Well-positioned Calcar Screws Have Decreased Variability in Mechanical Loading Compared to More Distant Screws in Proximal Humerus Fracture Fixation

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Purpose

Locking plate implants provide an attractive option for proximal humerus fracture fixation, but their clinical success largely relies upon fracture reduction quality and the restoration of the medial calcar support. Placement of a screw inferiorly and parallel to the calcar is a technique that is commonly employed to enhance stability. The locking screws used in these implants have rigidly defined trajectories, and thus, ideal placement of the calcar screws is not always possible in a clinical setting due to plate positioning. The biomechanical consequences of "missing" the calcar in proximal humerus fixation are not well defined. This study sought to elucidate the mechanisms associated with proximal or distal placement of locking plates in two-part proximal humeral fractures. We hypothesized that neutral placement of the plate would provide the best fixation, while distal and proximal plate locations would exhibit significant reductions in fixation strength.

Materials & Methods

Nine pairs of cadaveric humeri specimens (4 M, 5 F, average age 81.2) were used for this study. Specimens were skeletonized and two-part proximal humerus fractures were modeled by creating a 30° wedge osteotomy at the surgical neck of the humerus. Specimens were assigned to one of three groups: idealized calcar screw insertion (NEUT, n = 6), 4mm distal calcar screw insertion (DIST, n = 6), and 4mm proximal calcar screw insertion (PROX, n = 6) (Figure 1). Fractures were stabilized by a single experienced surgeon, using locking proximal humerus plates (DePuy Synthes), per manufacturer guidelines. Specimens underwent a series of biomechanical tests in a universal test frame to quantify the mechanical properties of the repair. Quasi-static torsional stiffness tests and quasi-static axial compression tests at 0, +20, −20 degrees of ab/adductions were conducted prior to a cyclic fatigue protocol consisting of compressive 0 degree axial loads ranging from 50-250N for 5000 cycles at a rate of 1 Hz. A ramp to failure at a rate of 0.1 mm/s was performed after completion of the fatigue test. Measures of initial torsional stiffness, initial axial stiffness, maximum humeral head displacement during fatigue loading, and ultimate load were recorded for each specimen. One-way ANOVAs with alpha = 0.05 were performed to determine differences between groups.

Result

There were no significant biomechanical differences between the DIST, NEUT and PROX groups for internal (p = 0.178) and external (p = 0.710) torsional stiffness. There were also no significant differences between groups for 0 (p = 0.744), +20 (p = 0.650), and -20 (p = 0.278) degree compression tests. No significant differences were found for maximum displacement (p = 0.777) or ultimate load (p = 0.368). Full details of results can be found in Table 1.

Discussion and Conclusions

Based on this cadaveric biomechanical model, in well-aligned, well-reduced two-part proximal humerus fractures, position of the calcar screw in the humeral head did not have a significant effect on torsional stiffness, axial stiffness, maximal displacement, or ultimate load. However, variations from the mean in stiffness, load, and displacement were least in the well-positioned calcar screws compared those

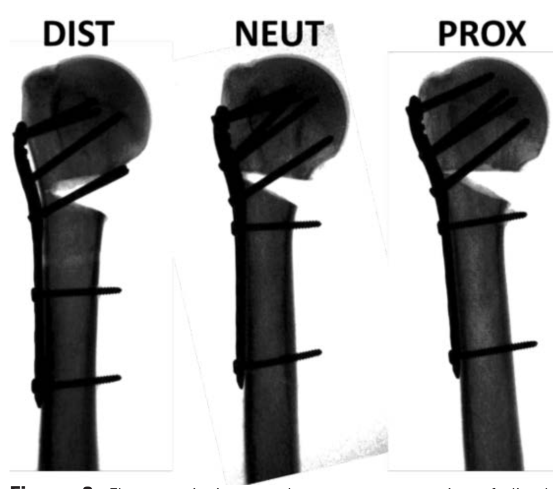

Figure 3. Fluoroscopic images that are representative of distal, neutral, and proximal placements of the locking plates within the study.

Table 1: Summary of Experimental Data (Means ± 1 Standard Deviation).

	DIST	NEUT	PROX	p-value
Int.Rot. Stiff. (Nm/deg)	0.837 (±0.316)	0.764 (±0.276)	0.536 (±0.200)	0.178
Ext. Rot. Stiff. (Nm/deg)	0.702 (±0.29.6)	0.736 (±0.224)	0.599(±0.318)	0.710
00° Anal Stiff. (N/mm)	391.6 (±158.5)	377.6 (±69.5)	337.8 (±127.7)	0.744
+20° Axial Stiff. (N/mm)	207.0 (±117.3)	199.3 (±65.2)	259.6 (±160.3)	0.650
−20° Anal Stiff. (N/mm)	356.57 (±142.2)	404.5 (±93.9)	387.4 (±270.5)	0.278
Max Disp. (mm)	0.936 (±0.486)	0.826 (±0.188)	0.961 (±0.304)	0.777
Ultimate Load (N)	910.8 (±245.6)	912.8 (±183.6)	105-.5 (±167.0)	0.386

screws placed too proximal or distal. Screw position in the well aligned, well-reduced fracture may be less critical than in fractures that are poorly reduced, where greater variability can be limited by screws placed closer to the calcar.

References

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