Biomechanical Comparison of Locked Plating and Spiral Blade Retrograde Nailing of Osteoporotic Supracondylar Femur Fractures

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Disclosure

• Synthes (Paoli, PA) provided with the implants used in the study
Introduction

• Distal femur fractures
  ▫ 10 times less common than proximal femur fx
  ▫ High vs. low energy
• Usually treated surgically
• Weight bearing is usually protected in early post-op period
Surgical options

Intramedullary nailing
- “Load sharing?”
- Antegrade vs. retrograde
- Indirect fracture reduction
- Distal fragment fixation
  - Spiral blade
  - Multiple angled screws

Plating
- Protect weight bearing
- Lateral vs. dual plating
- Anatomic reduction
- Distal fixation
  - Fixed angle blade plate (95°)
  - Locking plate with multiple locking screws
The Questions/Conclusions

• When subjected to immediate physiological weight-bearing, which method leads to better fixation in osteoporotic bone?

• If there is a difference, how significant is it?

• Can you safely allow early weight bearing with these implants?
• Loss of distal fixation in axial loading occurred in 1 of 16 cases with the LISS, in 3 of 8 cases with the ABP, and in 8 of 8 cases with the IMN

• Distal fixation was achieved by using 2 lateral-to-medial, 6.0-mm, interlocking screws
Internal Fixation of Type-C Distal Femoral Fractures in Osteoporotic Bone

By Dirk Wählen rt, MD, Konrad L. Hoffmeier, Dipl-Ing, Geert von Oldenburg, Dipl-Ing, Rosemarie Fröber, MD, Gunther O. Hofmann, MD, Dr rer nat, and Thomas Mückley, MD

Investigation performed at the Department of Traumatology, Hand and Reconstructive Surgery, Friedrich Schiller University Jena, Jena, Germany

• The locked plate had the least displacement and greatest torsional stiffness

• However, this was done in synthetic bone and tested in 33-C1 fx (intra-articular split)
Method

• Sample
  ▫ 10 pairs of embalmed femurs from cadavers aged 69-94 years
  ▫ Pre-experimental DEXA, x-rays

• Fracture fixation
  ▫ Right sided specimens were fixed with a titanium Retrograde/Antegrade EX Femoral Nail (RAFN)
  ▫ Left sided specimens were fixed with a stainless steel, 4.5 mm Locking Condylar Plate (LCP)
  ▫ 3cm osteotomy created at metaphysis
Method - Fracture fixation
Method - Experimental setup

- Designed to simulate normal gait with loading direction coinciding with the mechanical axis of the femur
- Spherical hip joint with center of rotation close to the femur head center
- The knee joint was allowed free rotation in the anterior-posterior direction
Method - Experimental setup
Method - Testing #1

- Axial load applied to each implant construct and overall deformation was measured
- Stiffness of the construct was calculated after 5 complete cycles loading and unloading
- Stiffness
  - Load/ displacement
  - Slope of stress/ strain curve
Method - Testing #2

• Replicated 6 weeks of post-op early weight-bearing ambulation by applying 200,000 cycles
  ▫ First 100,000 cycles of compression force of 190–790N
  ▫ Next 100,000 cycles with load range of 290–1180N

• Permanent deformation or subsidence was defined as the difference between displacement before and after cyclic loading
DEXA scan results

<table>
<thead>
<tr>
<th></th>
<th>BMD (g/cm²)</th>
<th>t-score</th>
<th>z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Normal BMD</td>
<td>0.91 ± 0.05</td>
<td>0.92 ± 0.02</td>
<td>-0.80 ± 0.16</td>
</tr>
<tr>
<td>Low BMD</td>
<td>0.55 ± 0.08</td>
<td>0.49 ± 0.08</td>
<td>-3.26 ± 0.66</td>
</tr>
</tbody>
</table>

5 paired femurs with t-score below 1 (Low BMD)
5 paired femurs with t-score above 1 (Normal BMD)
Sample characteristics

<table>
<thead>
<tr>
<th></th>
<th>Femoral Length (mm)</th>
<th>Head Diameter (mm)</th>
<th>Condyle Width (mm)</th>
<th>Midshaft Diameter (mm)</th>
<th>Midshaft Cortex Thickness (mm)</th>
<th>Age (years)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal BMD</td>
<td>475 ± 3.0</td>
<td>51.2 ± 1.3</td>
<td>51.0 ± 0.8</td>
<td>32.0 ± 2.0</td>
<td>10.4 ± 1.2</td>
<td>83.0 ± 3.1</td>
<td>5 M</td>
</tr>
<tr>
<td>Low BMD</td>
<td>475 ± 12.5</td>
<td>47.5 ± 1.7</td>
<td>45.4 ± 1.4</td>
<td>28.2 ± 1.5</td>
<td>6.8 ± 0.4</td>
<td>77.6 ± 3.3</td>
<td>4 F, 1 M</td>
</tr>
</tbody>
</table>
Results - Displacement

![Displacement Graph]

- **Average one body weight**: The red area represents the cumulative displacement over cycles, showing the average body weight effect.
- **Maximum one body weight**: The blue area indicates the maximum displacement achieved before subsidence, which is the vertical distance from the baseline to the top of the blue area.

The graph illustrates the displacement over cycles, with the x-axis representing cycles and the y-axis showing displacement in millimeters. Subsidence is indicated by the vertical distance from the baseline to the top of the graph.
Results - Construct stiffness
Results - Construct stiffness

- Construct stiffness is dependent on bone mineral density
- Significantly lower stiffness in retrograde femoral nail construct
Results - Subsidence
### Results - Subsidence

- Trend for greater subsidence with retrograde femoral nail construct in both normal and low bone mineral density groups
- No statistical significance

<table>
<thead>
<tr>
<th>Subsidence (mm)</th>
<th>Normal BMD</th>
<th>Low BMD</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RAFN</td>
<td>LCP</td>
<td>RAFN</td>
</tr>
<tr>
<td>1.0 ± 0.3</td>
<td>0.6 ± 0.1</td>
<td>3.8 ± 0.8</td>
<td>3.1 ± 0.3</td>
</tr>
<tr>
<td>( p )</td>
<td>0.056</td>
<td>0.18</td>
<td>0.066</td>
</tr>
</tbody>
</table>

*Note: RAFN = Retrograde Femoral Nail, LCP = Locking Compression Plate*
Failures
Failures

- Two of the five low BMD femurs fixed with RAFN failed after a few cycles
- Matched LCP femurs failed after 68,000 and 100,000 cycles
- T-score was -5.7 and -3.3
Conclusion

• We compared stiffness of modern RAFN vs. LCP constructs in supracondylar extra-articular comminuted fractures
• Matched cadaveric femurs with normal and low BMD were used
• LCP fixation construct had greater stiffness and less subsidence
• Stiffness of both constructs depends on BMD
Limitations

• Wide range of bone mineral density in the specimens used

• Few number of specimens used (10 pairs)

• Embalmed specimens

• Does not take into account the biologic response, i.e. fracture healing
The Questions/Discussions

- When subjected to immediate physiological weight-bearing, which method leads to better fixation in osteoporotic bone?

- If there is a difference, how significant is it?

- Can you safely allow early weight bearing with these implants?
The Questions/Discussions

• When subjected to immediate physiological weight-bearing, which method leads to better fixation in osteoporotic bone?
  ▫ Locked plating is stiffer, has less subsidence

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The Questions/Discussions

- When subjected to immediate physiological weight-bearing, which method leads to better fixation in osteoporotic bone?
  - Locked plating is stiffer, has less subsidence

- If there is a difference, how significant is it?
  - Subsidence was 3.1 vs 3.8mm. Maybe not clinically significant.

- Can you safely allow early weight bearing with these implants?
• When subjected to immediate physiological weight-bearing, which method leads to better fixation in osteoporotic bone?
  ▫ Locked plating is stiffer, has less subsidence

• If there is a difference, how significant is it?
  ▫ Subsidence was 3.1 vs 3.8mm. Maybe not clinically significant.

• Can you safely allow early weight bearing with these implants?
  ▫ Can’t say for sure with a biomechanical study, but answer is “No” for severe osteoporosis
Thank you

Questions?