Predicting Humeral Shaft Fracture Nonunion: The Radiographic Union Score for HUmeral fractures (RUSHU)

William M. Oliver, MBBS*; Thomas J. Smith, BS; Jamie A. Nicholson, MBCHB, MRCSED; Samuel G. Molyneux, FRCS (Ortho), MSc; Timothy O. White, MD, FRCS; Nicholas D. Clement, PhD; Andrew David Duckworth, FRCS, MBCHB, MSc, PhD*
Royal Infirmary of Edinburgh, Edinburgh, United Kingdom

Purpose: Nonunion complicates up to 20% of nonoperatively treated humeral shaft fractures and avoiding delay in the diagnosis may allow early intervention and reduce morbidity. Radiological scoring systems have been used to predict nonunion in other fractures, but we are unaware of such a score for the humerus. The primary aim of this study was to develop a reliable and effective radiological score-the Radiographic Union Score for HUmeral fractures (RUSHU)-to assess humeral shaft fracture healing. The secondary aim was to assess the predictive ability of the RUSHU in identifying patients at risk of nonunion following a humeral shaft fracture.

Methods: Patients were retrospectively identified from a trauma database held at the study center. 20 randomly selected patients with AP and lateral radiographs taken 6 weeks following their humeral shaft fracture were rated by 3 observers, with scoring based on the Radiographic Union Scale for Tibial fractures (RUST) system, to assess the reliability of the RUSHU score. After refinement of RUSHU scoring criteria, 60 sets of 6-week AP and lateral radiographs (40 patients who achieved fracture union, 20 who developed nonunion) were rated by 2 observers blinded to patient outcome. A receiver operating characteristic (ROC) curve was used to determine the optimal RUSHU cut-off score in predicting eventual nonunion.

Results: The interobserver intraclass correlation coefficient (ICC) was 0.68 (95% confidence interval [CI] 0.46 to 0.85). This improved after refinement to 0.79 (95% CI 0.67 to 0.87), indicating substantial agreement. At 6 weeks postinjury, patients who went on to unite (n = 40, median RUSHU = 10) had a significantly ($P < 0.001$) higher score than those who developed nonunion (n = 20, median RUSHU = 7). ROC curve determined a RUSHU cut-off of <8 to predict nonunion (area under the curve 0.84, 95% CI 0.74 to 0.94). Sensitivity was 75%, specificity 80%, positive predictive value (PPV) 65%, and negative predictive value 86%. Patients with a RUSHU <8 (n = 23) were 12 times more likely to develop nonunion than those with a score ≥8 (n = 37, odds ratio 12.0, 95% CI 3.4 to 42.9). Five of the 20 patients who developed a nonunion had a RUSHU ≥8 (false negative rate 25%). Based on a PPV of 65%, if all patients with a RUSHU <8 underwent fixation, the number of fixation procedures needed to avoid 1 nonunion would be 1.5.

Conclusion: The RUSHU is reliable and effective in identifying patients at risk of developing humeral shaft fracture nonunion at 6 weeks postinjury. The RUSHU requires validation in other centers, but has the potential to enhance decision-making in patients with a fracture of the humeral shaft and reduce the morbidity associated with delayed treatment of an established nonunion.