Biomechanical Effects of Nonanatomic Repair of the Posterior Root of the Lateral Meniscus

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Background

- Avulsion of the posterior roots of menisci result in significantly increased contact pressures, and decreased contact areas, across respective compartments \(^1,^2\)

- Lateral meniscectomy is associated with a higher risk of development of osteoarthritis, and poorer outcomes, than medial meniscectomy\(^3\)

- Anatomic repair of posterior root avulsions restores native biomechanical effects\(^2\)

Disclosure

- No disclosures related to the content of this study
  - James C. Dreese, MD participates in the speakers bureau for Zimmer Biomet Sports Medicine
Background

• Laprade et al. demonstrated nonanatomic in-situ posterior root medial meniscus repair resulted in significantly increased contact area and mean pressures at 0° and 90°, and significantly increased peak pressures at 90° compared to anatomic repair.

• Purpose
  • Assess the biomechanical effects of nonanatomic posterior root lateral meniscus repair in comparison to the intact state and anatomic repair.
Methods

- Biomechanical study based on Laprade et al. testing design\(^4\)
- 15 fresh-frozen cadaveric knees tested with custom pivot-table and Instron machine
  - Power analysis based on Laprade et al. (2015)
  - Knees excluded if damaged or >Outerbridge 1 arthritic change
  - Skin, subcutaneous tissue, muscle, tendon, and patella dissected from specimen
  - Lateral femoral condyle osteotomy allowed for access to posterior root
  - Tekscan (model 4011) sensors implanted under meniscotibial ligaments
Methods

- Testing
  - 5 testing states
    - Intact meniscus
    - Complete lateral root avulsion
    - Anatomic root repair
    - 5mm anterior nonanatomic repair
    - 5mm medialized nonanatomic repair
  - Repair states randomized for each specimen
  - 1000N axial force applied
  - Tested 0°, 30°, 60°, and 90° angles
  - Contact pressure map recorded for each specimen
Methods

• **Statistics**
  
  • For each specimen medial and lateral compartment contact area, mean contact pressure, and peak contact pressure were measured
  
  • Differences were detected using a two-way repeated measures ANOVA with a post-hoc Scheffe analysis
  
  • Statistical significance was considered for p-values < 0.05
## Results

### Lateral Contact Area (mm$^2$)

<table>
<thead>
<tr>
<th></th>
<th>Intact</th>
<th>Root Tear</th>
<th>Anatomic Repair</th>
<th>Nonanatomic Anterior</th>
<th>Nonanatomic Medialized</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>500</td>
<td>453</td>
<td>444</td>
<td>452</td>
<td>465</td>
<td>P=0.038</td>
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<td>30°</td>
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<td>448</td>
<td>444</td>
<td>462</td>
<td>481</td>
<td>P=0.011</td>
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<tr>
<td>60°</td>
<td>481</td>
<td>412</td>
<td>420</td>
<td>426</td>
<td>433</td>
<td>P=0.031</td>
</tr>
<tr>
<td>90°</td>
<td>450</td>
<td>404</td>
<td>382</td>
<td>402</td>
<td>405</td>
<td>P=0.016</td>
</tr>
</tbody>
</table>

### Lateral Mean Contact Pressure (KPa$^2$)

<table>
<thead>
<tr>
<th></th>
<th>Intact</th>
<th>Root Tear</th>
<th>Anatomic Repair</th>
<th>Nonanatomic Anterior</th>
<th>Nonanatomic Medialized</th>
<th>P-Value</th>
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<tbody>
<tr>
<td>0°</td>
<td>904</td>
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<td>924</td>
<td>879</td>
<td>910</td>
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<tr>
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<td>964</td>
<td>1075</td>
<td>862</td>
<td>864</td>
<td>838</td>
<td>P=0.006</td>
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<tr>
<td>60°</td>
<td>1154</td>
<td>1219</td>
<td>996</td>
<td>1005</td>
<td>876</td>
<td>P=0.005</td>
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<tr>
<td>90°</td>
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<td>1144</td>
<td>1150</td>
<td>1060</td>
<td>1086</td>
<td>P=0.302</td>
</tr>
</tbody>
</table>
Results

• Lateral Peak Contact Pressure (KPa²)

<table>
<thead>
<tr>
<th></th>
<th>Intact</th>
<th>Root Tear</th>
<th>Anatomic Repair</th>
<th>Nonanatomic Anterior</th>
<th>Nonanatomic Medialized</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>2439</td>
<td>3143</td>
<td>2535</td>
<td>2428</td>
<td>2590</td>
<td>P=0.137</td>
</tr>
<tr>
<td>30°</td>
<td>2226</td>
<td>2865</td>
<td>2364</td>
<td>2199</td>
<td>2020</td>
<td>P=0.008</td>
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<tr>
<td>60°</td>
<td>2960</td>
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<td>2694</td>
<td>2569</td>
<td>2263</td>
<td>P=0.003</td>
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<tr>
<td>90°</td>
<td>3197</td>
<td>3527</td>
<td>3323</td>
<td>2952</td>
<td>2916</td>
<td>P=0.429</td>
</tr>
</tbody>
</table>

• Pooled across all flexion angles
  – Significantly increased mean and peak pressures with root avulsion vs. intact state and all repairs
  – Significantly lower mean pressure with medialized repair vs. intact state (926 vs. 1077 KPa², p=0.031)
Discussion

• Complete avulsion of the posterior root of the lateral meniscus significantly decreases contact area and increases contact pressures when compared to the intact state
  – Similar to other studies that show decreased effect of root tear at lower flexion angles
  – Perez-Blanca et al. demonstrated maximum increase in mean pressure from root avulsion at 60° compared to the intact state
  – Forkel et al. demonstrated no significant difference in contact area or pressure in full extension unless meniscofemoral ligaments sectioned

• Anatomic repair of complete posterior root lateral meniscus tears improved mean and peak pressures when compared to the avulsed state
  – No significant difference in repair state from intact state at any flexion angle
  – Improved contact pressures in repair state from avulsed state at all flexion angles
    • Significance achieved at mid-flexion angles (30°, 60°)
    • Laprade et al. only demonstrated significant decrease in mean contact pressures with repair compared to the avulsed state at 45°, 60°, and 90° and no significant improvement in peak pressures
    • Perez-Blanca et al. demonstrated a significant decrease in mean contact pressures with repair when compared to the avulsed state, 30°, and 60° and a significant decrease in peak pressure only at 0°
Discussion

Medialization of the posterior root of the lateral meniscus decreased contact pressures in comparison to the intact state

- Mean and peak contact pressures were decreased compared to the intact state at 30°, 60°, and 90°
  - Significantly decreased mean pressures when pooled across all flexion angles
  - Significantly decreased mean and peak pressures at 60°
- Differences between repair states did not reach significance
Limitations

- Biomechanical study
- Static load applied
- Meniscofemoral ligaments left intact
- Cadaveric tissue used
- These are complete root avulsions. This may or may not apply to partial root avulsions.
- We did not measure the tension in the posterior root of the meniscus directly. Nonanatomic medialization and anteriorization may increase the tension within the posterior root of the lateral meniscus, predisposing it to failure.
Conclusions

- Posterior root lateral meniscus repair restores contact pressure to near-normal levels

- No significant difference in contact pressures or areas between anatomic, anteriorized, or medialized repairs

- Medialization may decrease mean and peak pressures across the joint compared to the intact state
  - Likely increases tension across the repair site, leading to higher risk of clinical failure


