June 30, 2015/16/17/18/19 were enrolled in a hospital registry of elderly patients with hip fracture. The cohort was separated into 2 groups: «pre-COVID» (PC), including 470 patients, and «COVID» (C), consisting of 77 patients. All C patients tested negative for SARS-CoV-2. Patients were stratified based on demographic characteristics. Outcome measures were 30-day complications, readmissions, and mortality.

Results: Age, sex, type of fracture, time to surgery, and hospital discharge were similar between both groups ($P>0.05$). All C patients were American Society of Anesthesiologists class III or IV and had a higher score for Charlson and Clinical Frailty Scale ($P<0.05$). Both in-hospital (20, 7%) and 30-day (33, 7%) complication rates increased ($P<0.01$). Thromboembolic disease and blood transfusions were the most relevant. Readmissions (all negative for SARS-CoV-2) were similar between both groups ($P = 0.34$). No difference was detected for 30-day mortality ($P = 0.151$).

Conclusion: Patients in the C group, subjected to a prolonged lockdown, were more fragile and comorbid than the control group. Such characteristics translated into an increased number of complications following treatment.

Outcomes of Femoral Intertrochanteric Fractures in Elderly Patients: Has Anything Changed Over the Last Decade?

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Purpose: Over the past decade, significant policy changes in treatment of geriatric intertrochanteric fractures (ITFs) occurred worldwide. These have not skipped our center as well and included a tendency for the widespread use of cephalomedullary nails (CMNs) instead of sliding hip screws (SHSs) and faster time to surgery from admission, as mandated by national health policy changes. The aim of this study was to describe the outcome of patients treated surgically for ITFs regarding mortality, reoperation, and surgical complications over two separate decades at the same academic Level I trauma center.

Methods: A total of 485 geriatric patients with ITFs were selected from two different time periods. Two patient cohorts comprising 214 and 271 cases were treated in 2006-2007 and 2017-2018, respectively. Fracture AO/OTA classification was made by a fellowship-trained orthopaedic trauma surgeon and an orthopaedic trauma fellow. Patients' demographics, major comorbidities (divided into 6 major groups), surgery type, and time from admission to operation were retrospectively analyzed and correlated with clinical outcomes in terms of 30-day and 1-year mortality, length of stay, revision surgery, and complications.

Results: The comparison between the two study groups did not demonstrate significant differences in fracture subtypes (AO/OTA). Time from admission to surgery was significantly reduced in the 2017-2018 group with 87.8% (n = 237) of surgeries performed within 48 hours (mean time decreased from 37.55 hours to 31.56 hours [$P = 0.04$]). CMNs were used in only 5 patients in 2006-2007 (2.3%, n = 5), while extramedullary devices (Gotfried PCCP [percutaneous compression plate]) in 2017-2018 were the majority of fixation devices (57.4%, n = 155). Patients treated with CMNs had a longer hospitalization period compared to extramedullary-treated patients (mean operation to discharge, 8.95 and 7.23 days, respectively). Outcome measures, mortality rates (30-day, 1-year), rehospitalization, reoperations, and postoperative complication were similar among the two study groups.

Conclusion: Although our surgical practice has changed according to the general evidence-based guidelines (decreased admission to operation periods and increased use of intramedullary nailing devices for unstable fracture patterns), our clinical outcomes regarding mortality, reoperation, and major surgical complications remained the same.

Do We Need to Use the Largest Possible Size of the Proximal Femoral Nail Antirotation (PFNA) in Intertrochanteric Fracture? A Study of Distal PFNA Intramedullary Canal Occupying Ratio (ICOR)

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Purpose: The primary objective in this study is to evaluate the effect of proportion between the diameter of distal proximal femoral nail antirotation (PFNA) and diameter at intramedullary canal (intramedullary canal occupying ratio (ICOR) to bone union and complications. We hypothesized that higher ICOR would yield a higher rate of bone union. Secondary objective is to study the other factors that may affect bone healing.

Methods: Between January 2018 and January 2020, patients aged ≥60 years with unilateral intertrochanteric fracture treated with PFNA were retrospectively evaluated. Patients were divided into a high ICOR group (≥0.78) and low ICOR group (<0.78). The ICOR was calculated by measuring the ratio of distal PFNA diameter to diameter of intramedullary canal at femoral isthmus area in both-hip AP film. Bone union was evaluated using postoperative Radiographic Union Score for Hip (RUSH) method at 2 weeks, 6 weeks, and 3-month follow-up. Demographic data, AO classification, American Society of Anesthesiologists physical status (ASA), distal reaming status, RUSH, Baumgaertner reduction grade, tip-apex distance, estimated total blood loss calculated by Gross and Nadler method, intraoperative blood loss, length of stay, operation time, and postoperative pain score were compared between the 2 groups by using t and $\chi 2$ tests. The relationship of RUSH to ICOR and other parameters were assessed by multiple linear regression analysis.

Results: 115 patients were recruited in this study. 58 patients were allocated in high ICOR group and 57 patients were allocated in low ICOR group. The high ICOR group had average RUSH of 13.2 ± 1.5, 18.6 ± 1.9, and 27 ± 1.5 while low ICOR group had average RUSH of 13.8 ± 1.6, 18.6 ± 1.9, and 27.3 ± 1.5 at 2 weeks, 6 weeks, and 3 months, respectively. There was no significant relationship between RUSH and ICOR in all 3 time frames (P>0.1). The rate of bone union between the 2 groups was equal at 2 weeks (0% union) and 3 months (100% union). However, at 6 weeks, there was a higher rate of union in high ICOR group, even though there was no statistical significance (P = 0.64). However, the Baumgaertner reduction grade was actually the factor that affected the RUSH significantly (P<0.01).

Conclusion: None of the patients had bone union at 2-week follow-up (RUSH<18) and all of the patients had bone union at 3-month follow-up (RUSH ≥18). At 6-week follow-up, we found higher rate of bone union in high ICOR group but this was statistically insignificant. From multiple linear regression analysis, the quality of reduction showed significant relationship to bone union, which stresses the importance of good reduction over other evaluated factors in this study. Based on findings in this study, choosing the smaller size of PFNA (ICOR <0.78) in intertrochanteric fracture yields comparable bone union rate with larger nail size (ICOR ≥0.78). In addition, it can decrease the chance to perform intramedullary canal reaming.

Straight Nail Insertion Through Laterally Shifted Entry for Diaphyseal Atypical Femoral Fractures with Bowing: Good Indication and Limitation of the Technique

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Purpose: To achieve good quality of reduction in atypical femoral fracture (AFF) with anterolateral bowing is challenging but essential for favorable outcome. A simple technique, shifting the entry point of straight nail (piriformis fossa entry nail) laterally to the tip of the greater trochanter, has been introduced and used for treating AFFs with bowing. The current study aimed to determine the degree of bowing, which this nail entry shifting technique can successfully manage, by retrospective analysis of diaphyseal AFFs.

Methods: Diaphyseal AFFs treated with nail entry shifting technique at three institutions were retrospectively analyzed. 25 patients with 29 cases of diaphyseal AFFs, including 23 complete and 6 incomplete fractures, were analyzed. Radiologic parameters, including preoperative and postoperative bowing, location of nail entry and tip, union time, and complications were evaluated. The complete AFFs were divided into two groups according to the severity of the preoperative femur bowing: grade 0-II bowing and <20° lateral bowing (minimal or moderate deformity group, N = 15) and grade III bowing or ≥20° lateral bowing (severe deformity group, N = 8). Analysis according to the postoperative malalignment, ≥5° of lateral or anterior bowing change, was also performed.

Results: For the complete AFFs, a significant difference was found in preoperative lateral and anterior bowing between groups. Three out of 15 minimal or moderate deformity group showed >5° of lateral or anterior bowing change (malalignment) postoperatively. On the other hand, all the complete AFFs with severe deformity showed malalignment postoperatively. Change of bowing was significantly higher for severe deformity group in both lateral and anterior bowing (2.32° vs 5.13° for lateral bowing, 2.35° vs 7.59° for anterior bowing). Complications including iatrogenic fracture and nonunion showed no difference between groups. In the comparison according to postoperative malalignment, a significant difference was found for the percentage of severe deformity. Other parameters such as nail entry / tip location, fracture location (isthmic or infra-isthmic), and nail size did not significantly differ between well-aligned and malalignment groups. All incomplete AFFs were united without complication. There was no case of severe deformity for incomplete fractures.

Conclusion: Straight nail insertion through laterally shifted entry was found to be a simple method to manage diaphyseal AFFs with grade 0-II bowing and <20° anterior bowing successfully. However, for AFFs with more severe deformity, malalignment was found in all cases. Therefore, for AFFs with grade III bowing or ≥20° anterior bowing, other techniques such as inserting a contralateral nail or plating should be considered.

Analysis of Blood Loss Prior to Admission, Due to the Wait for Theater and Due to Surgery in Hip Fracture Patients

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Purpose: Perioperative hypotension is a risk factor for mortality in hip fracture patients. We have accepted the role in major trauma patients for aggressive resuscitation, major transfusion protocols, and early administration of tranexamic acid (TXA), but not in hip fracture patients. Do we underestimate the blood loss caused by fracture prior to arrival in the Emergency Department (ED) and the ongoing blood losses prior to surgery? The aim of this study was to determine and investigate the effect on outcome, of blood loss in the interval between (1) injury and admission, (2) ED and theater, and (3) operative losses in the first 24 hours.

Methods: All patients admitted with a hip fracture over 12 months to a Level I trauma center having a full blood count (Hb/Hct) within 90 days prior to admission, on admission, immediate preoperative, and day 1 postoperative were included. Blood loss was determined using the Nadler and Mercuriali methods, accounting for transfusions between blood samples. Three intervals were compared: injury losses pre-ED (T1), interval ED to surgery (T2), and operative losses for first 24 hours (T3). Interval blood loss, fracture type, anticoagulants, and surgery type were analyzed, along with the effect on transfusion rates and mortality.

Results: Of 936 patients, 366 were eligible for inclusion and had full data sets including preinjury Hb/Hct within 90 days prior to fracture. Median age was 82.5 years with a female predominance (67.5%). Intracapsular (IC) fractures were more common (59.6%). Modal American Society of Anesthesiologists (ASA) grade was 3. Oral anticoagulants were present in 52.5% of patients. Blood loss was significantly higher for extracapsular (EC) fracture at each time point versus IC fractures (all $P<0.01$). Overall, median blood loss from injury to day 1 postoperative were significantly higher for EC fractures versus IC fractures (490.4 vs 244.1 mL; $P<0.001$), AO A3>A2>A1 vs IC fracture types (843.6 vs 556.6 vs 290.0 vs IC 244.1; $P<0.001$) and higher for those receiving an intramedullary nail versus a dynamic hip screw, hemiarthroplasty, or total hip replacement (674.8 vs 314.5 vs 224.9 vs 255.2, respectively; $P<0.001$). Largest median blood loss was seen at T3>T1>T2 (172.4 vs 49.8 vs 49.5; $P<0.001$). Preoperative transfusion (T2) rate was 63/366 (98 units) versus 68/366 (82 units) postoperatively (T3), which was not significantly different ($\chi2(1) = 0.232$; $P = 0.6297$). Mortality was 5.7% at 30 days, and 27.9% at 1 year. At 1 year, mortality was higher for males versus females (44.5% vs 19.9%; $P<0.001$), a procedure that was not a total hip replacement ($P = 0.017$), and those on anticoagulant medication (32.8% vs 29.7%; $P = 0.035$).

Conclusion: Blood loss in hip fracture patients is significant, even prior to surgery. EC fractures subsequently treated with intramedullary nailing (A3) have the largest blood loss at all time points. There is significant blood loss and transfusion demand as a result of the injury, and the wait for surgery. TXA administration at time of diagnosis may mitigate against this.

The Impact of Aging on Mortality Following Subtrochanteric Fractures

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Purpose: The aim of this study was to define the incidence and investigate the risk factors associated with mortality and medical complications, in patients presenting with subtrochanteric femoral fractures and subsequently treated with an intramedullary nail, with a special reference to advancement of age.

Methods: A retrospective review, covering an 8-year period, of all patients admitted to a Level I trauma center with the diagnosis of subtrochanteric fractures was conducted. Normality was assessed for the data variables to determine the further use of parametric or non-parametric tests. Logistic regression analysis was performed, to identify the most important risk factors for each event. A P value <0.05 was considered significant.

Results: A total of 545 patients (561 fractures) were included in our study. The average length of hospital stay was 22.5 days (median: 18 days; standard deviation [SD]: 18.6 days). Mortality was 6.0% and 20.8% for 30 days and 1 year, respectively. Pathological fracture was the most important risk factor (odds ratio [OR] 12.835) for mortality. Other risk factors included CCS (Charlson Comorbidity Score) >6 (OR 3.607), low albumin on admission (OR 3.664), dementia (OR 3.282), and presence of chest infection during hospital stay (OR 2.645). The incidence of venous thromboembolism (VTE) was 3.9% while the incidence of cardiac events/CVA (cerebrovascular accidents) was 4.1%. Increasing age and American Society of Anesthesiologists class (ASA) had a direct correlation to an increasing incidence of cardiac events/CVA; mortality within this group was also higher. The incidence of hospital-acquired pneumonia (HAP) was 16.6%, and the risk increased with increasing CCS (OR 4.190 to 6.309), presence of asthma/chronic obstructive pulmonary disease (COPD) (OR 2.355), ICU/HDU (high dependency unit) stay (OR 2.864), and a length of stay >21 days (OR 2.580). The incidence of postoperative delirium was 10.0%, with dementia (OR 3.969), chest infection (OR 1.983), urinary tract infection (UTI) (OR 3.587), history of asthma/COPD (OR 2.726), deteriorating renal function postoperatively (OR 2.565), and need for an increased level of care (OR 2.953) presenting as risk factors. Finally, there was no evidence of the so called «weekend effect» on mortality.

Conclusion: Our study has opened the field for the investigation of medical complications within the subtrochanteric fracture population. Identification and modification of the risk factors for complications and mortality will help decreasing the incidence and prevalence of a poor outcome.

Pseudoaneurysm Following Intramedullary Nail Fixation of Hip Fracture: Recognizing and Avoiding a Rare But Dangerous Complication

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Purpose: Pseudoaneurysm is a potentially life-threatening, but rare, complication of hip fracture. Reports of delayed diagnosis have been published, highlighting the need to increase awareness. We analyzed a case series to identify the presenting features to aid earlier recognition and prevention where possible.

Methods: A single major trauma center (Shaare Zedek Medical Centre, Jerusalem, Israel) database search was performed for all pseudoaneurysms following hip fractures over a 4-year period (1 January 2016 until 31 December 2019). The etiology, presenting features, diagnosis, and treatment were examined.

Results: Six patients out of 1919 (0.31%) treated for hip fracture had a consequent pseudoaneurysm. All 6 had intertrochanteric fractures, and all lesions involved the profunda femoris artery. Two pseudoaneurysms were caused by direct trauma from a sharp lesser trochanter fragment. Three were iatrogenic, caused while drilling the distal locking screw. In one case the etiology was undetermined. All patients suffered from a triad of symptoms: greater than expected thigh pain, thigh swelling/bruising, and reduced hemoglobin despite transfusion. The median hemoglobin drop was 39 g/L (interquartile range [IQR] 19). A median of 3.5 units (IQR 6) of red blood cells were transfused over a median 4 days (IQR 12). All lesions were confirmed via CT angiography and treated by embolization. In cases caused by the fracture, time to diagnosis was calculated from admission; in iatrogenic cases it was calculated from surgery. In 5 patients the median time to diagnosis was 6 days (IQR 5.5). One patient's pseudoaneurysm was diagnosed as a late sequala at 50 days postsurgery, requiring 21 units of red blood cells before diagnosis.

Conclusion: We identified two causes of pseudoaneurysm following hip fracture: direct trauma from the fracture and iatrogenic (whiie drilling the medial cortex). Care must be taken when drilling locking screws. Pseudoaneurysm should be considered for unexplained/continued blood loss following intertrochanteric fractures.

Do Increased Parental Presence, Reduced Outdoor Sports Activities, and School Attendance Affect the Incidence of Pediatric Trauma Requiring an Operative Intervention? A Matched Cohort Study Before and During the First and Second COVID-19 Lockdown Periods in the UK

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Purpose: In the UK, during the first wave of the COVID-19 pandemic, a national lockdown (FLD) was initiated necessitating people to stay at home with limited outdoor sporting activities and schools were closed for children. During the second wave, a second lockdown (SLD) was initiated, necessitating people to stay at home with limited outdoor sporting activities; however, schools remained open for all children. Our aim was to evaluate if increased parental presence, reduced outdoor sports activities, and school attendance affect the incidence of pediatric trauma requiring an operative intervention in the UK.

Methods: This was a retrospective single center study that evaluated all pediatric patients (age <16 years) who had injuries requiring an operative intervention during the FLD and SLD. The FLD period in this study was between March 22, 2020 and June 22, 2020. The SLD period was between Novermber 5, 2020 and December 2, 2020. To establish the effect of a national lockdown on the incidence, and accommodate this into our investigation, pediatric patients who had injuries requiring an operative intervention pre-COVID-19 between March 22, 2019 and June 22, 2019 were also analyzed. Demographic data, the type of injury sustained, and the operative intervention performed were collected and analyzed. The absolute percentage of each was then used to make the comparisons.

Results: During the FLD, 47 operations were performed on 46 patients with an average age of 9 years. Manipulation under anesthetic (MUA) was performed in 32% of the cases, Kirschner-wire (K-wire) fixation in 26%, open reduction and internal fixation (ORIF) in 13%, and 23% had washouts for exposed wounds. 28% had a distal radius fracture (DRF), 13% had a supracondylar humeral fracture (SCHF), 17% had hand injuries with exposed wounds (HIW), and 15% had lower limb fractures (LLFs). During the SLD, 15 operations were performed on 14 patients with an average age of 10 years. MUA and K-wire fixation was performed in 20%, ORIF and washouts in 7% of the cases. 20% had a DRF, none had an SCHF, 7% had HIW, and 7% had LLFs. During the pre-COVID-19 pandemic period, 110 operations were performed on 110 patients with an average age of 9 years. MUA and K-wire fixation was performed in 33% and 11% of the cases, respectively. 19% had an ORIF and 13% had washouts. 34% had a DRF, 5% had a SCHF, 5% had HIW, and 4% had LLFs.

Conclusion: The COVID-19 national lockdown has reduced the overall incidence of pediatric trauma requiring an operative intervention in the UK. Comparison between the FLD and pre-COVID-19 has shown reduced incidence of DRF and LLF that required an operative intervention. Comparison between the FLD and SLD, investigating the effect of school attendance, has shown an overall reduction in the operative interventions performed for pediatric trauma in all the different categories. From our study, we conclude that increased parental presence, reduced outdoor sports activities, and school attendance reduces the overall incidence of pediatric trauma requiring an operative intervention.

Shear's Role in Nonunion: Defining the Mean Angle of Long Bone Multifragmentary Nonunions

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Purpose: Both mechanical and biological theories have been proposed in the development of nonunion. With respect to mechanical theory, it is specifically the strain environment of a fracture that may predispose it to nonunion. In multifragmentary fractures, a nonunion may form along any of the original fracture lines; however, the plane that experiences the highest strain is at 45°—the shear plane. We hypothesize that in multifragmentary fractures the initial fracture line that most often fails to unite will tend toward 45°. The aims of this study are (1) to define the mean angle of nonunion in a cohort of tibial and femoral multifragmentary fractures and (2) to define the mean angle of initial fracture planes within tibial and femoral multifragmentary fractures that go on to form a nonunion.

Methods: A retrospective cohort study of patients requiring treatment for diaphyseal or metaphyseal nonunions in the tibia or femur was performed. Those with multifragmentary fractures were included. A published technique was utilized to measure fracture and nonunion angles. The initial fracture and nonunion radiographs were compared to determine which initial fracture plane matched the plane of the nonunion. Both the initial fracture angles and resultant angle of established nonunions were recorded from AP and lateral radiographs. The mean angle of both the initial fracture plane resulting in a nonunion and the mean angle of nonunion were calculated.

Results: 183 nonunions were screened; after exclusions, 68 patients (mean age 46 years, range 20-84, M:F 52:16) were included. 40% of the fractures had 4 or more fragments. 33% of the fractures were femoral and 67% tibial. The mean angles of initial multifragmentary fracture planes resulting in nonunion were 49° (standard deviation [SD] 18) on AP and 48° (SD 17) on lateral views. The mean angles of nonunion were 50° (SD 19) for both AP and lateral views.

Conclusion: In patients with multifragmentary fractures that go on to nonunion, both the angle of the initial fracture that goes on to nonunion and the nonunion angle tend toward 45°. This supports the mechanical theory that strain from the shear plane is an important factor in the formation of nonunions.

Managing Tibial Bone Defects: Analysis of Direct Medical Costs Between Distraction Osteogenesis With an Ilizarov Frame and the Masquelet Technique

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Purpose: Successful management of segmental bone defects remains one of the biggest clinical challenges. Primary aim was to define the direct medical cost of the surgical treatment of tibial bone defects in a single tertiary referral center. Secondary end points were (1) to compare the direct cost between Ilizarov bone transport (ILF) versus the internal fixation staged Masquelet (MIF), and (2) to compare the direct cost between cases of acute tibial bone loss versus bone loss generated during the treatment of infections/nonunions.

Methods: Prospectively collected data were analyzed. Patients <18 years of age or with follow-up <12 months were excluded. Random selection of patients treated with MIF or ILF was performed. Data included demographics, comorbidities, severity of trauma, defect size, duration of surgery, exact numbers of sterile kits and types of implants, transfusions, laboratory and imaging investigations, medications, length of hospital stay, visits to clinics, time to union, and time to final discharge. A cost-effectiveness analysis was performed including full inpatient, intraoperative, and follow-up direct medical costs. As the end point of clinical efficacy, the time to union of the bone defect was used. We have utilized the records of the finance departments of our hospital, the 2019/2020 National Tariff, and the British National Formulary, as well as the price list from industry partners in regard to all utilized implants.

Results: 10 patients with acute and 10 with nonunion defects, treated half with ILF and half with MIF, were included. The mean defect size was 5.6 cm (range, 2.7-9.5), the mean time to union was 12.9 months (4.6-22.2), with an overall cost of £453,974. No statistically significant difference (ssd) was proven to the mean age, ISS, American Society of Anesthesiologists class, defect size, follow-up duration, length of stay, and cost of inhospital stay. The overall direct medical cost of the MIF group was 74% of that of the ILF. There was ssd favoring the MIF group on the average time to union (10 vs 15.6 months, $P = 0.02$), the number of surgical procedures (3 vs 4, $P = 0.049$), the number of admissions (2 vs 3, $P = 0.026$), the intraoperative cost (£8857 vs £14,087, $P = 0.001$), the cost of outpatient clinic follow-up (£2147 vs £5240, $P<0.001$), the cost per cm of defect (£1935 vs £3799, $P = 0.047$), and the overall cost of treatment (£18,131 vs £26,126, $P = 0.011$). No ssd of cost was found between acute and nonunion defects managed with an ILF. When the MIF was used, the mean time to union (7.91 vs 12.67 months, $P<0.001$), as well as the cost of outpatient follow-up (£1368 vs £3122, $P<0.001$) were significantly lower on acute versus nonunion defects.

Conclusion: The successful management of segmental tibial defects requires surgical expertise, time, and significant resources. There were clear differences in the direct medical costs between the 2 most common procedures. Even with an uncomplicated clinical course, the high cost of the implants, the considerable time until defect union, and the need for follow-up and secondary procedures highlight the importance of robust reimbursement, since both techniques are indispensable.

LagLoc: A New Surgical Technique for Locking Plate Systems

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Purpose: Treatment of oblique and spiral fractures still remains challenging. The aim of this study was to introduce and investigate the new LagLoc technique for locked plating of such fractures with generation of interfragmentary compression, combining the advantages of lag screw, locking-head screw, and far-cortical screw techniques.

Methods: Oblique fracture was simulated by a 30° osteotomy in 18 artificial diaphyseal bones, assigned to three groups for plating with a 7-hole locking compression plate. Group I was plated with three locking screws in holes 1, 4, and 7. The central screw crossed the fracture line. In group II, the central hole was occupied with a lag screw perpendicular to the fracture line. Group III was instrumented applying the new LagLoc technique as follows. Hole 4 was predrilled perpendicularly to the plate, followed by overdrilling of the near cortex and insertion of a locking screw whose head was covered by a holding sleeve to prevent temporarily the screwhead from locking in the plate hole and thus generate interfragmentary compression. Subsequently, the screwhead was released and locked in the plate hole. Then holes 1 and 7 were occupied with locking screws. Interfragmentary compression in the fracture gap of all specimens was measured using pressure sensors.

Results: Interfragmentary compression in group I (167 ± 25 N) was significantly lower in comparison to groups II (431 ± 21 N) and III (379 ± 59 N), the latter representative for the new LagLoc technique, $P \leq 0.005$. The difference in compression between group II and III remained not significant ($P = 0.999$).

Conclusion: The new LagLoc technique offers an alternative tool to generate interfragmentary compression using locking plates. It unites the biomechanical and clinical advantages of lag screw, locking screw, and far-cortical locking screw fixations and can be recommended for treatment of oblique and spiral fractures.

The Mexican Hip Fracture Registry:
A Proposal and Methodology for the Latin-American Population

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Purpose: In Latin America and the Caribbean (Latam), with a multi-ethnic population above 669 million people and increasing elderly population, the incidence and prevalence of osteoporosis and hip fractures are high, together with a limited access to diagnostic tools and therapy. This has led hip fracture to be an important personal, social and economic burden. For 2050 we expect to double the number of hip fractures in Latam countries. No hip fracture registries exist in Latam. Hip fracture registries allow us to measure the problem magnitude and real epidemiology. That will allow making more efficient guidelines at a national level and the proper health policy changing.

Methods: Through an analysis of the different social determinants, health systems, care work models, and epidemiological scenarios on medical care for hip fractures, a group of experts from 3 specialties (orthopaedic surgeons, geriatricians, and bone metabolism experts) use the MCD (Minimum Common Dataset) created by the FFN (Fragility Fracture Network) as a framework and the variables were adapted to make them suitable for the Latam situation.

Results: We propose that the data registry of each patient be made up of 31 multiple-choice variables, the first 27 being answered during the patient›s hospitalization (Table 1) and in a follow-up visit 30 to 45 days after the initial event. The data collection is completed with 4 multiple choice variables where mortality, complications, ambulation, and treatment of osteoporosis are assessed.

Conclusion: Through this dataset, we can help Latam start with a local or national Hip fracture registry by using the same database, which will help to compare and improve the care of hip fractures with an international perspective.

Chart 1
Hip fracture registry proposed variables.

-	**Pre-fracture residence**	-	**Type of surgery**
-	**Number of comorbidities**	-	Type of anesthesia
-	**Functional Ambulation Categories (FAC) score**	-	Duration of surgery
-	**Ambulation device use. (FAC segment)**	-	Need for blood transfusion
-	**Pfeiffer scale**	-	Mobilization first 48 hours (sitting outside bed)
-	**Pre-fracture independence level (career response)**	-	Walking in the first 4 days or hospital discharge
-	**Pre-fracture Osteoporosis treatment.**	-	Presence of delirium
-	**ASA score**	-	Presence of pressure ulcers
-	**Type of fracture AO/OTA**	-	Mortality
-	**Side of the fracture**	-	In-hospital other complication
-	**Pathologic fracture presence**	-	Discharge osteoporosis treatment
-	**Associated fractures**	-	Discharge anticoagulation
-	**Time from initial attention to surgery.**	-	Destination at discharge.
-	**Medical Specialties who treat the patient**		

Elderly Hip Fracture During the COVID Pandemic: What We Are Learning

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Purpose: In December 2019, when the first cases of COVID-19 appeared, we were not able to predict the spreading capacity or infectious aggressiveness of this virus. European health services have been blocked to control this pandemic state. Orthopaedic departments have reduced their activities just for treating emergent and urgent pathologies such as hip fracture. The goal of this study is to describe and analyze hip fracture COVID-positive patient outcomes and compare them with those observed in COVID-negative patients.

Methods: This is an observational, retrospective, descriptive study. We have registered clinical and demographic data from 43 patients who were admitted to the emergency department of Hospital Universitario Gregorio Marañón with a hip fracture, from March 14 until April 22, 2020. The minimum follow-up was 19 days.

Results: We registered 43 patients, 10 men and 33 women. 9 were COVID-19-positive. Seven patients died in the first month (5 of them were COVID-19-positive), achieving a mortality rate of 62.5% in COVID-19-positive patients and 9% in noninfected patients. Half of the COVID-19-positive patients showed pneumonic signs on the chest radiograph.

Conclusion: COVID-19 is a single risk factor for death after surgery.

The Effect of Anterior Support Screw (AS2) for Unstable Femoral Trochanteric Fractures: A Multicenter Randomized Controlled Trial

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Purpose: The importance of reduction is recognized in the treatment of unstable femoral trochanteric fractures. There are many opinions that bony support of the anterior medial part is particularly important. We devised a new technique to add a screw anterior to the nail in order to prevent reduction loss (anterior support screw [AS2]).

Methods: A multicenter, prospective, randomized controlled trial was conducted to verify the effect of this procedure for unstable femoral trochanteric fractures. The subjects of this study were femoral trochanteric fractures with posterior comminution and intramedullary displacement of proximal fragments. The results of previous studies indicate that this study requires 240 cases. Then, 240 patients were enrolled at 15 institutions. All cases were randomly divided into 2 groups, an additional screw group (AS2 group) and a no-additional screw group (control group). Three cases dropped out during the course, resulting in 118 cases in the AS2 group and 119 cases in the control group included in the final analysis. ZNN CM Asia nail (180-mm length) was used in all cases, and 5.0-mm cannulated screw was added to AS2 group. CT scans were taken twice for each case, immediately after surgery and within 3 weeks after surgery (14-21 days after surgery). Medial bony contact in the AP view and anterior bony contact in the lateral view were evaluated, and sliding distance was also measured.

Results: There was no difference in the rate of reduction loss in the AP view between the 2 groups, but there was a significant difference in the lateral view. The rate of reduction loss was 5.5% in the AS2 group and 18.6% in the control group. The average sliding distance was 1.8 mm ± 1.4 mm in the AS2 group and 2.8 mm ± 2.1 mm in the control group. The rate of reduction loss was significantly lower in the AS2 group ($P = 0.003$), and the sliding distance was significantly smaller in the AS2 group ($P<0.0001$).

Conclusion: Our method of adding AS2 to intramedullary nail fixation for unstable femoral trochanteric fractures with posterior comminution was found to be effective in maintaining anterior bony contact in the early postoperative period. The sliding distance was also reduced.

A Five-Year Experience with Dualis Cups

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Purpose: The concept of dual mobility (DM), introduced by Gilles Bousquet in 1974, is currently approved as a valid option for reducing the risk of dislocation, with an incidence ranging from 0.5% to 10%. The principle is to achieve a high joint stability through a large diameter polyethylene (PE) liner, and to reduce cutting forces due to a «low-friction» head-liner coupling mechanism. The purpose of this paper is to prove that DM is the most effective system in reducing the postoperative risk of dislocation and revision surgery, followed, in order, by the use of large femoral heads, constrained liners, and conventional single mobility prostheses.

Methods: From March 2015 to March 2020, 138 patients were treated with uncemented Dualis cups for a total of 141 Dualis cups implanted (3 cases were bilateral). The average age at the time of the surgery was 77 years (range, 46-94). Patients' clinical and radiographic follow-up was at 1, 3, 6, 12 months, and then once a year.

Results: All cases were retrospectively reviewed to assess complications. Eight patients were lost due to death. Nine patients had less than 6-month follow-up, so they were excluded from the mid-term evaluation of cup survival, which was carried out on the remaining 124 hips. Seven patients (5%) had complications that required a second surgery, but only 1 (0.7%) was directly ascribable to the DM cup—a case of intraprosthetic dislocation that required cup revision. No other Dualis cup showed radiographic evidence of loosening, obtaining a cup survival rate of 99.2% (95% confidence interval 94.8%-99.9%) at 5 years; the Kaplan-Meier method was used to run the analysis. Other complications found are common to all total hip arthroplasties, regardless of the implant used. One patient suffered from a periprosthetic fracture following a new trauma and was treated with plate fixation. One patient needed a periprosthetic ossification removal 1 year after the first surgery. Four patients underwent debridement and liner-head replacement due to early infection.

Conclusion: Improvements in design and materials of the third generation DM cups allowed both to reduce the rate of dislocations in high-risk patients (ie, patients with neuromuscular deficits and cognitive disorders, patients needing revisions, osteosynthesis failures, femoral neck fractures) and to achieve a survival rate similar to standard cups, ensuring a range of motion very close to the physiological one. However, placing DM cups on the market again reopened the debate on increasing metal ion blood levels. In our brief experience, Dualis cups showed results comparable to those reported in the literature for DM. If these data are confirmed by long-term studies, the use of DM cups could be extended even for young patients with high functional demands.

Midterm Outcomes After the Surgical Treatment of Atypical Femoral Fractures: Minimum 3-Year Follow-up

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Purpose: The incidence of atypical femoral fractures (AFFs) continues to increase. However, there are currently limited long-term studies on the complications of AFFs and factors affecting them. Therefore, we attempted to investigate the outcomes, complications, and affecting risk factors for complication through mid-term follow-up of more than 3 years.

Methods: From January 2003 to January 2016, 305 patients who underwent surgery for AFFs at 6 hospitals were enrolled. After exclusion, a total of 147 patients were included. We retrospectively evaluated medical records, and reviewed radiographic images to investigate the fracture site, femur bowing angle, presence of delayed/nonunion, contralateral AFFs, and peri-implant fracture. Statistical analysis was performed on the affecting factors.

Results: The mean follow-up period was 70.2 months (range, 36-191). There were 146 cases (99.3%) in women and the average age was 71.6 years (range, 48-89). The subtrochanter and shaft fractures were in 52 cases (35.4%) and 95 cases (64.6%), respectively. The preoperative mean anterior/lateral femoral bowing angle were $10.5° \pm 5.7°/6.1° \pm 6.2°$. The postoperative mean anterior/lateral bowing value were changed by $8.7° \pm 5.4°/4.6° \pm 5.9°$, respectively. Bisphosphonates were used in 115 cases (78.2%) for an average of 52.4 months preoperatively. Nailing was performed in 133 cases (90.5%), and bony union was obtained at an average of 23.6 weeks (range, 7-85). Delayed union occurred in 41 cases (27.9%), and nonunion occurred in 13 cases (8.8%). Contralateral AFF occurred in 79 cases (53.7%), and the use of a bisphosphonate significantly influenced the occurrence of contralateral AFFs ($P = 0.019$). Peri-implant fractures occurred in a total of 13 cases (8.8%), and a significant increase was observed in cases with plating ($P = 0.021$) and high-grade postoperative anterolateral bowing ($P = 0.044$).

Conclusion: The use of a bisphosphonate was found to be a risk factor for contralateral AFF, and high-grade postoperative anterolateral bowing and plate fixation significantly increased the occurrence of peri-implant fractures. Therefore, long-term follow-up studies on the bilaterality of AFFs and peri-implant fractures are necessary.

Postoperative CT Scan Findings and Functional Outcome in Patients Treated by Syndesmotaxis with an Ilizarov External Fixator for Tibial Plateau Fractures

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Purpose: We evaluated postoperative CT scan findings and the clinical outcome of tibial plateau fractures treated by syndesmotaxis with an Ilizarov external fixator.

Methods: This was a prospective study spanning between March 2010 and September 2018 involving 45 patients with a mean age of 39.5 years. Inclusion criteria were tibial plateau fractures Schatzker II to VI, in patients aged over 18 years. All of the patients were treated by syndesmotaxis with the application of an Ilizarov external fixator, with knee-bridging and mini-open reduction. Pre- and postoperatively, the patients underwent a CT scan of the knee, and the postoperative functional outcome was assessed according to the American Knee Society Score (AKSS). Mean follow-up was 12 months. Statistical analysis was carried out using SPSS version 21.00 (IBM Corporation).

Results: According to postoperative CT scan and articular impaction, the patients were divided into three groups. Eleven patients had less than 2 mm of impaction, 27 had 2 to 4 mm, and 7 had >4 mm. Patients with an articular impaction less than 4 mm showed a 95% chance for an excellent AKSS, in contrast to those with a greater impaction who presented with poor AKSS results. Every additional 1 mm of articular impaction reduced the AKSS by 15 points, as proved by the very high value of R2 in statistical analysis. An up to 5° deviation of the mechanical axis compared to the other limb presented a positive correlation to a good clinical outcome without being related to AKSS.

Conclusion: Syndesmotaxis combined with an lIizarov external fixator with knee-bridging and mini-open reduction provides adequate stabilization and restores the articular surface. CT scan of the knee is the sole most valuable imaging tool for preoperative planning no matter which classification system is used. Postoperative articular impaction is a useful prognostic tool for the final functional result.

Flexion-Distraction Fracture of the Pelvis: Review of the Literature and a Conceptual Classification

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Purpose: Pelvic fractures make up 16% of all major trauma. They represent high-energy trauma associated with a high mortality rate (31%). The majority of these fractures are classified using the common classification systems, ie, Young and Burgess or Tile classifications. Some fracture patterns, however, do not fit into any fracture classification system. We present a rare case of a flexion-distraction fracture of the pelvis with a proposed conceptual classification. The aim of this report is to highlight a rare pelvic injury treated in a South African Tertiary Hospital. Secondly, we propose a conceptual classification for this injury pattern based on other clinical case observations of atypical injuries that also seem to mimic this injury pattern. A management algorithm forms part of our proposal.

Methods: A 26-year-old male presented to the emergency department following a head-on high-energy motor vehicle collision. He was a restrained driver and sustained multiple injuries, including intraperitoneal urinary bladder rupture, blunt renal and hepatic trauma, left midshaft femur fracture, bilateral ankle fractures (open fracture on the right), right talus fracture, and lastly a bilateral symmetric transverse fracture of the iliac wings also involving the sacrum. This was associated with a Morel-Lavallée lesion, which was debrided and had a washout with vancomycin powder mixed in saline wash. He had sensory paresthesia in the S2-S5 region. Clinically, motor function of upper and lower limbs was unaffected. Debridement and fixation of the open ankle injury was undertaken with subsequent wound closure in the second sitting. He also underwent an antegrade intramedullary femur nail for the left femur. He required a long stay in the ICU for improved ventilation. The pelvic fracture was treated surgically by the first author.

Results: At 6-month follow-up, the patient was fully mobile and pain-free from the pelvic fracture. No adverse events were documented.

Conclusion: Symmetrical bilateral transverse fracture of the pelvis is an extremely rare injury. This fracture does not fit into any existing classification system. This is associated with high-energy trauma and management should focus on life-threatening injuries first. On the basis of the limited available literature, the fracture is associated with a relatively good prognosis and a good functional outcome can be expected. We present the first conceptual classification to help guide surgeons› clinical decision-making. Understanding that what is rare now may not be in the future, we hope to have added value to the body of science.

Treatment of APC II Pelvic Fractures: Variables That Affect the Outcomes

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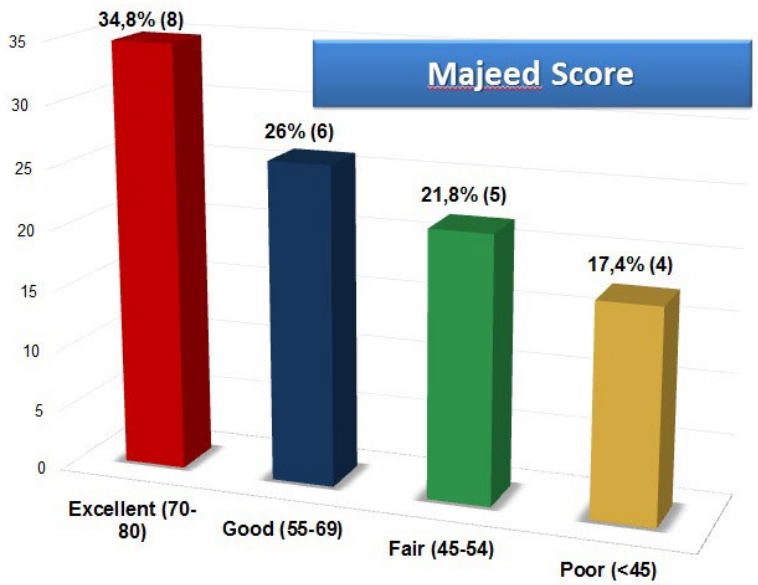
Purpose: Pelvic fractures are frequently associated with high-energy trauma. Mortality varies from 5% to 46%. In patients with unstable pelvic ring fractures, the factors related to poor outcomes are still controversial. The purpose of this study is to evaluate which variables affect the long-term outcomes of the treatment of an anterior-posterior compression type II pelvic fracture (APC II; AO/OTA: 61B2.3).

Methods: In this retrospective study with Level-III evidence between 2014 and 2018, 79 cases were analyzed and 23 patients remained for evaluation according to inclusion and exclusion criteria. We evaluated pelvic radiographs (AP, inlet, and outlet) and CT scans. Young and Burgess classification was used to define fracture pattern and Majeed score for clinical results. The following variables were analyzed: treatment at emergency, associated injuries, delay for definitive fixation, method of fixation, quality of immediate postoperative reduction, and surgical site infection. Each variable was studied and compared with the Majeed clinical score between groups (Student t test).

Results: We did not find any statistically significant association between the type of treatment at emergency and the long-term clinical outcome. No statistically significant association was found between the clinical outcome and the associated injuries. Patients with less than 7 days of delay to surgery obtained better functional results. Better functional results were obtained in patients who were treated with a pubic plate fixation combined with posterior percutaneous sacroiliac screws. Better functional results were obtained with postoperative reduction of less than 1 cm. Patients with surgical site infection obtained poorer functional results.

Conclusion: The variables cited (delay for definitive fixation, method of fixation used, quality of immediate postoperative reduction, and surgical site infection) in patients with APC II pelvic fracture had a strong relation with long-term functional and clinical outcomes.



Distal Tibial Nonunion Treated with a Tibial Nail Using Distal Angular Stable Locking Screws: Reliable and Patient-Friendly

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Purpose: Distal tibial nonunion after failed primary surgical treatment of distal tibial fractures is a challenging problem in which the best surgical treatment is not well established. Stability of the construct is a key principle for successful outcome. Our hypothesis is that intramedullary nailing using distal angle-stable screws is an effective operative technique with a low rate of soft-tissue complications allowing immediate weight bearing.

Methods: This is a case series of consecutively collected patients with distal tibial nonunion treated by a single surgeon with the expert tibial nail during the period from 2010 to 2019. Patients were allowed to immediately fully weight-bear. Failure is defined as need for revision surgery to obtain bridging callus. Postoperative radiographs and postoperative complications were recorded.

Results: 18 patients met the criteria, of whom 7 patients could be analyzed (3 F, 14 M). Average age was 46 years (range, 22-66). Among initial injuries were 11 open fractures and 4 had involvement of the pilon. 12 patients were primarily treated with plates, 3 with nails, and 2 with external fixation. 8 developed infection. Nonunion level was between 2 and 10 cm. Average follow-up was 19 months (range, 6-62 months). Full weight bearing was possible after an average time of 2 weeks (range, 3 days-5 weeks). Radiographic bridging callus was achieved in all patients at an average time of 16 weeks (range, 12-36 weeks). Grafts were applied in 9 cases, of which 8 autograft and 2 allograft bone chips were impregnated with vancomycin. There were no secondary displacements. 3 needed removal of the nail due to continuing infection, 1 correction of malrotation, and 1 addition of autograft.

Conclusion: The use of an expert tibial nail with distal angular stable locking screws in a distal tibial nonunion is a very effective method to achieve bony union even in periarticular located tibial nonunions and in the presence of an active infection. The high stability of the construct allows immediate weight bearing with minimal risk for secondary displacement.

Prospective Study: Functional Results of the Reverse Shoulder Fracture Prosthesis Versus Conservative Treatment and Plate Osteosynthesis in Displaced Multipart Proximal Humerus Fractures

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Purpose: Despite the PROFHER (PROximal Fracture of the Humerus: Evaluation by Randomisation) trial that proposes conservative treatment for all proximal humerus fractures (PHFs), the optimal treatment for displaced PHFs remains controversial, especially complex fractures with 3 or 4 displaced parts. PROFHER did not distinguish complex PHFs from mildly displaced fractures, and furthermore complex 3- and 4-part fractures were underrepresented. Sound evidence guiding us in the treatment of complex displaced multipart PHFs is therefore still required. Our hypothesis is that the reverse shoulder arthroplasty (RSA) reduces pain and increases functional results in comparison to conservative treatment in displaced multipart PHFs.

Methods: In this case-control study, patients were included with a multipart PHF that were treated with an RSA. At 1-year follow-up, three questionnaires were administered: Constant Shoulder Score (CSS), the Oxford Shoulder Score (OSS), and the Disabilities of the Arm, Shoulder and Hand (DASH) score. Pain was assessed through the visual analog scale (VAS). Patients were matched to patients treated conservatively for morphologically similar fractures (based on the Neer classification) and matched for age and comorbidities.

Results: 131 patients were treated with an RSA. Until now, 62 patients had a 1-year follow-up and were included. The median pain score was 2 (interquartile range [IQR] 4), median forward flexion 108° (IQR 53), external rotation 16° (IQR 26), and abduction 96° (IQR 43). The median score of CSS was 27 (IQR 21.75), the DASH score was mean 26.7 (IQR 23.3), and the OSS 39 (12.75).

Conclusion: Initial results of the study of the optimal treatment of complex, displaced PHFs are promising. To put results in perspective, the above-mentioned patient cohort will be matched to patients treated conservatively in this ongoing study.

Tactile Comparison of Screw Insertion of 3D-Printed Versus Sawbones Tibia Models

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Purpose: As orthopaedic residents are expected to master increasingly complex and numerous procedures, they must acquire many skills through surgical simulation laboratories. Access to these simulations is limited due to the high cost and limited availability of cadaver models. Sawbones models are an alternative that are more accessible and more cost-effective than cadaver bones without sacrificing anatomic accuracy. A chief complaint of orthopsedic surgeons is that Sawbones do not provide the same tactile sensation as real human bone. 3-dimensional (3D)-printed models provide a potential solution to this quality gap while also adding customizability and a lower cost. This study aimed to determine if a 3D-printed tibia model can better simulate the tactile sensation of real human bone than a Sawbones model and at what relative cost.

Methods: This study was a double-blind crossover-controlled trial involving 24 orthopaedic surgery residents and attending physicians. Participants were asked to drill and insert a screw into three proximal tibia models (one Sawbones and two 3D-printed) using a drill and plate system. The 3D models were printed using a consumer-grade FDM 3D printer. They varied in the number of solid shells (4 vs 6) that composed the outer layer, simulating the cortex of the bone. Both contained a 15% density infill, simulating the cancellous portion of the bone. After each screw insertion, the surgeons completed a survey indicating which model they felt was most similar to "healthy bone" and rated that similarity on a scale from 0 to 2 (0 = "not similar at all"; 2 = "very similar"). A two-sided binomial test was run to look for evidence that the chosen most similar model was not 33% (what would be expected by chance). A Bonferroni correction was used to adjust for the three tests run, setting $\alpha = 0.05/3$ to determine significance.

Results: 19 of 24 surgeons (79.2%) selected the 6-shell 3D model as most similar to "healthy bone" ($P<0.0001$), 16.7% (4 of 24) selected the 4-shell 3D model ($P = 0.1270$), and 4.2% (1 of 24) selected the Sawbones model ($P = 0.0016$). Additionally, when asked to rank each model's similarity to bone on a scale from 0 to 2, 58.3% of surgeons ranked the 6-shell 3D model as 2 ("very similar"), whereas no surgeons ranked it as 0 ("not similar at all"). Only 8.3% of surgeons ranked the Sawbones model as 2, whereas 20.8% ranked it as 0. A simple cost analysis showed that each 3D-printed proximal tibia model was approximately 35% of the cost of an anatomically identical Sawbones model, which costs $11.25.

Conclusion: This study suggests that 3D-printed bone models can better replicate the tactile sensation of real human bone than commercially available Sawbones models. This, in addition to being lower-cost and easily customizable, may allow surgeons in training more access to higher-quality simulations for surgical skills acquisition. Further work will confirm the tactile similarity and compare the mechanical properties of a 3D-printed bone model to real human bone.

LagLoc: A New Surgical Technique for Locking Plate Systems

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Purpose: Treatment of oblique and spiral fractures still remains challenging. The aim of this study was to introduce and investigate the new LagLoc technique for locked plating of such fractures with generation of interfragmentary compression, combining the advantages of lag screw, locking-head screw, and far-cortical screw techniques.

Methods: Oblique fracture was simulated by a 30° osteotomy in 18 artificial diaphyseal bones, assigned to three groups for plating with a 7-hole locking compression plate. Group I was plated with three locking screws in holes 1, 4, and 7. The central screw crossed the fracture line. In group II, the central hole was occupied with a lag screw perpendicular to the fracture line. Group III was instrumented applying the new LagLoc technique as follows. Hole 4 was predrilled perpendicularly to the plate, followed by overdrilling of the near cortex and insertion of a locking screw whose head was covered by a holding sleeve to prevent temporarily the screwhead from locking in the plate hole and thus generate interfragmentary compression. Subsequently, the screwhead was released and locked in the plate hole. Then holes 1 and 7 were occupied with locking screws. Interfragmentary compression in the fracture gap of all specimens was measured using pressure sensors.

Results: Interfragmentary compression in group I (167 ± 25 N) was significantly lower in comparison to groups II (431 ± 21 N) and III (379 ± 59 N), the latter representative for the new LagLoc technique, $P \leq 0.005$. The difference in compression between group II and III remained not significant ($P = 0.999$).

Conclusion: The new LagLoc technique offers an alternative tool to generate interfragmentary compression using locking plates. It unites the biomechanical and clinical advantages of lag screw, locking screw, and far-cortical locking screw fixations and can be recommended for treatment of oblique and spiral fractures.

Percutaneous Achilles Tendon Reconstruction with a Central Turndown Flap and Semitendinosus Augmentation

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Purpose: Our objective was to report the results of a new minimally invasive Achilles reconstruction technique and to assess the perioperative morbidity, medium- to long-term outcomes, and functional results.

Methods: Our series was composed of 14 patients (11 men and 3 women), with a mean age of 45.6 years at surgery. Each patient had a chronic Achilles tendon rupture. The mean interval from rupture to surgery was 5.5 months (range, 2-10). The mean total follow-up was 30.1 months (range, 12-78). All patients were operated with a central turndown flap augmented with free semitendinosus tendon graft and percutaneous sutures in a minimally invasive approach assisted by endoscopy. The patients underwent retrospective assessment by clinical examination, the American Orthopaedic Foot & Ankle Society (AOFAS) ankle and hindfoot score, and the Achilles Tendon Total Rupture Score (ATRS). Paired t tests were used to assess the preoperative and postoperative AOFAS scores, ATRS, and ankle range of motion.

Results: The length of the defect ranged from 3 to 8 cm (mean, 5.1), while the length of the turndown flap ranged from 8 to 13 cm (mean, 10.1). The mean AOFAS score improved from 64.5 points preoperatively to 96.9 points at last follow-up. The mean ATRS improved from 49.4 preoperatively to 91.4 points at last follow-up. None of the patients developed a wound complication. No patient had a rerupture or sural nerve damage.

Conclusion: All patients in our study had a favorable outcome with no complications. We believe that with this triple-repair technique, one can achieve a strong and robust repair such as in open surgery while at the same time reducing the incidence of complications.

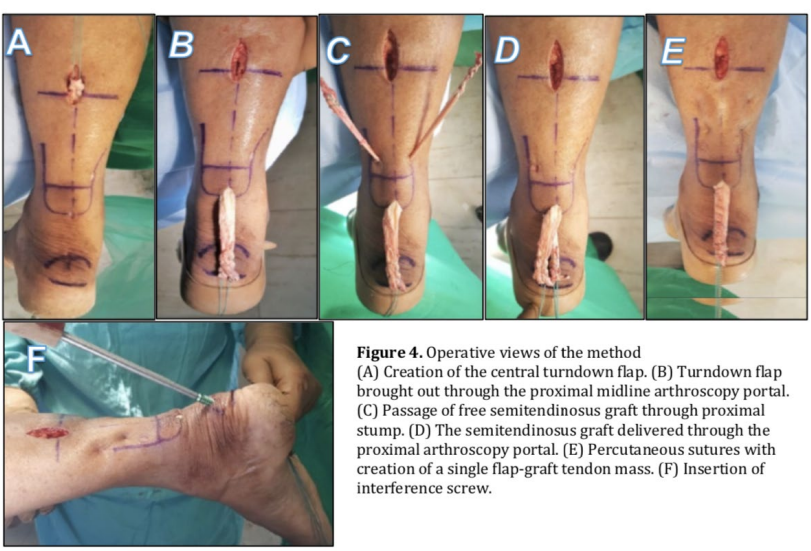

Figure 4. Operative views of the method
(A) Creation of the central turndown flap. (B) Turndown flap brought out through the proximal midline arthroscopy portal. (C) Passage of free semitendinosus graft through proximal stump. (D) The semitendinosus graft delivered through the proximal arthroscopy portal. (E) Percutaneous sutures with creation of a single flap-graft tendon mass. (F) Insertion of interference screw.

Tibiotalar Arthrodesis Using Antegrade Intramedullary Tibial Nails: A Salvage Procedure

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Purpose: This study describes the clinical outcomes and complication rate of tibiotalar arthrodesis (TTA) performed using a tibia intramedullary nail (IMN). Retrograde tibiotalocalcaneal (TTC) arthrodesis with a hindfoot nail has become an accepted technique for distal tibia fractures in high-risk, low-demand patients. This procedure is an alternative to TTC arthrodesis that preserves the accommodative motion of the subtalar joint.

Methods: A retrospective review was performed to identify patients who underwent TTA using a tibial IMN at a Level I major trauma center. Patient demographics, comorbidities, and 30-day complications were collected. Fractures were classified using the OTA / AO and modified Gustilo Anderson classification.

Results: 17 underwent TTA with a tibial IMN. The median patient age was 79 years (range, 51-102) with a male:female ratio of 2:15. Six patients had an open fracture at presentation. Average time to TTA was 37 days (range, 1-107). Four patients died from causes unrelated to surgery. One patient developed a deep surgical site infection within 30 days of surgery and ultimately required further surgery. At final follow-up, 16 patients reported good functional outcomes and have been able to return to baseline activity.

Conclusion: This study describes the clinical outcomes following TTA using a tibia IMN at our institution. This technique may serve as a salvage procedure with indications similar to those for TTC arthrodesis in lower-demand patients including complex distal tibial fractures and comminuted intra-articular fractures, especially for patients with vulnerable soft tissues. The added benefits of this technique over TTC arthrodesis is in preservation of the subtalar joint and motion thus avoiding the creation of a rigid lever arm from the calcaneus, terminating in the mid-tibia, and therefore risking periprosthetic fracture. The objective of this minimally invasive approach is to avoid disturbing soft tissue and bone vascularity, and thus minimizing postoperative complication.

Barbed Suture Repair of Deltoid Ligament Is an Effective Alternative to Suture Anchors

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Purpose: Deltoid ligament injury is frequently associated with ankle fractures, and repair techniques have varied. With this technique, we repair the deltoid ligament with multiple passes of single barbed suture (barbed PDS [polydioxanone] suture) and find the technique to be effective for joint reduction, as well as cost-effective compared to suture anchors. Barbed suture repair allows multiple passes of the suture with multiple limbs crossing the repair interval, ideal for the poor tissue condition that is often encountered. Proximally, periosteum provides reliable tissue strength. Compared to individual sutures or suture anchors, we have noted excellent strength and even tensioning of the repair construct. This suture repair effectively reduces and maintains the medial clear space (MCS) intraoperatively and during healing, and minimizes cost, need for specialized instrumentation, and adverse events associated with traditional approaches.

Methods: A single-institution retrospective review was performed on patients treated operatively with barbed suture repair for isolated deltoid ligament disruption between 2015 and 2019. Patients with ipsilateral extremity injuries, open fractures, and/or previous ankle injuries were excluded. Demographic data and fracture characteristics were recorded. Additionally, intraoperative reductions, additional plate fixation, and post-reduction MCS widening were assessed. 1:1 matching based on demographic and surgical technique of deltoid ligament repair with suture alone versus with suture anchor was conducted. Patient follow-up was evaluated including weight-bearing status and 6-week and 3-month radiographic healing in suture repair compared to suture anchor repair.

Results: 12 patients underwent deltoid repair from 2015 to 2019 with either barbed suture (6 patients) or suture anchor (6 patients). Mean age was 48 ± 23 versus 35± 9 years with a body mass index of 35.6 ± 6.3 versus 30.0± 6.72 kg/m2 for barbed suture and suture anchor fixation, respectively. At 3-month evaluation, none of the suture group had MCS widening, compared to 1 (16%) in the suture anchor cohort. The barbed suture technique does not result in inferior radiographic outcomes at 3 months compared to deltoid ligament repair with suture anchor.

Conclusion: Deltoid repair with barbed PDS suture is a viable, cost-effective alternative to suture anchor repair, and in this pilot series resulted in no widening of the MCS on radiographs at 3 months after surgery.

Cortical Screw Fixation as an Alternative to Kirschner Wire Fixation for Temporary Lateral Column Stabilization in Displaced Lisfranc Joint Fracture-Dislocations

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Purpose: The tarsometatarsal joint complex, or Lisfranc joint, stabilizes the midfoot arch via three columns. Injuries ranging from purely ligamentous to multidirectionally unstable midfoot fracture-dislocations are anatomically fixed to minimize long-term sequelae including posttraumatic arthritis, pes planus deformity, and chronic pain. Lateral column disruption is commonly treated with temporary Kirschner wire (K-wire) fixation, maintaining alignment during healing and allowing resumption of physiologic motion after hardware removal. More unstable fracture patterns may require temporary cortical screw fixation to maintain adequate reduction. We evaluated the efficacy of temporary lateral column screw fixation compared to K-wire fixation for Lisfranc fracture-dislocation treatment.

Methods: This retrospective cohort study reviewed 45 patients over 14 years who underwent Lisfranc fracture-dislocation fixation at a Level I trauma center. All patients underwent medial and middle column fixation; 31 underwent lateral column fixation. 26 patients remained after excluding those without electronic records or follow-up. The primary outcome was radiographic lateral column healing before and after hardware removal; secondary outcomes included pain, ambulation, and return to normal shoe wear.

Results: Twenty patients were male, with mean age 41 years. Thirteen patients underwent cortical screw fixation and twelve K-wire fixation. One had both implants. 24 patients underwent lateral column hardware removal; all had radiographic evidence of bony healing before hardware removal. The cortical screw cohort had significantly longer mean time to hardware removal ($P = 0.002$). The K-wire cohort had significantly more disuse osteopenia ($P = 0.045$) and postoperative pain ($P = 0.019$).

Conclusion: Clinical and radiographic outcomes of unstable Lisfranc fracture-dislocation treatment support temporary lateral column screw fixation as an alternate technique.

Medial Approach for Reduction and Buttress Plating of Plantar Medial Tuberosity Calcaneus Fractures

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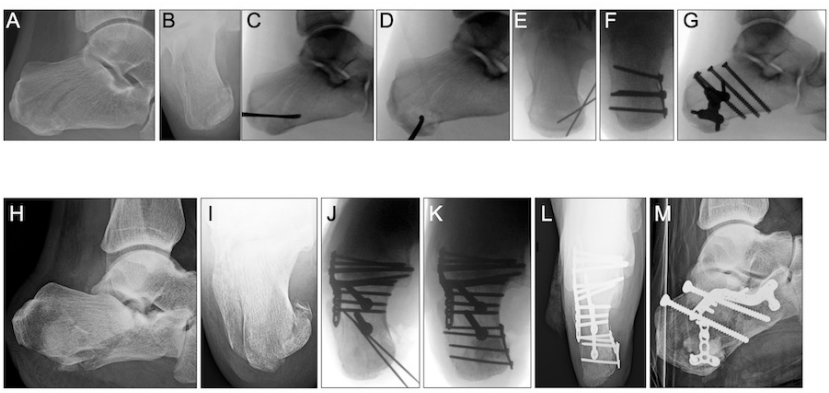
Purpose: Up to 73.6% of tongue-type calcaneus fractures have a concomitant avulsion of the plantar medial tuberosity, a structure that serves as the origin for the heel pad and the plantar fascia. Failure to address displaced plantar medial avulsions may result in disability for patients. To our knowledge, an operative technique for neutralization of the medial displacement vector has yet to be described. The purpose of this study is to describe our approach to reduction and buttress plating of plantar tuberosity fractures via a medial exposure.

Methods: Twelve patients with plantar medial tuberosity fractures (Fig. 1: A, B, H, I) were treated operatively using the described technique. 11 of 12 patients were males. Age was 32.1 ± 10.7 years. A transverse incision is made over the tuberosity medially (C) at the glabrous/non-glabrous skin border and carried to the medial wall. The distal aspect of the incision is limited by the calcaneal branch of the tibial nerve. The overlapping medial wall fragment is disimpacted, translated inferiorly and laterally, with the aid of a shoulder hook (D) and small bump under the lateral heel as a fulcrum, and anchored with wires in place temporarily to help facilitate reduction (E, J). A cervical H-plate (F, G) or minifragment locking plate (K-M) is bent appropriately and screws are inserted to buttress the tuberosity medial to lateral. The skin layer is closed with Allgower-Donati nylon sutures, and the patient is placed into a splint after a gastrocnemius recession is performed to mitigate the contribution of equinus to the pathoanatomy. Patient is kept non-weightbearing for a total of 3 months. At 2 weeks, gentle ankle and subtalar range of motion begins. All patients had radiographs that were reviewed during the postoperative period.

Results: There were no reoperations or complications in this technique-based case series.

Conclusion: A medial approach to reduction and buttress plating is a viable option for fragment-specific fixation of plantar medial tuberosity calcaneus fractures.



Cerclage Suture Fixation of Comminuted Navicular Fractures

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Purpose: Comminuted and displaced navicular fractures are difficult to treat. These fractures result from forces that compress the talar head into the navicular causing radial fracture displacement like the staves of a barrel. In a case report from Foot & Ankle International, Naidu and Singh (2005) showed a displaced comminuted navicular fracture that was innovatively treated with a cerclage wiring technique. To our knowledge, this is the only published report of a navicular fracture treated with this approach. Since that time the senior author has treated over 25 of these severe fractures with a similar, less-invasive cerclage wiring technique. Over time this technique has evolved and now preferentially involves use of a long chain ultra-high molecular weight polyethylene (UHMWPE) suture tape. Advantages of this technique include reduced operative time, minimal dissection, no need for hardware removal, and no obstruction of fracture imaging.

Methods: The surgical technique uses a small incision made over the medial pole of the navicular. A lead suture is then passed subperiosteally along the plantar surface of the navicular and received at a similar incision at the lateral pole. Subperiosteal dissection is performed along the dorsal surface with a Kelly clamp or small periosteal elevator. The lead suture is then delivered to the medial pole. The suture tape is then passed by pulling the lead suture, which delivers the UHMWPE suture circumferentially. Suture tensioning provides indirect reduction by radial compression as it is tightened.

Results: We have performed over 25 cases using the suture tape or wire and in our experience have found this to be the best fixation and reduction technique available (Fig. 1).

Conclusion: This approach demonstrates a safe, expedited, minimal incision surgical approach that provides optimal fixation of these difficult navicular fractures.

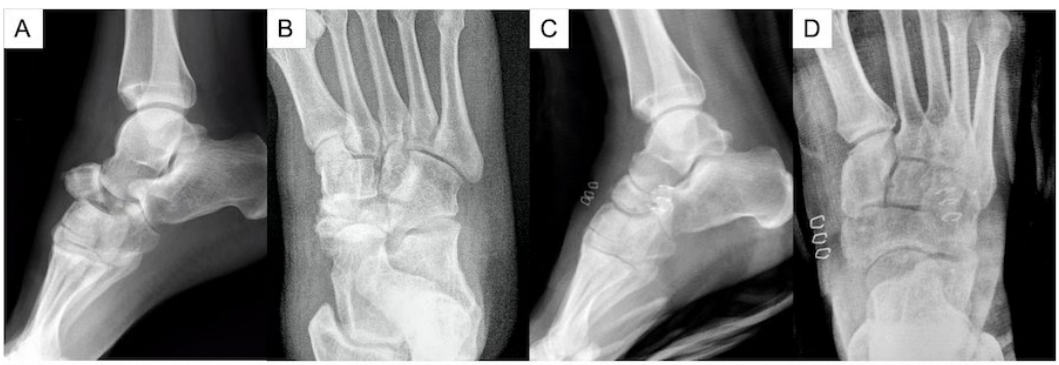

Figure 1: Preoperative lateral (A) and AP (B) view radiographs of a comminuted navicular fracture dislocation compared to postoperative lateral (C) and AP (D) view radiographs s/p navicular cerclage with UHMWPE suture tape in a right foot.

Low Rates of Soft-Tissue Complication with a Staged Protocol for Treatment of High-Energy Tongue-Type Calcaneus Fractures

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Purpose: Tongue-type calcaneus fractures are reconstructive challenges often presenting with both soft-tissue compromise and severe articular injury. Early definitive intervention through a hostile soft-tissue envelope leads to wound problems. Thus, we have adopted a staged protocol consisting of early percutaneous reduction and temporary fixation. Anatomic joint reconstruction occurs when the soft-tissue envelope defervesces. We hypothesized that staged management of tongue-type calcaneus fractures would be associated with low rates of soft-tissue complications.

Methods: A single-center retrospective case series consisting of tongue-type calcaneus fractures treated with a staged protocol and minimum 3-month follow-up was performed. The primary outcome was reoperation for soft-tissue complication and a logistic regression was performed to assess for risk factors.

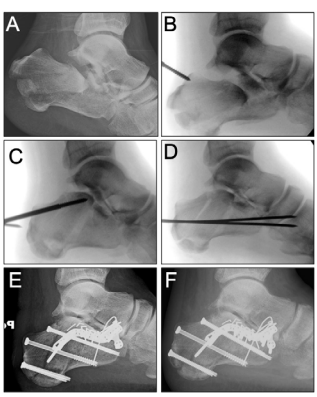
Results: 28 patients were identified. Mean Bohler's angle was –6.5° (±24.6). 28 of 29 involved intra-articular extension, and 18 (66.7%) were Sanders III/IV. Soft-tissue compromise was present in 25 of 28 (89%). Definitive surgery occurred a median 16 days after injury (interquartile range 10.3-20 days). Soft-tissue–related reoperations occurred in 3 patients (10.7%). Type III open injuries ($P = 0.03$) were the only risk factor for the primary outcome.

Conclusion: In this series of tongue-type calcaneus fractures, initial displacement, soft-tissue injury, and degree of articular involvement were severe. Staged management with definitive reconstruction 2 to 3 weeks after injury was associated with a low rate of overall soft-tissue complications. High-grade open wounds were associated with subsequent wound-related complications, whereas initial displacement, lateral extensile approach, and time to definitive fixation were not.

	Median/range	IQR/SD
Age (years)	40.4 (14-83)	+/- 15.2
BMI (kg/m²)	26.6 (17.7-41.8)	+/- 6.1
Gender		
Female	4/28	14%
Male	24/28	86%
Tobacco Use		
Yes	18/28	64.3%
No	10/28	35.7%
Sanders		
II	9/28	33.3%
III	14/28	51.9%
IV	4/28	14.8%
Open Fracture		
Closed	23/28	82.1%
Open	5/28	17.9%
Soft Tissue Compromise		
Absent	3/28	10.7%
Present	25/28	89.3%
Time	**Median**	**IQR**
Injury to Stage 1 (days)	0	0 – 1
Injury to Stage 2 (days)	16	10.3-20
	Number	**%**
Approach		
Lateral extensile	16/28	57.1%
Sinus	5/28	17.9%
Percutaneous	6/28	21.4%
External fixator	1/28	3.6%
Soft Tissue-Related Reop.	3/28	10.7%

Risk factors for Soft tissue complication

Risk Factor	OR	95% CI	p-value
Age	1.1	0.98-1.1	0.16
Male Sex	0.4	0.04-10.2	0.5
Bohler's angle	0.99	0.95-1.04	0.8
Smoker	1.8	0.2-39.5	0.63
Open fracture	7.0	0.7-81.8	0.1
PF angle	1.0	0.98-1.1	0.27
Type III open	**23**	**1.6-665**	**0.03**
Gastroc slide	0.2	0.01-1.8	0.2
Lateral extensile	0.7	0.08-6.8	0.8
Time to definitive	1.0	0.83-1.23	0.95



A) Lateral view of a displaced intra-articular tongue type calcaneus fracture with threatened skin. (B,C) a 4.0mm schanz pin drilled into the dense subchondral bone of the posterior facet manipulates the tongue fragment. D) smooth 7/64" Steinmann pins drilled across the calcaneocuboid joint and anchored into the cuboid resist displacement. E) 16 days later definitive treatment occurred through a sinus tarsi approach. F) Radiographs at 6 months demonstrated preserved height and articular congruity.

Automated Volume Measurement of the Syndesmosis Using 3D Weight-Bearing CT

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Purpose: Recent studies have shown that weight-bearing CT (WBCT) that allows 3-dimensional (3D) volume measurement of the distal syndesmosis while under physiologic load brings about a higher accuracy in detection of syndesmotic instability, especially if subtle. Since the volume measurement method is complex, time-consuming, and has a noticeable interobserver bias, most clinicians might not still be interested in utilizing it in practice. Automatization of this measurement using computer-assisted methods will not only reduce the interobserver bias but also will be faster and more applicable in practice. This study aimed to develop an automated 3D syndesmosis volume measurement tool using image processing methods and compare the speed and the interobserver bias with human interpreters.

Methods: Herein, we included 30 patients with subtle syndesmotic instability who had undergone WBCT and were diagnosed intraoperatively. 30 individuals with otherwise healthy ankles who had WBCT images were allocated to the control group. The volume measurement up to 5 cm proximal to the tibial plafond was considered the most sensitive and specific method to assess syndesmotic stability based on the literature. An algorithm was developed using MATLAB software that could recognize and calculate the syndesmotic volume using WBCT images. The volume measurement method was used by two orthopaedic surgeons for the same population. The time spent by each surgeon and the algorithm was measured. Finally, the values were compared using the t test; the interobserver correlation coefficient (ICC) was also calculated. $P<0.05$ was considered statistically significant.

Results: There was no significant difference regarding the demographic data of the two groups. The ICC between the clinicians was 75%, while using the algorithm showed 97%. The mean time spent by the clinicians was 268.4 ± 56.4 and by the algorithm was 2.9 ± 0.3 seconds ($P<0.001$).

Conclusion: Developing a faster and more accurate method for 3D volume measurement of the syndesmosis renders this method more practically reliable and easier to use by the clinicians.

Traumatic Degloving Wounds Treated with Low Continuous Wall Suction Drainage: A Novel and Effective Technique to Prevent Recurrence

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Purpose: Soft-tissue degloving wounds overlying fractures represent a technical challenge with a high rate of recurrence. The purpose of the present study is to introduce a novel technique for managing soft-tissue degloving wounds in the setting of fractures requiring operative fixation.

Methods: 11 consecutive patients with soft-tissue degloving wounds in the setting of operatively managed fractures were treated using a novel technique for "dead space" elimination in the perioperative period. All degloving wounds were thoroughly debrided at the time of initial surgery to remove any devitalized tissue. A layered closure was performed at procedure end over a #10 flat Jackson Pratt (JP) drain. One drain was used for each 100 cm2 of wound size. The drain is then placed on low continuous wall suction for a minimum of 4 days. Wall suction is then stopped when drainage is recorded at less than 10 cc per 8-hour shift. Drain is then converted to bulb suction for a period of approximately 7 days and is typically removed at a scheduled office visit. All patients were followed for a minimum of 60 days to allow for complete wound healing. Primary outcome measure was return to the operating room for recurrence of degloving wound.

Results: No patients in the series developed a recurrence of the degloving wound. The mean wound size in the study population was 125 cm2. Patients spent an average of 16 days in the hospital, 7 days on wall suction, and 6 days on bulb suction. The mean drain output on wall suction was 1464 cc. All wounds healed postoperatively and no patients had a recurrence after drains were removed. One patient developed a postoperative infection requiring return to the operating room but this was related to copious gross contamination from the initial injury. The degloving wound on this patient still healed successfully without further intervention.

Conclusion: This patient series presents low continuous wall suction drainage as a simple, reproducible method for treating degloving wounds in the setting of operative fractures. Degloving wounds have a high rate of recurrence due to refilling the dead space with fluid despite standard bulb suction drainage. The use of low continuous wall suction provides enough negative pressure to eliminate the dead space and allow for the delaminated tissue layers to heal together, preventing recurrence of fluid collection. In the present study the use of wall suction drainage did not prolong the hospital stay as all patients remained in the hospital for additional days after the drain was converted to bulb suction. However, these data merit investigation into portable methods for negative pressure suction in large degloving wounds to potentially reduce hospital length of stay.

The Feasibility of Customized Implant Production for Acute Fracture Fixation

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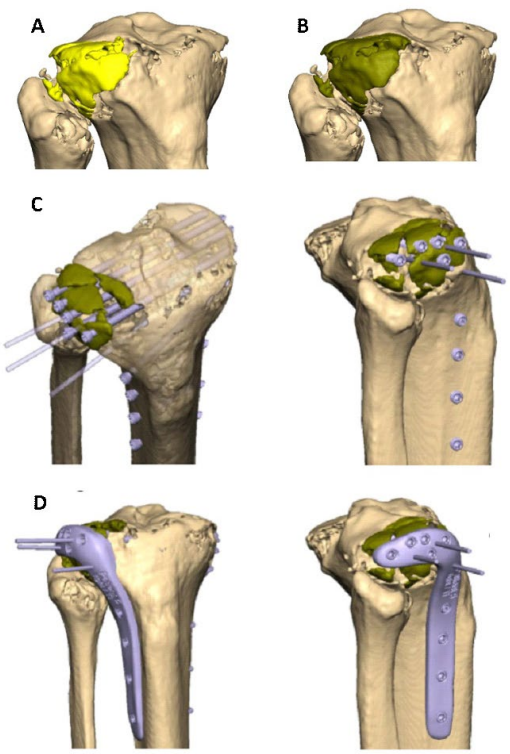
Purpose: Use of customized implants for 3-dimensional (3D) printing has largely been limited to elective, non-urgent settings due to the lead time required for implant production. The aim of this study was to assess the feasibility of 3D printing a customized implant at the point of care for acute fracture fixation, from a manufacturing and logistics perspective. We hypothesized that customized plate production would be possible within a clinically relevant time frame of 72 hours using currently available technology.

Methods: This study uses 6 cadaveric lower limbs to simulate real-life surgical patients. Split-depressed lateral tibial plateau fractures were created in an identical fashion in the cadaveric lower limbs. CT scans of the fractures were obtained and digital reconstructions were used to design customized patient and fracture-specific 3D-printed plates. These were subsequently printed in medical grade stainless steel 316L and post-processed at a local additive manufacturing center. Surgical fixation of the fractures was then carried out using these plates, following which postoperative radiographs were obtained. The time taken for each step in plate production from the initiation of preoperative CT scan to the completion of the postoperative radiograph was recorded.

Results: Six customized proximal tibia locking plates were produced with accompanying surgical drill guides. The mean total time taken for plate fabrication from completion of CT scan was approximately 24 hours and 7 minutes, with a maximum of 28 hours and 46 minutes.



Conclusion: Production of patient-specific 3D-printed plates for fixation of proximal tibia fractures at the point of care is achievable within a clinically acceptable time frame provided adequate manufacturing facilities and skilled manpower are in place. Implant production time is likely to decrease further with streamlining of processes and optimization of production workflows.

Fabricating Large-Diameter Antibiotic-Coated Interlocking Nails of any Size with Limited Resources: A Technical Trick

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Purpose: The treatment of long bone fracture-related infection and nonunion is challenging. Many techniques for antibiotic-coated nails have been described. In select instances, a single-stage large-diameter antibiotic-coated interlocking nail (LDACIN) can be utilized. Unfortunately, the diameter of many commercially available products (chest and cardiac tubing, custom molds) limits the maximal final diameter of the construct. Many centers lack readily available resources required for fabrication, particularly in the developing world where supplies can often be limited. We describe a simple technical trick that allows for customization and fabrication of an LDACIN of any diameter.

Methods: Canals were reamed to 1.5 mm larger than planned final diameter of the LDACIN. Commercially available standard trauma interlocking nails were utilized. The nail was roughened on the back table with a universal chuck or bone rasp to enhance cement bonding. The desired volume of antibiotic powder was hand mixed with2 batches of cement using previously described techniques. Bone wax was used to temporarily block nail interlocking holes. The nail was then coated entirely by hand in a uniform fashion with a desired goal of an additional 1 to 2-mm circumferential cement mantle. Using the plastic portion of a commercially available suture packet, a sizing hole was cut with an 11-blade scalpel to 1 mm larger than the predetermined final construct dimeter to serve as a sizing guide. When available, a comparison template was also used to confirm the final desired diameter. The cured implant was then inserted over a guidewire and standard interlocking screws were implanted.

Results: All LDACINs were able to be successfully sized and passed over a guidewire with this technical trick.

Conclusion: Using this technical trick, LDACINs of any size can be fabricated with limited resources in a reliable and reproducible fashion.

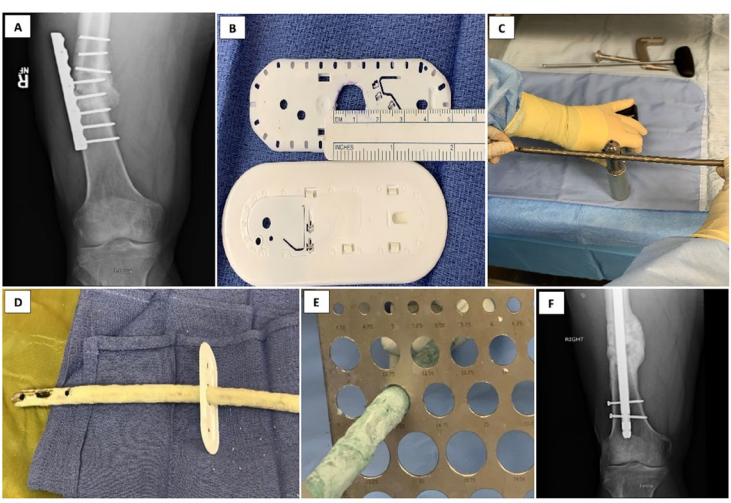

Figure 1 (a) AP femur radiograph demonstrating catastrophic hardware failure following treatment of Streptococcus anginosus osteomyelitis. Based on clinical and host factors, a single-stage large diameter antibiotic coated interlocking nail was selected. (b) A 12mm nail was selected after reaming to 15mm. A 14.5mm hole was then cut in the plastic portion of a suture packet to allow for an anticipated 1.5mm cement mantle. (c) The nail surface is roughened to increase bonding of the antibiotic laded polymethylmethacrylate. (d) The customized plastic sizing guide is used to assess final construct diameter to ensure the nail will pass through the reamed canal. (e) A comparison template (Zimmer Biomet, Warsaw, IN) can also be used to assess final desired construct diameter. (f) Final AP radiograph at 12 months demonstrating osseous union, no evidence of infection recurrence and no hardware related complications.

Comminuted Intra-Articular Distal Tibia Fracture Fixation Using Computer Surgical Planning and 3D Prototyping Techniques

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Purpose: Comminuted intra-articular distal tibia fractures are often associated with significant fragment displacement and severe soft-tissue injury. Surgeons use plain film radiographs and CT scans (2-dimensional [2D] or 3D) to determine fracture pattern and displacement; however, it can still be difficult to identify the location of all fracture fragments. The purpose of this study was to determine if a 3D-printed plastic prototype of injury could enhance the surgeon's preoperative (preop) plan and impact clinical outcomes. The hypothesis was that the 3D-printed plastic prototype can enhance a surgeon's preop plan.

Methods: Pilot Study: Patients aged 18 to 75 years with isolated, distal tibia fractures (AO/OTA 43C) were randomized to group 1: enhanced preop planning (3D-printed plastic prototype and routine imaging) or group 2: preop planning using routine imaging alone (3D-reconstructed CT and radiographs). Models of the injury were imported into a computer-aided design software (Unigraphics NX8; Siemens PLM) and converted into plastic prototypes (V-Flash 3D printer; 3D System Corp; 1:1.2 ratio). Surgeons (blinded to assignment) completed an initial preop plan for all patients using routine imaging alone. Afterward, surgeons were provided a 3D plastic prototype of injury (group 1) and repeated the preop surgical plan. 3D-printed plastic prototypes were used intraoperatively for visualization as needed. Final surgical details were collected for comparison. Percentage of agreement and surgeon confidence was calculated (9 categories: approach, sequence, anatomic contoured plate tibia, anatomic contoured plate fibula, small fragment plate, mini-fragment plate, mini vs extensile, fibula fixation, bone graft).

Results: 20 total participants had mean age 44 years, 60% male, 60% fall from height, 60% closed injury (1 infection withdrawn). Group 1 (enhanced n = 11) averaged 84.8% level of agreement between the initial surgical plan without versus with the 3D prototype, and had an increase in confidence from 80.5% to 84.6% (confidence in group 2 was 78.1%, n = 8). Agreement with preop plan and final operative events was 76% in group 1 and 71.4% in group 2. In one case, after review of the 3D-printed prototype, the surgeon changed the surgical approach and ultimately eliminated a third stage of surgery. Clinical outcomes did not differ between groups after 1 year postoperatively.

Conclusion: This study assessed the impact of 3D-printed plastic prototype models in the surgical plan of complex distal tibia fractures. Although the percentage of agreement with the preop plan to final operative events was not very high, the 3D-printed plastic prototype increased the surgeon's confidence with the preop plan. In 1 case, a return surgery was eliminated. Further studies need to explore the potential cost benefit of a 3D printing program.

Effect on Mobilization of Pelvic Fragility Fractures Treated with a Nail System

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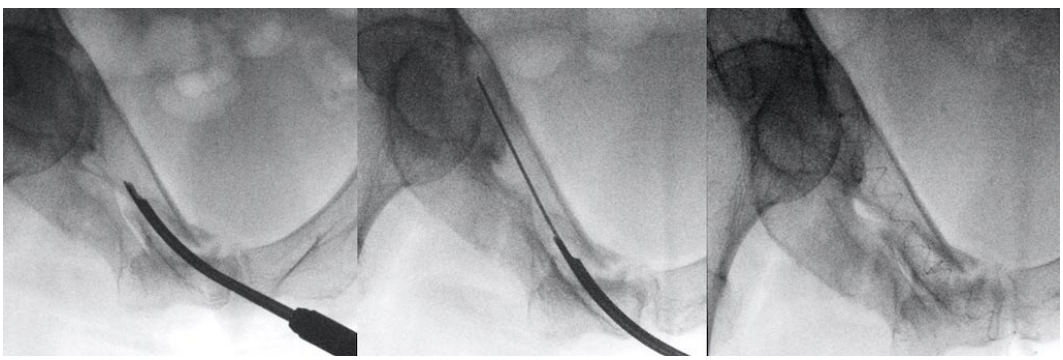
Purpose: Our objective was to evaluate the clinical outcome of the first 38 patients with fragility anterior pelvic ring fractures, treated with an intramedullary implant system.

Methods: 38 patients with fragility fractures of the pelvic ring were included in this single-center retrospective observational study. All were treated with the patient-conforming polymeric rod. The implant is introduced through a small 3 to 4-cm incision over the os pubis, positioned within the ramus superior up to the acetabular dome across the fracture. The implant is filled with the liquid monomer to conform to the intramedullary space. After polymerization under the influence of blue light, the polymerized monomer hardens and gives direct stabilization of the fracture. The median age was 77 years (range, 46-96 years). 31 were female, 7 were male, 27 had a fall from standing height, 3 a fall from bicycle, 4 unknown, 3 multitrauma, and 1 due to metastatic bone disease. American Society of Anesthesiologis ts classification was 1, 3%; 2, 42%; and 3, 55%. Hospital stay averaged 11 days (range, 1-25 days). All patients had a preoperative CT scan, and 17 had concomitant sacral fractures.

Results: All fractures consolidated visual analog scale scores dropped from 3.4 preoperative to 1.7 on the first postoperative day. 24 patients returned to pre-trauma ambulation and activities of daily living. 22 patients returned to their homes. 5 patients died during follow-up not related to the procedure: 1 intestinal ischemia, 1 urosepsis, 1 preexisting cardiac condition, 1 COVID-19, and 1 unknown cause. 15 patients went to a rehabilitation center before going to their homes.

Conclusion: The nail system is a simple and reliable fracture stabilization method with a great potential for the fragile patient with a fragility fracture due to the rapid postoperative mobilization and thus reducing postoperative morbidity.



Dual Construct Fixation of Geriatric Distal Femur Fractures to Allow for Immediate Mobilization and Whole Bone Protection

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Purpose: Geriatric distal femur fractures are associated with high rates of perioperative mortality. Plate fixation has been limited by protected weight bearing, nonunion, and implant failure, which can compromise mobilization and perioperative mortality. Dual constructs to facilitate healing and early mobilization have recently been reported. We describe our experience using a novel nail-plate construct allowing for immediate weight bearing and prophylactic whole bone protection.

Methods: 10 patients were treated using a retrograde intramedullary nail (rIMN) and lateral plating technique. Surgery commences with fracture reduction and rIMN insertion. The nail is intentionally left short such that the nail just engages the femoral isthmus and is secured with interlocking screws proximally and distally. A variable angle locking compression plate (VA-LCP) is placed in a minimally invasive fashion, with the proximal aspect of the plate lying near the vastus ridge. The plate is aligned proximally along the femoral shaft and secured with unhindered bi-cortical screw fixation proximal to the nail. Distal locking screws are placed through the plate around the nail. Prophylactic fixation of the femoral neck is performed by placing 1 or 2 cortical screws into the femoral neck and head through the most proximal holes. Patients are permitted immediate unrestricted weight bearing.

Results: Technical details of the procedure include (average, range): IMN length (28, 24-36 cm) and diameter (12, 10-14 mm), number of bicortical screws placed above IMN, operative time (198, 130-290 min), and blood loss (360, 150-600 mL).

Conclusion: This technique offers improvements to previously described nail-plate fixation methods. Using a short IMN, fixation through the proximal aspect of the lateral plate is unhindered by the nail and resists the stress riser created at the proximal aspect of the nail. Prophylactic protection of the femoral neck is permitted through strategically placed screws at the proximal aspect of the VA-LCP.

Pelvic Ring Fractures in the Elderly Treated with a Branded Implant

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Purpose: Our objective was to evaluate the clinical results, hospital stay, and return to function after treating anterior pelvic ring fractures in geriatric patients with a branded implant. A growing geriatric patient population with increased incidence of low-energy pelvic fractures has led us to find alternative and potentially improved means of fracture fixation.

Methods: This was a single-center retrospective observational study of 56 patients (February 2015 to November 2019) treated with a branded implant. The patient-conforming implant is introduced through a small suprapubic incision of ~3 cm at the symphysis. The implant is delivered into the superior ramus up to and/or over the acetabular dome spanning the fracture. Fracture patterns involving the posterior pelvic ring were additionally treated with an iliosacral screw. The median age was 82.1 years (range, 51-100), 79% of the patients were female, and the median American Society of Anesthesiologists class was 2.9. 38 patients (68%) also had concomitant posterior sacral screw fixation All of the fractures were caused by low-energy trauma. The fracture pattern was Ia in 17 patients (30%), Ib in 2 (4%), IIb in 3 (5%), IIc in 14 (25%), IIIb in 4 (7%), and IIIc in 16 (29%).

Results: Time from fracture to surgery averaged 5.1 days, and average procedure time was 83 minutes, from anesthesia to skin closure. 46 patients (88%) were ambulatory from the first postoperative day and returned to their home for independent living. Seven patients (12%) were newly dependent on nursing care at time of discharge from the hospital. Hospital stay averaged 7.9 days (range, 2-25 days). The flexibility of the delivery system allowed for the treatment of complex fractures at the anterior symphysis typically treated in our institution with plates. While not specifically measured, patients appeared to experience less postoperative pain, used less postoperative pain medications, and were able to ambulate sooner than with plate osteosynthesis.

Conclusion: Our results treating geriatric patients with a branded implant are quite positive. Good clinical function was demonstrated with the use of a branded implant, and patients also experienced a low degree of complications. The flexible nature of the catheter allows for precise positioning of the implant, allowing for the treatment of more complex cases, providing the stability of intramedullary nailing with the flexibility of balloon catheters. The reduced incisional size and minimal postoperative pain allows elderly patients to regain mobility faster and decrease costs for the health-care system as they may be discharged to their homes faster. While promising, further investigations must be conducted.

Early Clinical Series Using a Branded Implant to Treat Forearm Fragility Fractures

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Purpose: The purpose is to demonstrate an alternative treatment for distal forearm fractures in elderly patients with poor bone quality. In the Medicare population alone, there are approximately 90,000 distal forearm fractures annually in the US. Current treatment options are conservative: closed reduction and immobilization in a cast, or open reduction and internal fixation (ORIF), which may result in skin issues with casting, loss of independence, delaying therapy, and increased time to return to activities of daily living.

Methods: A branded implant was introduced through a small incision at the radial styloid, infused with liquid monomer to expand the implant, and then cured with the application of visible blue light, to treat geriatric patients who had sustained extra-articular or minorly intra-articular fractures of distal radius and/or distal ulna. Patients had poor bone quality, poor skin elasticity, and significant comorbidities. All patients were operated under an upper extremity block and sedation. 13 patients were treated in the first 3 months of the clinician using the device. All were female, median age 75 years (range, 62-89 years). Six patients were treated as inpatients in the hospital. Seven were treated in outpatient surgery center, two patients had distal radius and distal ulna fractures, both fractures treated with branded implants. One patient was treated with an adjunctive volar plate.

Results: All patients were discharged to home within 24 hours. Patients got postoperatively a soft cast that was transitioned to a removable wrist splint within 48 hours. The splint had to be worn during sleep and when out of the house for 2 to 4 weeks. All patients started physical therapy 1 week after surgery. Pain was managed with 800 mg ibuprofen daily, with only 1 patient needing 1 dose of Percocet. There was no secondary loss of reduction, and 1 patient developed de Quervain tenosynovitis.

Conclusion: The branded implant is an excellent alternative to conservative treatment or ORIF that enables patients to remain mobile and independent without the risk of a major surgery.

Femoral Corrective Osteotomy Using a Patient-Specific 3D-Printed Guide

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Purpose: Surgical treatment of complex multiplanar deformities might result in multiple failed surgeries. Complications may generate conditions such as diminished bone quality, increased infection risk, or affect the adjacent joints. Management of these disorders represent a challenge in the attempt to offer an adequate outcome. The use of 3-dimensional (3D)-printed devices can result in a better understanding of the deformity correction and, in consequence, may produce a more accurate intervention. Our objective is to demonstrate that the use of 3D models and custom-made osteotomy guides improve preoperative planning and provide a more precise correction angle for the osteotomy with the benefit of enhanced surgical training techniques, improving the surgeon's confidence during the definitive surgical procedure and thereby decreasing the risk of inappropriate correction osteotomies.

Methods: A 25-year-old male patient had a severe multiplanar deformity of the femur secondary to a hip fracture as a 9-year-old child. Through the years, two valgus and one derotation osteotomy were performed, complemented by femur lengthening with an external fixator. Four years after the last surgical procedure he suffered a distal third femoral fracture treated initially with a pelvipodalic cast, resulting in a femoral angular deformity. He came to the orthopaedic trauma surgery clinic because of limb shortening, varus plus recurvatum deformity of the femur, and knee rigidity. An alignment osteotomy fixed with a retrograde femoral nail was performed. The site and configuration of the osteotomy was selected using finite element analysis, determining the site of highest stress, and a 3D-printed cutting guide was made. The surgery was first performed in the biomechanics laboratory in a 3D-printed model of the femur and the femoral analysis was performed by calculating a closing wedge of 43.68° to achieve the desired alignment in the coronal and sagittal planes. During surgery, a quadricipital shortening was evident, so a quadriceps tendon reconstruction was performed using an autograft from the gracilis and semitendinosus tendons.

Results: Correction was achieved obtaining an alignment in the coronal plane from a varus of 46.9° to 4.3°. The anterior deformity was corrected from 47.4° to 2.7°. This procedure corrected the length discrepancy from 6.9 to 1.3 cm. Knee flexion was recovered from 10° to 100°. The patient is now completely functional and walks without crutches.

Conclusion: Preoperative planning assisted with 3D-printed models is useful for replicating the procedure in the laboratory before the definitive surgery. This helps to prevent complications, efficiently improves the osteotomies, and provides precise cuts with the use of prefabricated 3D guides. It is a low-cost resource that diminishes the possibility of failure. These models were used initially for complex cases only but nowadays they are being used more frequently. Novice surgeons may benefit from this technology since it can be used as an innovative training tool.

Trochanteric Hip Fractures and SIGN Hip

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Purpose: To ensure hip function in trochanteric fractures, the anatomical reduction needs to be performed. So the different materials of bone implant such as dynamic hip screw (DHS) or proximal femoral nail (PFN) are one of the frequent choices for this kind of fracture. However, in some countries where there is a lack of this modern equipment, another material, the SIGN (Surgical Implant Generation Network) Hip Construct (SHC), also plays an essential role for the treatment of trochanteric fractures until the union of fracture side. Our objective was to report the safety profile and complication rates and to evaluate hip fracture by the using of the different types of SHC, which include standard hip nail, standard SIGN nail, and standard fin nail (using compression screws or intramedullary nail only), without C-arm and fracture traction table, and also analyze the results.

Methods: For this retrospective review of trochanteric fractures in department of neurotrauma and orthopaedic surgery from August 2015 to September 2016, 12 patients with trochanteric fractures were recruited. 7 patients were followed up by appointment or phone with a clinical and radiological complete file. 5 patients are incomplete for follow-up or lost contact. Inclusion criteria were standard hip nail, standard SIGN nail, standard fin nail, and fracture radiographs available; exclusion criterion was inadequate radiographs.

Results: During 1 year, 12 patients with trochanteric fractures in the age group of 15 to 60 years old were operated by using the SHC nail for our study. By Gustilo classification, 11 cases are closed fracture (91.63%), 1 case is open fracture (8.37%). Based on AO/OTA classification there are 1 case of A1 fracture, 8 cases of A2 fracture, and 3 cases of A3 fracture. Based on the reduction quality, the average days of bone callus is 45 days, with the longest duration being 6 months. By using Salvati and Wilson score, 7 patients have complete follow-up; 4 cases in our study were rated as excellent results, 1 was rated as good results, and 1 case was rated as poor results, which means that >90% of the results are acceptable.

Conclusion: The 3 kinds of SHS provide the early mobilization from maintaining acceptable fracture reduction until the union of fracture side. These kinds of implants can be achieved safely without an image intensifier and also gives us good stability and good function with an acceptable result. It may be good equipment for developing countries where access to fluoroscopy is limited or nonexistent.

Minimally Invasive Cerclage Stabilization of Proximal Femur Fractures Using a Cerclage Suture Device

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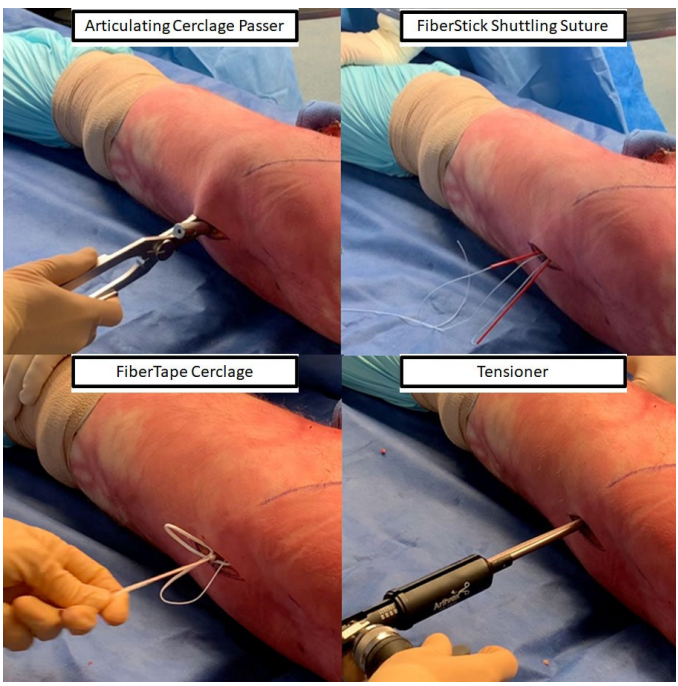
Purpose: This paper describes a novel, minimally invasive cerclage technique utilizing a two-part articulating cerclage passing device and a radiolucent cerclage suture tape for proximal femur fractures (OTA/AO 32A1) undergoing intramedullary nailing (IMN).

Methods: Utilizing the same lateral incision (3-4 cm) used for lag screw placement in cephalomedullary nails, a two-part articulating cerclage passer is passed on the anterior and posterior aspects of the femur and mated on the medial side. This is done in a manner with minimal soft-tissue stripping and without the need for direct visualization of the fracture site or cerclage device. Once the passer is in place, a FiberStick is threaded through the passers to facilitate shuttling the FiberTape cerclage around the femur. Once length and rotation are confirmed, the suture cerclage is then tensioned and tied to obtain and maintain the final reduction. Figure 1 shows the steps for cerclage reduction. The suture tails are then cut and the nail is placed using standard techniques.

Results: In 2020, this technique was utilized in five patients who underwent IMN of a proximal femur fracture that was amenable to cerclage reduction prior to nail placement. In all cases, a near anatomic reduction was achieved and maintained during the nailing process. No complications were noted at 2-week follow-up.

Conclusion: This technique describes a minimally invasive way to pass a radiolucent, cerclage suture device around proximal femur fractures undergoing IMN. In this limited series, each fracture was reduced to nearly anatomic and there were no complications in early follow-up.



Osseointegration Implant Failure and Surgical Revision in Persons with a Transfemoral Bone-Anchored Prosthesis

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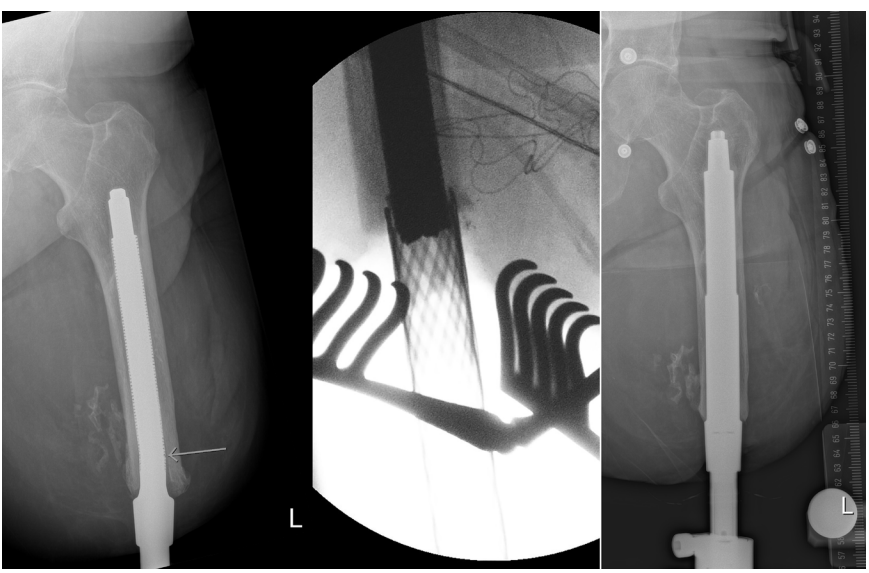
Purpose: The aim of this study was to identify potential risk factors for transfemoral osseointegration (OI) implant failure and describe the surgical revision strategy and technique that was performed.

Methods: This retrospective cohort study includes all patients treated with a press-fit cobalt-chromium-molybdenum transfemoral OI implant between May 2009 and July 2015. We analyzed the patient characteristics, implant details, and event characteristics in patients with and without failure of the OI implant system. The revision of a failed intramedullary stem due to breakage consists of three stages in which the broken stem is removed in two separate procedures with a custom-made water-cooled hollow drill. Finally, after wound-healing, the new intramedullary stem is installed. In case of septic loosening of the intramedullary stem, the stem is removed in two separate stages by using a high-speed surgical saw and water-cooled hollow drill. Bone cultures are taken during these procedures. When these cultures are negative, a third surgery is performed to install the new intramedullary stem.

Results: Of the 58 patients included, 6 patients had breakages and 1 septic loosening. The cumulative survival rate was 77% after 9.0 years. These patients had a significantly smaller intramedullary stem diameter and more infectious events compared to the non-failure group.

Conclusion: Small stem diameter and number of infectious events are possible risk factors for OI implant system failure. All seven patients underwent successful revision with a larger diameter titanium OI implant.



Multicenter Observational Prospective Unblinded Case-Control Study to Evaluate the Effect of the Distal Targeting System for the Gamma3 Long Nail on Radiation Exposure and Time for Distal Screw Placement

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Purpose: Our objective was to determine if the Distal Targeting System (DTS) for the Gamma3 long nail decreases radiation exposure, fluoroscopy time, and total time for distal screw placement compared to the freehand "perfect circles" technique.

Methods: Between December 2019 and December 2020, 58 consecutive patients with hip/femoral shaft fractures underwent repair with a Gamma3 long nail and were assigned to the DTS (N = 29) or control "perfect circles" cohort (N = 29). An a priori power analysis revealed that 29 patients per cohort were necessary to demonstrate: 40% reduction in radiation exposure and 30% reduction in distal locking time ($\alpha = 0.05$ and power of 0.80). Fracture classifications included AO/OTA 31-A1, 31-A2, 31-A3, 31-B3, and 32-A1. All patients had 2 distal interlocking screws placed. Intraoperative measurements for radiation exposure (mGy), continuous fluoroscopy time (sec), and intraoperative time (sec) between lag screw and final interlocking screw placement were recorded. Mann-Whitney U test was performed to compare differences between these metrics.

Results: The DTS cohort had 76.9% (4.3×) lower radiation exposure, 63.5% (2.7×) lower continuous fluoroscopy time, and 60.0% (1.7×) lower intraoperative time from end of cephalad screw placement to end of distal interlocking screw (P<0.001 for all outcomes). There were no significant differences in patient demographics, injury characteristics, or hospital quality outcome measures (Table 1).

Conclusion: Data suggest that the DTS for the Gamma3 long nail significantly reduces radiation exposure, fluoroscopy time, and intraoperative time for distal screw placement compared to the freehand "perfect circles" technique when used for hip and femur fracture repair.

Intra-operative Measures			
	Control (N=29)	**Distal Targeting (N=29)**	***p*-value**
Mean Radiation Exposure (mGy)	1.86 ± 1.02	0.43 ± 0.36	<0.001
Mean Continuous Fluoro Time (sec)	35.26 ± 17.68	12.88 ± 5.51	<0.001
Mean Time Between Cephalad & Interlocking Screw (sec)	626.38 ± 210.19	376.03 ± 117.18	<0.001
Demographics			
Mean Age, yrs (±SD)	80.56 (±10.87)	77.05 (±12.24)	0.689
Mean BMI (±SD)	24.83 (±4.47)	27.00 (±7.23)	0.201
Mean CCI, yrs (±SD)	1.62 (±1.88)	1.79 (±1.74)	0.722
Female, %	67.6%	75.0%	0.545
Race, White %	61.8%	62.5%	0.519
Race, Black %	14.7%	12.5%	
Race, Hispanic %	14.7%	0.0%	
Race, Asian %	8.8%	12.5%	
Race, Other %	0.0%	12.5%	
Hospital Quality Outcome Measures			
In-Hospital Complications	9	16	0.309
Minor Complications	11	14	0.437
Major Complications	3	4	0.696
30-Day Readmission	2	2	0.552
90-Day Readmission	0	4	0.258
Surgical Site Infection	0	1	1.000
Hardware Complications	1	1	1.000
Death During Admission	1	1	0.68

Synchronous Cerclage Wiring and Intramedullary Nailing for Unstable Femoral Fractures: Revisiting the Dead Bone Sandwich

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Purpose: Unstable femoral fractures occasionally mandate open reduction to facilitate cortical alignment prior to intramedullary nailing. Although cerclage wires can support fracture reduction, their use when combined with reamed nailing has been traditionally associated with increased risk of periosteal stripping and impaired fracture healing. Our unit has employed this technique in select cases and anecdotally has not observed complications. The aim of this study was to describe our technique and assess the safety of intramedullary femoral nailing in combination with synchronous open cerclage wiring.

Methods: A consecutive series of patients who underwent cerclage wiring and intramedullary femoral nailing were identified over a 6-year period from a prospectively gathered database. Patient demographics and complications were identified with a retrospective review of patient notes. All patients were a minimum of 1 year postoperation at time of analysis.

Results: 50 consecutive patients were identified with a mean age of 74 years (standard deviation 15.4). Operations were undertaken by 10 consultant surgeons. The femoral fracture location was 38 subtrochanteric, 3 diaphyseal, and 9 distal. 8 patients died within 1 year of surgery. There were no cases of postoperative infection or further surgery for loss of fracture reduction. There was one case of delayed union, but this united without further intervention. 29 patients had serial radiological follow-up and the remainder did not represent.

Conclusion: Synchronous intramedullary nailing with cerclage wiring of unstable fracture patterns appears to be a useful technique to maintain fracture reduction without an increased risk of postoperative complications.

Femoroacetabular Stabilization Using a Suspensory Fixation Device in Posttraumatic Hip Instability

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Purpose: Hip dislocations and femoral head fractures are well-described, devastating injuries following high-energy trauma. Despite appropriate initial surgical fixation, subsequent native hip instability due to surrounding soft-tissue incompetence is a known complication with significant morbidity and few treatment options. We describe a novel technique to stabilize the hip following traumatic instability.

Methods: The patient is placed supine on a radiolucent table. Using a modified Stoppa approach, the anastomosis between the external iliac and obturator artery is identified and clipped; periosteum is cleared off the quadrilateral surface, protecting the obturator neurovascular bundle. A lateral approach is made to the proximal femur; the guidewire is directed up the femoral neck, exiting the femoral head centrally in the fovea. Prior to exiting the femoral head, the hip is positioned into 40° of abduction, 0° of flexion, and 15° of internal rotation. Using fluoroscopy, the guidewire is directed into the cotyloid fossa, and the guidewire is advanced into the pelvis, in the inferior portion of the quadrilateral plate under direct visualization. A suspensory fixation device with suture button can be used alone or with tendon allograft. The tendon allograft is prepared on the back table with the suspensory fixation device. The guidewire is reamed, and the graft/suture construct is passed. The construct is secured medially with washers and a suture button, and tensioned laterally with a suture button over a one-third tubular plate. The hip is placed in 10° of adduction, 0° of hip flexion, and neutral rotation during tensioning. Postoperatively, the patient is allowed toe-touch weight bearing for the first 6 weeks with progression to weight bearing as tolerated. Early range of motion is encouraged.

Results: A total of 4 patients had posttraumatic hip instability. 2 patients were treated with a suspensory fixation device without allograft and 2 with suspensory fixation device/allograft. At 3-month follow-up interval radiographs and clinical examinations demonstrate congruent femoroacetabular joints with intact hardware. One patient with allograft developed a deep infection, requiring revision surgery. The remaining 3 had no complaints of persistent instability and were ambulating with no assistive device.

Conclusion: We present a novel technique with promising short-term results. Our construct utilizes a suspensory fixation device to reconstruct the ligamentum teres of the hip, thus acting as a soft-tissue restraint. Stabilization of the femoroacetabular joint allows early range of motion, obviates the need for posterior hip precautions, and prevents further cartilage damage from repeat dislocations.

Warm Saline Irrigation Protocol Decreases Cement Curing Time in Hip Arthroplasty

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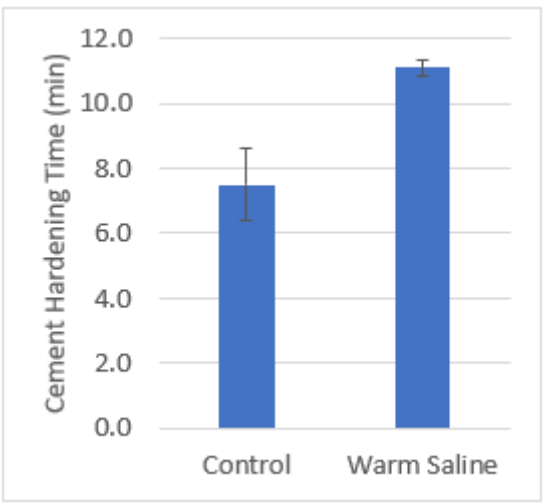
Purpose: Cementation in hip arthroplasty is a common and reliable technique for achieving a stable bone-component interface. However, there are significant costs and risks to the patient, surgeon, and hospital related to the use of cement. It has been previously demonstrated that increasing ambient temperature and femoral component temperature decreases cement curing time.

Methods: Patients undergoing cemented hip arthroplasty were enrolled. A protocol utilizing 100°F warmed saline irrigation within the surgical field and a bath for the femoral component was developed. Time from cement mixing to curing was recorded. Completed curing was defined as the inability of a fresh 15-blade scalpel to indent the inserted cement against gravity resistance. We performed a comparative cohort study with a control group to investigate if this protocol reduced time to cement curing in an in vivo setting.

Results: Ten patients were enrolled in the experimental group and 11 patients in the control group. Time to cement curing was significantly lower in the experimental group (7.5 min vs 11.1 min, $P<0.0001$, Fig. 1). A post hoc power analysis showed that with the current sample size, there was >99% power to detect the observed mean difference of 3.6 minutes in cement curing time.

Conclusion: The use of a simple and inexpensive warmed saline irrigation protocol during cemented hip arthroplasty decreases time to cement curing by 32%.



Clamp-Assisted Reduction Via Lag Screw Window in Cephallomedullary Nailing for Subtrochanteric Femur Fractures: A Technical Trick

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Purpose: Subtrochanteric (ST) femur fractures are complex fracture patterns with high complication rates and often require difficult reduction maneuvers to restore anatomic alignment due to strong deforming forces. Once it is decided to do open reduction and internal fixation, incisions should be strategically placed to allow control of the proximal fragment and facilitate clamp placement, while also minimizing the number of incisions to prevent creation of avascular skin bridges due to incision proximity. We exhibit a novel method to minimize skin incisions by predicting where cephalomedullary nail (CMN) fixation will be placed so a single incision can be used for both clamp-assisted reduction and for head-neck fixation.

Methods: We have utilized this technique on 22 patients since 2018. Excluding patients with less than 1-year follow-up and patients with pathologic fractures, 11 patients comprised this series. Closed reduction is attempted before proceeding to open reduction and internal fixation. Placement of a single lateral incision is determined by the following technique. The insertion jig with aiming arm for the CMN fixation is assembled on the back table. The jig is then placed on the anterior aspect of the prepped limb and positioned such that the jig is superimposed with the nail entry point at the tip of the greater trochanter using fluoroscopy. The sleeve for ultimate CM screw fixation is slid through the aiming arm and advanced down to the skin of the lateral thigh to mark the approximate location of the future incision needed for lag screw fixation. A roughly 5-cm incision is made at this location just posterior to the mid-lateral axis of the femur. This incision can be extended as necessary for proximal fragment control. Reduction clamps are left in place for the entire duration of intramedullary nailing, and not moved until both proximal and distal locking screws are secured.

Results: Mean age of included patients was 66 years (range, 17-93). There were 3 males and 8 females. Mean follow-up duration was 1.95 ± 0.8 years. All surgeries were performed by one of two fellowship-trained orthopaedic traumatologists. Mean duration of surgery was 96.9 ± 15.9 minutes. Long IMN implants were used in all but 2 patients. One patient had a short intramedullary nail (IMN) placed due to the presence of a stemmed total knee arthroplasty prosthesis distally. The second short IMN implant was in a patient with significant bowing deformity to her femur due to osteogenesis imperfecta and multiple healed femoral shaft fractures. There were 2 complications in our series. One patient underwent removal of hardware of a lateral spanning femur plate. A second patient had a postoperative deep vein thrombosis. There were no nonunions or malunions observed.

Conclusion: This is a surgical technique trick that can be utilized to aid in reduction of ST femur fractures. Planning incision placement for open reduction in complex fractures minimizes complications while facilitating adequate reduction.

Use of a Novel Augmented Reality Software to Assist in Cephalad Lag Screw Placement Into the Femoral Head for Cephalomedullary Nails

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Purpose: Our objective was to study the effect of a novel augmented reality software designed to aid in lag screw placement into the femoral head for cephalomedullary nails.

Methods: Between November 2017 and December 2020, 114 consecutive patients with a hip fracture that underwent repair with a cephalomedullary nail by one of two orthopaedic trauma surgeons at a single institution were reviewed. Fracture classifications included AO/OTA 31-A1, 31-A2, 31-A3, and 31-B3. The first 57 patients underwent fracture repair without the software (control), and the subsequent 57 patients underwent repair with use of the augmented reality software (AR). Tip-apex distance (TAD), distance to bone (DTB), and femoral head quadrant (AP: superior, center, inferior; lateral: anterior, center, posterior) were measured using standardized techniques. Independent sample t tests and $\chi 2$ tests of homogeneity were completed using IBM SPSS to compare measurements between these two cohorts.

Results: The mean TAD was lower for the AR versus control cohort (11.9 ± 4.3 vs 15.4 ± 3.8; $P<0.001$). The mean DTB was lower for the AR versus control cohort (5.1 ± 2.0 vs 6.7 ± 1.8, $P<0.001$). TAD <10 mm for AR versus control was 20 (35.1%) versus 3 (5.3%), $P<0.001$. TAD <15 mm for AR versus control was 25 (43.9%) versus 44 (77.2%). On the AP view, center position was achieved in 42.1% versus 7.0% of cases for the AR versus control cohorts, respectively. On the lateral view, center position was achieved in 37.4% versus 12.3% of cases for the AR versus control cohorts, respectively.

Conclusion: This study suggests that use of the novel augmented reality software for assistance in lag screw positioningwithin the femoral head improves overall TAD, DTB, and ability to achieve the center-center position.

Tip-Apex Distance in AR vs. Control Groups			
TAD	**Control (N=57)**	**AR (N=57)**	***p*-value**
<10.0 mm	3 (5.3%)	20 (35.1%)	0.000
10.0-14.9 mm	22 (38.6%)	24 (42.1%)	0.703
15.0-19.9 mm	27 (37.4%)	10 (17.5%)	0.001
20.0– 24.9 mm	4 (7.0%)	3 (5.3%)	0.696
≥25.0 mm	1 (1.8%)	0 (0.0%)	0.315
Femoral Head Quadrant in AR vs. Control Groups			
Alignment	**Control (N=57)**	**AR (N=57)**	***p*-value**
Vertical Alignment			
Superior	2 (3.5%)	10 (17.5%)	0.015
Inferior	51 (89.5%)	23 (%)	0.000
Center	4 (7.0%)	24 (42.1%)	0.000
Rotational Alignment			
Anterior	18 (31.6%)	12 (21.1%)	0.202
Posterior	32 (56.1%)	18 (31.6%)	0.008
Center	7 (12.3%)	27 (37.4%)	0.000

Evaluating and Correcting for Rotational Deformity During Retrograde Femoral Intramedullary Nailing

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Purpose: The standard of care for the majority of femoral shaft fractures is locked intramedullary nailing. Retrograde insertion offers advantages in a number of clinical circumstances over antegrade methods; however, malrotation remains a common complication. Our novel technique describes a workflow for assessing and correcting rotational deformity during retrograde femoral nailing.

Methods: This technique uses the proximal and distal interlock holes that are offset 90° as reference points for matching rotational alignment to the uninjured side. In addition, we use a perfect lateral of the knee and a hip image 90° from this view to assess rotation. The injured extremity undergoes standard retrograde intramedullary nailing. When the same hip image is obtained on the injured side, the nail is rotated to have superimposed perfect circles and then the nail is locked proximally. When returning to the knee for a lateral image, a perfect lateral and matching perfect circles in the same view will indicate correct rotational alignment. Finally, the nail is locked distally. Rotation is assessed clinically and with CT of the bilateral femurs to evaluate femoral version.

Results: We provide several example cases that demonstrate the success of this technique. The mean rotational difference between injured and uninjured extremities was 1.4°.

Conclusion: We describe a novel technique that uses the orientation of the locking holes to efficiently assess and correct malrotation during retrograde intramedullary nailing of femoral shaft fractures.

Modified Triangular Osteosynthesis Technique Utilizing S1 Pedicle Screws for Spinopelvic Dissociation U- and H-Type Sacral Fractures with Kyphotic Deformity

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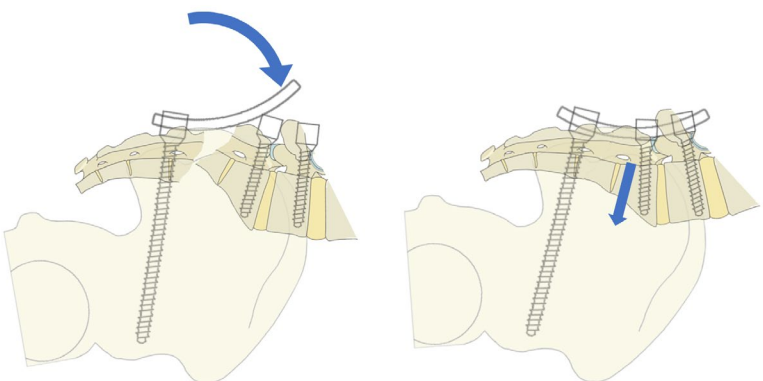
Purpose: Our objective was to describe a novel modified triangular osteosynthesis (TOS) construct and reduction technique for spinopelvic dissociation (SPD) U-/H-type sacral fractures and to report radiographic and clinical outcomes.

Methods: A retrospective chart review of SPD cases from 2014 to 2018 was performed. All patients had preoperative and postoperative CT scans. Imaging outcomes included fracture union, sacral kyphosis, and analysis of multiplanar fracture reduction using sacral CT reconstructions. Clinical outcomes were recorded. The L5 and S1 pedicles are instrumented with pedicle screws and iliac bolts are placed. By remaining low in the posterior ilium to the anterior inferior iliac spine osseous fixation pathway (OFP), the S1 pathway for iliosacral/transsacral screws remains unobstructed. The titanium rods are contoured into hyperlordosis to facilitate fracture reduction and restoration of lumbosacral lordosis. Bilateral S1 screws allow direct fracture manipulation and reduction and act as the critical hinge for movement of the upper sacral segment relative to the ilium to correct both translation and kyphosis (Fig. 1). Reduction of the kyphotic deformity restores the central portion of the S1 OFP for iliosacral/transsacral screw placement.

Results: 20 patients, average age 37.6 years (range, 20-71), with SPD injuries were identified and all underwent TOS fixation with S1 pedicle screws. Average follow-up was 1 year, and all fractures went on to radiographic union at an average of 55.5 days (range, 25-113). Axial, sagittal, and coronal plane fracture displacement improved on average from 17.2 mm to 4.7 mm ($P<0.01$), 12.4 mm to 3.2 mm ($P<0.01$), and 10.3 mm to 2.5 mm ($P<0.01$), respectively. Kyphotic displacement improved from 24.7° to 14.3° ($P<0.01$). The average neurologic Gibbons score improved significantly from 2.7 preoperative to 1.7 postoperative ($P<0.01$).

Conclusion: The use of S1 pedicle screws in TOS for reduction and fixation of SPD injuries is safe and effective. Reductions were on average near anatomic and improved clinical outcomes were noted.



Using a Positioner System for the Surgery of Both-Column Fracture of the Acetabulum

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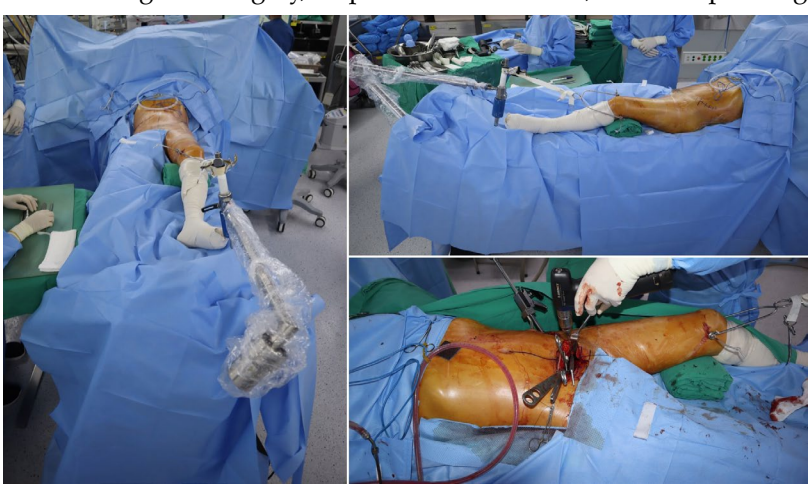
Purpose: Manual traction of the affected leg is often required for fracture reduction while operating acetabular fractures. Especially in the fractures that accompany central femoral head dislocation, continuous traction is very helpful in reducing fractures and is often necessary as a result. However, there is a limitation to maintain the constant traction manually throughout the operation time. Accordingly, we surgically treated such injury while maintaining traction using a Limb Positioner System and investigated the result.

Methods: The study included 13 patients with both-column fractures of the acetabulum. There were 8 men and 5 women, with a mean age of 47 years. The cause of the injury was traffic accidents in 9 and fall from a height in 4. Nine of 13 (69.2%) had a central femoral head dislocation. Surgery was performed after patient condition stabilized, mean 10.4 days after injury. After transfixing the Steinmann pin on the distal femur and attaching the bow, this was connected to the Limb Positioner System, and traction was performed. While maintaining traction with it, fracture reduction and fixation were carried out through an anterior approach. Three cases required posterior fixation through an additional posterior approach. The bony union and reduction status were assessed at the final follow-up, and functional was appraised using Merle d'Aubigne score. The average follow-up period was 22.9 months.

Results: Primary bony union was obtained in all cases at an average of 17.4 weeks. The quality of reduction assessed by Matta's criteria was excellent in 7 and good in 6. The average Merle d'Aubigne score at the final follow-up was 16.4. As a complication, invasion of the screw into the joint occurred in 1 case.

Conclusion: Surgical treatment of both-column fractures of the acetabulum using the Limb Positioner System is thought to be a useful and convenient method because it allows continuous traction with constant force throughout surgery, helps to reduce fracture, reduces operating room personnel, and yields excellent radiologic and functional outcome.



Continuous Compression Implant-Assisted Reduction and Orthogonal Fixation for APC Pelvic Ring Injuries: A Novel Use for a Time-Tested Implant

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Purpose: Symphyseal disruptions in APC (anteroposterior compression) type 2 and 3 pelvic ring injuries are typically secondary to high-energy trauma. These injuries commonly require anterior fixation of the pelvis to achieve stability and decrease the likelihood of implant failure and poor outcomes. In an effort to accurately and effectively reduce the anterior pelvic ring and provide orthogonal stability with minimal rectus abdominus soft-tissue stripping, we present a technical trick that has been utilized in a small series of patients who underwent continuous compression implant-assisted reduction of the pubic symphysis prior to plate and screw fixation for APC type 2 and type 3 injuries.

Methods: This technique is commonly utilized as the standard-of-care treatment for these injuries. Patients undergo a standard anterior approach to the pubic symphysis. A Weber or Jungbluth clamp is utilized to reduce the anterior pelvic ring and a 2- or 4-prong 20-mm bridge × 15-mm leg CCI (continuous compression implant) staple is placed along the anterior pubis bridging the symphysis. This allows for minimal anterior soft-tissue stripping, preliminary reduction clamp removal, and improved fluoroscopic visualization of the posterior pelvic ring for possible percutaneous fixation. Additionally, this method of flexible provisional fixation allows for fine-tuning of the posterior ring reduction. Further benefits include orthogonal (90/90) symphyseal fixation after a superior-based plate and screws are placed, conferring additional stability.

Results: 24 patients underwent open treatment of acute APC ring injuries. No patients were deceased at last follow-up. No revision surgeries were required for loss of fixation. All patients had fracture union at their final follow-up and were without pain related to their pelvic ring injury.

Conclusion: CCI-assisted reduction and orthogonal fixation for APC pelvic ring injuries with a continuous compression staple appears to be a reasonable strategy to increase anterior pelvic ring stability in addition to internal fixation.

A-C: AP pelvis, volume rendered inlet and outlet demonstrating type 3 APC injury
D-E: Initial anterior pelvic ring reduction with Jungbluth clamp and (F) placement of anterior symphyseal CCI staple
G: Posterior pelvic ring fixation performed without clamp obscuring c-arm imaging
H-J: Final intraoperative images demonstrating application of anterior plate and screws with orthogonal CCI staple and reduction of the posterior pelvic ring
K-M: 1-year post-operative AP, inlet and outlet films demonstrating stable pelvic ring alignment, without evidence of hardware failure

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Percutaneous Extraction of Intra-Articular Posterior Wall Acetabular Fragment: Surgical Technique and Case Series

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Purpose: Posterior wall fractures are the most common type of acetabular fracture. A relatively uncommon variant is the posterior rim fracture. This fragment can often be flipped into the joint during the reduction of a dislocated hip. The fragment becomes incarcerated between the femoral head and intact acetabulum. The fragments are often small enough that they do not contribute to hip joint stability; however, they cannot be left in the joint. The purpose of this report is to describe the technique to percutaneously remove the fragment from the joint to eliminate the morbidity of a Kocher-Langenbeck approach.

Methods: The patient is positioned supine on a radiolucent traction table. The hip joint is distracted. An incision is made at the posterior aspect of the tip of the greater trochanter. A tonsil is then directed into the joint. Using a combination of palpation and fluoroscopy, the tip of the tonsil is initially directed into the superior dome and then carefully maneuvered posterior and lateral to flip out the rim fragment. Traction is released to ensure a concentric hip joint. The reduction is then confirmed with either arthroscopy, intraoperative 3-dimensional imaging, or with postoperative CT. The hip joint is then stressed under fluoroscopy to ensure stability. Postoperatively, the patient is allowed to weight-bear as tolerated with assistive devices as needed and posterior hip precautions.

Results: This technique has been used five times in the past 5 years. In each case, the patient presented with a dislocated hip that was reduced in the emergency department. After reduction, a CT scan was obtained that revealed the incarcerated posterior wall rim fracture. The above operative technique was then used to remove the fragment from the joint. The described technique was successful each time. There were no instances of conversion to an open approach. At most recent follow up (average 2 years), each patient was doing well with minimal to no hip pain and no evidence of radiographic progression of arthritis.

Conclusion: Posterior wall acetabular rim fractures represent a small minority of acetabular fractures. When incarcerated in the joint, they must be removed. These can be treated with a percutaneous technique, saving the patient the morbidity of a Kocher-Langenbeck approach.

Use of an Intraoperative Limb Positioner for Adjustable Distraction in Acetabulum Fractures with Femoral Head Protrusion

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Purpose: Anatomic reduction of acetabular fractures with femoral head protrusion requires lateralization of the femoral head to facilitate reduction and definitive fixation. Several methods exist to apply traction in pelvis and acetabular surgery. Limb positioners designed originally for upper extremity surgery and for arthroscopic procedures have gained favor in the lower extremity due to their ease of adjustment intraoperatively. The use of a limb positioner has not been previously described for this application. Here we report the application of a technique to modify an arthroscopic limb positioner to apply easily adjustable distraction vectors in acetabular fracture surgery.

Methods: A 71-year-old male fell from a ladder, sustaining an associated both-column acetabulum fracture with medialization of the femoral head (Fig. 1A). He was placed supine on a radiolucent table. A limb positioner was attached to the table (Fig. 1B). A 5.0-mm Schanz pin was inserted into the femoral neck and head in line with the femoral neck, and with minimal distraction the head was lateralized and located back under the anterior column (Fig. 1C). The Schanz pin was affixed to the limb positioner using a modified limb positioner adaptor, in which a universal chuck had been welded to the adaptor (Fig. 1D). The attachment is easy to affix to the positioner, as the manufacturer's connector for the limb positioner is cut and welded to a universal T-handle chuck. Distraction was applied through the Schanz pin and maintained with the pneumatic limb positioner (Figs. 1 E-G).

Results: An ilioinguinal approach was made to the right acetabulum. The fracture was reduced and clamped. Buttress plates were applied to the anterior column anterior and medially. Distraction was adjusted and maintained throughout the case as needed. Postoperative plain radiographs demonstrated anatomic reduction (Figs. 2A-C).

Conclusion: A limb positioner can provide appropriate on-table traction in pelvis and acetabular surgery to neutralize deforming forces and facilitate reduction and fixation.

Figure 1

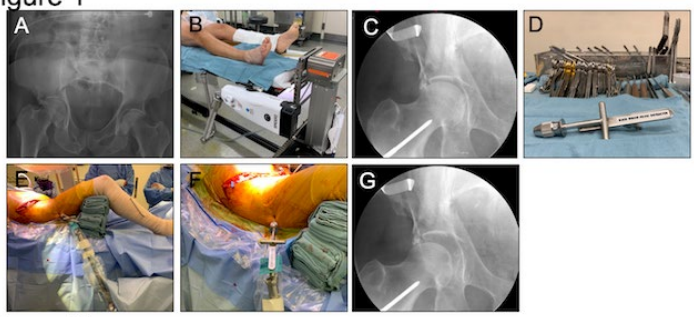

Figure 2

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Low-Profile Triangular Osteosynthesis for Unstable Posterior Pelvic Ring Injuries: Technical Note

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Purpose: Conventional triangular lumbopelvic fixation can be problematic because (1) it requires an advanced skill set for pedicle and iliac screw placement; (2) the connecting construct is technically demanding because of the screw insertion angles, often requiring offsets or rod bending; (3) reduction of the fracture may have to be done with Schanz pins and a femoral distracter followed by replacement by pedicle screws; and (4) may result in prominent instrumentation with subsequent wound breakdown. The purpose of this study is to describe our technique using implants that solve all these issues.

Methods: The patient is placed prone on a flat-top spinal Jackson table. We use a Schanz pin–based spine implant system (USS Fracture DPS /Johnson & Johnson). A lateral Wiltse approach is made between L5 and the posterior superior iliac spine (PSIS) for triangular fixation or bilateral Wiltse for U-shaped sacral fractures. The L5 Schanz pin is placed with AP fluoroscopy and and the Iliac pin is placed using the obturator outlet, obturator inlet, and iliac oblique views. The Schanz pins are placed parallel in the sagittal plane and at a 45° offset in the axial plane. The iliac pin is placed from the sacrum across the sacroiliac joint and below the PSIS so that it is not prominent. These are connected with a straight rod and 2 clamps. The hemipelvis can be distracted into reduction and then the clamps are tightened. This is followed by a horizontal screw such as a transacral screw.

Results: This series consisted of 18 consecutive patients who underwent lumbopelvic instrumentation for a sacral fracture/pelvic ring injury. We included only patients with a complete disruption through either the sacrum or sacroiliac joint from blunt trauma (AO/OTA Type C injuries). Reduction was measured by the modified Keshishyan Index and superior migration of the hemipelvis on the Bonesetter App (Detroit Bonesetter). There was no loss of reduction during the healing period, no failure of implants, or infection.

Conclusion: This technique does not require rod bending or an offset clamp, and results in a more recessed iliac screw and connecting rod to prevent wound breakdown.

Table 1: List of 18 patients who underwent lumbopelvic fixation (LPF) with associated pelvic injury, indication for treatment, type of treatment, and AO/OTA Classification

Patient	Injury	Indication for LPF	Treatment	AO/OTA Classification
1	R sacral fx, L APC2, b/l pubic rami fxs	Comminuted, displaced sacral fracture	R LPF, R S1 ISS, S2 TSS, INFIX	61C2.3(c,e,m)
2	R sacral fx, PS injury	Comminuted, displaced sacral fracture	R LPF, PS plate, R S1 ISS, S2 TSS	61C1.3(d)
3	R sacral fx, b/l pubic rami fx	Comminuted, displaced sacral fracture	R LPF, R S1 ISS, S2 TSS, INFIX	61C1.3(b)
4	R sacral fx, R pubic rami fx	Comminuted, displaced sacral fracture	R LPF, R S1 ISS, S2 TSS, INFIX	61C1.3(a)
5	L sacral fx, L pubic rami fx	Comminuted, displaced sacral fracture	L LPF, L S1 ISS, S2 TSS, INFIX	61C1.3(a)
6	R sacral fx, R pubic rami fx	Comminuted, displaced sacral fracture	R LPF, R S1 TSS, INFIX	61C1.3(a)
7	R sacral fx, L pubic rami fx	Sacral fx with L5/S1 facet extension	R LPF, R S2 TSS, INFIX	61C1.3(c)
8	R sacral fx, R pubic rami tilt fx	Comminuted, displaced sacral fracture	R LPF, R S1 TSS, INFIX	61C1.3(a,f)
9	L sacral fx, R APC2, b/l pubic rami fx	Comminuted, displaced sacral fracture	L LPF, L S1 ISS, S2 TSS INFIX	61C2.3(b,m)
10	B/l SI joint fx/dislocation	Bilateral SI joint fracture/dislocation	B/l LPF, B/l S1 ISS, S2 TSS, INFIX	61C3.1(j)
11	R sacral fx, L APC2, b/l pubic rami fx	Comminuted, displaced sacral fracture	R LPF, L S1 ISS, S2 TSS, INFIX	61C2.3(b,m)
12	R SI joint dislocation, PS injury	Sacral fx with L5/S1 facet extension	R LPF, PS plate, R S1 ISS	61C1.2(d)
13	L sacral fx, R APC2, PS injury	Comminuted, displaced sacral fracture	L LPF, PS plate, R S1 ISS, R S2 TSS	61C2.3(d,n)
14	Sacral U-fx, b/l pubic rami fx	Sacral U-type fracture with kyphosis	B/l LPF, L S1 ISS, S2 TSS, INFIX	61C3.3(b)
15	R sacral fx, R pubic rami fx, PS injury	Comminuted, displaced sacral fracture	R LPF, R S1 TSS, INFIX	61C1.3(a,d)
16	B/l sacral fx (b/l L5/S1 facet), L pubic rami	Bilateral sacral fractures with bilateral L5/S1facet extension	B/l LPF, R S1 ISS, S2 TSS, INFIX	61C3.3(b)
17	R sacral fx, L APC2, L ilium fx, L acetabulum fx	Comminuted, displaced sacral fracture	R LPF, R S1 TSS, R S2 TSS. L S1 ISS, L LC2S, INFX	61C2.3(d,n)
18	Sacral U-fx, L4-5 TP fx	Sacral U-type fracture with kyphosis	B/l LPF, R SI ISS, S2 TSS	61C3.3

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

Tibial Nailing in a Lateral Decubitus Position Facilitating Simultaneous Harvest of Scapular Flaps for Single-Stage Definitive Orthoplastic Management

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Purpose: Open tibial fractures can be challenging to manage because of the paucity of soft tissue available locally to cover any wound post debridement. They commonly require both skeletal stabilization and complex soft-tissue reconstruction. The optimal method of managing these patients is to perform a debridement on day one and then a combined "fix and flap" procedure no more than 72 hours later. The purpose of this project was to find a way to increase the use of scapula and parascapular flaps for orthoplastic reconstructive surgery. The scapula flap is an extremely reliable fasciocutaneous flap with a reliable, long and wide pedicle that facilitates rapid harvest and potentially low complication rates. Unfortunately with supine tibial nailing, it is not possible for plastic surgeons to raise this flap at the same time as fracture fixation due to access. Therefore the less reliable fasciocutaneous anterolateral thigh flap is used as an alternative.

Methods: In this series we present a group of patients who underwent suprapatella tibial nailing in a lateral position with the injured side both down and up, purely to facilitate ease of access to the back so scapula and para-scapula flap could be harvested.

Results: Four patients underwent lateral positioned tibial nailing. Two patients went on to unite, 1 is ongoing, and 1 patient was lost to follow-up.

Conclusion: Stabilizing open tibial fractures that require intramedullary tibial nailing and a free flap in a lateral position promotes orthoplastic teamwork. It facilitates the harvesting of a relatively straightforward flap in a time-efficient manner as both surgical teams can operate simultaneously. Increasing surgical efficiency, promoting orthoplastic teamwork, and utilizing a more reliable flap gives the best chance of recovery for these complex injuries.

Arthroscopic-Assisted Docking Procedure After Bone Transport

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Purpose: Resection of dead bone and fibrous tissue is key to succesful docking after bone transport and to treat infected nonunion. However, assessing vitality of the remaining bone is difficult during an open procedure and skin may be fragile.

Methods: With bone ends 7 to 10 mm apart, an arthroscopy is performed with a standard shaver to remove fibrous tissue from the docking area (or nonunion site) and to refresh the bony ends. Fluorscopy locates the site; needles can be inserted to guide the scope. When releasing water pressure, endosteal bleeding should occur. If not, more shaving is performed. Autologous bone graft can be inserted concomitantly.

Results: Figure 1 demonstrates adequate bleeding from the bone after arthroscopic refreshing.

Conclusion: Arthroscopy of a docking or nonunion site is an elegant, minimally invasive procedure, helpful to resect and evaluate the vitality of bony ends and to percutaneously graft the site, providing a safe, gentle, and efficient docking. During the arthroscopy, the water pressure serves as an internal tourniquet, and as the camera amplifies the picture of the site, an excellent overview is provided.

TECHNICAL TRICKS AND TIPS

Management of Post-Traumatic Osteomyelitis in Distal Tibia by Ankle Arthrodesis Using Retrograde Intramedullary Nail

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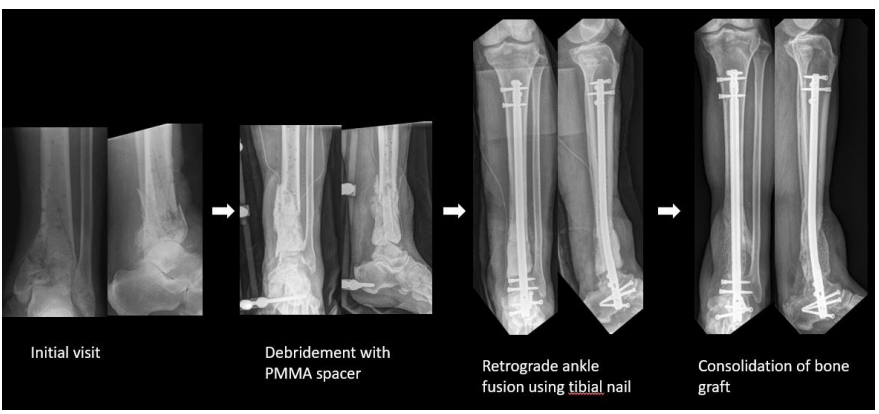
Korea University Guro Hospital, Seoul, Korea, Republic of

Purpose: Management of critical bone defect in posttraumatic osteomyelitis (PTOM) is challenging. The purpose of this study is to introduce management of PTOM in distal tibia by retrograde ankle joint arthrodesis using tibial nail and assess the success rate of bone reconstruction.

Methods: Between August 2014 and August 2020, 10 patients who were diagnosed as PTOM in distal tibia and treated by ankle joint arthrodesis using intramedullary nail at our Level I trauma center were included. Patients› demographic data and surgical details were collected using medical chart and PACS (picture archiving and communication system). PTOM was managed in 3 stages. Thorough debridement and antibiotics-loaded polymethylmethacrylate (PMMA) spacer with temporary fixation was done in first stage. When post-debridement culture was negative, we proceeded to second stage, which is definitive fixation. For definitive fixation, tibial nail was inserted in retrograde fashion from calcaneus to proximal tibia to achieve longer working length and stability due to severe bone defect after debridement of osteomyelitis. In third stage, bone graft was done. Consolidation of bone graft was evaluated using RUST scores (Radiographic Union Scores for Tibia Fractures).

Results: Mean follow-up period was 2.8 years. Average bone defect size after debridement was 6.64 cm. Average distal tibia bone stock length was 0.17 cm. One patient had fatigue failure with 1 broken screw but had no functional effect. Eight patients had successful reconstruction and in 2 patients implant removal and debridement was done due to recurrence of infection. In 2 patients, implant removal was done after complete fusion out of patient's desire.

Conclusion: Retrograde ankle joint arthrodesis using tibial nail can be a treatment option in patients with PTOM around the ankle joint with severe bone defect, when hindfoot fusion nails are not available. Successful reconstruction can be achieved with nail in posterior angulation with enough stability.



ICG-Based Fluorescence Imaging to Guide Local Tissue Rearrangement in Complex Soft-Tissue Wounds Around the Hip: A Technical Trick

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Purpose: Complex soft-tissue defects, dead space, and degloving injuries about the hip are rare but challenging cases. Exposed bone and / or hardware often requires complex coverage. Plastic surgery collaboration is beneficial, but not always readily available. The utilization of tissue perfusion assessment by indocyanine green (ICG)-based dynamic fluorescence imaging continues to evolve in orthopaedics. We present a technical trick to assist with local tissue rearrangement around the hip by utilizing this technology.

Methods: Following thorough staged debridements, large-volume complex sterile wounds about the hip were evaluated with intraoperative laser angiography using the SPY Elite system (Stryker). Intravascular ICG was injected and allowed to circulate for 60 seconds. Dynamic perfusion imaging of the proposed adjacent soft-tissue flap was then assessed to identify dominant perforating vessels. Keystone perforator island flaps (KPIFs) were designed with a flap-to-defect ratio of 1.5 to 1 by incorporating dominant perforating vessels identified on imaging. Flaps were mobilized by previously described principles. De-epithelization of the leading flap edge was used to decrease dead space over exposed hardware or bone if necessary. Closure was accomplished over multiple deep suction drains with monofilament inverted suture for the deep dermal layer and nylon sutures or staples for the epidermis. ICG-based fluorescence imaging was used again after closure to assess perfusion of flap edges.

Results: All complex hip wounds healed without dehiscence, infection, or need for secondary intervention.

Conclusion: Intraoperative ICG-based fluorescence perfusion assessment can help guide local tissue rearrangement by KPIFs to provide durable coverage of complex soft-tissue defects around the hip. With experience and discretion, this technique can be applied by the orthopaedic trauma surgeon who may not have robust plastic surgical services readily available.

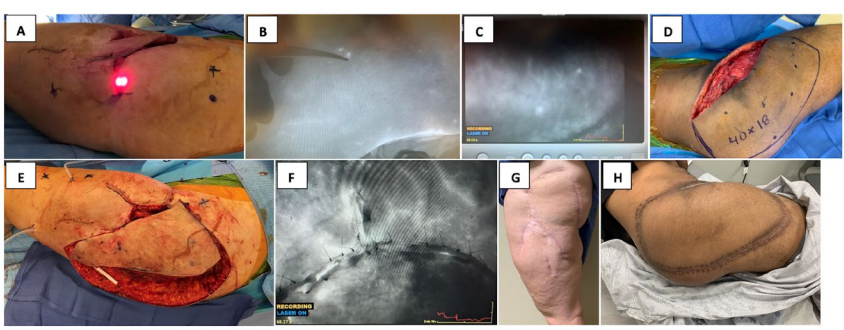

Figure 1. (A) The Spy Elite laser angiography machine is draped, buffered, and focused on the anatomic site of desired perfusion assessment. (B,C) Following intravascular injection of ICG, the operating room lights are turned down and perfusion is assessed. Dominant perforating vessels are then identified (D) Intra-operative photo demonstrating marked cutaneous perforators based on dynamic fluorescence imaging (marked in blue ink) (E) Intra-operative photographs demonstrating KPIF locoregional flap mobilizations in separate patients. (F) Perfusion is re-assessed following epidermal closure with ICG-based fluorescence imaging demonstrating perfused flap edges. (G,H) Final clinical follow-up photographs demonstrating healed flaps.

The Use of a 3D-Printed Resorbable Graft Cage in the Treatment of Critical-Sized Segmental Bone Defects

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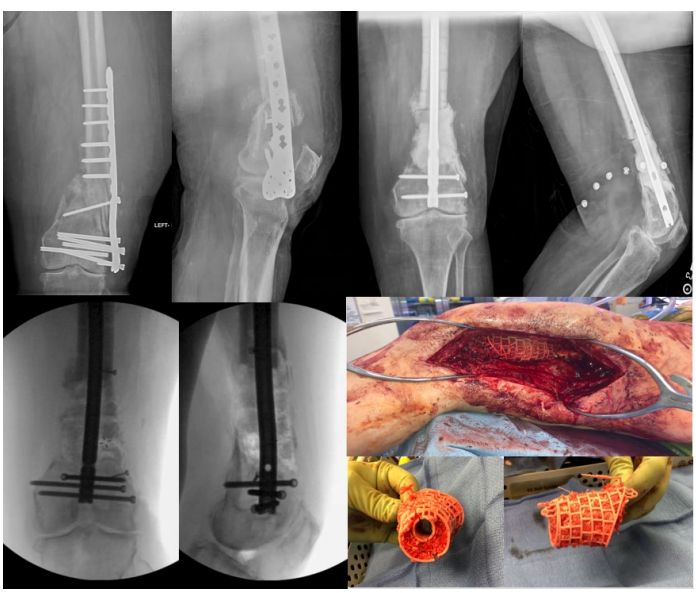
Purpose: Critical-sized segmental bone defects (CSSBDs) in the lower extremity (LE) are a challenging problem for numerus reasons. Several operative interventions have been well described in treating CSSBDs in the LE. The TRUMATCH Graft Cage (GC) is a 3-dimensionally (3D)-printed resorbable implant designed specifically to patient anatomy and bone defect size. The implant is designed to retain bone graft at the bony defect site while allowing the use of intramedullary nailing or plating for bony stabilization. The purpose of this study is to report a technical trick and early outcomes of 3D-printed resorbable GC in the treatment of CSSBDs of the LE.

Methods: Three patients with CSSBDs of the LE underwent staged induced membrane technique (IMT) with definitive bone grafting and 3D-printed graft cage at our academic Level I trauma center. We retrospectively collected data regarding patient demographics, comorbidities, complications, and follow-up.

Results: Two of the three patients had CSSBD of the distal femur and one had a CSSBD of the proximal one-third tibia. Two patients had infected nonunions of the distal femur after open plating at an outside hospital. The third patient developed osteomyelitis of the tibia after sustaining an open tibia fracture several decades previously. The average defect size was 9.33 cm (range, 7.5-12 cm). All three patients were treated with a staged IMT. First stage included extensive debridement, antibiotic cement spacer placement, and intravenous antibiotics. After clearance of infection (confirmed by laboratory values and clinical examination), all three patients underwent intramedullary nailing (two retrograde femoral nails and one suprapatellar tibial nail) and GC placement with autogenous bone. Average follow-up after GC placement was 16 weeks. All patients were fully weight bearing at last follow-up. One patient had exchange of distal interlocking screws at 6 weeks postoperatively due to screw prominence. There were no other early complications noted.



Conclusion: Early results of 3D-printed GC constructs appear promising as a treatment option for CSSBDs of the femur and tibia.

TECHNICAL TRICKS AND TIPS

The Laparoscopic Irrigator Aspirator: A Cost and Time-Saving Alternative Irrigation Method for Open Fractures

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Purpose: The laparoscopic irrigator aspirator (LIA) is an irrigation method used in laparoscopic surgery that is ubiquitously available in all operating rooms (ORs). The LIA uses a battery-powered pump and has the ability to deliver irrigation efficiently, as well as aspirate that fluid in a similar manner. At our institution, the LIA has become the primary method for irrigation of open fractures due to its efficiency. The purpose of this study is to compare the cost and time between gravity tubing, pulse lavage, and LIA for one 3-L bag of normal saline (3L NS bag) and to extrapolate those data to estimate time and cost savings for open tibia fractures treated at our institution over 1 year.

Methods: Three methods of irrigation (gravity tubing, pulse lavage, and LIA) were set up with the bottom of a 3L NS bag at a height of 7 feet (213 cm) and the distal end of the irrigation delivery device at a height of 4 feet (122 cm). The time needed to drain one 3L NS bag was recorded for each. The prices for each method of irrigation were obtained and the time and cost saved per 3L NS bag was multiplied by three for the total time and cost for 9 L.

Results: For a 3-L bag of NS, pulse lavage was the slowest form of irrigation (4:02 [minutes: seconds]), followed by gravity tubing (2:45), and the LIA was the most efficient method (1:04). In our state, the average cost of OR time is $37.45 per minute. For 3 L, the LIA was 101 seconds faster than gravity tubing and 178 seconds faster than pulse lavage. For 9 L, LIA saved 303 seconds compared to gravity tubing and 534 seconds compared to pulse lavage. At our institution, the cost of an LIA is $39.16, pulse lavage is $38.66, and gravity tubing is $6.19. Over 9 L, the LIA results in $156.15 saved over gravity and $332.80 saved over pulse lavage when accounting for both the cost of OR time and the irrigation device. At our institution, 34 open tibia fractures were treated with the LIA in 2019, which resulted in 2.86 hours and $5309.10 saved over gravity tubing and 5.04 hours and $11,315.2 saved over pulse lavage.

Conclusion: The LIA is a viable alternative to gravity tubing and pulse lavage for open fracture irrigation and results in both time and cost savings.

Treatment of Infected Nonunion of the Lower Extremity with an Antibiotic Cement-Coated Intramedullary Rod: A Case Series of 38 Patients

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Purpose: Infected nonunion of the long bones is a notoriously complex condition to treat. Eradication of the infection prior to definitive internal or external fixation involves multiple washout procedures and/or exchange(s) of antibiotic-coated delivery devices. Antibiotic cement-coated intramedullary (ACCIM) rods can deliver a high concentration of antibiotics while maintaining stability of the nonunion site. Our study highlights the efficacy and practicality of using ACCIM rods as a dual-purpose treatment modality to clear infection and work toward union.

Methods: This study is an IRB-approved retrospective case series of 38 patients with an infected nonunion of the lower extremity treated with an ACCIM rod between 2001 and 2019 at a Level I academic trauma center. We reviewed chart notes, laboratory data, and radiographs to determine our primary outcomes of number of procedures and time needed to eradicate infection, and to subsequently achieve union. We collected information on the type of antibiotic used for the ACCIM rod and complications during rod removal or exchange. All patients have a minimum 1-year follow-up.

Results: Infection was successfully treated in 36 of 38 patients (94.7%) with only 4 patients experiencing infection relapse. Patients required an average of 6.5 months (range, 1-20 months) to eradicate their infection. Union was achieved in 30 of 38 patients (78.9%) with or without additional procedures, requiring an average of 9.6 months (range, 1-20 months) to achieve union. 23 of 38 patients (60.5%) required an average of 1.2 (range, 1-2) additional procedures to achieve successful union. 7 of 38 patients (18.4%) had successful union without the need for additional procedures other than ACCIM nailing. Of the 8 patients who did not achieve union, 4 patients had an implant-dependent union and 4 had persistent nonunion. Debonding of cement during removal of ACCIM nail was seen in only 1 case. Mean follow-up was 33.7 months.

Conclusion: ACCIM rods are an effective and efficient treatment modality to manage infected nonunion of the lower extremity. Here we present a simple method to construct an ACCIM rod using widely available instrumentation with a low rate of complications during insertion and removal. This is a cost-effective construct that may allow some bony healing along the same timeline as infection treatment, and thus may reduce the number of procedures needed to manage such a complex disease.

The T-Bar External Fixator for Definitive Management of Tibia Fractures with Soft-Tissue Compromise

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Purpose: Tibia fractures with associated soft-tissue compromise are challenging to manage. For fractures with significant swelling or open injury not amenable to internal stabilization, external fixators can provide sufficient stability for bony healing. Ring fixators and hybrid constructs provide adequate stability for healing but are costly and challenging to apply and maintain. We present the "T-bar" external fixator, a novel construct that can be maintained until bony union, allowing for range of motion of adjacent joints.

Methods: The T-bar external fixator uses standard pins and bars in a novel arrangement. It can be applied for OTA type 41/42/43 injuries, with or without supplemental fixation for intra-articular patterns. Two divergent pins are placed in the short articular segment and connected with a bar parallel to the joint. A third pin is placed in this segment, bisecting the first two. Two to three additional pins are placed anterior to posterior in the tibial diaphysis. The bisecting and diaphyseal pins are connected with a bar parallel to the tibial shaft and the two bars are connected with a clamp, forming a T-shape. We report the demographics, as well as clinical and radiographic outcomes, of 34 patients treated definitively with this construct.

Results: Between 2008 and 2015, 34 patients were treated for tibia fracture with T-bar external fixation, with intention to treat in a definitive manner. 29 were male, and average age was 44.3 years. 31 sustained high-energy mechanisms of injury. 20 were Gustilo type 2 or 3 fractures. Of 14 closed fractures, 12 were Tscherne type 2 or 3. 12 of 15 OTA41 fractures were followed to radiographic union. All achieved bony union, with 2 having staged bone grafting prior to external fixator removal. Radiographic knee arthritis was noted in 9 patients followed to union. 6 achieved coronal alignment within 5° of neutral, and 8 had posterior slope angle within 5° of 10°. 10 of 13 OTA42 fractures were followed to radiographic union. 9 of 10 achieved bony union, with 3 having staged bone grafting prior to external fixator removal. 7 achieved coronal and sagittal alignment within 5° of neutral. There was one case of osteomyelitis, and another transient pin site infection. 5 of 6 OTA43 fractures were followed to radiographic union. 3 of 5 resulted in nonunion, addressed with internal fixation. Radiographic ankle arthritis was noted in 4 patients followed to union. 4 and 5 achieved coronal and sagittal alignment within 5° of neutral, respectively.

Conclusion: The T-bar external fixator offers an alternative to ring and hybrid external fixator constructs in the treatment of tibia fractures with significant soft-tissue compromise. Of 28 patients with complete follow-up, only one case of osteomyelitis was reported. All patients were managed without amputation. 3 required revision for nonunion, all OTA-type 43.

Nail Plate Fixation Technique to Optimize Indirect Reduction and Fixation of Proximal Tibia Fractures

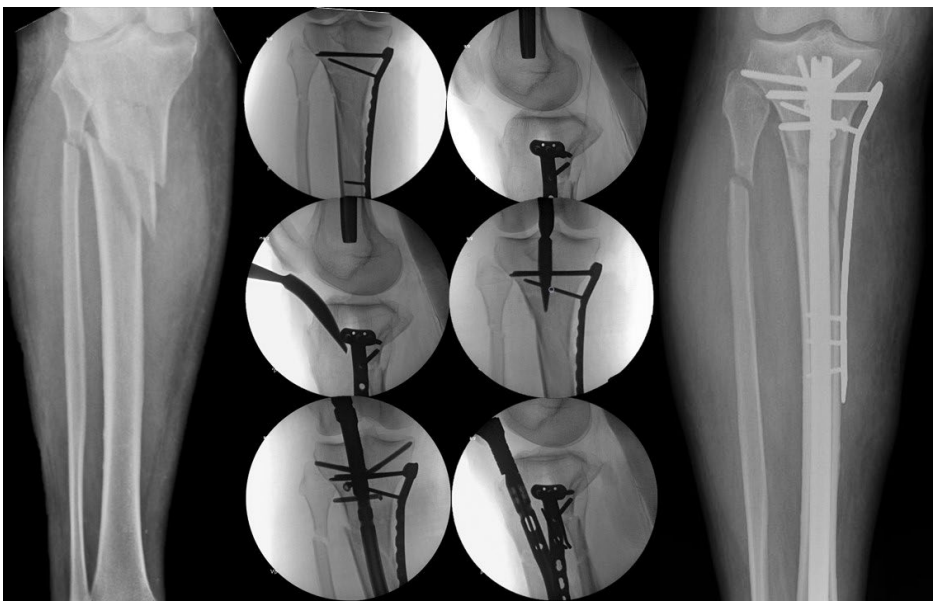
***Mitchel Obey, MD**; Marschall B. Berkes, MD*
Washington University in St. Louis, St. Louis, MO, United States

Purpose: Treatment of proximal quarter and fifth tibia fractures can be very difficult. Intramedullary nailing is associated with predictable apex anterior angular and translational deformities as well as coronal plane displacement. This can be combated with blocking screws, but they can be difficult to place precisely and perhaps not feasible in cases of metaphyseal comminution. Achieving and maintaining a reduction is relatively easy with plate fixation, particularly with precontoured anatomic plates; however, plate fixation may be suboptimal, particularly in unreliable patients. The goal was to describe our technique involving minimally invasive plating of proximal tibia fractures to achieve an indirection reduction followed by intramedullary nailing.

Methods: We provide the step-by-step surgical technique for fixation of proximal tibia fractures with a nail plate construct (Fig. 1). All patients who underwent this technique for fixation of a proximal tibia fracture at our institution between July 1, 2017 and October 1, 2019 were reviewed to evaluate clinical and radiographic outcomes.

Results: Six patients (7 tibias) with a mean age of 51.6 years were identified. Mean follow-up was 148 days. At time of final follow-up, we observed union of all fractures without loss of reduction or alignment, and there were no instances of implant failure or complications.

Conclusion: This technique for fixation of proximal tibia fractures can reliably achieve and maintain alignment and provide optimal fixation in these challenging fractures with good outcomes.

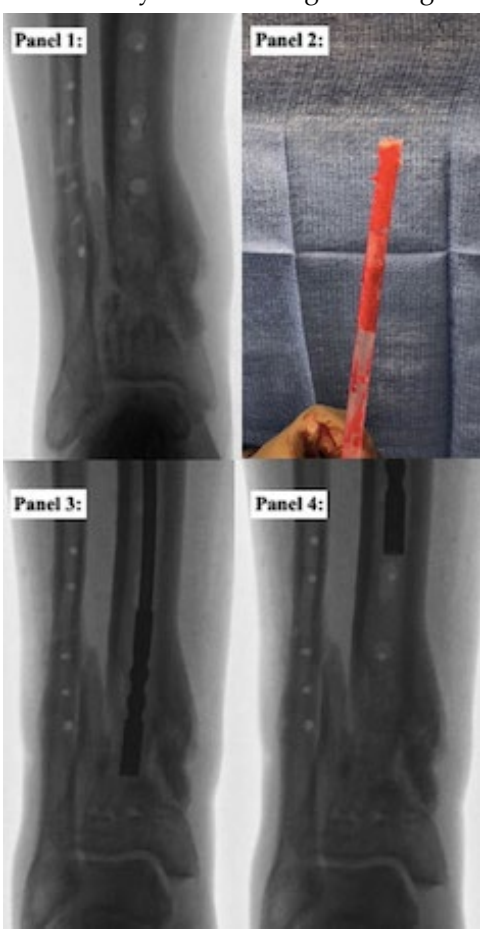


Intramedullary Delivery of Autologous Bone Graft to Long Bone Defects Using Reamer Irrigator Aspirator 2 System

Joshua Nelson Speirs, MD; Matthew Neil Cahill Wilson, BS; ***Joseph Johnson, MD***
Loma Linda University, Loma Linda, CA, United States

Purpose: Management of nonunions and bone defects remain a persistent orthopaedic challenge. Traditional methods of autologous bone graft are complicated by donor site morbidity, limited graft availability, and local morbidity imposed from surgical dissection around the nonunion. This case demonstrates a method of autologous bone grafting that avoids many of these patient morbidities while delivering a large volume of bone graft to the nonunion site.

Methods: Here we describe a novel method utilizing the Reamer Irrigator Aspirator 2 System (RIA2) to harvest and deliver ipsilateral autologous bone graft intramedullary to the distal tibia nonunion without the need for further surgical dissection. The patient was a 66-year-old male who sustained an open distal tibia pilon fracture (AO 43C1.3) that developed a metaphyseal nonunion. Figure 1 shows delivery of the bone graft using the RIA2 equipment (Panel 1, pre-bone graft; Panel 2, bone graft packed into RIA tubing; Panel 3, bone graft delivery using RIA tubing and reamer insert; Panel 4, after graft placement).



Results: This technical trick successfully delivered a large volume of bone graft intramedullary to the nonunion site without additional surgical dissection or extra equipment.

Conclusion: Using the RIA2 equipment, a large volume of autologous bone graft can be delivered to the nonunion site intramedullary without additional fracture site dissection or additional harvest site morbidity.

First Clinical Results with Micromotion Intramedullary Nailing of Tibial Fractures

Hannah L. Dailey, PhD; ***James Anthony Harty, FRCS (Ortho)***
Cork University Hospital, Cork, Ireland

Purpose: The objective of this study was to assess clinical outcomes for tibial shaft fractures treated with a new intramedullary (IM) nailing system that produces controlled axial interfragmentary micromotion. Clinical outcomes were compared to the current standard of care (tibial nail with static interlocking).

Methods: All patients were treated in a Level I trauma center over a 2.5-year period. Group allocation was not randomized; both the micromotion nails and static locking nails (control group) were commercially available in the center and selected at the discretion of the surgeons on call. All micromotion patients were prospectively recruited. The control group was a mixed prospective-retrospective design to ensure accurate reporting of the nonunion rate. Patient and injury characteristics were recorded, and Nonunion Risk Determination (NURD) scores were calculated. Radiographic progress was assessed every 6 weeks until clinical union. Low-dose CT scans were acquired at 12 weeks and virtual mechanical testing was performed on each fracture to objectively assess virtual torsional rigidity (VTR). VTR is expressed as a percentage, where 0% indicates no healing and 100% indicates structural equivalence with the patient's intact tibia.

Results: A total of 98 primary tibial fractures were evaluated. Of these, 39 patients were treated with micromotion and there were 37 complete records (1 lost to follow-up, 1 suspended due to COVID-19). The control group included 59 patients and there were 46 complete records (8 lost to follow-up, 5 suspended due to COVID-19). There were no significant differences between the micromotion and control groups in terms of median age (40 vs 35 years, $P = 0.996$), gender (70% male both groups), the proportion of open fractures (22% vs 19% open, $P = 0.752$), or median NURD score (3 vs 1, $P = 0.157$). There were no nonunions in the micromotion group versus five (11%) in the control group. There were no deep infections in either group. The proportion of fractures united was significantly higher in the micromotion group compared to controls at 12 weeks (54% vs 30% united, $P = 0.043$), 18 weeks (81% vs 59%, $P = 0.034$), and 24 weeks (97% vs 74%, $P = 0.005$). Considering all injury types and comorbidities together, there was no difference in average VTR score at 12 weeks with micromotion compared to control (100% ± 18% vs 95% ± 25%, $P = 0.467$). However, considering the subset of only closed fractures, patients with biological comorbidities such as smoking and diabetes had significantly higher VTR scores with micromotion than without (closed comorbidities subset: micromotion VTR = 103% ± 12% [N = 11] vs control VTR = 81% ± 13% [N = 7], $P = 0.008$).

Conclusion: In this pilot clinical series, micromotion fixation was associated with reduced nonunion and improved healing compared to standard tibial nailing. Further prospective clinical studies will be needed to assess the potential benefits of micromotion fixation in IM nailing of the tibia.

Removal of Broken Nails Using Mini-Fragment Screws

Alejandro Ordas-Bayon, MD*; Rumina Begum; Matija Krkovic, MD*
Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

Purpose: Removal of metalwork such as intramedullary nails can be surgically challenging, particularly if they are broken. We present an effective technique for removing the distal end of a broken tibial nail.

Methods: After removing the proximal part of the tibial nail, remove the distal locking screws, leaving the broken distal end of the nail in situ. Pass the olive tip guidewire to the end of the distal nail. Depending on the diameter of the nail and the olive tip guidewire, select an appropriate screw that will fit into the distal locking hole of the nail with the guidewire in situ. For example, for a standard olive tip guidewire in an 8-mm tibial nail, we found a 2-mm screw to be the ideal size. In addition, ensure the screw length is the same as the nail diameter. Tie the screw head using a 2/0 Vicril suture (for easy retrieval if required) before mounting it on a screwdriver. Gently tap the 2 × 8-mm screw into the distal locking hole using a mallet under fluoroscopic guidance. Once the screw is in, the guidewire can be carefully pulled back until it gets jammed with the 2-mm screw.

Results: This then allows the guidewire together with the broken nail to be removed by gentle taps on a T-handle (Fig. 1).

Conclusion: We have demonstrated a technique for removing a broken tibial nail that is both safe and effective without any need for additional surgical exposures, therefore minimizing trauma to the soft tissues and bone.

Antibiotic Cement Nails Manufactured with Threaded Rods or Cannulated Intramedullary Nails Are Better than Those Made with Guidewires

***Ryan Bray, DO**; Abdul Zalikha, MD; Zain Sayeed, MD; Derrek Woodbury, DO; Devone Mansour, DO; Rahul Vaidya, MD*
Detroit Medical Center, Detroit, MI, United States

Purpose: Antibiotic nails are frequently used as an adjunct treatment for infected long bones. This delivery method allows high doses of local antibiotic with minimal risk for systemic effects. Various forms of antibiotic nails are currently used in practice. Nails constructed out of polymethylmethacrylate mixed with antibiotics are thought to provide great elution profiles. We have found debonding of the cement from the structural core can be a problem during removal of the rod, which leaves cement in the intramedullary canal. Removing this cement can be a challenge necessitating the use of reamers osteotomes and long pituitary rongeurs. The purpose of this study is to compare antibiotic cement nails with cores made with an intramedullary guidewire ($120), a regular intramedullary nail ($1100), or a threaded rod from the Ilizarov set ($60) for debonding at the time of removal.

Methods: An IRB-approved retrospective study was performed on 33 antibiotic nails that had been implanted for a tibial infection after intramedullary nailing. All antibiotic nails were manufactured intraoperatively by the treating surgeon using 2 g vancomycin and a single package of tobramycin cement. The powder, antibiotic, and polymer was hand mixed in a bowl then poured into an antibiotic cement mold. The core device was inserted and the mold ripped off with the tabs once the cement had hardened. There were 12 intramedullary nails (8 mm), 7 threaded rods, and 14 guidewires. The nails were imbedded from 6 weeks to 10 months. At the time of removal, the nails were assessed for cement debonding.

Results: Debonding occurred in 0 of the 12 cement nails manufactured with an intramedullary nail, 0 of 7 threaded rod nails, and 6 of 14 guidewire nails. Removal of the remnant cement was accomplished with thin osteotomes, long pituitary rongeurs, or a series of reamers. The canal was visualized using an arthroscopy camera to ensure complete removal of the cement.

Conclusion: Polymethylmethacrylate antibiotic nails manufactured with a standard intramedullary nail or threaded rods did not lead to any debonding. Debonding of the cement from the inner core of an antibiotic nail often requires a significant effort to remove the remnant cement. The use of a standard intramedullary nail coated with antibiotic cement allows static locking in cases of nonunion associated with infection. In healed infected tibias, the choice of an antibiotic cement nail manufactured with a threaded Ilizarov rod is cheaper ($60 vs $120), leads to no debonding, and can be inserted or removed with a threaded Ilizarov attachment.

Surgical Elbow Dislocation: Technique and Comparative Outcomes

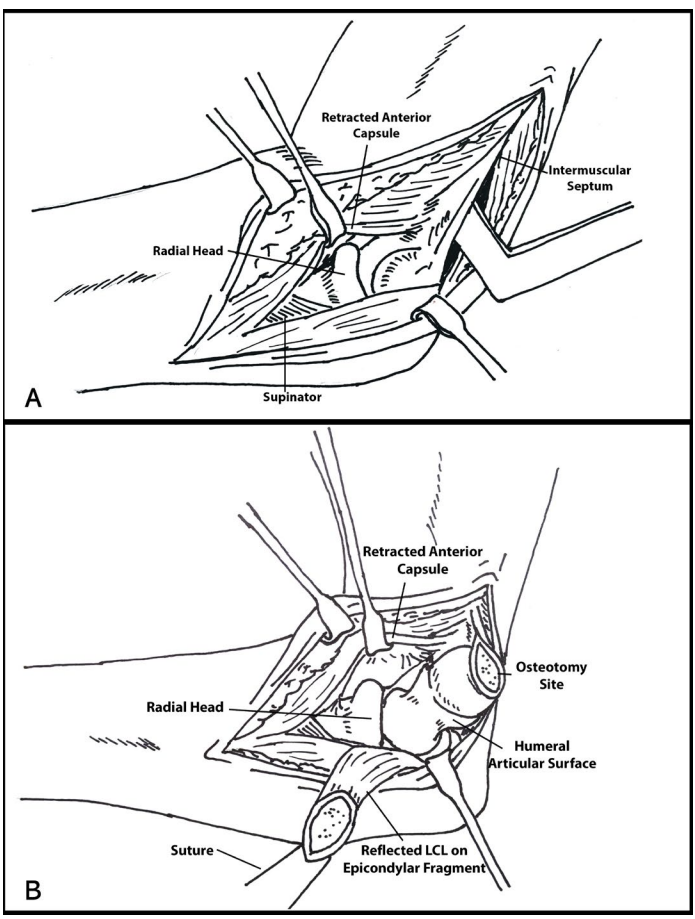
Benjamin W. Hoyt, MD*; Desraj Clark, MD; Sarah Anne Walsh, BA; Raymond A. Pensy, MD*
University of Maryland Shock Trauma Center, Bethesda, MD, United States

Purpose: Surgical access to lateral column fractures of the distal humerus is difficult via traditional approaches due to limited anterior articular exposure for direct reduction and fixation. We have refined a surgical elbow dislocation approach to the articular surface of the distal humerus for fixation of lateral column injuries, which may permit improved access for operative fixation.

Methods: We performed a retrospective review of lateral column fractures treated with open reduction and internal fixation at our institution between 2009 and 2019. We divided patients into three cohorts based on surgical approach: surgical dislocation (n = 10), lateral (n = 17), and posterior (n = 9). Surgical reports, radiographs, and patient records were reviewed for hardware positioning, tourniquet time, estimated blood loss (EBL), postoperative reduction quality, and patient outcomes including range of motion (ROM), neurovascular injury, development of heterotopic ossification (HO), and pain on a visual analog scale.

Results: With the numbers available, we were unable to detect a significant difference in outcomes including pain, ROM, or blood loss. No patients treated with this approach experienced neurovascular injury, instability, or nonunion at follow-up.

Conclusion: The surgical elbow dislocation is a powerful tool to aid reduction and osteosynthesis of intra-articular fractures of the lateral distal humerus. It may enable greater articular access for complex distal humerus patterns without deleterious effects on surgical or patient-reported outcomes.



Lateral Clavicular Fractures Associated with Acromioclavicular Luxation Treated by Osteosynthesis and Coracoclavicular Stabilization: A Surgical Technique

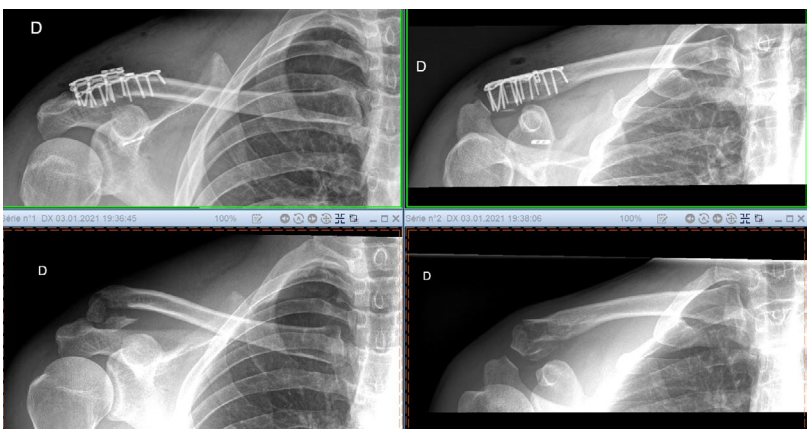
Nermine Habib, MD*; Paolo Fornaciari, MD; Timothee Helmstetter, MMED (Ortho); Gregoire Thuerig, MD; Moritz Tannast, MD; Philippe Vial, MD*
University of Fribourg, Fribourg, Switzerland

Purpose: Unstable distal clavicle fractures associated with lesions of the coracoclavicular (CC) ligaments demonstrate a high symptomatic nonunion rate if treated conservatively. A variety of surgical techniques have been described. Many of these techniques were associated with high failure rates. Therefore, we have adopted a surgical technique that aims at stabilization of the CC ligaments in combination with osteosynthesis of the clavicle. We questioned: (1) loss of reduction; (2) clinical function in terms of the Oxford Shoulder Score (OSS), American Shoulder and Elbow Surgeons Shoulder Score (ASES), and visual analog scale (VAS); (3) return to work; and (4) return to sports.

Methods: This was a retrospective single-center case series conducted between 2015 and 2019 of patients who had a lateral clavicular fracture associated with a CC ligament lesion and underwent stabilization of the CC ligaments by FiberWire and osteosynthesis by low-profile plating (thickness 1.3 mm). Only acute lesions were included. Thirteen patients, with an average age of 48 years, had a clinical and/or radiological average follow-up of 3 years.

Results: Only one of the patients showed loosening of more than 5 mm of the CC ligaments, without horizontal instability and was completely asymptomatic. No loss of reduction was determined. The clinical function at an average of 38 months showed a complete recovery in 10 of the patients. The average OSS was 47 of 48, ASES 99, and VAS 0. All the patients, except two pensioners, went back to work within 2 months and back to sports within 5 months of the operation. Four of the patients were reoperated with the removal of the implants due to discomfort. No other complications were encountered.

Conclusion: Stabilization of the CC ligaments in combination with osteosynthesis of the lateral clavicle using low profile plating provides a surgical treatment option with complication rates consistent with the current literature, a very satisfactory clinical outcome, as well as early return to work and sports.



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Acromioclavicular and Coracoclavicular Ligament Reconstruction by Endobutton: A Surgical Technique

*Gregoire Thuerig, MD; **Nermine Habib, MD**; Paolo Fornaciari, MD; Mauro Maniglio, MD; Moritz Tannast, MD; Philippe Vial, MD*
University of Fribourg, Fribourg, Switzerland

Purpose: Acromioclavicular (AC) joint reconstruction is a frequently performed procedure. Recent scientific interest has led to a drive to develop surgical techniques that more reliably restore horizontal stability. Many of these techniques were associated with high failure rates. We have therefore adopted a modified surgical technique. We questioned: (1) efficacy of the reconstruction; (2) clinical function in terms of the American Shoulder and Elbow Society Score (ASES), Oxford Shoulder Score (OSS), and visual analogue scale (VAS), and (4) return to work.

Methods: This was a retrospective analysis of patients with acute AC dislocation (Rockwood type III-V) from 2015 to 2019. 19 patients, with an average age of 41 years, had a clinical and/or radiological average follow-up of 20 months. This technique consists of drilling a 2.5-mm coracoid tunnel in a 30° angle from posterosuperior to anterolaterally with a 20° medial tilt, which is then widened by a 3.5-mm drill. The coracoid button is mounted with 2 FiberTapes and passed through the tunnel. Three clavicular tunnels are done using a 2.5-mm drill: two posterior tunnels and one anterior tunnel. The posterolateral (PL) and posteromedial (PM) tunnels are drilled from posterosuperior to anteroinferior in a 20° angle, and the anterolateral (AL) tunnel is created from anterosuperior to posteroinferior in a 0° to 5° angle. The PL tunnel is then overdrilled using a 3.5-mm drill. One FiberTape is passed through the PM and PL and the other FiberTape through the PL from inferior to superior and then through the AL from superior to inferior.

Results: The difference in coracoclavicular (CC) distance was significant between the preoperative and postoperative radiographs (17.2 vs 7.6 mm; $U = 7.000$, $P<0.0001$) respective to the last made conventional radiographs (17.2 vs 9.9 mm; $U = 40.500$, $P<0.0001$). In the most recent conventional radiographs, the CC distance had increased significantly to 9.9 mm (±3.64; $U = 77.000$, $P = 0.002$) compared to the postoperative control. The clinical function was restored in all of the patients, with a median ASES of 98.3, OSS of 48, and VAS 0. At 6 weeks, 41.2% of the patients returned to work. At 12 weeks, a total of 78.9% of the patients had returned to their previous jobs, and at 20 weeks, all of the patients were back to work. Three patients showed a secondary displacement >5 mm, of whom 2 patients were treated conservatively due to clinical stability in asymptomatic patients. The third patient showed persistent anteroposterior instability, and a secondary reconstruction was done using a palmaris longus graft.

Conclusion: The study describes a surgical open technique for a three-point anatomical reconstruction of the CC ligaments. All patients could regain their professional activity in a timely manner. It has shown promising clinical results and potential benefits. However, long-term studies are needed to show socioeconomic and clinical benefits.

Ultrasound-Guided Distal Radius Fracture Reduction

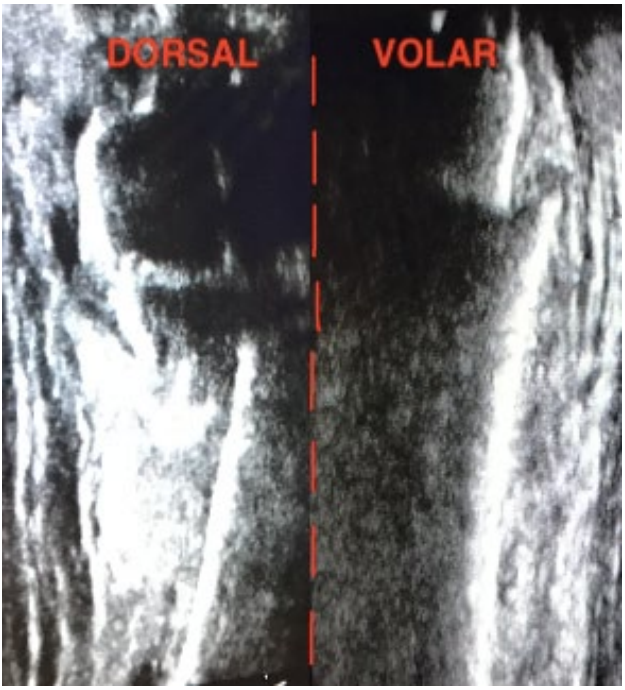
Andrew Hadeed, DO*; Jacqueline J. Krumrey, MD; Charles Edward Hoffler, MD*
Miami Hand Institute, Miami, FL, United States

Purpose: The purpose of this report is to demonstrate how ultrasound imaging can be used as an alternative to fluoroscopy and provide a real-time assessment of a distal radius fracture reduction.

Methods: An 88-year-old woman with a closed dorsally displaced distal radius fracture elected to proceed with closed reduction. She underwent an ultrasound examination of the dorsal, radial, and volar cortices. Closed reduction was performed with regional anesthesia followed by repeat ultrasound examination. The reduction was assessed with fluoroscopy also.

Results: Distal radius fracture displacement can be seen on ultrasound imaging prior to the reduction. The projection of the volar and dorsal surfaces can be viewed side by side to create an anatomic representation of the distal radius fracture (Fig.1). Post-reduction ultrasound and fluoroscopy demonstrated reduction of the volar cortex, the dorsal comminution, and radial translation. The patient was followed post-procedurally with serial plain radiographs and healed uneventfully.

Conclusion: Ultrasound is a feasible option for real-time reduction assessment when fluoroscopy is not available. The ultrasound technique described allows assessment of the volar cortex, dorsal cortex, and coronal translation of the distal radius.



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ORTHOPAEDIC TRAUMA ASSOCIATION HISTORY

PAST PRESIDENTS

Ramon B. Gustilo, MD, Founding President	
Michael W. Chapman, MD	1985-87
Charles C. Edwards, MD	1987-88
John A. Cardea, MD	1988-89
Bruce D. Browner, MD	1989-90
Joseph Schatzker, MD	1990-91
Richard F. Kyle, MD	1991-92
Robert A. Winquist, MD	1992-93
Peter G. Trafton, MD	1993-94
Kenneth D. Johnson, MD	1994-95
Alan M. Levine, MD	1995-96
Lawrence B. Bone, MD	1996-97
James F. Kellam, MD	1997-98
David L. Helfet, MD	1998-99
Andrew R. Burgess, MD	1999-00
M. Bradford Henley, MD, MBA	2000-01
Donald A. Wiss, MD	2001-02
Thomas A. Russell, MD	2002-03
Marc F. Swiontkowski, MD	2003-04
Roy Sanders, MD	2004-05
Paul Tornetta, III, MD	2005-06
Michael J. Bosse, MD	2006-07
Jeffrey O. Anglen, MD	2007-08
J. Tracy Watson, MD	2008-09
David C. Templeman, MD	2009-10
Timothy J. Bray, MD	2010-11
Andrew N. Pollak, MD	2011-12
Robert A. Probe, MD	2012-13
Andrew H. Schmidt, MD	2013-14
Ross K. Leighton, MD	2014-15
Theodore Miclau III, MD	2015-16
Steven A. Olson, MD	2016-17
William M. Ricci, MD	2017-18
David C. Teague, MD	2018-19
Michael D. McKee, MD	2019-20
Heather A. Vallier, MD	2020-21

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—TRAUMA—
ASSOCIATION

ORTHOPAEDIC TRAUMA ASSOCIATION HISTORY

IN MEMORIAM

Franklin D. Shuler, MD, PhD (2021)
Huntington, West Virginia

Berton Roy Moed, MD (2020)
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Jeffrey J. Tucker, MD, FACS (2020)
Houston, Texas

William G. Delong, Jr., MD (2020)
Bethlehem, Pennsylvannia

Stephan M. Perren, MD (2019)
Davos, Switzerland

Thomas Fishler, MD (2019)
Scottsdale, Arizona

Jeffrey W. Mast, MD (2019)
Reno, Nevada

Arsen M. Pankovich, MD (2019)
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New York, NY

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New York, NY

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Dallas, Texas

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St. Paul, Minnesota

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Rochester, NY

Raymond O. Pierce, MD (2014)
Indianapolis, Indianna

Spencer Roy McLean, MD (2013)
Calgary, Alberta

Forney Hutchinson, MD (2013)
Charlotte, North Carolina

Clifford H. Turen, MD (2013)
Dover, Delaware

James Bradley Carr, MD (2011)
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John A. Ogden, MD (2011) |
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Wiiliam J. Mills, III, MD (2011)
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Joseph F. Slade III, MD (2010)
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CDR Michael T. Mazurek (2009)
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Alan M. Levine, MD (2009)
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Maurice Mueller, MD (2009)
Bern, Switzerland

Phillip G. Spiegel, MD (2008)
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Orlando, FL

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Detroit, MI

Fred F. Behrens, MD (2005)
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E. Frederick Barrick, MD (2004)
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Emile Letournel, MD (1994)
Paris, France

John Border, MD (1997)
Buffalo, NY

Bertram Goldberg, MD (1995)
Englewood, CO

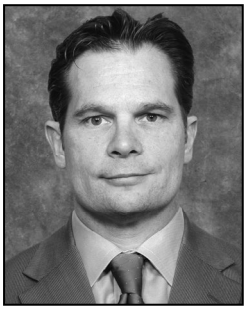
ORTHOPAEDIC TRAUMA ASSOCIATION HISTORY
ANNUAL MEETINGS

September 14 - 15, 1985	New York, New York, USA
November 20 - 22, 1986	San Francisco, California, USA
November 19 - 21, 1987	Baltimore, Maryland, USA
October 27 - 29, 1988	Dallas, Texas, USA
October 19 - 21, 1989	Philadelphia, Pennsylvania, USA
November 7 - 10, 1990	Toronto, Ontario, Canada
October 31 - November 2, 1991	Seattle, Washington, USA
October 1 - 3, 1992	Minneapolis, Minnesota, USA
September 23 - 25, 1993	New Orleans, Louisiana, USA
September 22 - 24, 1994	Los Angeles, California, USA
September 29 - October 1, 1995	Tampa, Florida, USA
September 27 - 29, 1996	Boston, Massachusetts, USA
October 17 - 19, 1997	Louisville, Kentucky, USA
October 8 - 10, 1998	Vancouver, British Columbia, Canada
October 22 - 24, 1999	Charlotte, North Carolina, USA
October 12 - 14, 2000	San Antonio, Texas, USA
October 18 - 20, 2001	San Diego, California, USA
October 11 - 13, 2002	Toronto, Ontario, Canada
October 9 - 11, 2003	Salt Lake City, Utah, USA
October 8 - 10, 2004	Hollywood, Florida, USA
October 20 - 22, 2005	Ottawa, Ontario, Canada
October 5 - 7, 2006	Phoenix, Arizona, USA
October 18 - 20, 2007	Boston, Massachusetts, USA
October 15 - 18, 2008	Denver, Colorado, USA
October 7 - 10, 2009	San Diego, California, USA
October 13 - 16, 2010	Baltimore, Maryland, USA
October 12 - 15, 2011	San Antonio, Texas, USA
October 3 - 6, 2012	Minneapolis, Minnesota, USA
October 9 - 12, 2013	Phoenix, Arizona, USA
October 15 - 18, 2014	Tampa, Florida, USA
October 7 - 11, 2015	San Diego, California, USA
October 5 - 8, 2016	National Harbor, Maryland, USA
October 11 - 14, 2017	Vancouver, British Columbia, Canada
October 17 - 20, 2018	Kissimmee (Orlando Area), Florida, USA
September 25 - 28, 2019	Denver, Colorado, USA
October 21 - 24, 2020	Virtual
October 20 - 23, 2021	Fort Worth, Texas, USA

ORTHOPAEDIC TRAUMA ASSOCIATION ORGANIZATION

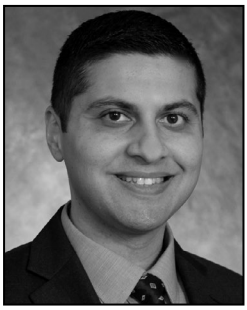
OCTOBER 2020 - OCTOBER 2021 BOARD OF DIRECTORS

Heather A. Vallier, MD
President



Michael Archdeacon, MD
President Elect

Brendan Patterson, MD
2nd President Elect



Hassan Mir, MD
Chief Financial Officer

Thomas F. Higgins, MD
Secretary

IOTA Steering Committee Chair:
Theodore Miclau III, MD
(ex-officio non-voting BOD member)
(Ex-Officio non-voting BOD participant)

ORTHOPAEDIC TRAUMA ASSOCIATION ORGANIZATION

OCTOBER 2020 - OCTOBER 2021 BOARD OF DIRECTORS

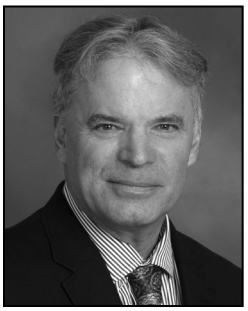
Michael D. McKee, MD
Immediate Past President

David C. Teague, MD
2nd Past President

Anna Miller, MD
Member-at-Large

Philip R. Wolinsky, MD
Member-at-Large

Joseph Hsu, MD
Member-at-Large



Stephen Kottmeier MD
Annual Program Chair

ORTHOPAEDIC TRAUMA ASSOCIATION COMMITTEES

Appointed Committees:

ANNUAL PROGRAM
Stephen Kottmeier, Chair (2013–2021)
Gerard Slobogean, Co-chair (2015–2023)
Ed Harvey (2019–2022)
Gregory Della Rocca (2016-2022)
Brett Crist (2017–2023)
Kelly Lefaivre (2020–2023)
Andrew Choo (2018–2024)
Nirmal Tejwani (2019–2022)
Harmeeth Uppal (2019–2022)
Ed Harvey (2019–2022)
Animesh Agarwal (2020–2023)

Ex-officio:
Aaron Nauth
(Basic Science Sub-committee chair)

Incoming committee members:
Gerard Slobogean, Chair (2015–2023)
Ed Harvey, Co-chair (2019–2025)
Mark Lee (2021–2024)

Basic Science Sub-committee:
Aaron Nauth, Chair (2019–2022)
Andrew Evans (2018–2024)
Justin Haller (2018–2024)
John Wixted (2019–2022)
Michael Hast (2019–2022)
Christopher Lee (2018–2024)

Ex-officio:
Jonathon Copp – Resident member (2020–2022)
Emil Schemitsch – Presidential Consultant
Andrew Trenholm – Research Committee Chair
Saam Morshed – SRI Committee Chair

BY-LAWS & HEARINGS
Thomas DeCoster, Chair (2017–2023)
Robert Reddix (2018–2021)
Eric Meinberg (2015–2021)

Incoming committee members:
Steven Cherney (2021–2024)
Steven Morgan (2021–2024)

CLASSIFICATION & OUTCOMES
Meir Marmor, Chair (2020–2023)
Jarrod Dumpe (2017–2023)
Mai Nguyen (2018–2021)
Geoffrey Marecek (2017–2023)
John Scolaro (2017–2021)
Zachary Working (2020–2023)
Gillian Soles (2017–2023)
Stephen Sims (2019–2022)

Ex-officio:
Eric Baranek – Resident member (2020–2022)
Julie Agel – Presidential Consultant
Jim Kellam – Presidential Consultant
Eric Meinberg – Classification Compendium Rep

Incoming committee members:
Kyle Schweser (2021–2024)
Ashley Levack (2021–2024)
Mai Nguyen – Presidential Consultant (2021–2022)

DISASTER MANAGEMENT PREPAREDNESS
Roman Hayda, Chair (2017–2023)
Eric Meinberg (2017–2023)
Kory Cornum (2018–2024)
Usha Mani (2016–2022)
Ken Nelson (2016–2022)
Daniel Stinner (2019–2022)
John Hagedorn (2018–2024)

Ex-officio:
Augustine Saiz – Resident member (2020–2022)
Jim Ficke – COT Representative

EDUCATION
Samir Mehta, Chair (2012–2021)
Brian Mullis (2017–2023)
David Weiss (2018–2024)
Theodore Toan Le (2017–2023)
Eben Carroll (2017–2023)
Utku Kandemir (2015–2021)
Michael Kain (2020–2023)

Ex-officio:
Megan Couso – Resident member (2020–2022)
Nicholas Danford – Resident member (2020–2022)
Thomas DeCoster – OKO
Daniel Horwitz – AAOS Trauma Content Committee Chair
PA/NP Course Chairs:
Jennifer Hagen (2020–2021)
Ryan Wilson (2020–2021)
Fall RCFC Chairs:
Holly Pilson (2020–2021)
Seth Yarboro (2020–2021)
Spring RCFC Chairs:
Thuan Ly (2020–2021)
John Ketz (2020–2021)
Core Curriculum Phase V Project Directors:
Lisa Cannada
Kyle Jeray
Samir Mehta
Eben Carroll – RATTC Chair (2020–2021)
Derek Donegan – RATTC Co-chair (2020–2021)
Paul Tornetta – AAOS/OTA Course (2020–2021)
J. Tracy Watson – AAOS/OTA Course (2020–2021)
Roy Sanders – JOT Editor-in-Chief

Incoming committee members:
Brian Mullis, Chair (2017–2023)
Janet Conway (2021–2024)
Jennifer Bruggers (2021–2024)

EVIDENCE BASED VALUE & QUALITY
Jaimo Ahn, Chair (2019–2022)
Clay Spitler (2017–2023)
Peter Krause (2017–2023)
Michael Leslie (2018–2021)
Gudrun Mirick (2015–2021)
William Reisman (2018–2024)
Jason Strelzow (2019–2022)
Ryan Harrison (2019–2022)

Ex-officio:
Alexander Benedick – Resident member (2020–2022)
Anna Miller – COT Chair

Incoming committee members:
Kyle Judd (2021–2024)
Mara Schenker (2021–2024)

FELLOWSHIP & CAREER CHOICES
Madhav Karunakar, Chair (2019–2022)
William Obremskey (2019–2022)
Michael Weaver (2017–2023)
Matthew Karam (2020–2023)
Paul Perdue (2019–2022)
Yelena Bogdan (2018–2024)
David Templeman (2018–2024)
Brad Yoo (2016–2022)
Joshua Gary (2020–2023)

Ex-officio:
J. Brock Walker – Fellow (2020–2022)
Jason Roberts – Fellowship Compliance Chair

Incoming committee members:
Dan Schlatterer – Fellowship Compliance Chair

Fellowship Compliance Sub-Committee:
Jason Roberts, Chair (2015–2021)
Michael LeCroy (2017–2023)
Kyle Schweser (2020–2023)
Paul Lafferty (2018–2024)
Dan Schlatterer (2016–2024)

Ex-officio:
Lisa Taitsman – Presidential Consultant
Madhav Karunakar – Fellowship & Career Choices Committee Chair

Incoming committee members:
Dan Schlatterer, Chair (2016–2024)
David Beigler (2021–2024)

FINANCE AND AUDIT
Douglas Lundy, CFO, Chair (2018–2021)
Alan Jones (2019–2022)

Ex-officio:
Brendan Patterson – Immediate Past CFO

Incoming committee members:
Hassan Mir, CFO, Chair (2021–2024)
Douglas Lundy – Immediate Past CFO

FUND DEVELOPMENT
Dan Horwitz, Chair (2017–2023)
Ross Leighton (2019–2022)
M. Brad Henley (2019–2022)
Joseph Hoegler (2017–2023)
Jeff Anglen (2020–2023)
Lisa Cannada (2017–2021)
Toney Russell (2018–2024)

Ex-officio:
Alvin Shieh – Resident member (2020–2022)
Douglas Lundy – OTA CFO
Andrew Trenholm – Research Committee Chair

Incoming committee members:
Hassan Mir – OTA CFO

HEALTH POLICY & PLANNING
Todd Swenning, Chair (2014–2021)
Bryant Oliphant (2020–2023)
Lisa Cannada (2019–2021)
Chris McAndrew (2017–2023)
Niloofar Dehghan (2018–2024)
Ashraf El Naga (2019–2022)
Brad Dart (2018–2024)
Dan Schlatterer (2019–2022)
John Campbell (2015–2021)

Ex-officio:
Dane Brodke – Resident member (2020–2022)
Will Reisman – EBQVS Liaison
Anna Miller – COT Chair
Bruce Browner – Presidential Consultant

Incoming committee members:
Milan Sen, Chair (2021–2024)
David Carmack (2021–2024)
Wade Gordon (2021–2024)

HUMANITARIAN
Richard Coughlin, Chair (2015–2021)
Todd Mailly (2017–2021)
Rachel Reilly (2016–2022)
Emily Benson (2019–2022)
Peter Trafton (2015–2021)
Paul Whiting (2019–2024)
Carla Smith (2020–2023)

Ex-officio:
Chad Ishmael – Resident member (2019–2021)
Eliza Anderson – Resident member (2020–2022)
Roman Hayda – Disaster Management Preparedness Committee Chair
Hans-Christoph Pape – International Relations Committee Chair
Lewis Zirkle – Presidential Consultant

Incoming committee members:
Paul Whiting, Chair (2019–2024)
Steven Becher (2021–2024)
Miguel Daccarett (2021 - 2024)
Rahul Vaidya (2021–2024)

INTERNATIONAL RELATIONS
Hans-Christoph Pape, Chair (2019–2022)
Kevin Tetsworth (2020–2023)
Fernando De La Huerta (2015–2021)
Theodore Toan Le (2016–2021)
Robert Zura (2018–2024)
Anjan Shah (2018–2024)
Victor de Ridder (2019–2022)
Shi-Cong Tao (2020–2021)

Ex-officio:
Jeffrey Donahue – Resident member (2020–2022)
Emil Schemitsch – OTAI Editor
Toney Russell – Presidential Consultant
Richard Coughlin – Humanitarian Committee Chair
Ted Miclau – IOTA Steering Committee Chair

Incoming committee members:
Rodolfo Zamora (2021–2024)
Hiro Minehara (2021–2024)
Meshal Alhadhoud (2021–2024)
Paul Whiting – Humanitarian Committee Chair

MILITARY
Christopher LeBrun, Col (ret), Chair (2019–2022)
Jaime Lyn Engel (2020–2023)
James Blair (2017–2023)
Christiaan Mamczak (2019–2022)
Michelle Gosselin (USN) (2019–2022)
Max Talbot (2017–2023)
Chris Renninger (2020–2023)

Ex-officio:
Benjamin Childs – Resident member (2020–2022)
MAJ Daniel Stinner – Presidential Consultant

Incoming committee members:
Benjamin Wheatley (2021–2024)

ONLINE DISCUSSION FORUM
Hasson Mir, Chair (2019–2021)
Jeff Anglen (2019–2022)
Mike Beebe (2019–2022)
Yelena Bogdan (2019–2022)
Joseph Hsu (2019–2021)
Jason Lowe (2019–2021)
Saam Morshed (2019–2021)
Brian Mullis (2019–2021)
Charles Moon (2020–2023)
Christopher Lee (2020–2021)
Niloofar Dehghan (2020–2023)
Nicholas Romeo (2020–2023)

Incoming committee members:
Richard Yoon, Chair (2019–2024)
Steven Cherney (2021–2024)

PRACTICE MANAGEMENT
Frank Liporace, Chair (2019–2022)
Robert Reddix (2019–2022)
Brian Cunningham (2020–2023)
Adam Kaufman (2016–2022)
Lisa Cannada (2020–2023)
Michael Milshteyn (2019–2022)
John Iaquinto (2018–2024)

Ex-officio:
Brian Page – Resident member (2019–2021)
Christopher Flanagan – Resident member (2020–2022)
M. Brad Henley – Presidential Consultant
William Creevy – Presidential Consultant

PUBLICATIONS
Michael Gardner, Chair (2019–2022)
Roy Sanders JOT Editor-in-Chief (2017–2023)
Emil Schemitsch OTAI Editor-in-Chief (2020–2023)
Mark Hake – Video Library Chair (2020–2023)
Robert Ostrum – Rockwood & Green Editor-in-Chief (2017–2023)
Cory Collinge – Rockwood & Green Living Text Editor (2017–2023)
Mai Nguyen (2020–2023)
Stephen Warner (2020–2023)

Ex-officio:
Peter Mittwede – Resident member (2019–2021)
Jenn McIntire WK rep – OTA Online
Douglas Lundy – OTA CFO
Stephen Kottmeier – Annual Program Chair
Gerard Slobogean – Annual Program Chair (2021–2023)
Aaron Nauth – BSFF Chair
Samir Mehta – Education Committee Chair
Brian Mullis – Education Committee Chair (2021–2023)
Philip Wolinsky – Patient Education Project Team Chair
Ted Miclau – IOTA Steering Committee Chair
Hassan Mir – Online Discussion Forum Chair
Vindra Dass – WK rep JOT
Brian Brown – WK rep R&G

Incoming committee members:
Peter Wasky – Resident member (2021 – 2023)
Hassan Mir – OTA CFO (2021–2024)
Gerard Slobogean – Annual Program Chair (2021–2024)
Richard Yoon – Online Discussion Forum Chair (2021–2024)
Brian Mullis – Education Committee Chair (2021–2023)

Podcast Sub-committee of Publications:
Sanjit Konda, Chair (2020–2023)
Paul Whiting (2020–2023)
Conor Kleweno (2020–2023)
Michael Blankstein (2020–2023)
Arun Aneja (2020–2023)

Ex-officio:
Michael Gardner – Publications Committee Chair
Mike Donoghue – ConveyMD

Video Library Sub-committee of Publications:
Mark Hake, Chair (2020–2023)
Zachary Working (2019–2021)
Jason Strelzow (2019–2022)
Harmeeth Uppal (2018–2021)
David Cinats (2020–2023)
Akshay Goel (2020–2023)
Joseph Hoegler (2019–2022)
Matthew Herring (2019–2022)
Kyle Jeray (2015–2021)
James Blair (2020–2021)
Philip Mitchell (2020–2023)

Incoming committee members:
Paul Lafferty (2021–2024)
Christopher Finkemeier (2021–2024)
Joseph Johnson (2021–2024)

PUBLIC RELATIONS
Jason Lowe, Chair (2020–2023)
Theodoros Tosounidis (2017–2023)
Milan Sen (2017–2021)
Paul Henkel (2020–2023)
Rodolfo Zamora (2020–2021)
Lori Reed (2016–2022)
Miguel Daccarett (2016–2021)
Craig Bartlett (2017–2023)

Ad Hoc:
Jonathon Schneider – Resident member (2019–2021)
Nathan Olszewski – Resident member (2020–2022)
Mike Githens – OrthoInfo Project Team Co-chair
Jason Lowe – OthoInfo Project Team Co-chair
Jason Lowe – Newsletter Editor (2020–2021)

Incoming committee members:
Jennifer Hagen (2021–2024)
Don Anderson (2021–2024)
Taylor Yong – Resident member (2021–2023)
William Ryan – Resident member (2021–2023)
Babar Shafiq – Newsletter Editor (2021–2024)

RESEARCH
Andrew Trenholm, Chair (2019–2022)
Patrick Bergin (2017–2023)
Laurence Kempton (2019–2022)
Philipp Leucht (2018–2024)
Leah Gitajn (2020–2023)
Eric Swart (2020–2023)
Reza Firoozabadi (2015–2021)
Andrew Duckworth (2020–2023)
Mara Schenker (2018–2021)
Frank Avilucea (2017–2023)
Emil Schemitsch (2015–2021)
Dave Wellman (2019–2022)

Incoming committee members:
Michael Beltran (2021–2024)
Arun Aneja (2021–2024)
Prism Schneider (2021–2024)

STRATEGIC RESEARCH INITIATIVE
Saam Morshed, Chair (2018–2024)
Paul Matuszewski (2020–2023)
Sheila Sprague (2020–2023)
Chelsea Bahney (2020–2023)
Mitch Harris (2018 – 2024)

Ex-officio:
Andrew Trenholm - Research Chair
Aaron Nauth - BSFF Chair
Dan Horwitz - Fund Development Chair

TRAVELING FELLOWSHIP
Anna Miller, Chair (2019–2022)
Andrew Burgess (2019–2022)
Brendan Patterson (2019–2022)
Philip Wolinsky (2019–2022)
Samir Mehta (2019–2022)

Ex-officio:
Heather Vallier - Presidential Consultant

YOTS (YOUNG ORTHOPAEDIC TRAUMA SURGEONS)
Arvind von Keudell, Chair (2021–2024)
Christina Seifert (2021–2025)
John Morellato (2021–2023)
Kevin Phelps (2021–2024)
Daniel Kaplan (2021–2023)
Edgar Araiza (2021–2024)
Giselle Hernandez (2021–2024)
Nishant Suneja (2021–2023)
Burak Altintas (2021–2023)
Kyla Huebner (2021–2024)
Luke Lopas (2021–2023)
Matthew Riedel (2021–2023)
Steven Shannon (2021–2023)
Jane Liu (2021–2025)

OTA Elected Committees:

NOMINATING
William Ricci, Chair (2020–2021)
Raymond White (2020–2021)
Geoffrey Miller (2020–2021)
James Elmes (2020–2021)
Steve Rabin (2020–2021)

Incoming committee members:
Michael McKee, Chair (2021–2022)
Michael Gardner (2021–2022)
Gerard Slobogean (2021–2022)
Mohit Bhandari (2021–2022)
Saam Morshed (2021–2022)

MEMBERSHIP
Conor Kleweno, Chair (2018–2021)
Peter Althausen (2018–2021)
Marcus Sciadini (2019–2022)
John Scolaro (2019–2022)
Catherine Humphrey (2020–2023)

Ex-officio:
Susan Scherl
Dan Coll

Incoming committee members:
Marcus Sciadini, Chair (2021–2022)
Milton Little (2021–2024)
Toni McLaurin (2021–2024)

OTA Project Team Task Forces:

PATIENT EDUCATION TASK FORCE
Philip Wolinsky, Chair
Chris Domes
Roy Sanders
Mark Lee
Paige Whittle
Michael Willey
Saqib Rehman
Babar Shafiq
Paul Perdue

REGISTRY TASK FORCE
William Obremskey (Chair)
Philip Wolinsky (ACS T-QIP Lead)
Michael Gardner (AAOS Lead)
Saam Morshed (M2S Lead)
Eric Meinberg (AO Lead)
Douglas Lundy (CFO)

DIVERSITY TASK FORCE
Gil Ortega (Chair)
Emily Benson
Lisa Cannada
Jacque Krumrey
Gerald Lang
Milton Little
Douglas Lundy
Toni McLaurin
Samir Mehta
Sarah Pierrie
Nirmal Tejwani

Ex-officio:
Sarah Blumenthal (Resident member)

TASK FORCE ON MORAL INJURY, ADVOCACY AND MEMBER WELLBEING
Matthew Garner (Chair)
Derek Donegan
Milton Little
Anna Miller
Andrew Choo
John Tidwell
Jeff Smith
Ryan Will
Kelly Lefaivre
Philip Wolinsky

Ex-officio:
Katy Metcalf (Resident member)

EDUCATIONAL AUDIT TASK FORCE
Ken Egol (Chair)
Brian Mullis
Samir Mehta
Jennifer Hagen
Anjan Shah
Usha Mani
Paul Whiting
Robert Reddix
Yelena Bogdan
Joseph Cohen
Aaron Nauth
Charles Moon

Ex-officio:
Amanda Pawlak (Resident member)

EDUCATIONAL OUTREACH FOR LOW INCOME COUNTRIES TASK FORCE
Emily Benson (Chair)
Heather Vallier
Samir Mehta
Robert Zura
Tim White
Holly Pilson
Douglas Lundy
Joseph Hoegler
Todd Mailly
Jason Lowe
David Shearer

Orthopaedic Organizational Liaisons:

AAOS BOS (Board of Specialty Societies)
William Ricci, Presidential Line Rep
Lisa Taitsman, BOS Match Oversight
Hassan Mir, Member Rep (also BOS rep to AAOS Health Care Systems Committee)
Kathleen Caswell, CAE, Executive Director Rep

ACS COT (American College of Surgeons Committee on Trauma)
Anna Miller (Chair)
James Ficke
Clifford Jones
James Krieg
A. Alex Jahangir
Carol Lin
Hassan Mir
Bryant Oliphant
Michael Suk

USBJI BMUS Chapter Authors
Jaimo Ahn (Lead Author)
Arvind Nana
Gudrun Mirick
Anna Miller
Christopher Renninger, Michelle Gosselin (Military)

Other Orthopaedic Liaison Positions
Bruce Browner – Member-at-Large USBJI
Andy Schmidt – Civilian Rep, EWI
James Ficke – Board member, National Trauma Institute

Note: Please visit the OTA website to apply for 2022 Committee positions, opening in December.

OTA HEADQUARTER STAFF

Kathleen Caswell, CAE
Executive Director
Phone: 847-430-5131

Barbara Shozda
Managing Director
Phone: 847-430-5137

Sharon Moore
Senior Education Manager
Phone: 847-430-5130

Peter Pollack
Senior Manager, Publications and Online Education
Phone: 847-430-5138

Sara Arns
Education Coordinator
Phone: 847-430-5142

Kiersten Davison
Website, Social Media, and Society Projects Coordinator
Phone: 847-430-5136

Bonnie Emberton
Fund Development Manager
Phone: 847-430-5141

Jennifer Gangler
Exhibits and Marketing Manager
Phone: 847-430-5132

Alanna Kaiser
Education Director
Phone: 847-430-5143

Julia Markos
OTA Accounting and Society Projects Coordinator
Phone: 847-430-5133

Rachel O'Connell
Fellowship and Meetings Manager
Phone: 847-430-5135

Christine Schreiber
Membership & IT Projects Manager
Phone: 847-430-5139

Diane Waligurski
Annual Meeting Program, Education Manager
Phone: 847-430-5134

Headquarters Office Orthopaedic Trauma Association
9400 W Higgins Rd, Suite 305
Rosemont, IL 60018 USA
Tel: 847-698-1631
Fax: 847-430-5140
E-mail: OTA@ota.org
web: www.ota.org

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT ACKNOWLEDGMENTS

COTA 2021-22 Academic Year Fellowship Program Awards:

Allegheny Health Network – Pittsburgh, PA
Gregory Altman, MD

Carolinas Medical Center – Charlotte, NC
Madhav Karunakar, MD

Cedars-Sinai Medical Center – Los Angeles, CA
Milton T. Little, MD

Cooper University Hospital/Cooper Medical School of Rowan University – Camden, NJ
Rakesh P. Mashru, MD

Denver Health Medical Center – Denver, CO
Cyril Mauffrey, MD

Duke University – Durham, NC
Rachel Reilly, MD

Georgia Orthopaedic Trauma Institute – Macon, GA
Daniel S. Chan, MD

Harvard, Combined Mass General and Brigham and Women's Hospitals – Boston, MA
Michael J. Weaver, MD

Hospital for Special Surgery – New York, NY
William Ricci, MD

Indiana University School of Medicine – Indianapolis, IN
Roman Natoli, PD, PhD

Los Angeles County / USC Medical Center – Los Angeles, CA
Jackson Lee, MD

Orlando Regional Medical Center – Orlando, FL
George J. Haidukewych, MD

OrthoIndy Trauma – Indianapolis, IN
Tim Weber, MD

Prisma Health, Greenville – Greenville, SC
John D. Adams, MD

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT ACKNOWLEDGMENTS

Reno Orthopaedic Trauma – Reno, NV
Timothy J. Bray, MD

Rutgers, NJMS Department of Orthopedics – Rutgers, NJ
Mark Adams, MD

Saint Louis University – St. Louis, MO
J. Tracy Watson, MD

Sonoran Orthopaedic Trauma – Scottsdale, AZ
Gilbert Ortega, MD, MPH

Stanford University – Redwood City, CA
Michael J. Gardner, MD

Tampa General Hospital – Tampa, FL
Roy Sanders, MD

University Hospitals Cleveland Medical Center – Cleveland, OH
Robert Wetzel, MD

University of California, Davis, Sacramento – Sacramento, CA
Mark A. Lee, MD

University of California, San Francisco – San Francisco, CA
Theodore Miclau III, MD

University of Cincinnati – Cincinnati, OH
Henry Claude Sagi, MD

University of Florida, Gainesville – Gainesville, FL
Jennifer Hagen, MD

University of Maryland, R. Adam Cowley Shock Trauma Center – Baltimore, MD
Robert V. O'Toole, MD

University of Minnesota, Regions Hospital – St. Paul, MN
Peter A. Cole, MD

University of Mississippi – Jackson, MS
Matt Graves, MD

University of Missouri – Columbia, MO
Brett D. Crist, MD

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT ACKNOWLEDGMENTS

University of Oklahoma, St. John Health System Foundation – Tulsa, OK
Mark Calder, MD

University of Texas Health Science Center at Houston – Houston, TX
Timothy S. Achor, MD

University of Texas Health Science Center at San Antonio – San Antonio, TX
Boris Alexander Zelle, MD

University of Washington, Harborview Medical Center – Seattle, WA
David P. Barei, MD

Vanderbilt University Medical Center – Nashville, TN
William Obremskey, MD

Wake Forest University School of Medicine – Winston-Salem, NC
Eben A Carroll, MD

Washington University – St. Louis, MO
Christopher M. McAndrew, MD

WellSpan York Hospital – York, PA
Thomas G DiPasquale, DO

Yale University – New Haven, CT
Brad Yoo, MD

Funded by the generous medical education contributions from:

Smith & Nephew, Stryker, DePuy Synthes & Medtronic

CONGRATULATIONS
2020-2021 OTA Fellowship Graduating Class:

Alice Hughes, MD and **James Jung, MD**
Allegheny Health Network, Pittsburgh, PA
Gregory Altman, MD, Director

Jana Davis, MD, MAJ, **Givenchy Manzano, MD** and **Suman Medda, MD**
Carolinas Medical Center, Charlotte, NC
Madhav Karunakar, MD, Director

Maxim Danilevich, MD
Cedars Sinai Orthopaedic Center, Los Angeles, CA
Milton Little, MD, Director

Michael Hadeed, MD
Denver Health Medical Center, Denver, CO
Cyril Mauffrey, MD, Director

Ryan Bray, MD
Detroit Medical Center / Wayne State University, Detroit, MI
Rahul Vaidya, MD, Director

Michael K. Blatter, DO
Duke University Medical Center, Durham, NC
Rachel Reilly, MD, Director

Peter M. Bishara, DO, MBS
Georgia Orthopaedic Trauma Institute, Macon, GA
Daniel Chan, MD, Director

Blake Saul, DO and **David Zupruk, DO**
Grant Medical Center, Columbus, OH
Ben Taylor, MD, Director

D'Ann E. Arthur, MD, **Malcolm R. DeBaun, MD**,
Lawrence H. Goodnough, MD, PhD, **Krystin Hidden, MD** and **Alvin Shieh, MD**
Harborview Medical Center, Seattle, WA
David P. Barei, MD, Director

Tyler Caton, MD and **Eric Chen, MD, PhD**
Harvard Orthopaedic Trauma, Boston, MA
Michael Weaver, MD, Director

2020-2021 OTA Fellowship Graduating Class, continued

Matthew Stillwagon,MD
Hennepin County Medical Center, Minneapolis, MN
David C. Templeman, MD, Director

Lawrence Colby Ward, DO
Hennepin Trauma & Reconstruction Center, Minneapolis, MN
Richard Kyle, MD, Director

Eric Baranek, MD and **Amarpal Cheema, MD**
Hospital for Special Surgery, New York, NY
William Ricci, MD, Director

Atsushi Endo, MD, MPH
Hughston Orthopaedic Trauma Service (HOTS), Columbus, GA
John C. P. Floyd, MD, FACS, Director

Jason Chen, MD and **Amy Ford, MD**
IU Methodist Orthopaedic Trauma Fellowship, Indianapolis, IN
Roman M. Natoli, MD, PhD, Director

Michael Jung, MD
Los Angeles County / USC Medical Center, Los Angeles, CA
Jackson Lee, MD, Director

Jeffrey Donahue, MD
MetroHealth Medical Center, Cleveland, OH
Ari Levine, MD, Director

Dennis Murphy, MD
Orlando Regional Medical Center, Orlando, FL
George Haidukewych, MD, Director

Kevin Henrichsen, MD and **Anna van der Horst, MD**
OrthoIndy Orthopaedic Trauma, Indianapolis, IN
Timothy Weber, MD, Director

Bryan M. Armitage, MD
OrthoONE Trauma at Swedish, Englewood, CO
Wade Smith, Director

Jennifer Sharp, DO
Orthopaedic Trauma Surgeons of Northern California, Carmichael, CA
Paul Gregory Jr. MD, Director

2020-2021 OTA Fellowship Graduating Class, continued

Kevin Perry, MD, DPT
Penn State University, College of Medicine, Hershey, PA
J. Spence Reid MD, Director

J. Brock Walker, MD
Prisma Health System, Greenville , SC
Kyle Jeray, MD, Director

Adam Boissonneault, MD, **Elizabeth Harkin, MD**, **Ishaq Ibrahim, MD**, **Brian A. Schneiderman, MD** and **Brandon G. Wilkinson, MD**
R. Adams Cowley Shock Trauma Center, Baltimore, MD
Robert V. O'Toole, MD, Director

Albert George, MD and **Andrew Mills, MD**
Regions Trauma Center /University of Minnesota , St. Paul, MN
Peter A. Cole, MD, Director

Daniel C. Flinn, DO
Reno Orthopaedic Trauma Fellowship, Reno, NV
Timothy Bray, MD, Director

Emily Wild, MD
Rutgers New Jersey Medical School, Newark, NJ
Mark R. Adams, MD, Director

Paul James Goodwyn, MD
Sonoran Orthopaedic Trauma Surgeons, Scottsdale, AZ
Gilbert Ortega, MD, Director

Mikel Headford, DO
St. Louis University, Saint Louis, MO
J. Tracy Watson, MD, Director

Alexander M. Crespo, MD
Stanford University, Redwood City, CA
Michael Gardner, MD, Director

Ryan Fairchild, MD, **Ishvinder Grewal, MBBS** and **Zachary Louis Telgheder, MD**
Tampa General Hospital, Tampa, FL
Roy Sanders, MD, Director

Robert O'Connor, MD
The CORE Institute , Phoenix, AZ
Niloofar Dehghan, MD, MSc, FRCSC, Director

2020-2021 OTA Fellowship Graduating Class, continued

Anokha Padubidri, MD
University Hospitals Cleveland Medical Center, Cleveland, OH
Robert Wetzel, MD, Director

Jonathan Copp, MD and **Joseph M. Radley, MD**
University of California (Davis) Medical Center, Sacramento, CA
Mark A. Lee, MD, Director

Joseph G. Elsissy, MD
University of California, San Diego, San Diego, CA
Alexandra K. Schwartz, MD, Director

Zachary Lim, MD and **Aden Malik, MD**
University of California, San Francisco, San Francisco, CA
Theodore Miclau, MD, Director

John M. Yingling, DO
University of Cincinnati, Cincinnati , OH
Claude Sagi, MD, Director

Matthew P. Bakos, DO
University of Florida, College of Medicine, Gainesville, FL
Jennifer Hagen, MD, MS, Director

Devan Michelle Irving, DO and **Christopher Molligan, MD**
University of Kentucky, Lexington, KY
Raymond D. Wright Jr., MD, Director

Imad Abushahin, SR, MBBS, **Sherif Dabash, MD** and **Ali Mansour, MD**
University of Louisville, School of Medicine, Louisville, KY
David Seligson, MD, Director

Erika Garbrecht, MD
University of Miami/Jackson Memorial Medical Center, Miami, FL
Gregory Zych, DO, Director

Marshall Gillette, MD
University of Mississippi, Jackson, MS
Matt Graves, MD, Director

Hilary Anna Felice, MD, MSc and **Robert Miles Hulick, MD**
University of Missouri, Columbia, MO
Brett D. Crist, MD, Director

2020-2021 OTA Fellowship Graduating Class, continued

Trevor E. Crean, DO
University of New Mexico Hospital, Albuquerque, NM
David Chafey III, MD, Director

William Doss, MD
University of Oklahoma, Tulsa, OK
Mark Calder, MD, MPH, Director

Brendan Casey, DO
University of Pittsburgh, Pittsburgh, PA
Ivan S. Tarkin, MD, Director

Jason S. Lipof, MD
University of Rochester, Rochester, NY
Kyle Judd, MD, Director

Timothy Ashworth, MD
University of Tennessee / Campbell Clinic, Memphis, TN
John Weinlein, MD, Director

Evan L. Hanna, MD
University of Tennessee / Erlanger Health Systems, Chattanooga, TN
Warren Gardner, MD, Director

Gerard Chang, MD, **John Michael Garlich, MD**, **Michelle Gosselin, BS, MD** and **Travis M. Hughes, MD**
University of Texas Health Science Center at Houston, Houston, TX
Timothy S. Achor, MD, Director

Shain Howard, DO
University of Texas Health Science Center at San Antonio , San Antonio, TX
Boris Zelle, MD, Director

Samuel Joseph Mease, MD
UT Southwestern/Parkland Health & Hospital System, Dallas, TX
Adam Starr, MD, Director

Nicole Stevens, MD and **Andrew Farley Tyler, MD, PhD**
Vanderbilt University Medical Center, Nashville, TN
William Obremskey, MD, Director

Korey Yngstrom, DO
Virginia Commonwealth University, Richmond, VA
Paul Perdue, MD, Director

2020-2021 OTA Fellowship Graduating Class, continued

Kelly Stumpff, MD
Wake Forest University, Winston Salem, NC
Eben A. Carroll, MD, Director

Erin Hofer, MD
Washington University School of Medicine/Barnes-Jewish Hospital, Saint Louis, MO
Christopher McAndrew, MD, MSc, Director

William Naylor, DO
Wright State University, Dayton, OH
Michael J. Prayson, MD, Director

Shady Mahmoud, MD
Yale University, New Haven, CT
Brad Yoo, MD, Director

Aubrey Kotey Ashie, DO
York Hospital, York, PA
Thomas DiPasquale, DO, FACOS, FAOAO, Director

AWARDS

OTA HUMANITARIAN SCHOLARS

The OTA has established a Humanitarian Scholarship designed to provide orthopaedic trauma education for young surgeons from low-middle income countries. Scholarship award covers the individuals travel, room and board for attending OTA Annual Meeting and the opportunity to participate in an observership at a U.S. Institution with an OTA member serving as a mentor during the visit.

Congratulations to the following 2020 scholarship recipients:

Daniele Sciuto, MD - *Kenya*
Faseeh Shahab, MD - *Pakistan*
Samual Hailu, MD - *Ethiopia*

Congratulations to the following 2021 scholarship recipients:

Chloe Marie Samarita, MD - *Philipines* - (Paper #59)
Devendra Singh Bhat - *Nepal* - (Paper #41)
Dennis Rono - *Kenya* - (Paper #21)

EDWIN G. BOVILL, Jr., MD AWARD WINNER

Best paper from the 2018 and 2019 Annual Meeting.*
Dedicated to Edwin G. Bovill, Jr., MD, (1918 - 1986)
Surgeon, traumatologist, educator, academician, and gentleman;
co-founder of the Orthopaedic Trauma Association.

2019 – Locked Plating versus Nailing for Proximal Tibia Fractures: A Multicenter RCT
Orthopeadic Trauma Research Consortium - *Paul Tornetta III, MD (presenter); Kenneth A. Egol, MD; Clifford B. Jones, MD, FACS; Robert F. Ostrum, MD; Catherine A. Humphrey, MD; Robert Paul Dunbar, MD; William M. Ricci, MD; Laura Phieffer, MD; David C. Teague, MD; Henry Claude Sagi, MD; Andrew N. Pollak, MD; Andrew H. Schmidt, MD; Stephen A. Sems, MD; Hans-Christoph Pape, MD; Saam Morshed, MD; Edward Perez, MD; Brian Mullis, MD*

2020 – Vitamin D3 Supplementation Does Not Improve Fracture Healing: A Double-Blinded Randomized Controlled Trial
Gerard Slobogean, MD*; Nathan N. O'Hara; Zachary Hannan, BS; Sofia Bzovsky, MSc; Daniel Connelly, BS; Jonathan Derrick Adachi, MD; Sheila Sprague, PhD; Vita-Shock Investigators, MD*

2020 OTA AFA COMMUNITY SURGEON ACHIEVEMENT AWARD* RECIPIENT

**Orthopaedic Trauma Association (OTA) and American Fracture Association (AFA) co-founded this annual award in 2017.*

2020 – Gilbert Ortega, MD

OTA MEMORIAL AWARD (Resident Research Award)

2020 – Fascia Iliaca Block Decreases Hip Fracture Postoperative Opioid Consumption: A Prospective Randomized Controlled Trial
Jeffrey Thompson, DO*; David Galos, MD; Mitchell Long, DO; Charles J. Ruotolo, MD; Rhyne Champ Dengenis, DO*

Title: **Virtual Mechanical Testing of Humeral Fracture Healing and Nonunion**
Principal Investigator: **Hannah Dailey, PhD**
Co-Principal Investigators: **Paul Tornetta, III, MD, Louis Gerstenfeld, PhD**
Awarded Funds: **$80,000** Grant Funded by: **OTA/AirCast Foundation**

Title: **Primary Ankle Arthrodesis versus Open Reduction and Internal Fixation for Fragility Fractures Around the Ankle in the Frail Elderly: A Prospective, Randomized, Multi-Center, Clinical Trial**
Principal Investigator: **Emil H Schemitsch, MD**
Co-Principal Investigator: **Abdel-Rahman Lawendy**
Awarded Funds: **$79,890** Grant Funded by: **OTA/DePuy**

Title: **Biological Activity of Human Induced Membranes in Bone Defects: Correlation of an In Vitro Analysis with Clinical Outcomes, Comparing Femoral and Tibial Locations**
Principal Investigator: **Vaida Glatt, PhD**
Co-Principal Investigator: **Kevin Tetsworth, MD**
Awarded Funds: **$79,863** Grant Funded by: **OTA**

Title: **Impact of Nutrition Status on Clinically Relevant Outcomes after Femoral Fragility Fractures**
Principal Investigator: **Michael Willey, MD**
Co-Principal Investigator: **JL Marsh, MD**
Awarded Funds: **$79,528** Grant Funded by: **OTA**

Title: **Acute Application of Intrawound Antibiotic Powder in Open Extremity Fracture Wounds**
Principal Investigator: **Nicholas Alfonso, MD**
Co-Principal Investigator: **Cyril Mauffrey, MD**
Awarded Funds: **$79,991** Grant Funded by: **OTA/Smith & Nephew**

Title: **Correlating Early Markers of Joint Health with PROMIS-29 Following Tibial Plafond Fracture**
Principal Investigator: **Justin Haller, MD**
Co-Principal Investigator: **Donald Anderson, PhD**
Awarded Funds: **$100,000** Grant Funded by: **OTA/AOTNA**
Co-Branded Grant: **OTA/AOTNA**

Title: **Low Middle Income Country (LMIC) Setting: Is Low Vitamin D Associated with Fracture Risk in Children Younger than 10 Years? A Matched Case Control Study**
Principal Investigator: **Shahryar Noordin, MBBS, FCPS, FACS**
Co-Principal Investigators: **Andrew Howard, Zulfiqar Bhutta**
Awarded Funds: **$19,729** Grant Funded by: **OTA**
OTA International Grant

Title: **Cast OFF-2: One Versus Four-five Weeks of Plaster Cast Immobilization for Non-reduced Distal Radius Fractures. A Randomized Stepped Wedge Design**
Principal Investigator: **Michael Edwards**
Co-Principal Investigator: **Emily Boersma**
Awarded Funds: **$20,000** Grant Funded by: **OTA**
OTA International Grant

OTA 2021 RESIDENT AWARDED GRANTS

(January 1, 2021 - December 31, 2021 Grant Cycle)

Title: **Evaluating the Effect of Combination Local Antibiotics on the Treatment of Chronic Low-Grade Infection in the Setting of Fracture Healing**
Principal Investigator: **Jhase Sniderman, MD**
Co-Principal Investigator: **Aaron Nauth, MD**
Awarded Funds: **$20,000** Grant Funded by: **OTA/FOT**

Title: **Comparison of a Novel Modified All-Suture Construct Versus Suture-Button Fixation in a Syndesmotic Injury Model**
Principal Investigator: **Hayden Patrick Baker, MD**
Co-Principal Investigators: **Daryl Dillman, Jason Strelzow, Kelly Hynes**
Awarded Funds: **$19,820** Grant Funded by: **OTA/FOT**

Title: **Treatment of Humeral Shaft Fractures with Immediate Sarmiento Bracing**
Principal Investigator: **Ferras Stephen Albitar, MD**
Co-Principal Investigator: **Arun Aneja**
Awarded Funds: **$20,000** Grant Funded by: **OTA/FOT**

Title: **Feasibility of a Porcine Model of Compartment Syndrome with Associated Tibia Fracture**
Principal Investigator: **Dillon Christopher O'Neill, MD**
Co-Principal Investigator: **Justin Haller, MD**
Awarded Funds: **$20,000** Grant Funded by: **OTA/FOT**

Title: **Bicolumnar Fixation of Distal Femur Fractures Through Supplementation of Lateral Locked Plating with Medial Column Screw: A Biomechanical Study**
Principal Investigator: **Joseph Henningsen, MD**
Co-Principal Investigator: **Michael Prayson, MD**
Awarded Funds: **$7,110** Grant Funded by: **OTA/ Globus Medical**

Title: **A Novel Approach to Determining Muscle Viability Using an Oximeter**
Principal Investigator: **Yu Min Suh**
Co-Principal Investigator: **Yu Min Suh**
Awarded Funds: **$19,902** Grant Funded by: **OTA**

Title: **Targeted Delivery of GSK-3β Inhibitor Loaded Nanoparticles for Fracture Healing in a Murine Nonunion Model**
Principal Investigator: **Brittany Haws, MD**
Co-Principal Investigators: **Danielle Benoit, John Ketz, MD**
Awarded Funds: **$20,000** Grant Funded by: **OTA**

Title: **A Novel Fluoroscopic Method for Evaluating Tibial Malrotation in Tibial Shaft Fractures: A Prospective Clinical Validation Study**
Principal Investigator: **Michael Scott Roberts, MD**
Co-Principal Investigator: **Patrick Schottel, MD**
Awarded Funds: **$17,042** Grant Funded by: **OTA**

Title: **A Novel Fluoroscopic Method for Evaluating Tibial Malrotation in Tibial Shaft Fractures: A Prospective Clinical Validation Study**
Principal Investigator: **Eamon Bernardoni, MD**
Co-Principal Investigators: **Kyle Miller, MD, Laura Lins, Paul Whiting, MD, Wan-Ju Li**
Awarded Funds: **$19,998.14** Grant Funded by: **The AirCast Foundation**

Title: **4DCT Analysis of Syndesmostic Motion after Posterior Malleolus Fixation**
Principal Investigator: **Murray Wong**
Co-Principal Investigator: **Prism Schneider, MD, PhD**
Awarded Funds: **$20,000** Grant Funded by: **OTA**

Title: **Characterization of Local Soft Tissue Antibiotic Pharmacokinetics Following Routine Tourniquet Use for Closed Lower Extremity Fracture Surgery**
Principal Investigator: **Thomas Lynch, MD**
Co-Principal Investigators: **Joseph Wenke, MD, Sarah Pierrie, MD, Taylor Bates, MD**
Awarded Funds: **$19,550** Grant Funded by: **OTA**

INFORMATION

IS WI-FI AVAILABLE?

Yes, in the Fort Worth Convention Center

Wi-Fi Login: **OTA2021**

Password: **OTA2021**

WHERE CAN I DOWNLOAD THE OTA ANNUAL MEETING APP?

iTunes and Google Play store

Search: **Orthopaedic Trauma Association**

HOW DO I GET MY CME CREDITS?

- Download the 2021 OTA Annual Meeting App or watch your email for the post meeting evaluation
- Complete the evaluation for CME credits earned
- Upon submittal of the evaluation; a CME certificate will appear
- Save and print later

MOTHERS ROOM

Located on the Mezzanine level at the 12th Street entrance.

Room details posted on Annual Meeting FAQ page of website.

Mission Statement

The mission of the Orthopaedic Trauma Association (OTA) is to promote excellence in care for the injured patient, through provision of scientific forums and support of musculoskeletal research and education of orthopaedic surgeons and the public.

Vision Statement

The OTA will be the authoritative source for the optimum treatment and prevention of musculoskeletal injury, will effectively communicate this information to the orthopaedic and medical community and will seek to influence health care policy that effect care and prevention of injury.

Value Statement

The OTA is adaptable, forward thinking and fiscally responsible and is composed of a diverse worldwide membership who provide care and improve the knowledge base for the treatment of injured patients. OTA members provide worldwide leadership through education, research and patient advocacy.

Annual Meeting Scientific Meeting Objectives

The OTA is an organization dedicated to the discovery and dissemination of knowledge and information regarding the prevention, diagnosis, and treatment of musculoskeletal injuries. This 37th Anniversary Annual Meeting of the OTA will allow all registrants to:

- Assess the efficacy of new treatment options through evidence-based data
- Recognize that there is a still a roll for nonoperative treatment of fractures and identify when to abandon nonsurgical treatment plans
- Evaluate various nonsurgical and surgical treatment options in musculoskeletal injury management
- Synthesize the most current research study findings in pelvic fracture management
- Interpret relevant clinical practice guidelines for pain management, augmentation of fracture repair and revision surgery.

Research sessions will include: original paper presentations dedicated to specific anatomic injury and original basic science papers.

Educational objectives will be fulfilled through the presentation of scientific presentations and symposia with subsequent discussions in an open forum. Ample opportunity will be available to express common concern, share relevant experiences and provide alternative treatment approaches.

General themes of orthopaedic trauma care will also be presented by topic focused symposia, case presentations, scientific poster presentations and technical exhibits.

ACCREDITATION – CME INFORMATION

The Orthopaedic Trauma Association (OTA) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians. OTA designates this live activity for a maximum of **21** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credits commensurate with the extent of their participation in the activity.

The Orthopaedic Trauma Association designates the live activity of the Basic Science Focus Forum for a maximum of **12.0** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

The Orthopaedic Trauma Association designates designates the live activity of the International Trauma Care Forum for a maximum of **11** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

FDA STATEMENT

All drugs and medical devices used in the United States are administered in accordance with the Food and Drug Administration (FDA) Regulations. These regulations vary depending on the risks associated with the drug or medical device, the similarity of the drug or medical device to products already on the market, and the quality and scope of clinical data available.

Some drugs or medical devices described or demonstrated in OTA educational materials or programs have not been cleared by the FDA or have been cleared by the FDA for specific uses only. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or device s/he wishes to use in clinical practice.

DISCLAIMER

The material presented at the 37th Annual Meeting has been made available by the *Orthopaedic Trauma Association* for educational purposes only. The material is not intended to represent the only, nor necessarily best, method or procedure appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the faculty which may be helpful to others who face similar situations.

The Orthopaedic Trauma Association disclaims any and all liability for injury or other damages resulting to any individual attending the Annual Meeting and for all claims which may arise out of the use of the techniques demonstrated therein by such individuals, whether these claims shall be asserted by physician or any other person.

DISCLOSURE

The names of authors presenting the papers at the 37th Annual Meeting are printed in **boldface**.

As an accredited provider of continuing medical education CME, OTA is required by the Accreditation Council for Continuing Medical Education (ACCME) to obtain and share with participants of an OTA CME activity any potential conflicts of interest by faculty, program developers and CME planners.

The ACCME Standards of Commercial Support, Standard 2 states the requirements:

2.1 The provider must be able to show that everyone who is in a position to control the content of an education activity has disclosed all relevant financial relationships with any commercial interest to the provider. The ACCME defines "'relevant' financial relationships" as financial relationships in any amount occurring within the past 12 months that create a conflict of interest.

2.2 An individual who refuses to disclose relevant financial relationship will be disqualified from being a planning committee member, a teacher, or an author of CME, and cannot have control of, or responsibility for the development, management, presentation or evaluation of the CME activity.

The OTA disclosure policy requires that faculty submit all financial relationships occurring within the past 12 months that create a potential conflict.

Each participant in the Annual Meeting has been asked to disclose if he or she has received something of value from a commercial company or institution, which relates directly or indirectly to the subject of their presentations.

Authors who completed their financial disclosures have identified the options to disclose as follows:

n. Respondent answered 'No' to all items indicating no conflicts;
1. Royalties from a company or supplier;
2. Speakers bureau/paid presentations for a company or supplier;
3A. Paid employee for a company or supplier;
3B. Paid consultant for a company or supplier;
3C. Unpaid consultant for a company or supplier;
4. Stock or stock options in a company or supplier;
5. Research support from a company or supplier as a PI;
6. Other financial or material support from a company or supplier;
7. Royalties, financial or material support from publishers;
8. Medical/orthopaedic publications editorial/governing board;
9. Board member/committee appointments for a society.

An indication of the participant's disclosure appears after his/her name in the alphabetical listing in the app along with the commercial company or institution that provided the support. Disclosures may also be searched through the AAOS Disclosure Program at: https://disclosure.aaos.org.

The OTA does not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of the author's participation in the meeting.

Δ Indicates presentation was funded by a grant from the Orthopaedic Trauma Association.

Cameras or video cameras may not be used in any portion of the meeting.

OTA MANDATORY DISCLOSURE POLICY FOR GOVERNANCE GROUPS AND CONTINUING MEDICAL EDUCATION CONTRIBUTORS

PHILOSOPHY

In order to promote transparency and confidence in the educational programs and in the decisions of the Orthopaedic Trauma Association (hereinafter collectively referred to as "OTA"), the OTA Board of Directors has adopted this mandatory disclosure policy.

The actions and expressions of Fellows, Members, and Others providing education of the highest quality, or in shaping OTA policy, must be as free of outside influence as possible, and any relevant potentially conflicting interests or commercial relationships must be disclosed. Because the OTA depends upon voluntary service by Fellows, Members, and Others to conduct its educational programs and achieve its organizational goals, this disclosure policy has been designed to be realistic and workable.

The OTA does not view the existence of these interests or relationships as necessarily implying bias or decreasing the value of your participation in the OTA.

OBLIGATION TO DISCLOSE

Each participant in an OTA CME program or author of enduring materials, and members of the OTA Board of Directors, Committees, Project Teams or other official OTA groups (collectively "OTA governance groups"), has the obligation to disclose all potentially conflicting interests. Disclosure information is to be submitted through the AAOS on-line Disclosure Program (or other disclosure form provided and approved by the OTA). Participants are responsible for the accuracy and completeness of their information. In addition, participants who disclose via the AAOS on-line Disclosure Program have an obligation to review and update their personal information in the AAOS Orthopaedic Disclosure Program at least semiannually (usually April and October). It is recommended that participants note any changes to the AAOS Orthopaedic Disclosure Program as soon as possible after they occur.

Failure of a required participant to disclose will result in the participant being asked not to participate in the OTA CME program and OTA governance groups.

A list of all participants in OTA CME programs and OTA governance groups, along with their disclosures, will be included in all meeting materials.

Participants in OTA governance groups have an obligation to indicate any potential conflicts they may have during discussions affecting their personal interests during the meeting of the OTA governance group. At each meeting of the OTA governance group, members of the group will be reminded that full disclosure must be made of any potential conflict of interest when a matter involving that interest is discussed.

The chair of the governance group shall also have the prerogative of requesting a participant to provide further information or an explanation if the chair identifies a potential conflict of interest regarding that participant. Based on the information provided in the OTA Orthopaedic Disclosure Program and/or upon a further review, the chair of the OTA governance group may determine that the participant shall:

Disclose the conflict and continue to participate fully in the OTA governance group's deliberations

Disclose the conflict, but abstain from discussing and voting on the matter; or

Disclose the conflict and leave the room until the matter has been fully discussed and acted upon.

If one of the latter two actions is taken, it should be reflected in the minutes of the OTA governance group's meeting.

Adopted: February 2011
Revised: March 2014

Orthopaedic Trauma Association
ANTITRUST POLICY
(Adopted July 2012)

Discussions at OTA meetings often cover a broad range of topics pertinent to the interests or concerns of orthopaedic surgeons. As a general rule, except as noted below, discussions at OTA meetings can address virtually any topic without raising antitrust concerns if the discussions are kept scrupulously free of even the suggestion of private regulation of the profession. However, a number of topics that might be (and have been) discussed at OTA meetings may raise significant complex antitrust concerns. These include:

- Membership admissions, rejections, restrictions, and terminations;
- Method of provision and sale of OTA products and services to non-members;
- Restrictions in the selection and requirements for exhibitors at the OTA Annual Meeting or in CME activities;
- Establishment of the professional compliance program and adoption of Standards of Professionalism;
- Collecting and distributing certain orthopaedic practice information, particularly involving practice charges and costs;
- Obtaining and distributing orthopaedic industry price and cost information;
- Professional certification programs;
- Group buying and selling; and
- Inclusions or exclusion of other medical societies in organizational activities or offerings.

When these and related topics are discussed, the convener or members of the OTA group should seek counsel from Legal Counsel.

OTA urges its Board, committees and other groups not to participate in discussions that may give the appearance of or constitute an agreement that would violate the antitrust laws.

Notwithstanding this reliance, it is the responsibility of each OTA Board or committee member to avoid raising improper subjects for discussion. This reminder has been prepared to ensure that OTA members and other participants in OTA meetings are aware of this obligation.

The "Do Not's" and "Do's" presented below highlight only the most basic antitrust principles. OTA members and others participating in OTA meetings should consult with the OTA Presidential Line and/or General Counsel in all cases involving specific questions, interpretations or advice regarding antitrust matters.

Do Nots

1. Do not, in fact or appearance, discuss or exchange information regarding:
    a. Individual company prices, price changes, price differentials, mark-ups, discounts, allowances, credit terms, etc. or any other data that may bear on price, such as costs, production, capacity, inventories, sales, etc.
    b. Raising, lowering or "stabilizing" orthopaedic prices or fees;
    c. What constitutes a fair profit or margin level;
    d. The availability of products or services;
    e. The allocation of markets, territories or patients.

2. Do not suggest or imply that OTA members should or should not deal with certain other persons or firms.
3. Do not foster unfair practices regarding advertising, standardization, certification or accreditation.
4. Do not discuss or exchange information regarding the above matters during social gatherings, incidental to OTA-sponsored meetings.
5. Do not make oral or written statements on important issues on behalf of OTA without appropriate authority to do so.

Do

1. Do adhere to prepared agenda for all OTA meetings. It is generally permissible for agendas to include discussions of such varied topics as professional economic trends, advances and problems in relevant technology or research, various aspects of the science and art of management, and relationships with local, state or federal governments.
2. Do object whenever meeting summaries do not accurately reflect the matters that occurred.
3. Do consult with OTA counsel on all antitrust questions relating to discussions at OTA meetings.
4. Do object to and do not participate in any discussions or meeting activities that you believe violate the antitrust laws; dissociate yourself from any such discussions or activities and leave any meeting in which they continue.

Special Guidelines for Collecting and Distributing Information

The collection and distribution of information regarding business practices is a traditional function of associations and is well-recognized under the law as appropriate, legal and consistent with the antitrust laws. However, if conducted improperly, such information gathering and distributing activities might be viewed as facilitating an express or implied agreement among association members to adhere to the same business practices. For this reason, special general guidelines have developed over time regarding association's reporting on information collected from and disseminated to members. Any exceptions to these general guidelines should be made only after discussion with the Office of General Counsel. These general guidelines include:

1. Member participation in the statistical reporting program is voluntary. The statistical reporting program should be conducted without coercion or penalty. Non-members should be allowed to participate in the statistical reporting program if eligible; however, if there is a fee involved, they may be charged a reasonably higher fee than members.
2. Information should be collected via a written instrument that clearly sets forth what is being requested.
3. The data that is collected should be about past transactions or activities; particularly if the survey deals with prices and price terms (including charges, costs, wages, benefits, discounts, etc,), it should be historic, i.e., more than three months old.

4. The data should be collected by either the OTA or an independent third party not connected with any one member.
5. Data on individual orthopaedic surgeons should be kept confidential.
6. There should be a sufficient number of participants to prevent specific responses or data from being attributable to any one respondent. As a general rule, there should be at least five respondents reporting data upon which any statistic or item is based, and no individual's data should represent more than 25% on a weighted average of that statistic or item.
7. Composite/aggregate data should be available to all participants – both members and nonmembers. The data may be categorized, e.g., geographically, and ranges and averages may be used. No member should be given access to the raw data. Disclosure of individual data could serve to promote uniformity and reduce competition.
8. As a general rule, there should be no discussion or agreement as to how members should adjust, plan or carry out their practices based on the results of the survey. Each member should analyze the data and make business decisions independently.

Orthopaedic Trauma Association
CODE OF ETHICS FOR BOARD MEMBERS
(Adopted December 2008)

OTA Board Members agree to:

1. Faithfully abide by the Articles of Incorporation, by-laws and policies of the organization.

2. Exercise reasonable care, good faith and due diligence in organizational affairs.

3. Disclose information that may result in a perceived or actual conflict of interest.

4. Disclose information of fact that would have significance in Board decision-making.

5. Remain accountable for prudent fiscal management to association members, the Board, and nonprofit sector, and where applicable, to government and funding bodies.

6. Maintain a professional level of courtesy, respect, and objectivity in all organization activities.

7. Strive to uphold those practices and assist other members of the Board in upholding the highest standards of conduct.

8. Exercise the powers invested for the good of the organization rather than for his or her personal benefit, or that of the nonprofit they represent.

9. Respect the confidentiality of sensitive information known due to Board service.

10. Respect the diversity of opinions as expressed or acted upon by the Board, committees and membership, and formally register dissent as appropriate.

11. Promote collaboration and cooperation among association members.

12. Procedure to Distribute and Approve Form 990
    The OTA Board of Directors retains the services of an independent CPA firm to audit the organization's form 990. Management reviews the completed form 990 and provides a full copy to all voting members of the OTA Finance Committee prior to filing. The Board of Directors is provided a reasonable period of time to review the form 990 and direct any questions to organization management or the independent CPA firm prior to filing. If necessary, conference call may be requested and scheduled for the CPA firm and organization management to discuss the form 990 with the OTA Finance Committee.

Orthopaedic Trauma Association
CONFLICT OF INTEREST POLICY
(Revised March 2013)

ARTICLE I

Purpose:

The purpose of this Board's conflict of interest policy is to protect the interests of the organization in all matters where a potential conflict may exist; especially when contemplating entering into a transaction or arrangement that might benefit the private interests of an officer or director by creating unfair personal advantages with regard to industrial, institutional or political relationships; or by the failure to disclose concurrent relationships that potentially conflict with the mission, values or governance of the OTA (referred to as 'conflict of commitment').

The OTA bylaws mandate that the Board's governance provides continued review and monitoring of potential conflicts with regard to intellectual information presented at national meetings, educational offerings and sponsored research. The policy recognizes the educational level of its members and their individual capability to determine what may represent a conflict. This policy also recognizes that all potential conflicts may not be clearly identifiable, and the Board will strive, at all times, to identify and protect the interests of the organization. Finally, this policy recognizes the Standard of Conduct and the Board agrees to abide by the provisions as outlined below.

This policy is intended to supplement but not replace any applicable state and federal laws governing conflict of interest applicable to nonprofit and charitable organizations.

ARTICLE II

Definitions:

1. Interested Person

Any director, board member, or committee chair with governing board delegated powers, who has a direct or indirect financial interest or commitment, as defined below, is an interested person.

2. Financial Interest

A person has a financial interest if the person has, directly or indirectly, through business, investment, or family:

a. An ownership or investment interest in any entity with which the Organization has a transaction or arrangement,

b. A compensation arrangement with any entity or individual with which the Organization has a transaction or arrangement, or

c. A proposed ownership or investment interest in, or compensation arrangement with, any entity or individual with which the Organization is negotiating a transaction or arrangement. Compensation includes direct and indirect remuneration as well as gifts or favors that are not insubstantial.

3. Conflict of Commitment

During the tenure of the OTA leadership position, any member being considered for or in a leadership position must disclose concurrent board or committee chair appointments in any other professional organization deemed potentially competitive to the mission of the OTA.

A 'financial interest' or 'conflict of commitment' is not necessarily a conflict of interest. A person who has a financial interest or conflict of commitment may have a conflict of interest only if the appropriate governing board or committee decides that a conflict of interest exists.

ARTICLE III

Procedures:

As stipulated in the OTA Mandatory Disclosure Program, members of the OTA Board of Directors, Committees, Project Teams or other official OTA groups (collectively "OTA governance groups"), has the obligation to disclose all potentially conflicting interests at least semi-annually. A list of all participants in OTA governance groups, along with their disclosures, will be included in all meeting materials. Participants in OTA governance groups have an obligation to indicate any potential conflicts they may have during discussions affecting their personal interests during the meeting of the OTA governance group.

Based on the information provided in the Disclosure Program and / or upon a further review, the chair of the OTA governance group may determine that the participant shall:

a) Disclose the conflict and continue to participate fully in the OTA governance group's deliberations

b) Disclose the conflict, but abstain from discussing and voting on the matter; or

c) Disclose the conflict and leave the room until the matter has been fully discussed and acted upon.

ARTICLE IV

Records of Proceedings:

The minutes of the Board and all committees with board delegated powers shall contain:

a. The names of the persons who disclosed or otherwise were found to have a financial or commitment interest in connection with an actual or possible conflict of interest, the nature of the financial / commitment interest, any action taken to determine whether a conflict of interest was present, and the Board's or Executive Committee's decision as to whether a conflict of interest in fact existed.

b. The names of the persons who were present for discussions and votes relating to the transaction or arrangement, the content of the discussion, including any alternatives to the proposed transaction or arrangement, and a record of any votes taken in connection with the proceedings.

ARTICLE V

Recusal from Voting:

A voting member of any committee whose jurisdiction includes allocating and/or distributing OTA resources is precluded from voting on matters pertaining to the distribution of awards, funding or compensation that could potentially benefit the voting member or his/her interests or institutions.

ARTICLE VI

Affirmation of Understanding of OTA Policies:

1. Each director, principal officer and member of a committee with Board delegated powers shall annually sign a statement which affirms such person:
    a. Has received a copy of the conflict of interest policy and code of conduct.
    b. Has read and understands the policy and code.
    c. Has agreed to comply with the policy by signing the compliance agreement. (Attachment)

2. If at any time during the year, the information in the annual statement changes materially, the director shall disclose such changes and revise the annual disclosure form.

3. The appropriate governance Committee shall regularly and consistently monitor and enforce compliance with this policy.

ORTHOPAEDIC TRAUMA ASSOCIATION

Welcome to the OTA Discussion Forum

a private community where OTA members can collaborate on individual cases, build consensus, improve and advance medical skills and knowledge, educate colleagues, train new practitioners, receive or offer career mentorship, and discover new medical data and technologies.

education
research
mentorship
outreach happens here
case discussion
community
engagement
success

It's a members only benefit.

https://community.ota.org/home

INDUSTRY SESSIONS

Session	Title	Faculty
IS01 Skeletal Dynamics Wednesday, 6:30 - 8:00 PM *(114)*	Advancements in the Treatment of Distal Elbow Fracture-Dislocations	*Jorge L. Orbay, MD*
IS02 Integra Life Sciences Wednesday, 6:30 - 8:00 PM *(113)*	Get Some Closure: The Latest in Soft Tissue Solutions	
IS03 Stryker Wednesday, 6:00 - 9:00 PM *(The Aston Depot)*	The Stryker Experience Event	
IS05 Smith & Nephew Thursday, 11:15 AM - 1:00 PM *(103AB)*	Current Concepts of Periprosthetic Fractures	*J. Tracy Watson, MD (Moderator);* *Samir Mehta, MD*
IS06 DePuy Synthes Thursday, 11:15 AM - 12:45 PM *(121C)*	Expanding Fixation Options for Periprosthetic Fractures	*Frank Liporace, MD* *Cory Collinge, MD* *George Haidukewych, MD*
IS07 DePuy Synthes Thursday, 11:15 AM - 12:45 PM *(121D)*	Improving Stability in Femur and Tibia Fractures with the Advanced Nailing System	
IS08 DePuy Synthes Thursday, 11:15 AM - 12:45 PM *(121E)*	Enhancing Plate-to-Bone Conformity by Mapping Clavicle Morphology and Its Relation to Patient Height	*Thomas Higgins, MD* *Christopher Finkemeier, MD*
IS09 Zimmer Biomet Thursday, 11:15 AM - 12:45 PM *(108)*	Solutions to Peri-Prosthetic and Challenging Distal Femoral Fractures	*Michel Tilley, MD* *Ravi Karia, MD*
IS10 Stryker Thursday, 11:15 AM - 12:45 PM *(114)*	Treating Distal and Diaphyseal Femur Fractures Featuring Stryker's New T2 Alpha Femur Retrograde Nailing System	

INDUSTRY SESSIONS, continued

Session	Title	Faculty
IS11 Skeletal Dynamics Thursday, 11:15 AM - 12:45 PM *(121B)*	The Next Generation of Distal Humerus and Humeral Shaft Fracture Management	*Jorge L. Orbay, MD*
IS12 SI-BONE Thursday, 11:15 AM - 12:45 PM *(106)*	***Now Launching*** The iFuse-TORQ Implant System for Pelvic Trauma!	*Michael Gardner, MD (Stanford)* *Bharat Desai, MD (Golden, CO)* *Craig Bartlett, MD (University of Vermont)*
IS13 3M Health Care Thursday, 11:15 AM - 12:45 PM *(121A)*	Reducing the Risk in Surgical Site Infections in Lower Extremity Surgery	
IS14 NuVasive Thursday, 11:15 AM - 12:45 PM *(113)*	Early Clinical Results: Treating Segmental Bone Defects with the Precice Bone Transport System	*James Blair, MD* *Matthew Gardner, MD* *Stephen Quinnan, MD* *John Scolaro, MD*

OTA GRATEFULLY ACKNOWLEDGES THE FOLLOWING EXHIBITORS FOR THEIR SUPPORT OF THE 37TH ANNUAL MEETING:

Booth #	Company Names	City, State
521	**3M Health Care**	San Antonio, TX
520	**Abyrx, Inc.**	Irvington, NY
209	**Acumed/OsteoMed**	Hillsboro, OR
332	**AMDT Holdings, Inc**	Collierville, TN
215	**AO Trauma North America**	Wayne, PA
309	**Arthrex, Inc.**	Naples, FL
617	**Austin Medical Ventures**	Germantown, TN
323	**Baudax Bio**	Malvern, PA
233	**Biedermann Motech**	Miami, FL
532	**BioAccess, Inc.**	Baltimore, MD
420	**Biocomposites**	Wilmington, NC
428	**BioSkills of North Texas**	Fort Worth, TX
317	**Bone Foam, Inc.**	Corcoran, MN
620	**Bone Solutions, Inc.**	Colleyville, TX
321	**BONESUPPORT**	Cambridge, MA
629	**C2Dx**	Schoolcraft, MI
423	**CarboFix Orthopedics, Inc**	Ocean Isle Beach, NC
422	**Curvafix**	Bellevue, WA
Office A	**Curvafix**	Bellevue, WA
601	**DePuy Synthes**	West Chester, PA
Office B	**DePuy Synthes**	West Chester, PA
223	**ECA Medical Instruments**	Thousand Oaks, CA
517	**EDGe Surgical, Inc.**	Chicago, IL
734	**Endeavor Orthopaedics**	Tulsa, OK
235	**Exactech, Inc.**	Gainsville, FL
335	**FX Shoulder USA**	Dallas, TX
623	**Gauthier Biomedical, Inc.**	Grafton, WI
509	**Globus Medical**	Audubon, PA
621	**IlluminOss Medical Inc**	East Providence, RI
534	**Innomed, Inc.**	Savannah, GA

EXHIBITORS LISTING, continued

Booth #	Company Names	City, State
334	**Innov8ortho**	Englewood Cliffs, NJ
633	**Integra Lifesciences**	Plainsboro, NJ
327	**Invibio Biomaterials Solutions**	West Conshohocken, PA
720	**ITS.**	Maitland, FL
333	**JC Orthoheal PVT LTD**	Gujarat, India
329	**KLS Martin Group**	Jacksonville, FL
533	**Lifespans Limited**	Wong Chuk Hang, Hong Kong
522	**McGinley Orthopedics**	Casper, WY
535	**Medartis, Inc.**	Exton, PA
632	**Medtronic**	Minneapolis, MN
421	**MY01, Inc.**	Montreal, QC
722	**Naked Prosthetics**	Olympia, WA
523	**Next Science, LLC**	Jacksonville, FL
435	**NexTek**	Austin, TX
328	**NuVasive Specialized Orthopedics, Inc.**	Aliso Viejo, CA
529	**ODi (Orthopedic Designs, Inc.)**	Tampa, FL
627	**Orthofix**	Lewisville, TX
635	**OrthoGrid Systems, Inc.**	Salt Lake City, UT
426	**Orthomed, Inc.**	Tigard, OR
432	**OrthoXel**	Bishopstown, Cork
609	**OsteoCentric Technologies**	Austin, TX
221	**Pacific Instruments**	Honolulu, HI
433	**Puracyn Plus by Innovacyn**	Rialto, CA
434	**Retrofix Screws, LLC**	Salisbury, NC
628	**RTT Medical**	Orlando, FL
726	**Sanara MedTech**	Fort Worth, TX
429	**Shukla Medical**	St. Petersburg, FL
526	**SI-BONE, Inc.**	Santa Clara, CA
201	**Skeletal Dynamics**	Miami, FL
500	**Smith & Nephew**	Cordova, TN

EXHIBITORS LISTING, continued

Booth #	Company Names	City, State
427	**Starr Frame LLC**	Richardson, TX
409	**Stryker**	Mahwah, NJ
Office C & D	**Stryker**	Mahwah, NJ
728	**Surgical Affiliates Management Group, Inc.**	Sacramento, CA
622	**Synergy Health Partners**	Bozeman, MT
320	**The Orthopaedic Implant Company**	Reno, NV
417	**TriMed, Inc.**	Santa Clarita, CA
528	**Wolters Kluwer**	Philadelphia, PA
301	**Zimmer Biomet**	Warsaw, IN

FUTURE EVENTS

Most Educational Opportunities include *AMA PRA Category 1 Credits™*
Visit www.ota.org for details.

MEMBERSHIP APPLICATION DEADLINES (apply online)
November 1, 2021 / May 1, 2022

RESIDENT GRANT APPLICATION OPENS (apply online)
Early November, 2021

FULL GRANT PRE-PROPOSAL OPENS (apply online)
Early November, 2021

OTA SPECIALTY DAY
March 26, 2022 Chicago, IL

SPRING RESIDENT COMPREHENSIVE FRACTURE COURSE
April 27 - 30, 2022 Nashville, Tennessee

FELLOWS COURSE
Tentative

RESIDENT ADVANCED TRAUMA TECHNIQUES COURSE
Spring 2022

RESIDENT COMPREHENSIVE FRACTURE COURSE
October 12 - 14, 2022 Tampa, Florida

OTA 38TH ANNUAL MEETING & PRE-MEETING EVENTS
October 12 - 15, 2022 Tampa, Florida

PRE-MEETING EVENTS

Basic Science Focus Forum
International Trauma Care Forum
Orthopaedic Trauma Boot Camp
Young Practitioners Forum
OTA Member Fireside
Orthopaedic Trauma for NP's and PA's
E/M & Surgical Coding Course
Pelvis and Acetabulum Course
Soft Tissue Coverage Skills Course

Abstract Deadline: February 2, 2022

WiFi: **OTA2021** Password: **OTA2021**

Mobile App: Search **Orthopaedic Trauma Association** in your app store to download the app for full schedule, abstracts, attendee messaging, maps and more. Be sure to accept push notifications for updates.

ORTHOPAEDIC TRAUMA ASSOCIATION

Announcing the Release of the New OTA Core Curriculum Lectures!

New OTA Core Curriculum Lectures!

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- All Revised Content from Previous Versions
- Great Educational Resource!
- Project Directors:
  Lisa K. Cannada, MD
  Kyle J. Jeray, MD
  Samir Mehta, MD

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