UNIVERSITY of WASHINGTON

Biomechanical Evaluation of Metacarpal Fracture Fixation: Application of a 90º Internal Fixation Model

Authors: Andrew J. Watt MD, Jerry I. Huang MD, Randal P. Ching PhD

Purpose:

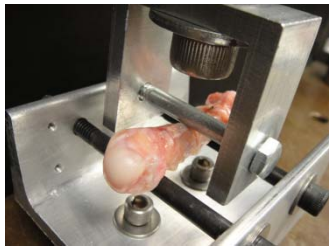
Internal fixation of metacarpal fractures is commonly employed in the treatment of unstable fracture patterns, in patients with multiple fractures as well as in patients desiring early return to function. Loss of hand motion, extensor lag and tendon adhesions are common. These complications increase in proportion to the severity of the initial injury and the invasiveness of the surgical fixation technique. This manuscript evaluates the feasibility of minimizing internal fixation construct size and soft tissue dissection, while preserving the advantages of stable internal fixation in a biomechanical model. In this study orthogonal mini-plate fixation is compared to standard dorsal metacarpal plating. We hypothesized that comparable construct stability could be achieved with mini-plates in an orthogonal configuration when compared with a standard dorsal plating technique.

Methods:

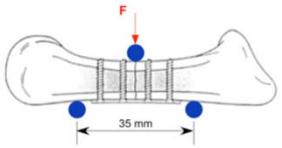
This hypothesis was evaluated in a cadaveric transverse metacarpal fracture model. 12 fresh metacarpals were divided into pair-matched groups and subject to either placement of a 2.0mm 6-hole dorsal plate or two 1.5mm 4-hole mini-plates in an orthogonal configuration. These constructs were tested to failure in a 3-point bending apparatus, attaining failure force, failure displacement, stiffness and failure moment for each metacarpal construct.

2.0mm 6-Hole Dorsal Plating Construct

1.5mm 4-Hole Orthogonal Construct



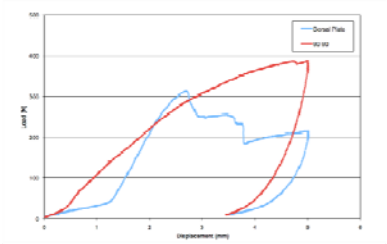
3-Point Bending Apparatus



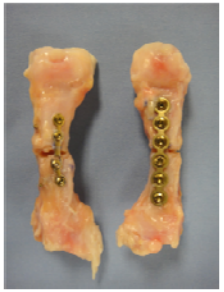
Apex Dorsal Model System

Results:

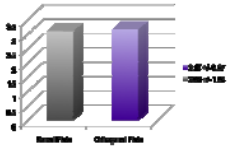
Mean Failure Force was 353.5 ± 121.1N for the 2.0mm 6-hole dorsal plating construct and 358.8 ± 77.1N for the 1.5mm 4-hole orthogonal construct. Mean Failure Displacement was 3.3 ± 1.2mm for the 2.0mm 6-hole dorsal plating construct and 4.1 ± 0.9mm for the 1.5mm 4-hole orthogonal construct. Mean Stiffness was 161.3 ± 50.0 N/mm for the 2.0mm 6-hole dorsal plating construct and 122.1 ± 46.6 N/mm for the 1.5mm 4-hole orthogonal construct. Mean Failure Moment was 3.09 ± 1.06Nm for the 2.0mm 6-hole dorsal plating construct and 3.14 ± 0.67Nm for the 1.5mm 4-hole orthogonal construct. All six constructs in the dorsal plating group failed via screw pullout at the screw/bone interface. In the orthogonal min-plate group 3 of 6 metacarpal constructs failed via screw pullout while 3 of 6 failed secondary to breakage of the plate.



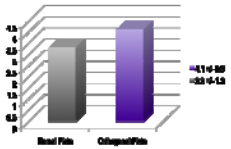
Failure Displacement Curve



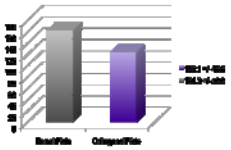
Modes of Failure



Failure Displacement (mm)



Failure Moment (N/M)



Stiffness (N/mm)

Conclusions:

When subject to apex dorsal bending in a cadaveric transverse metacarpal fracture model, the mini-plate orthogonal construct and the standard dorsal plate construct behaved comparably. These data suggest that despite its shorter length, lower height profile, and less substantial screws, the orthogonal construct provides sufficient rigidity to tolerate early motion rehabilitation. These results provide an essential “proof of concept” regarding the applicability of orthogonal plating in the metacarpal and provide the foundation for minimizing construct size and profile through the use of orthogonal constructs.