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

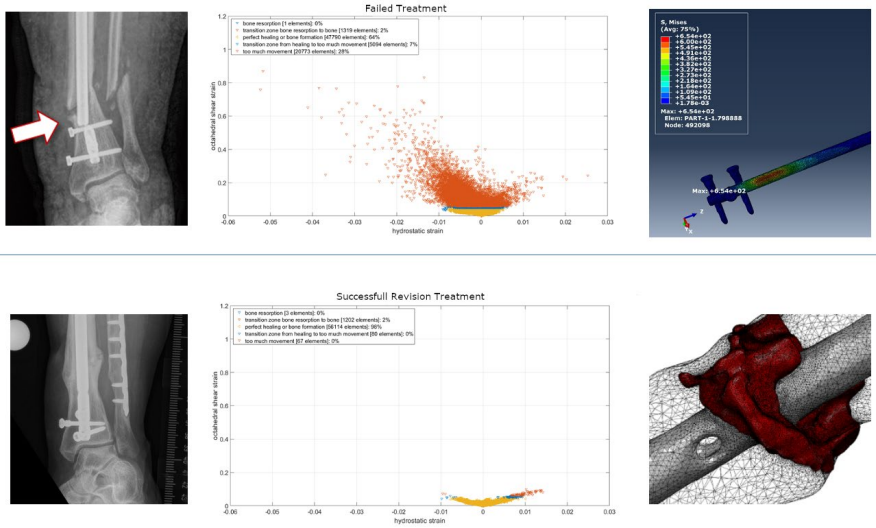
Benedikt J. Braun, MD; *Michael Roland, PhD; Marcel Orth, MD*
Saarland University Hospital, Homburg, Germany

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.