Plating of Metacarpal Fractures with Locked or Nonlocked Screws: A Biomechanical Evaluation of the Number of Cortices Necessary for Stable Fixation

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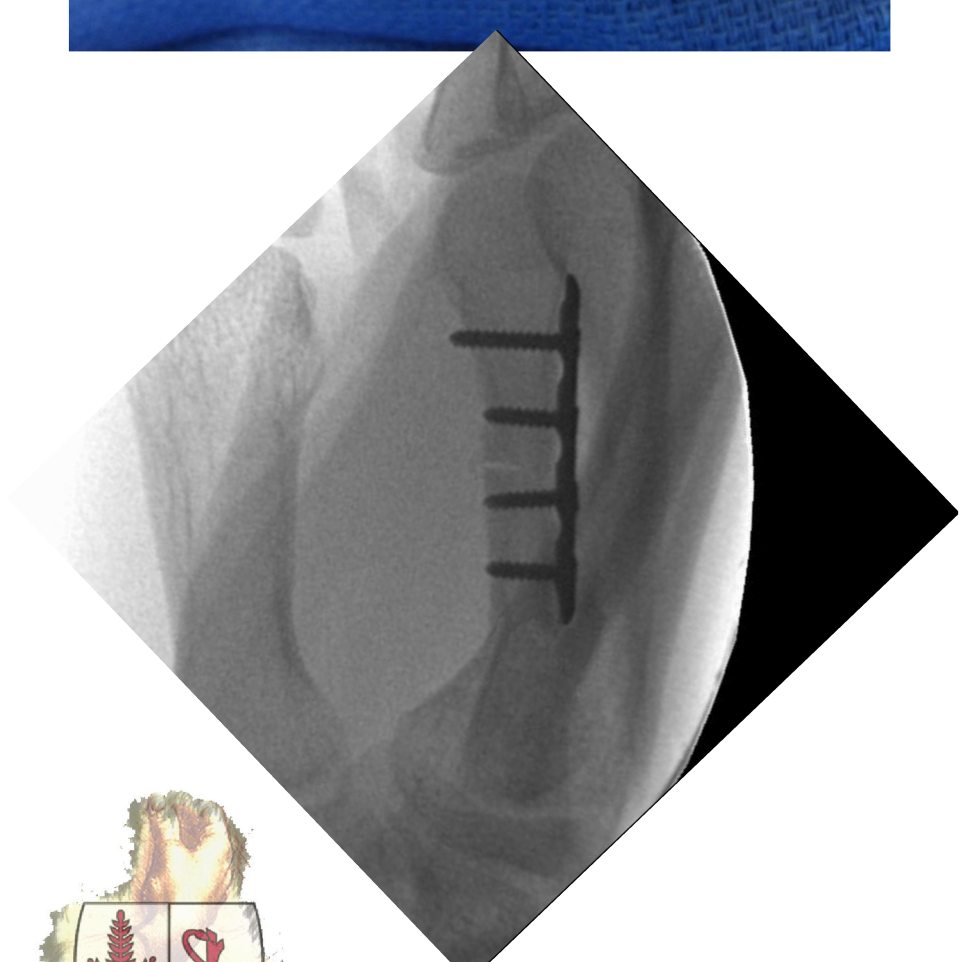
Hypothesis

When treating metacarpal fractures, if there is biomechanical equivalence demonstrated by constructs composed of plates secured with 6 nonlocking cortices (3 bicortical screws) per fracture segment (the gold standard) and plates with 4 locking cortices per fracture segment, less soft tissue dissection and smaller plate/screw constructs could be used to fix these fractures.



The authors have no financial relationships relevant to this study to disclose.

Introduction

Metacarpal fractures are a common hand injury and surgery is often chosen for unstable, open, irreducible, or comminuted fractures. Dorsal plate and screw fixation is a popular choice for stabilization. The balance between construct stability and soft tissue dissection remains a surgical dilemma. Historically, six cortices of bone fixation on either side of a fracture were deemed necessary. However, with the advent of locking technology, the use of fewer screws and therefore shorter plates may provide acceptable clinical and biomechanical results while minimizing soft tissue stripping and preserving blood supply to the bone. This study aims to elucidate whether 4 cortices of locked fixation on either side of the fracture is equivalent to the current gold standard of six cortices of nonlocked fixation on either side of the fracture. If so, less dissection to insert shorter plates with less screws could be used to stably fix these fractures.

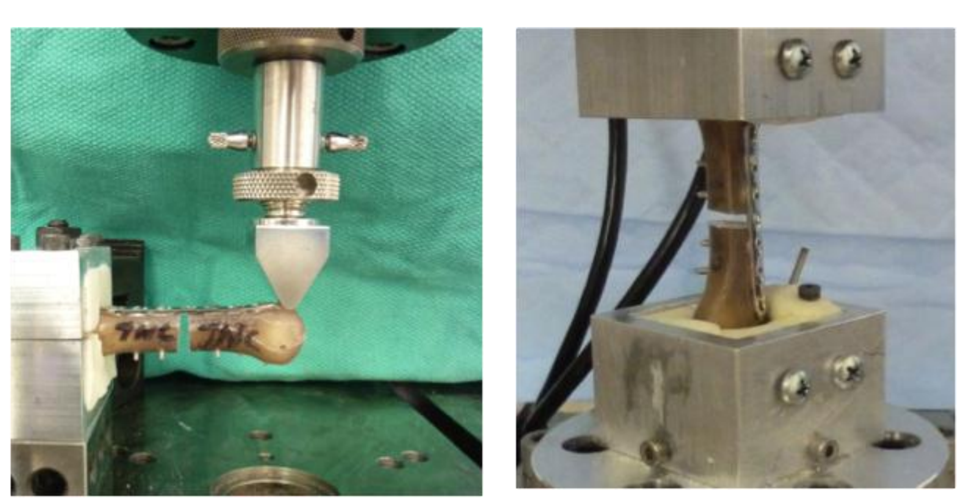


Figure 1. Testing apparatus for cantilever bending (Left) and torsion (Right).

Materials & Methods

Sixty metacarpal Sawbones (Pacific Research Laboratories, Inc., Vashon, WA) were cut using a custom jig creating uniform 3mm transverse diaphyseal fracture gaps. The specimens were then fixed with a seven-hole 2.0 mm LCP stainless steel straight plate (Synthes, West Chester, PA) and either six bicortical nonlocking screws or four bicortical locking screws.

For cantilever bending testing, bending stiffness, maximum load, and failure location were determined for each specimen (Figure 1 Left). For torsion testing, stiffness and maximum torque were recorded for each specimen (Figure 1 Right).

Comparisons between the two constructs were carried out with a two-tailed t-test with significance set at alpha = 0.05. If no statistical difference was found, we tested the hypothesis that the groups were equivalent using a 10% difference as the threshold for equivalence. The equivalence hypotheses were evaluated with a two one-sided test (TOST) procedure and by constructing confidence intervals for the differences between the means.

Results

There was no statistically significant difference ($p>0.05$) between the two constructs in any of the mechanical tests (Table 1). Equivalence testing was carried forward for each comparison.

The bending stiffness in the nonlocked and locked groups were 5.5 ± 0.5 and 5.4 ± 0.7 N/mm, respectively. These values were statistically equivalent ($p = 0.03$). The maximum bending load in the nonlocked (185 ± 22 N) and locked groups (184 ± 27 N) also reached statistical equivalence ($p = 0.03$). (Figure 2 Left).

The torsional stiffness in the nonlocked and locked groups were 68.6 ± 7.9 and 69.6 ± 9.3 Nmm/deg, respectively. This reached statistical equivalence ($p = 0.04$). The maximum torque in the nonlocked (1,862 $\pm$ 196 Nmm) and locked groups (1, 858 $\pm$ 161 Nmm) also reached statistical equivalence ($p = 0.004$). (Figure 2 Right).

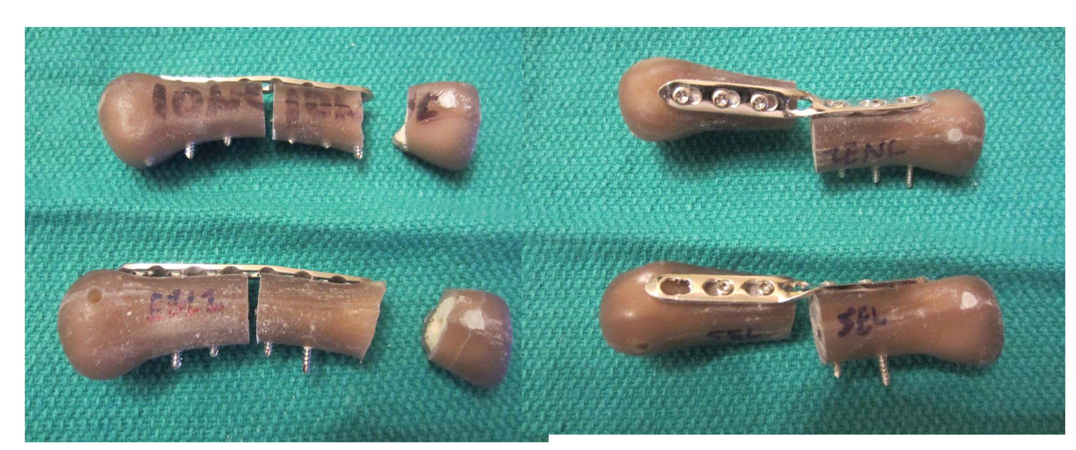


Figure 2. Failure modes for cantilever bending (Left) and torsion (Right). Nonlocked constructs are above and the locked constructs are below.

Conclusions

1. This study demonstrated biomechanical equivalence between simulated comminuted metacarpal fractures fixed using a dorsal plate with either 1) three nonlocking screws (six cortices of fixation) or 2) two locking screws (four cortices of fixation) on either side of the fracture.
2. With the use of fewer screws, there is an opportunity for less soft tissue disruption and the ability to plate more distal/proximal fractures with fewer screws
3. Further studies need to correlate the findings of this biomechanical study with clinical outcomes.

Table 1

Construct	Bending Stiffness (N/mm)*°	Maximum Bending Load (N)*°	Torsional Stiffness (Nmm/deg)*°	Maximum Torque (Nmm)*°
Locked, 4 cortices/segment	5.4 ± 0.7	184± 27	69.6 ± 9.3	1858 ± 161
Non-Locked, 6 cortices/segment	5.5 ± 0.5	185± 22	68.6 ± 7.9	1862 ± 196

*No statistical significant difference (p>0.05), ° Statistical equivalence (p<0.05)

References.

1.Firoozbakhsh KK, Moneim MS, Howey T, Castaneda E, Pirela-Cruz MA. Comparative fatigue strengths and stabilities of metacarpal internal fixation techniques. *J Hand Surg Am.* Nov 1993;18(6):1059-1068.
2.Ochman S, Doht S, Paletta J, Langer M, Raschke MJ, Meffert RH. Comparison between locking and non-locking plates for fixation of metacarpal fractures in an animal model. *J Hand Surg Am.* Apr 2010;35(4):597-603.
3.Gajendran VK, Szabo RM, Myo GK, Curtiss SB. Biomechanical comparison of double-row locking plates versus single- and double-row non-locking plates in a comminuted metacarpal fracture model. *J Hand Surg Am.* Dec 2009;34(10):1851-1858.
4.Lindvall EM, Sagi HC. Selective screw placement in forearm compression plating: results of 75 consecutive fractures stabilized with 4 cortices of screw fixation on either side of the fracture. *J Orthop Trauma.* Mar 2006;20(3):157-162; discussion 162-153.
5.Sohn RC, Jahng KH, Curtiss SB, Szabo RM. Comparison of metacarpal plating methods. *J Hand Surg Am.* Mar 2008;33(3):316-321.
6.Harris AH, Fernandes-Taylor S, Giori N. "Not statistically different" does not necessarily mean "the same": the important but underappreciated distinction between difference and equivalence studies. *J Bone Joint Surg Am.* Mar 2012;94(5):e29.