

# Bridge Plate Fixation of Distal Femur Fractures: Defining Deficient Radiographic Callus Formation and its Associations

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**INTRODUCTION:** Previous research has linked treatment-related factors such as construct material and fracture site motion with relatively deficient radiographic callus formation, however, many questions remain including whether these findings are reproducible and clinically relevant. An objective definition of deficient early callus could contribute to understanding the clinical relevance of these associations, and aid clinicians in identifying and treating patients at high risk of nonunion earlier and with greater accuracy. We hypothesized that deficient early callus formation could be defined objectively based on association with eventual nonunion and that specific patient, injury, and treatment factors would be independently associated with such deficient callus formation.

**METHODS:** Final healing outcomes (union vs. nonunion) were documented for 160 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 operator characteristic analysis based on association with eventual nonunion. Univariable and multivariable analyses then examined the association of patient, injury, and treatment factors with deficient callus formation.

**RESULTS:** Total callus area at 6 and 12 weeks was associated with the final healing outcome. This association remained as strong when assessing medial callus in isolation, which was more reliably measured radiographically. Medial callus area at 6 weeks < 24.8 mm<sup>2</sup> was associated with nonunion (12/39, 30.8%) vs. (12/109, 11.0%), p = 0.010. This association strengthened at 12 weeks with medial callus area < 44.2 mm<sup>2</sup> even more closely associated with nonunion (13/28, 46.4%) vs. (11/120, 9.2%), p < 0.001. Univariable logistic regression analyses found limited longitudinal motion and Charlson Comorbidity Index to each be associated with deficient callus at 12 weeks (Odds Ratios p = 0.003 and 0.026, respectively). Additional patient, injury, and treatment factors were not associated with deficient callus (open fracture, mechanism of injury, smoking, diabetes, plate material, bridge span, and shear). Multivariable logistic regression analysis demonstrated that limited longitudinal motion (OR 2.713 (1.12 to 6.60), p = 0.028) and incremental increases in CCI (1.362 (1.11 to 1.67), p = 0.003) were independently associated with deficient callus at 12 weeks.

**DISCUSSION AND CONCLUSION:** The findings objectively define deficient callus in the setting of bridge plate fixation of distal femur fractures and may allow for earlier identification and treatment of patients at high risk of nonunion. Further, treatment-related (construct-based fracture site motion) and patient-related (CCI) factors were independently associated with deficient callus. Improved methods of in vivo assessment of fracture site motion are necessary to further our ability to optimize fracture site motion for healing.

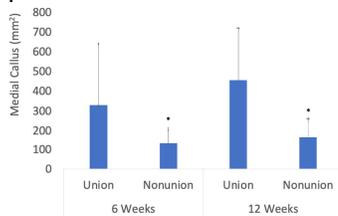


Figure 1. Medial callus area was significantly less for cases of nonunion vs. union at 6 weeks (125 vs. 329 mm<sup>2</sup>, p = 0.002) and 12 weeks (158 vs. 452 mm<sup>2</sup>, p < 0.001).

Callus Area	Time Point	AUC	p-value
Medial Callus Alone	6 Weeks	0.665	0.007
	12 Weeks	0.732	< 0.001
Posterior Callus Alone	6 Weeks	0.638	0.017
	12 Weeks	0.661	0.006
Medial + Posterior Callus	6 Weeks	0.665	0.003
	12 Weeks	0.714	< 0.001
Medial + Posterior + Anterior Callus	6 Weeks	0.655	0.005
	12 Weeks	0.704	< 0.001

Variables	Univariable Analysis	Multivariable Analysis		
	p-value	Odds Ratio	Confidence Interval	p-value
Open Fracture	0.796			
Increase in CCI	0.005	1.362	1.11 – 1.67	0.003
Smoking	0.380			
Diabetes	0.202			
Mechanism	0.995			
Construct Material	0.069			
Bridge Span	0.128			
Limited Longitudinal Motion	0.026	2.713	1.116 – 6.598	0.028
Shear Motion	0.142			