Fracture Risk through Oblique External Fixator Pin Tracks

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Introduction

• Fracture after fixator removal observed in up to 9% of cases

• Fractures through a pin track represent 27% of fractures after fixator removal
Introduction

• Orthogonal frame placement ideal

• Orthogonal half pins used to mount frame
  – Some fixator designs only allow pin placement in one direction
Introduction

• Once half pin removed, pin tracks can become stress risers
  – 30% decreased bone strength in anterior-posterior bending
  – 70% decreased bone strength with torsional load
Introduction

• Non-orthogonal pin placement may be superior to orthogonal pin placement
  – Increased bone purchase
  – More stability

• Does non-orthogonal pin placement help decrease the risk of fracture through a pin track?
Purpose

• Compare the bending and torsional forces required to cause a fracture through orthogonal and oblique pin tracks in a cylinder of cortical bone model.
Methods

• 36 humeral Sawbones specimens
• Mechanically tested with MTS after drilling 6 mm path

• All the drill holes were introduced in the medial-oblique plane at an angle of 15° to the sagittal plane of the bone model
4 groups of specimens

1. Perpendicular to the long axis of the bone (orthogonal)
2. $10^\circ$ divergent from orthogonal
3. $20^\circ$ divergent from orthogonal
4. $30^\circ$ divergent from orthogonal
Methods

• Drilling consistency with use of a drilling mill
• All specimens drilled at the same location (11.25 cm from proximal end of Sawbones)
• Ends of Sawbones securely mounted to MTS machine with custom plastic cast
Methods

• 3 of each specimen tested to failure by applying bending force
  – Anterior-posterior 0.10 cm/sec (flexion)
  – Medial-lateral 0.10 cm/sec (valgus)
  – Torsional load 0.5 deg/sec in a clockwise direction
Results

• Anterior-posterior bending and torsional load created a fracture through the pin site in all specimens

• Medial-lateral bending only produced a fracture through the pin site in one specimen in the orthogonal group and one specimen in the 30 degree divergent group
Results

• Bone model specimens illustrating fracture patterns
  – Spiral fracture through pin track due to applied torsional forces.
  – Transverse fracture through pin track due to applied anterior-posterior bending forces.
  – Oblique fracture away from the pin track due to applied medial-lateral bending forces.
# Results

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (0°)</th>
<th>Group 2 (10°)</th>
<th>Group 3 (20°)</th>
<th>Group 4 (30°)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torsion (Nm)</td>
<td>9.6 ± 0.6</td>
<td>10.3 ± 1.4</td>
<td>11.1 ± 0.8</td>
<td>12.4 ± 1.0</td>
<td>0.045*</td>
</tr>
<tr>
<td>AP Bending (N)</td>
<td>114.5 ± 8.1</td>
<td>114.8 ± 5.9</td>
<td>104.1 ± 25.6</td>
<td>100.8 ± 20.3</td>
<td>0.676</td>
</tr>
<tr>
<td>ML Bending (N)</td>
<td>202.5 ± 3.8</td>
<td>252.1 ± 54.0</td>
<td>249.5 ± 67.5</td>
<td>159.6 ± 28.9</td>
<td>0.110</td>
</tr>
</tbody>
</table>

- Torsion demonstrated statistically significant difference ($p = 0.045$) between the groups in the amount of needed torque (Nm)

- Anterior-posterior and medial-lateral bending forces showed no statistically significant difference between the groups
Results

- Pearson’s correlation coefficient (0.78) revealed strong and statistically significant ($p = 0.003$) association between the pin track orientation angle and amount of torque required to produce fracture.

- With increase in the half-pin diversion angle more torque is needed to produce a fracture through the drilled pin track.
Discussion

• Oblique half-pins have been shown to improve stability of fixation by increasing pull-out forces

• Divergent half-pins, when placed at angles up to 30° to the orthogonal orientation, confer increased stability against torsional strain

• At removal, the non-orthogonal pin tracks could have a protective effect by distributing the total amount of stress through the pin track to two separate levels in the bone cortex
Discussion

• There is no statistically significant difference in the AP and ML forces required to produce a fracture at the various pin track orientation angles.

• Under torsional forces, transverse pin tracks withstand less torque before fracturing than pin tracks oriented at oblique angles.

• As the pin track orientation increases, it requires more torque to cause a fracture through the pin site.
Discussion

• Results clinically significant because a twisting motion (torsion) is the most common mechanism of fracturing through a previous pin track site in patients after external fixator removal.

• Oblique pins will produce a protective effect against torsional fractures after fixator removal.
Study Limitations

• Mechanical testing was performed on plastic models and not real bone and there was no surrounding soft tissue envelope
• There were only three specimens tested in each group
• Study focused on a single drilled canal in the bone
  – Future studies may investigate the fracture risk of multiple parallel pin tracks (as seen in many uni-planar pin clamp devices) compared with multiple oblique pin tracks
Conclusion

• This study shows another advantage of oblique half-pin placement
• Oblique pin orientation appears to have a protective effect against fracture after external fixator removal compared with orthogonal pin placement
• The amount of torque required to cause a fracture through the pin track is proportional to the pin diversion angle from the orthogonal orientation
Thank You