Bringing Balance to the Force: Lateral Locking Plate Screw Configuration Alternatives for Comminuted Distal Femur Fractures with Major Bone Loss

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Purpose: Lateral locking plate (LLP) fixation is currently preferred for stabilization of extensively comminuted distal femoral fractures. The most common technical parameters that affect the outcome include both plate length and locking screw placement. The objective of this study was to investigate the biomechanical effect of different screw configurations on LLP fixation of a distal femoral metadiaphyseal fracture with a major (50-mm) segmental defect loaded under clinically relevant conditions.

Methods: Experimental test and finite element (FE) analyses (FEAs) were conducted in a synthetic bone model, using 4th generation composite femur substitute and an Instron unit. Stiffness testing was conducted using a 1000-N axial load to the femoral head with the shaft adducted 15°, simulating the point 10% of the way through the stance phase of the gait cycle. A simulated clinical case with a 50-mm segmental defect of the distal femur was created; a 350-mm stainless-steel LLP was applied, with a total of 9 x 5-mm bicortical locking screws. Strain gauges measured instantaneous strain levels across the construct at multiple locations throughout the load cycle, applied at a rate of 0.5 mm/s; the construct was investigated repeatedly with 8 alternative screw configurations. A 3-dimensional FE model replicating this 50-mm distal femur defect stabilized with internal fixation was then generated using Abaqus. The femur was simulated as a linear elastic isotropic material; the screws and plate were modeled as stainless steel. The stress and pull-out forces were calculated and compared for 11 screw configurations. The maximum stress was computed within the screws closest to the defect, and pull-out forces were computed for the screws closest to the femoral head.

Results: There was strong agreement between FEA predictions and experimental observations for the load-displacement data. Considering the ratio (Cp) between the proximal working length (WLp) and the distance to the first screw proximal to the fracture (Lp), where Cp = WLp/Lp, the maximum stress was up to 83% less when this ratio was less than 0.2; the maximum pull-out force in this most proximal screw was 99% less when Cp was higher than 0.4

Conclusion: Decisions regarding the screw configuration based on either normal or osteopenic bone quality are important with respect to the risk of failure of the construct. A longer working length on the proximal side benefits patients with low quality bone and limits the risk of screw loosening, while a shorter proximal working length is still suitable for patients with better quality bone.

PAPER ABSTRACTS