

## **In Vivo Correlation of RUST Scoring with Biomechanical Strength of Nailed Tibia Fractures: Can We Finally Define Union Radiographically?**

Paul Tornetta III, MD<sup>1</sup>; Jody Litrenta, MD<sup>1</sup>; William Ricci, MD<sup>2</sup>; Roy Sanders, MD<sup>3</sup>; Robert O'Toole, MD<sup>4</sup>; Henry Faber, MS<sup>5</sup>; Jason Nascone, MD<sup>6</sup>;

<sup>1</sup>Boston Medical Center, Boston, Massachusetts, USA;

<sup>2</sup>Washington University in St. Louis Department of Orthopedic Surgery, St. Louis, Missouri, USA;

<sup>3</sup>Orthopaedic Trauma Service, Tampa, Florida, USA;

<sup>4</sup>Shock Trauma Center, Baltimore, Maryland, USA; <sup>5</sup>Smith & Nephew, Memphis, Tennessee, USA;

<sup>6</sup>Shock Trauma Orthopaedics, Baltimore, Maryland, USA

**Background/Purpose:** The Radiographic Union Scale for Tibia fractures (RUST) is used to numerically report the progress to union after intramedullary nailing; however, there is currently no value that defines union. Additionally, the score has been evaluated in a wide range of fracture patterns treated with multiple nails and constructs. A modified score that allows for 4 scores per cortex has been described. The purpose of this study was to evaluate the standard RUST score and the modified RUST score in a large animal osteotomy model, and to evaluate the effect of canal visualization on the reliability of the RUST scores and the assessments of union. Most importantly, we sought to determine the standard and modified RUST scores that represent biomechanical union, based on the torsional stiffness of the affected versus the contralateral tibia in the animals.

**Methods:** Two groups of sheep had transverse midshaft osteotomies treated with locked 10-mm radiolucent carbon fiber (10) or radiodense titanium (10) nails after reaming to 11.5mm. Weightbearing was allowed as tolerated. AP and lateral radiographs were taken at standard intervals from 4 to 12 weeks. The cortices of each tibia at each time interval were evaluated by 5 senior orthopaedic trauma surgeons in 2 separate sessions 8 weeks apart. Evaluations were made with the type of nail blinded and unblinded. Cortical callus was graded as "none," "present," "bridging," or "remodeled" for the modified RUST score. The middle two were collapsed to give a standard RUST score. The tibiae were randomly ordered for each surgeon. Additionally, each set of radiographs was graded as "healed" or "not healed." The absolute intraclass correlation coefficient (ICC) was determined for the standard and modified RUST score at each interval and for the assessment of union. The percentages of fractures that were defined as united were tabulated by standard RUST and modified RUST score. The torsional stiffness of each tibia was tested at 12 weeks and expressed as a percentage of the contralateral side. We considered biomechanical union to be equal to 90% of the torsional stiffness of the normal side.

**Results:** The modified RUST score demonstrated consistently higher ICC for all evaluations (Table 1). The ICC for union was higher for the radiodense than the radiolucent nail for both unblinded (0.89 vs 0.69) and blinded (0.80 vs 0.69) evaluations. The overall percentage of tibiae graded as united by the reviewers is seen in Table 2. The standard RUST was 10.3 (range, 8.6 - 12) and modified RUST was 14.1 (12.2 - 16) for tibiae that were biomechanically united.

**Conclusion:** This is the first study to evaluate the RUST scoring methods in a controlled animal model including a biomechanical evaluation. The ICC for the modified RUST is

better than the standard RUST in a standardized animal osteotomy model irrespective of nail material or canal blinding. This indicates that the modified RUST is a better tool for assessing the progress of union over time. The ICC for the assessment of union was higher for the titanium nail and reached excellent agreement (0.8 blinded and 0.89 unblinded). Biomechanical union averaged 10.3 and 14.1 for the RUST and modified RUST scores, which is consistent with the surgeons' evaluations.

**Table #1: ICC's for Standard and Modified RUST Scores**

RUST	Unblinded			Blinded		
	Carbon	Titanium	All	Carbon	Titanium	All
Standard	.73	.67	.70	.69	.67	.68
Modified	.82	.81	.81	.85	.84	.84

**Table #2: Percentage of Reviewers Assigning Union by RUST Score (unblinded)**

Score	RUST			Modified RUST			
	8	9	10	11	12	13	14
% United	7%	53%	100%	14%	35%	74%	100%