Does the Modified RUST Score Correlate with the Biomechanical Properties of Bone? Evaluation in a Murine Model

*Paul Tornetta III, MD[1]; **Margaret Cooke, MD**[1]; Amira Hussein, PhD[1]; Jody Litrenta, MD[1]; William M. Ricci, MD[2]; Jason Nascone, MD[3]; Robert V. O'Toole, MD[3]; Louis Gerstenfeld, PhD[1]*
[1]Boston University Medical Center, Boston, Massachusetts, USA;
[2]Washington University in Saint Louis, Saint Louis, Missouri, USA;
[3]University of Maryland, Shock Trauma Orthopaedics, Baltimore, Maryland, USA

Background/Purpose: The modified Radiographic Union Score for Tibial fractures (mRUST score) is a radiographic tool used to evaluate healing of fractures using a cortical scoring system. This system has been shown to have high intraclass correlation coefficients (ICCs) in multiple environments; however, there is little evidence evaluating the score against the physical properties of the bone. The purpose of this study is to compare the mRUST score with biomechanical properties in a murine model using a normal and phosphate-deficient diet. Phosphate deficiency leads to osteomalacia and has been found to affect biomechanical properties of fracture healing in mice.

Methods: Closed stabilized femur fractures were generated in 8- to 12-week-old C3H/HeJ (C3) male mice. Phosphate deficiency (Pi) was initiated 2 days prior to fracture and was maintained for 17 days, after which a normal diet was resumed. Control animals were fed a normal diet throughout. Fracture calluses were harvested from N = 8-12 mice per time point at 14, 21, 35, and 42 days in both Pi and control groups. Micro-CT was used to evaluate the structural and material properties of the callus; additionally 2-dimensional projections were used to create AP and lateral images that were evaluated by 4 senior orthopaedic traumatologists and 1 orthopaedic fellow for mRUST score and whether they felt the bone was or was not healed. Mechanical properties were determined by torsion testing and were normalized to a nonfractured bone at day 0. Data were analyzed using 2-factor analysis of variance (ANOVA), ICC, and Pearson correlations.

Results: The mRUST scores among the 5 reviewers had an ICC of 0.86 (near perfect). Diet was not a significant factor in predicting mRUST score (ANOVA P = 0.15). Regarding the biomechanical properties of the fractured femora, the mRUST score positively correlated (P <0.0001) with bone mineral density (r: 0.87, CI: 0.81-0.91), stiffness (r: 0.49, CI: 0.32-0.63), rigidity (r: 0.45 CI: 0.27-0.60), and strength (r: 0.26, CI: 0.05-0.44, P = 0.01), (see figures). The total callus volume (r: -0.57, CI: -0.69 - -0.42) and ductility (twist to failure) (r: -0.42, CI: -0.58 - -0.24) were negatively correlated with increasing mRUST score (P <0.0001). As expected, RUST scores were higher over time (r: 0.85, CI: 0.78-0.90, P <0.0001). The ICC for union was 0.65, which represents a strong agreement.

Conclusion: The mRUST score correlated statistically with all mechanical properties of bone, although most strongly with bone mineral density (r = 0.87). The correlation was not influenced by a phosphate-deficient diet. These data suggest that mRUST may be a useful surrogate for progression of healing and estimating bone mineral density (BMD) after fracture.

Does the Modified RUST Score Correlate with the Biomechanical Properties of Bone? Evaluation in a Murine Model

Fig1: mRUST score positively correlates with % BMD.

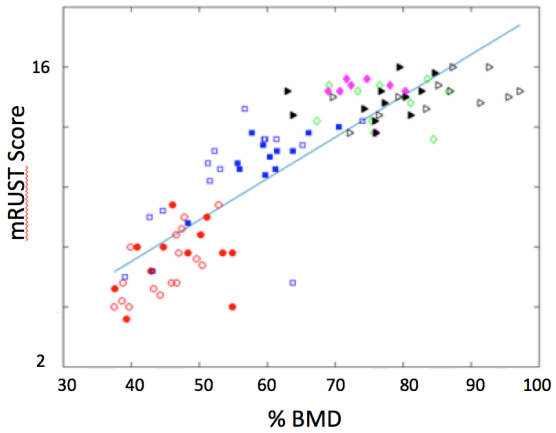


Fig2: % BMD increases over time regardless of diet.

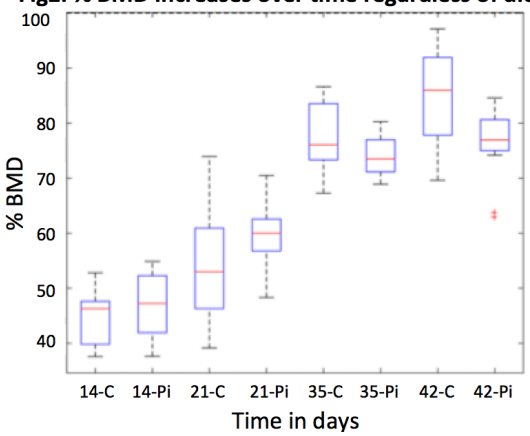
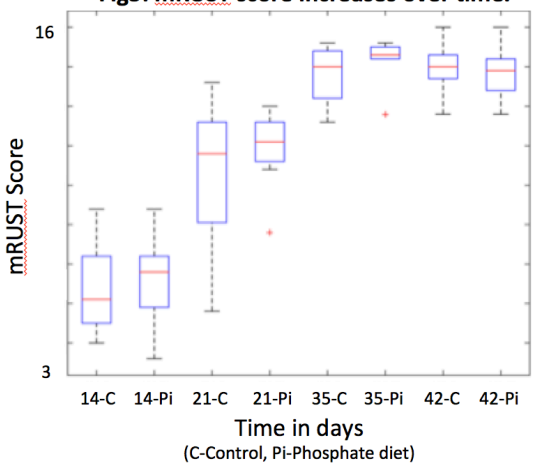


Fig3: mRUST score increases over time.



See pages 49 - 106 for financial disclosure information.