

**Prospective Prediction of Tibial and Femoral Shaft Fracture Nonunion at 4 Months**

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**Purpose:** A retrospective single-center study recently determined that the presence or absence of bridging callus at 4 months postoperatively accurately discriminated between tibial shaft fractures bound for union and nonunion. However, there remains no consensus regarding early prognostication of long bone nonunion. The purpose of this study was to prospectively assess the accuracy and reliability of the previously described assessment of any bridging callus at 4 months in a prospective cohort expanded to include both tibial and femoral shaft fractures.

**Methods:** A prospective prognostic study is being performed at a Level I trauma center. To date we have identified 78 consecutive tibial (OTA 42-A,B,C) and femoral (OTA 32-A,B,C) shaft fractures treated with intramedullary nailing. Ten patients had yet to achieve a final healing outcome, while others were excluded due to death before final outcome (2), early planned bone grafting for critical bone loss (1), and failure to return to clinic (5). Thus, the final analytic cohort included 60 fractures (26 tibias and 34 femurs). Postoperative digital radiographs were obtained between 3 and 4 months postoperatively and assessed independently by three orthopaedic traumatologists for the presence of bridging callus. The patients were followed to radiographic and clinical union. The accuracy of varying callus criteria (any bridging, bicortical bridging, and tricortical bridging) was assessed with the chi-square test for ability to predict union and nonunion. Interobserver reliability (kappa statistic) was calculated for each criterion.

**Results:** The nonunion rate was 6.7% (4 of 60). The presence of any bridging callus by 4 months postoperatively accurately predicted union when present and nonunion when absent (56/56 and 4/4 respectively,  $P < 0.001$ ). This included the prediction of nonunion in both the tibia (3/26) and femur (1/34) without error. Bicortical bridging was accurate for 59 of 60 (98.3%), predicting union when present and nonunion when absent (55/55 and 4/5, respectively,  $P < 0.001$ ), incorrectly predicting one healing fracture as a nonunion. Tricortical bridging was accurate for 50 of 60 fractures (83.1%), predicting union when present and nonunion when absent (46/50 and 4/14,  $P = 0.01$ ), incorrectly predicting ten healing fractures as nonunions. Interobserver reliability was calculated for any bridging callus (kappa = 0.96), at least bicortical bridging (kappa = 0.89), at least tricortical bridging (kappa = 0.58), and the exact number of cortices bridged (kappa = 0.51).

**Conclusion:** Prospective assessment for any bridging callus by 4 months postoperatively predicted union and nonunion with high accuracy and reliability. This clinical criterion is simple, reliable, and requires only standard radiographic views. This relatively early radiographic finding discriminates between fractures achieving late union with observation alone and those destined to nonunion. Requiring additional cortices to be bridged risks overestimation of the nonunion rate and is associated with relatively poor reliability.