

**NURD 2.0: Prediction of Tibial Nonunion at Any Time Within 3 Months of Injury**

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**Purpose:** The ability to predict likelihood of nonunion after tibial shaft fracture would be helpful to clinicians and patients. Previous risk models have been developed at discrete time points, but there exists no composite model that can predict nonunion regardless of the time of follow-up within the first 3 months. Our hypothesis is that a score (Nonunion Risk Determination score 2.0 [NURD 2.0]) will have adequate utility for clinical use.

**Methods:** In order to create a model that encompassed all time points, we combined data from 3 previously presented analyses. These data were based on a cohort of tibial shaft fractures treated with nail at our Level I trauma center from 2007 to 2014. We excluded patients who did not have contact between bone ends, who had planned bone graft procedures for acute bone defects, and those without adequate follow-up. Three models were combined that entailed 382 patients at time 0, 323 patients at 6 weeks, and 240 patients at 12 weeks. The nonunion rate in the entire cohort was 14.7%. We included 42 clinical and radiographic variables that had been previously hypothesized to be associated with nonunion in our analysis. Bivariate and multivariate regression analyses were used to determine variables significantly associated with nonunion. Predictive power was evaluated using the area under the curve (AUC) statistic. AUCs >0.8 suggest that 80% sensitivity/specificity can be achieved, and AUCs >0.9 may meet the threshold of clinical utility.

**Results:** The original NURD score at time of initial fixation was significantly improved through addition of 6 and 12-week RUST (Radiographic Union Score for Tibial Fractures) scores, infection and complications, smoking status, and the need for flaps. Individually, NURD-based models achieved AUCs of 0.81 at time of initial fixation, 0.87 at 6 weeks, and 0.88 at 12 weeks. Taken as a whole over the course of 12 weeks, the NURD-based model produced an AUC of 0.87 at the initial time of fixation and improved to over 0.9 at 6 and 12 weeks. It was possible to use this approach to bin patients into 5 clinically important risk strata ( $P < 0.001$ ). Patients in the lowest risk strata had 0% probability of nonunion (0 of 62 patients). Patients in the second lowest risk strata had a 3.4% (3 of 87) probability of nonunion. Patients in the 2 highest risk strata had 20.8% (25 of 120) and 53.7% (22 of 41) probabilities of nonunion.

**Conclusion:** We were able to combine 3 previous models into a new nonunion risk score that can predict nonunion at any time point in the first 3 months. The combination of baseline NURD scores and clinical measures identified during routine follow-up allow surgeons to bin patients into clinically important risk categories. About 40% percent of patients, those in the 2 highest risk categories, have a sufficiently high probability of nonunion to merit increased follow-up and possibly acceleration of intervention protocols. The new model (NURD 2.0) is a significant improvement over prior models that are based on a single time point from surgery. A computerized version of the score will allow surgeons and patients to easily use the score to help make decisions regarding the need for nonunion 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.