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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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 (six cortices of fixation) or 2) two locking screws (four cortices of fixation) on either side of the fracture.

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 N/mm/° respectively. This reached statistical equivalence (p = 0.04). (Figure 2 Right).

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

<table>
<thead>
<tr>
<th>Construct</th>
<th>Bending Stiffness (N/mm)**</th>
<th>Maximum Bending Load (N)**</th>
<th>Torsional Stiffness (N/mm/°)**</th>
<th>Maximum Torque (Nmm)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locked, 4 cortices/segment</td>
<td>5.4 ± 0.7</td>
<td>184.6 ± 27</td>
<td>69.6 ± 9.3</td>
<td>1058 ± 161</td>
</tr>
<tr>
<td>Non-Locked, 6 cortices/segment</td>
<td>5.5 ± 0.5</td>
<td>185.2 ± 22</td>
<td>68.6 ± 7.9</td>
<td>1062 ± 196</td>
</tr>
</tbody>
</table>

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

References.

2. Cameron Barr MD, Anthony Behn MS, Yi-Chao Huang MD, Jeffrey Yao MD. Comparison of six cortices of fixation to four cortices of fixation for metacarpal fractures. J Orthop Trauma. 2017;31(5):300-305

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