

Bridge Plate Fixation of Distal Femur Fractures: What Determines Callus Formation and How Much Is Needed to Achieve Union?

William Lincoln Crutcher, MD; Kyle M. Griffith, BA; Erik Arthur Magnusson, MD; Cory Allen Alford, MS; Ena Dawn Nielsen, MD; Jacob Elkins, PhD; Trevor Lujan, PhD; Conor P. Kleweno, MD; William Dean Lack, MD
University of Washington, Seattle, Washington, UNITED STATES

Purpose: Previous research has linked factors such as construct material and estimated fracture site motion with the formation of callus at a bridge-plated distal femur fracture. However, many questions remain including whether these relationships are clinically relevant. We hypothesized that deficient callus could be quantified and defined objectively based on final healing outcomes and that estimated fracture site motion would be independently associated with such deficient callus formation.

Methods: Final healing outcomes were documented for 161 distal femur fractures (OTA/AO classification of 33A or 33C) treated with locked bridge-plate fixation. Radiographic callus area was measured on postoperative radiographs until union or nonunion had been declared by the treating surgeon. Deficient callus was defined at 6 and 12 weeks via receiver operating characteristic curve analysis to determine if callus area was associated with nonunion and if so, to determine the callus area that was discriminatory between union and nonunion. Univariate and multivariate analyses then examined the association of patient, injury, and treatment factors with deficient callus formation.

Results: Callus area at 6 and 12 weeks was associated with the final healing outcome and this association remained as strong when assessing medial callus in isolation. Deficient callus at 6 weeks (<24.8 mm² of medial callus) was associated with nonunion (12/39, 30.8% vs 12/109, 11.0%; $P = 0.010$). Deficient callus at 12 weeks (<44.2 mm² of medial callus) was associated with nonunion (13/28, 46.4% vs 11/120, 9.2%; $P < 0.001$). Univariate logistic regression analyses found Charlson Comorbidity Index (CCI) and computationally modeled longitudinal motion (based solely on the construct employed) to be associated with deficient callus at 12 weeks ($P = 0.005$ and 0.026 , respectively). Open fracture, mechanism of injury, smoking, diabetes, plate material, bridge span, and shear were not associated with deficient callus. Multivariate logistic regression analysis demonstrated that limited longitudinal motion (odds ratio 2.713, 1.116 to 6.598; $P = 0.028$) and increased CCI (1.362, 1.11 to 1.67; $P = 0.003$) were independently associated with deficient callus.

Conclusion: Objective assessments of radiographic callus area at 6 and 12 weeks were associated with the final healing outcome, providing clinically relevant temporal definitions of deficient callus in the setting of bridge-plate fixation of distal femur fractures. Further, CCI and fracture site motion were independently associated with deficient callus formation. In vivo assessments of fracture site motion are necessary to more accurately assess the role of fracture site motion in the healing of these fractures.