Evaluation of Clinical Fixation Techniques for Metacarpal Base Fractures: A Cadaveric Study on Intramedullary Screw Versus Dorsal Plate Stability and Rigidity

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INTRODUCTION:

Intramedullary threaded nail fixation has shown promising biomechanical and clinical outcomes in the management of metacarpal shaft and neck fractures. Extraarticular fractures at the metacarpal base, while common, remain underrepresented in biomechanical research. This study aims to fill this gap by conducting a comprehensive biomechanical comparison of intramedullary (IM) screw fixation and plate fixation in metacarpal base fractures. Although limited clinical studies suggest superior outcomes for IM**"Evaluating Fixation Techniques for Metacarpal Base Fractures: A Cadaveric Study on Intramedullary Screw Versus Dorsal Plate Stability and Rigidity"** screw over plating in this fracture pattern, these studies often involve small sample sizes and lack biomechanical validation. To date, no biomechanical studies have evaluated the proximal limit of fracture stabilization achievable with intramedullary threaded screw, nor have they compared their performance to plate fixation in this context.

METHODS:

In this biomechanical study, 24 cadaveric metacarpals (thumb and small finger) from 12 upper extremities were used to compare the rigidity and stability of intramedullary (IM) screw fixation versus dorsal plate fixation for proximal metacarpal base fractures. Each metacarpal was skeletonized, measured, and marked at 20% of its total length from the proximal aspect; then, it was potted distally in cement. A standardized transverse fracture was created at the 20% mark using an oscillating saw. Specimens were randomized to receive either IM fixation using headless cannulated screws inserted antegrade and buried beneath the articular surface, or dorsal plate fixation (Figure 1). Cantilever bending tests were performed using a mechanical testing system (MTS) at a loading rate of 0.3 mm/s. The primary outcome was ultimate failure load, and the secondary outcome was construct stiffness.

RESULTS:

A total of 24 cadaveric metacarpals were randomized to undergo simulated fixation using either dorsal plate or IM screw fixation. Biomechanical testing demonstrated that, when all specimens were combined, plate fixation resulted in a significantly higher load to failure compared to IM fixation (147.54 N vs. 97.44 N, P = 0.01). However, IM constructs exhibited greater stiffness than plate constructs overall. Subgroup analysis showed a significant difference in the thumb metacarpals, where plate fixation had a higher load to failure than IM fixation (169.93 N vs. 110.98 N, P = 0.03). In the small finger metacarpals, although plate fixation also had a higher failure load than IM fixation (125 N vs. 84 N), the difference was not statistically significant. Across all subgroups, stiffness was consistently greater in the IM constructs compared to the plate constructs (Table 1).

DISCUSSION AND CONCLUSION:

Dorsal plate fixation demonstrated superior load to failure compared to intramedullary screw fixation for proximal base fractures of the thumb and small finger metacarpals, with statistical significance observed in the thumb. However, IM fixation provided greater construct stiffness across all specimens. These findings suggest that while plate fixation may offer greater strength, IM fixation provides increased rigidity, and implant selection may be guided by specific clinical needs, such as fracture stability versus construct stiffness.

Figure 1: Experimental setup demonstrating sample preparation. Top left: dorsal view of the simulated fixation of the metacarpal using a dorsal plate. Top right: volar view of the fixation. Bottom: lateral view of the fixation.

Table 1: Primary and secondary biomechanical outcomes stratified by fixation type

Thumb/Small Metacarpals	Plate (N=12)	Screw (N=12)	P-value
Load to Failure, mean ± SD	147.54 ± 51.14	97.44 ± 35.40	**0.01**
Stiffness, mean ± SD	16.86 ± 9.91	23.70 ± 15.68	0.266
Thumb Metacarpals			
Load to Failure, mean ± SD	169.93 ± 36.47	110.98 ± 36.58	**0.03**
Stiffness, mean ± SD	19.60 ± 11.23	29.53 ± 13.03	0.24
Small Metacarpals			
Load to Failure, mean ± SD	125.14 ± 56.75	83.89 ± 31.27	0.18
Stiffness, mean ± SD	14.11 ± 8.48	17.86 ± 17.02	0.94