A Biomechanical Comparison Between Superior and Anterior Plating Positions for Mid-Shaft Clavicle Fractures Using Pre-contoured Plates

Paul Toogood, MD/MS, Dezba Coughlin, PhD, David Rodriguez, Jeffery Lotz, PhD, Brian Feeley, MD

Disclosures

- Synthes
- OREF
- JOJ

Background

- Historic data suggested extremely low non-union rates with mid-shaft clavicle fractures
- Neer, JAMA, 1960:
  - 2235 non-operatively treated clavicles
  - 3 nonunions

Nonoperative Treatment Compared with Plate Fixation of Displaced Midshaft Clavicular Fractures

- Multicenter, prospective RCT
- N = 132
  - 67 ORIF
  - 65 sling
- Outcomes
  - DASH
  - Constant Score
  - Radiographic/clinical f/u
  - Time to Union:
    - ORIF: 16.4 wks
    - Sling: 28.4 wks
  - Non-unions:
    - ORIF: 2
    - Sling: 7
  - Complications:
    - ORIF: 37% (hardware irritation, infection)
    - Sling: 63% (non-union, malunion requiring treatment

Canadian Orthopaedic Trauma Society
JBJS, 2007
Plate Position

**Anterior**

1) Less prominent (less ROH)
2) Longer anterior-posterior screw purchase
3) Instrumentation away from at risk neurovascular structures

**Superior**

1) Flat surface
2) Less muscular stripping

Prior Literature: Limitations

<table>
<thead>
<tr>
<th>Author</th>
<th>Implants</th>
<th>Loading</th>
<th>Fracture Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harroongroj, 1996</td>
<td>1/3rd Tubular</td>
<td>Bending</td>
<td>Transverse Fx</td>
</tr>
<tr>
<td>Iannotti, 2002</td>
<td>Reconstruction</td>
<td>Compression, Torsion</td>
<td>Transverse Fx</td>
</tr>
<tr>
<td>Celestre, 2008</td>
<td>DCP</td>
<td>Compression, Torsion, Bending</td>
<td>Transverse Fx</td>
</tr>
<tr>
<td>Robertson, 2009</td>
<td>Reconstruction</td>
<td>Compression, Torsion, Bending</td>
<td>Transverse Fx</td>
</tr>
<tr>
<td>Partal, 2010</td>
<td>Reconstruction</td>
<td>Compression, Torsion, Bending</td>
<td>Transverse Fx</td>
</tr>
<tr>
<td>Taylor, 2011</td>
<td>Pre-contoured</td>
<td>Bending</td>
<td>Transverse Fx</td>
</tr>
</tbody>
</table>

Prior Literature

- No clinical comparisons
- Biomechanical Data:
  - Celestre, 2008, JOT
  - Harroongroj, 1996, Clin Biomech
  - Iannotti, 2002, JSES
  - Robertson, 2009, JSES
  - Taylor, 2011, Clin Biomech
  - Partal, 2010, JOT

Transverse Fracture Pattern

Epidemiologic data suggests these fractures are uncommon (~5%) clinically. Prior authors admit it is also uniquely stable fracture pattern.
Purpose

- To biomechanically compare superior and anterior plating positions of:
- Clinically relevant mid-shaft clavicle fracture patterns
- Using pre-contoured plates
- When loaded in axial compression, torsion, and cantilever bending.

Methods: Fracture Model

OTA/AO/ASIF Classification

- Oblique Fracture Pattern (B1.2): •Single most common fracture pattern (26.3%). •More reproducible than the spiral pattern, and less tested than the transverse pattern.

- Bending Wedge Fracture Pattern (B2.2): •The entire B2 category is amongst the more common fracture patterns (28.9%). •Of the three, it was felt the Bending wedge would be the most reproducible.
• Comminuted Fracture Pattern (B3.3):
  • When segmental fractures occur, they are overwhelmingly comminuted (79.9\%)\(^2\).

Methods: Fracture Model

B1.2: 32 degrees, superior-lateral to inferior medial
B2.2: Wedge will be 16% of clavicular length
B3.3: Comminuted section will be 21% of clavicular length

Methods: Clavicle Model

- Synthetic clavicles (Pacific Research Laboratories model 3408-1)
  - Easier to obtain
  - Reduces variability in bone geometry and quality
  - > 2 testing groups
  - Now produce an intact model

Methods: Implants

1) Pre-contoured Superior Left Locking Mid-shaft Clavicle Plate, 8-hole

2) Pre-contoured Anterior Left Locking Mid-shaft Clavicle Plate, 8-hole

Three locking screw on each side of the fracture
Lag screws placed across oblique and wedge patterns
Methods: Loading

Compression
Torsion
Cantilever bending

Results: Axial Compression

Superior stiffer than anterior for all fracture patterns
Oblique stiffer than wedge & comminuted patterns

Results: Torsion

Superior stiffer than anterior for all fracture patterns, except no difference oblique fx clockwise torsion*
Oblique stiffer than wedge & comminuted patterns
Results: Cantilever Bending

- Anterior stiffer than superior for all fracture patterns
- Oblique stiffer than wedge & comminuted patterns

Anterior Plate

- Resistance to Cantilever bending
  - Lies with a larger dimension (width) perpendicular to the line of force

Superior Plate

- Resistance to Torsion
  - Greater mass (18.5 vs 13 gm)
  - S-shape
    - Moves mass away from centroid, increasing polar moment of inertia
- Resistance to Compression
  - Flat along axis of compression

Limitations

- Little is know about in vivo loading of the clavicle
- Clinical failure is fatigue vs construct stiffness
- Sequential testing
Conclusions

- **Current study suggests that for multiple mid-shaft clavicle fracture patterns:**
  - Compression and torsion appear better controlled with a pre-contoured superior plate
  - Cantilever bending is better resisted by the improved areal moment of inertia of the pre-contoured anterior plate
- **Until the relative importance of these forces is known, reasons other than biomechanics should be used to determine plate position**

References

- 3) McKee MD. Compression and torsion appear better controlled with a pre-contoured superior plate.
- 4) Cantilever bending is better resisted by the improved areal moment of inertia of the pre-contoured anterior plate.
- 5) McKee MD. Until the relative importance of these forces is known, reasons other than biomechanics should be used to determine plate position.