

Fixed-Angle Plate Fixation in Simulated Fractures of the Proximal Humerus

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Introduction

Numerous devices of fixation for displaced proximal humerus fractures have been described. The most common devices include plate fixation, fixed-angle plate fixation, antegrade intramedullary fixation, tension band wiring, percutaneous fixation, and external fixation. We believe that a more optimal device potentially remains to be discovered.

Through evaluating the strengths and weaknesses of these previously described devices, we attempted to design a novel device and technique. Our efforts resulted in a percutaneously applied, low profile, fixed-angle plate with means to secure tuberosity fragments with tension band suture.

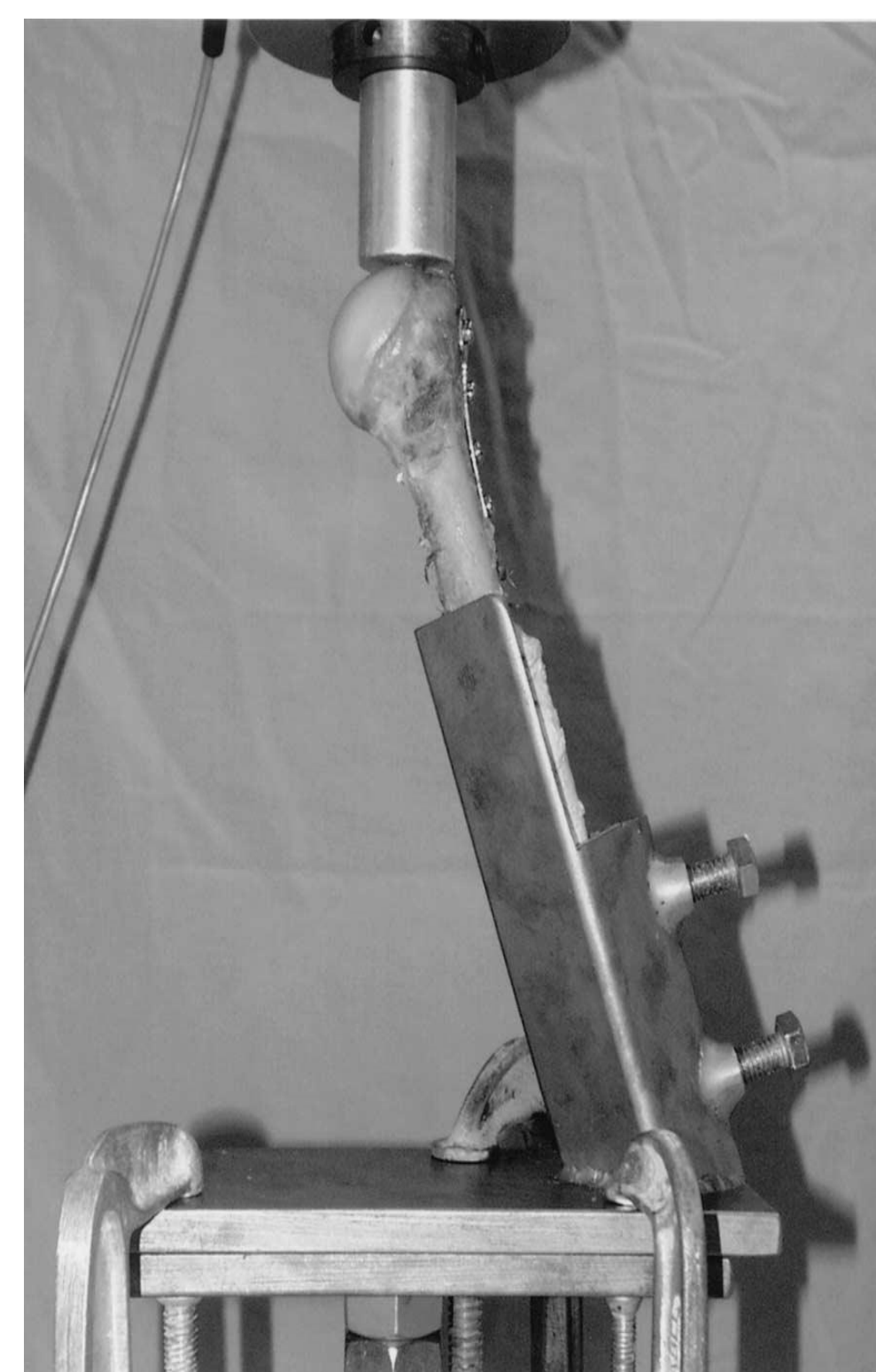


Experimental Device

Objectives

This study was performed to evaluate the biomechanical properties of a new device for displaced fractures of the proximal humerus. We attempted to design a novel device and technique; we undertook a biomechanical cadaver study to compare the stiffness, the displacement at physiologic loads, and the displacement, load, and energy absorbed at the point of ultimate load prior to failure of this new device against previous standards; and we tested our hypothesis that this new device would provide at least equivalent biomechanical properties to that of the ASIF T-plate.

Methods



Testing Model

Twenty-four pairs of humeri were harvested from embalmed cadavers with a mean age of 77.6. The humeri were all axially preloaded to 750N in the testing model. Through preloading, load displacement curves were created and determined the stiffness of the intact bone from the initial slope. This allowed us to normalize the experimental values for stiffness and to eliminate variability resulting from differences in side-to-side bone quality.

In 14 pairs of humeri, we simulated a noncomminuted 10°, oblique surgical fracture. In the other 10 humeri pairs, we simulated a comminuted fracture pattern. For each pair of humeri, the ASIF T-plate and the experimental device were assigned randomly and equally to the right and left specimens to control for side-to-side differences between dominant and nondominant extremities.

Following the testing protocol by Koval et al, all humerus constructs were loaded by the testing model. The humeri were continuously loaded to failure at a rate of 10 cm/ min. Failure was defined as a marked decrease or discontinuity in the load displacement curve or greater than 1 cm of displacement.

Results

In the noncomminuted trials the experimental device exhibited significantly higher values for absolute stiffness, the stiffness ratio (fractured/preloaded value), and ultimate load before failure (Figures 6 and 7). The experimental device also exhibited significantly less displacement at higher physiologic loads of 0.6 kN (Figure 8).

There was a trend for the experimental device to allow for more energy absorption before failure. In the comminuted trials the experimental device exhibited significantly higher values for absolute stiffness and ultimate load and energy absorbed before failure (Figures 6 and 7). The experimental device also exhibited significantly less displacement at higher physiologic loads (0.6 kN, Figure 8). There was a trend for the experimental device to exhibit a higher stiffness ratio.

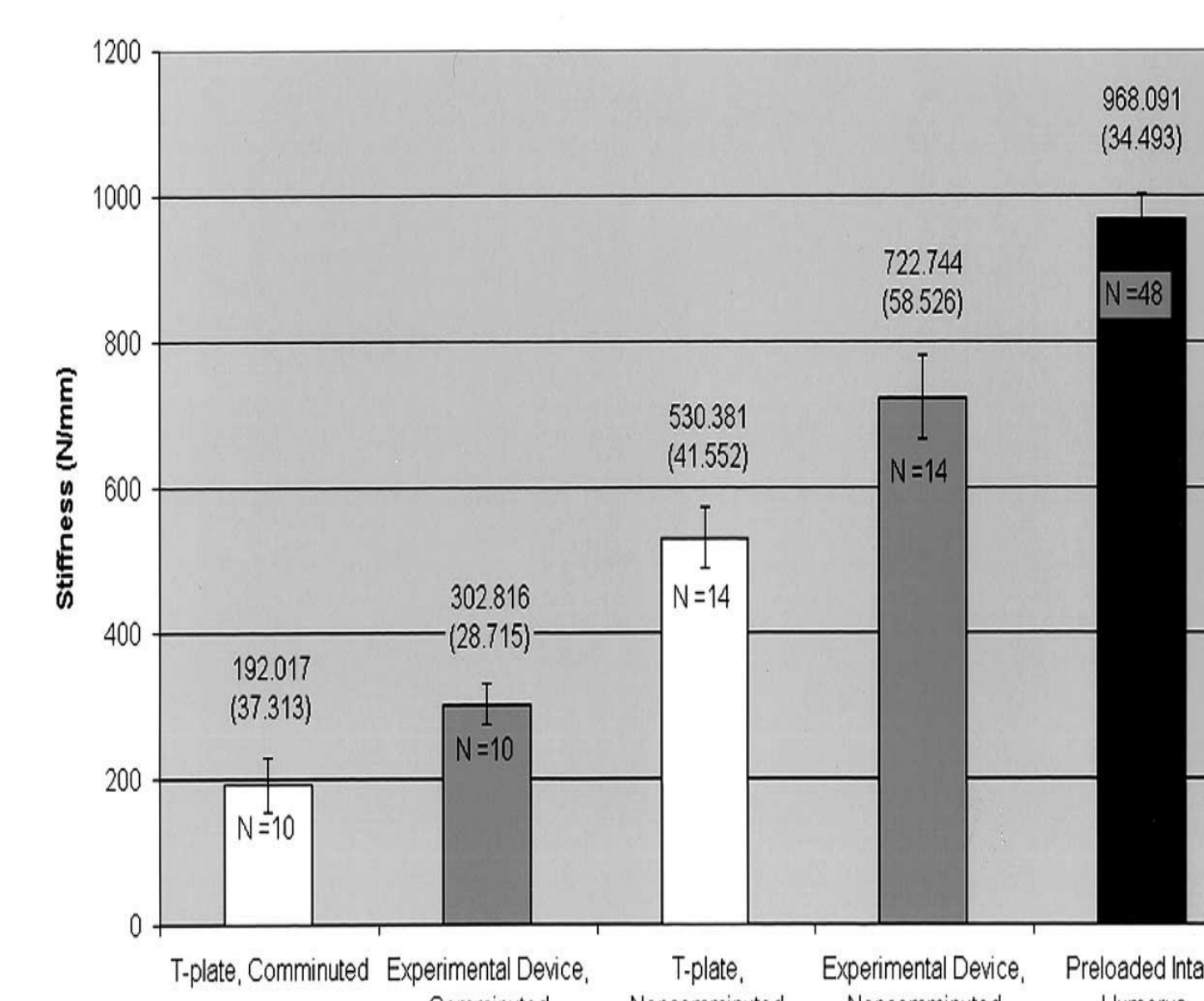


Figure 6

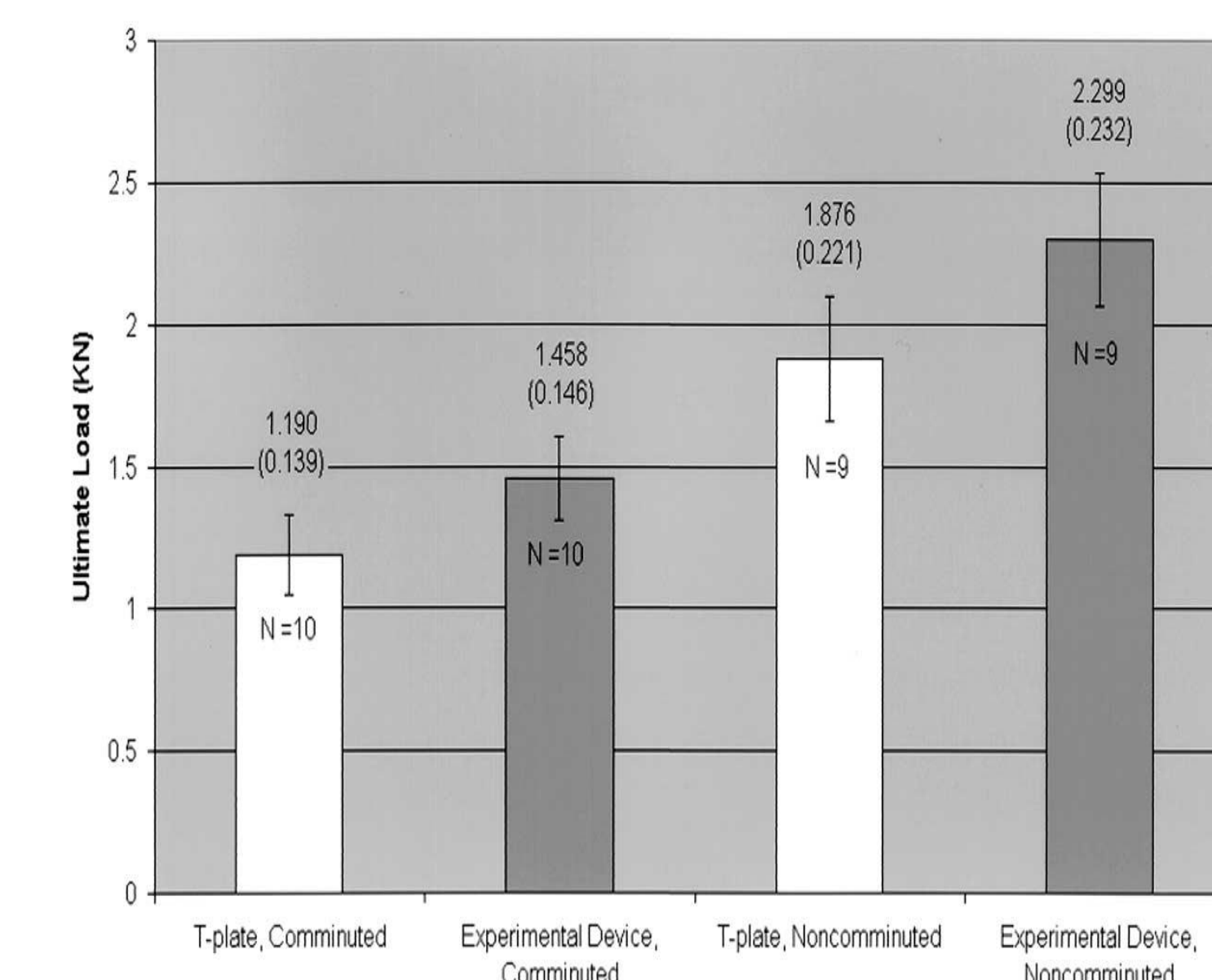


Figure 7

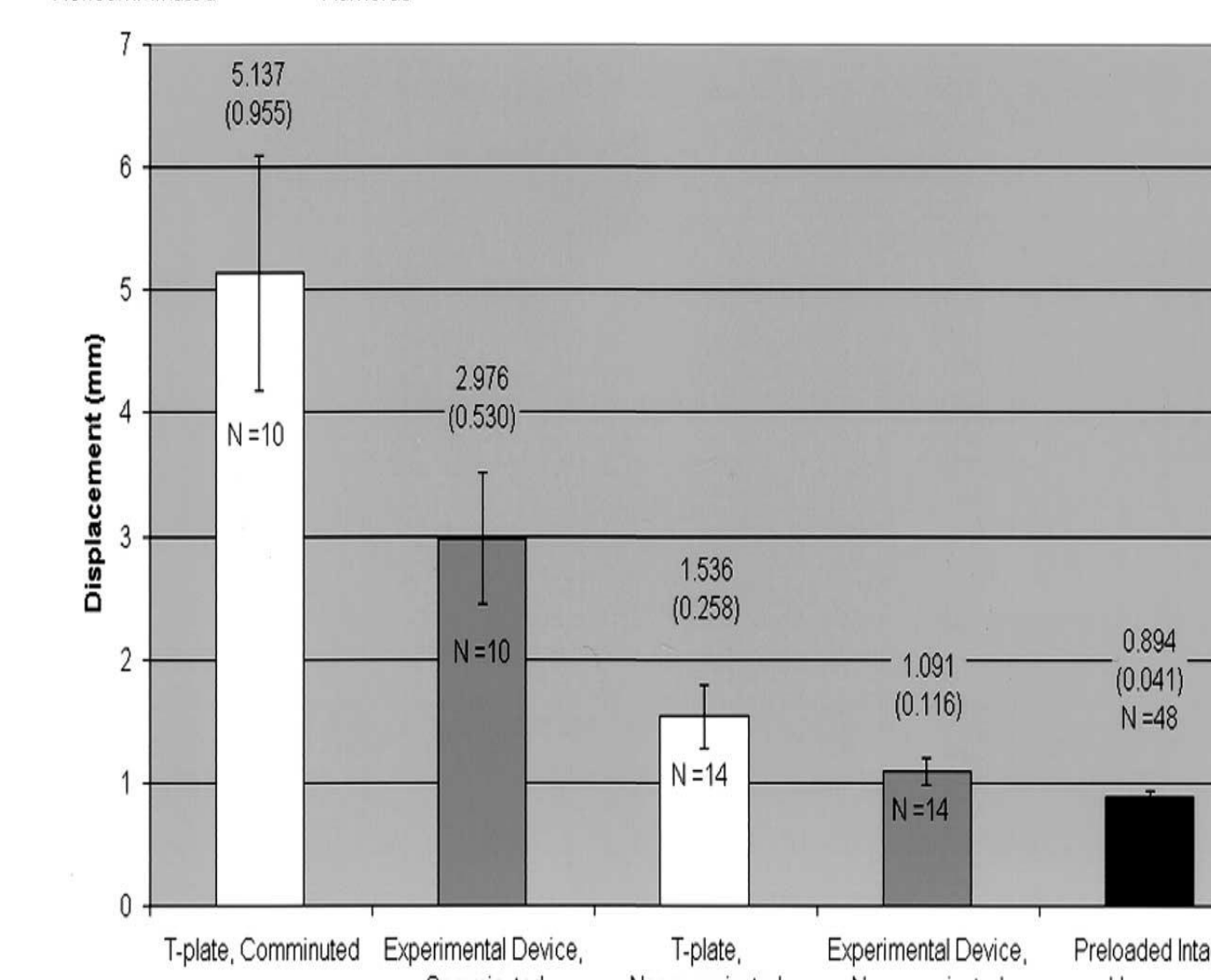


Figure 8

Conclusion

This new experimental design possesses many theoretical design advantages over the previous methods of fixation described for the treatment of displaced proximal humerus fractures. With the use of limited cadaveric model, we were able to demonstrate improvements in biomechanical properties relative to the ASIF T-plate. The differences in biomechanical properties between noncomminuted and comminuted trials reveal the significant role that fracture configuration plays in the fixation. The comminuted fractures, with the T-plate or experimental design exhibited significantly less stiffness and ultimate load before failure and significantly higher values for displacement at physiologic loads.