Biomechanical Evaluation of Capsulotomy and Capsular Repair in the Hip: Restoring Stability

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Introduction

• Hip arthroscopy has been used to treat various hip pathologies including Femoroacetabular Impingement (FAI)
• Capsulotomy facilitates adequate visualization and access for diagnostic and interventional purposes
• Current literature remains divided over the use of routine capsular closure

Purpose:
To assess the effect of capsulotomy size and subsequent repair on the biomechanical stability of the hip joint.

Methods

• Subjects: 8 fresh-frozen cadaveric hip specimens consisting of the hemipelvis, femur, and overlying soft tissues were used for this study (Table 1). Specimens were screened by computed tomography (CT) to assess for the absence of significant bony pathology

<table>
<thead>
<tr>
<th>Table 1. Subject Demographics</th>
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<tr>
<td>Age (Y)</td>
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<tr>
<td>Mean</td>
</tr>
<tr>
<td>Standard Deviation</td>
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</tbody>
</table>

• Experimental Setup:
  • Smooth load cycle between internal and external rotation
  • Testing included torsional loading for three cycles at amplitudes of 6 N·m at a rate of 0.3 N·m/sec

Figure 1. Representative testing set-up: A cadaveric hip specimen a right hip is rotated from internal (IR) to external rotation (ER) by the pulley system driven by the frame piston (F₁) opposed by the counterweight F₂w
• Distal femur (DF) is potted in PMMA cement within a 3 in diameter. PVC pipe placed within a mobile cylindrical base
• Iliac wing (IW) is secured with metal bolts to a rigid fixture which is kept stationary during testing

Methods (cont’d)

• Testing Conditions
  • Intact capsule, 4 cm inter-portal capsulotomy, 6 cm inter-portal capsulotomy, capsulotomy repair
  • Inter-portal capsulotomies were performed through a mini-open direct anterior approach to the capsule. The capsule was repaired with four high-tensile strength sutures

• Examined Variables: Measures of Joint Stability (Range of Motion, Hysteresis Area, Neutral Zone)

• Statistical Analysis: Relationships among capsular conditions and their measures of joint stability were evaluated by using a one-way ANOVA with post-hoc Tukey test (α = 0.05)

Results

• Positive correlations between the size of the capsulotomy and the hip ROM, hysteresis area, and neutral zone (Figure 3)

Significance: This study not only confirms the notion of introducing iatrogenic joint instability with larger sized capsulotomies, but also proposes the complete capsular closure as an appropriate solution.

Figure 2. Representative load-displacement diagrams for internal-to-external rotation cycles at different capsule conditions, A: Intact, B: 4 cm inter-portal capsulotomy, C: 6 cm inter-portal capsulotomy, D: Repaired state

Figure 3. Mean intraspecimen instability measures taken as a percentage of intact state. * denotes a statistically significant difference between capsular conditions where p<0.05, and ** denotes statistically significant differences where p<0.0001. Cases: A) Range of Motion, B) Hysteresis Area, C) Neutral Zone

<table>
<thead>
<tr>
<th>Capsule Conditions Comparison</th>
<th>Range of Motion</th>
<th>Hysteresis Area</th>
<th>Neutral Zone</th>
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<tbody>
<tr>
<td>Intact vs. 4 cm</td>
<td>.039</td>
<td>.241</td>
<td>.551</td>
</tr>
<tr>
<td>Intact vs. 6 cm</td>
<td>&lt;.0001</td>
<td>.007</td>
<td>.116</td>
</tr>
<tr>
<td>Intact vs. Repair</td>
<td>1.000</td>
<td>.999</td>
<td>.706</td>
</tr>
<tr>
<td>4 cm vs. 6 cm</td>
<td>.126</td>
<td>.382</td>
<td>.753</td>
</tr>
<tr>
<td>4 cm vs. Repair</td>
<td>.033</td>
<td>.195</td>
<td>.994</td>
</tr>
<tr>
<td>6 cm vs. Repair</td>
<td>&lt;.0001</td>
<td>.005</td>
<td>.600</td>
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Discussion

• Results suggest a direct relationship between the capsulotomy size and joint instability
• Repair demonstrated efficacy to reconstitute stability
• First study to look at the biomechanical consequences of capsulotomies and their repair on the hip joint with its surrounding soft tissue


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