Jones Fracture Fixation: A Biomechanical Comparison of the Intramedullary Screw Versus Low-profile Plate

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Disclosures

• Jones Fracture Fixation: A Biomechanical Comparison of the Intramedullary Screw Versus Low-profile Plate
  • Presenter: Jeannie Huh, MD

• My disclosures are in the Final AOFAS Mobile App.

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Background

- Jones fractures - most commonly stabilized by intramedullary (IM) screw
  - Improved union rates and faster return to activities than nonoperative management

- However, treatment failures still occur with IM screw fixation

- In addition to bending and tensile loads, proximal 5th metatarsal is subject to torsional loads during ambulation

- IM screws may have limited ability to resist relative rotation between fragments in Jones fractures
Fixation Alternative: Jones Fracture Plate (TriMed, Inc., Santa Clarita, CA)

- Theoretically offers better rotational stability than IM screw
  - Proximal intraosseous tines “hook” into proximal fragment
  - Compression through plate
  - Contoured to proximal 5th metatarsal
  - Low-profile

- Early clinical reports of plate fixation suggest acceptable union rates and functional outcomes

- No data exist regarding the biomechanical performance of Jones fracture plate fixation, particularly when compared to IM screw fixation
Study Purpose

• To quantify the bending and torsion resistance of Jones fractures stabilized with a fracture-specific plate compared to intramedullary screw.
Methods

• 16 fresh-frozen cadaveric 5th metatarsals
  – Matched pairs (8 left and 8 right specimens)
  – 12 males, 4 females
  – Mean age: 56 years
  – No difference in mean bone mineral density by DEXA scan

• Simulated Jones fracture
  – Planar and perpendicular to metatarsal shaft – “worse case” for rotational stability
  – Exiting 4-5 intermetatarsal joint

• Jones fracture fixation
  – 8 Jones Screws (TriMed, Inc., Santa Clarita, CA)
  – 8 Jones Fracture Plates (TriMed, Inc., Santa Clarita, CA)

• Controlled bending and torsion testing
  – Servohydraulic materials testing machine (Model 1321, Instron Corp., Norwood, MA)
Methods

Bending

- Plantar-to-dorsal
- Lateral-to-medial
- Monotonic loading
- Displacement (0.1mm/sec) applied until peak load (12N and 18N) reached
- Recorded at sampling rate of 250hz
- Outcomes:
  - Bending stiffness (Nm/deg)
  - Fracture site angulation (deg)

Torsion

- Clockwise (external rotation)
- Monotonic loading
- Rotation (0.5deg/sec) applied until peak torque (1 Nm) or 10deg rotation reached
- Recorded at sampling rate of 250hz
- Outcomes:
  - Torsional stiffness (Nm/deg)
  - Peak torque (N)
  - Fracture site rotation (deg)
Results

• Bending Stiffness (Nm/deg of angulation)
  – IM screw > Plate during plantar-dorsal bending, at both loads
  – IM screw > Plate during lateral-medial bending, at smaller load

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<tr>
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<th>Plantar-Dorsal</th>
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<th>Lateral-Medial</th>
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<tbody>
<tr>
<td></td>
<td>Load 1 (9-12N)</td>
<td>Load 2 (15-18N)</td>
<td>Load 1 (9-12N)</td>
<td>Load 2 (15-18N)</td>
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<tr>
<td>Screw</td>
<td>1161.6</td>
<td>1074.0</td>
<td>2233.2</td>
<td>1828.8</td>
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<td>Plate</td>
<td>397.7</td>
<td>390.1</td>
<td>1164.8</td>
<td>1457.5</td>
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<td><strong>p=0.012</strong></td>
<td><strong>p=0.017</strong></td>
<td><strong>p=0.017</strong></td>
<td><strong>p=0.208</strong></td>
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• Fracture Site Angulation (deg)
  – IM screw demonstrated less fracture site angulation than the plate in both directions, at both loads

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<tr>
<td>Screw</td>
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<td>Plate</td>
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<td><strong>p=0.012</strong></td>
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<td><strong>p=0.012</strong></td>
<td><strong>p=0.025</strong></td>
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Results

• Torsional Stiffness (Nm/deg)
  - IM screw > Plate at initiation of torsional loading until slip point
  - Plate stiffness gradually increased as rotation and torque applied

• Peak Torque (Nm) and Fracture Site Rotation (deg)
  - No difference in peak torque between fixation methods
  - IM screw demonstrated less fracture site rotation at peak torque than the plate

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<th>Peak Torque (Nm)</th>
<th>Rotation at Peak Torque (degrees)</th>
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<tr>
<td>Screw</td>
<td>0.623</td>
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<td>Plate</td>
<td>0.780</td>
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Jones Fracture Plate Fixation

• Gaining increasing attention as an alternative method for Jones fracture stabilization
  – Potentially offers better rotational control than IM screw

• Until now, no studies have been performed to confirm/deny this theoretical advantage

• This study was unable to show a biomechanical advantage of plate fixation over IM screw fixation for Jones fractures

• Disadvantages of plate fixation:
  – Need for larger incision
  – Risk of soft tissue irritation from hardware prominence

• May be useful in specific situations:
  – Comminuted fractures
  – Osteoporotic bone
  – When IM screw not an option
    • Canal diameter too small to accommodate minimum 4.5mm diameter screw
    • Canal diameter too large to accommodate available screw sizes (ie. multiple revisions for nonunion)
    • Loss of cortical integrity during screw insertion (ie. blowout)
Conclusions

• IM screw fixation demonstrated greater resistance to bending and less fracture site angulation than plate fixation.

• IM screw fixation demonstrated greater resistance to rotation at initiation of torsion and less fracture site rotation at peak torque than plate fixation.

• Based on this Jones fracture model, plate fixation offers no biomechanical advantage over IM screw fixation.
References


