PERSONAL DISCLOSURES

- Brian L. Walters, MD:
  - Nothing to disclose

- H. John Cooper, MD:
  - Paid Consultant: Smith & Nephew

- José A. Rodriguez:
  - Speaker’s Bureau: Smith & Nephew, DePuy, Wright Medical
  - Paid Consultant: Smith & Nephew, DePuy, Exactec, Arthrex, Wright Medical
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  - Board/Committee Appointments: AAHKS

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- North Shore LIJ Lenox Hill Hospital
INTRODUCTION

- Hip surgery has evolved in recent years as hip arthroscopy has become widely accepted and practiced
  - Precise capsular and pericapsular releases are required for these procedures to be performed effectively
  - Precise knowledge of hip anatomy and complex spatial relationships are required to master these techniques

- The orthopaedic literature provides little quantitative information on capsular and pericapsular anatomy of the hip
  - Despite several descriptive studies of individual structures, a comprehensive qualitative and quantitative anatomic description is lacking

The purpose of this investigation is to provide a detailed quantitative and qualitative description of the anatomy of the hip capsule and surrounding pericapsular structures.
METHODOLOGY

Anatomical Dissections

- 11 nonpaired fresh-frozen cadaveric hemipelvi
  - No history of prior injury or surgeries

- Iliocapsularis, gluteus minimus, piriformis, obturator externus, and the conjoint tendon were dissected from their origin and reflected distally towards their insertions
  - Rectus femoris was reflected in a distal-to-proximal direction
  - As muscles reflected, contributions to the hip capsule were recorded

Measurements taken:

- Size and location of capsular contributions of tendinous structures
- Footprints of tendinous insertions of the aforementioned structures and their relationships to reproducible bony landmarks
- Thickness of the hip capsule at 40 locations across its length and circumference using a modified hemi-quadrant system
- Width of the capsular origin and insertion
- Intraarticular distance of the capsular origin from the bony acetabular rim and the intra-articular distance of the capsular insertion from the femoral head-neck junction

Demographics

<table>
<thead>
<tr>
<th>Demographics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>72.3 years</td>
</tr>
<tr>
<td>Sex</td>
<td>4 ♂; 8 ♀</td>
</tr>
<tr>
<td>Weight</td>
<td>143.8 lb</td>
</tr>
</tbody>
</table>

¹Measurements made with a digital caliper to high degrees of accuracy (±0.02mm) and reliability (intra-class correlation coefficients > 0.9)
RESULTS

Capsular Attachments

- **Iliocapsularis** (arrows) had the largest capsular contribution
  - Adherent to the entire length of the anteromedial capsule from its origin at the AIIS to its insertion distal to the lesser trochanter

- **Rectus femoris (*)** had a consistent capsular contribution
  - Origin of the indirect (reflected) head over the anterosuperior acetabular rim

- **Gluteus minimus (**)** had a large capsular insertion laterally
  - Proximal to its bony insertion onto the greater trochanter
  - Although present in all specimens, the shape and pattern of the insertion was variable

- **Obturator externus tendon and conjoint tendon** coursed along the posterior aspect of the hip capsule.
  - Each had small but consistent capsular adhesions posteriorly near the acetabular rim

- **Piriformis tendon** did not have any capsular contributions
  - Could easily be dissected free of the capsule
## Dimensions of Capsular Contributions

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iliocapsularis (IC)</td>
<td>73.8 x 16.1</td>
</tr>
<tr>
<td>Indirect Head of Rectus (IR)</td>
<td>26.1 x 10.1</td>
</tr>
<tr>
<td>Gluteus Minimus (GM)</td>
<td>68.8 x 28.1</td>
</tr>
<tr>
<td>Piriformis</td>
<td>(none)</td>
</tr>
<tr>
<td>Conjont Tendon (CJ)</td>
<td>9.4 x 18.6</td>
</tr>
<tr>
<td>Obturator Externus (OE)</td>
<td>14.5 x 20.8</td>
</tr>
</tbody>
</table>

![Anterior](Image1.png)

![Superior](Image2.png)

![Posterosuperior](Image3.png)
**Tendinous Insertions onto the Trochanter**

- Bony insertions of the piriformis, conjoint tendon, and obturator externus were each located on the medial aspect of the greater trochanter.
  - Piriformis inserted just medial to the tip of the greater trochanter, midway from posterior to anterior.
  - Conjoint tendon inserted just anteriorly to the piriformis tendon into a shallow bony sulcus.
  - Obturator externus located in a fossa distal and slightly posterior from the greater trochanter and femoral neck.

**RESULTS**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Dimension of Insertion (mm)</th>
<th>Distance from Gr Troch (mm)</th>
<th>Distance from Capsule (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piriformis</td>
<td>10.3 x 4.1</td>
<td>3.8 ± 2.6</td>
<td>8.4 ± 5.1</td>
</tr>
<tr>
<td>Conjoint</td>
<td>12.1 x 6.0</td>
<td>9.3 ± 2.7</td>
<td>2.0 ± 1.8</td>
</tr>
<tr>
<td>Ob. Externus</td>
<td>7.7 x 5.1</td>
<td>17.2 ± 2.8</td>
<td>5.7 ± 3.3</td>
</tr>
</tbody>
</table>
RESULTS

**Capsular Thickness**

- **At the midpoint:**
  - Thickest superolaterally near gluteus minimus insertion (3.5 to 4.2 mm)
  - Thinnest in the posteroinferior / inferior hemiquadrants (1.6 to 1.7 mm)

- **Near the acetabular origin:**
  - Thickest superiorly and posterosuperiorly (3.7 to 4.0 mm)
  - Thinnest anteriorly and anteroinferiorly (1.3 mm)

- **At the femoral insertion:**
  - Thickest anteriorly (2.2 to 2.5 mm)
  - Thinnest in the posterior / postero-inferior hemiquadrants (0.7 to 0.9 mm)

<table>
<thead>
<tr>
<th>Acetabular Origin</th>
<th>Femoral Insertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 ± 1.2</td>
<td>Posterior</td>
</tr>
<tr>
<td>1.7 ± 0.9</td>
<td>Postero-inferior</td>
</tr>
<tr>
<td>1.5 ± 0.6</td>
<td>Inferior</td>
</tr>
<tr>
<td>1.3 ± 0.6</td>
<td>Antero-inferior</td>
</tr>
<tr>
<td>1.3 ± 0.6</td>
<td>Anterior</td>
</tr>
<tr>
<td>2.2 ± 1.6</td>
<td>Antero-superior</td>
</tr>
<tr>
<td>3.7 ± 2.2</td>
<td>Superior</td>
</tr>
<tr>
<td>4.9 ± 3.0</td>
<td>Postero-superior</td>
</tr>
</tbody>
</table>
RESULTS

Capsular Origin

- Capsule originated at a mean of 5.1mm proximal to bony rim of acetabulum
  - Created a small intracapsular recess between the outer rim and the inner capsule
  - This distance was smallest anterosuperiorly and was largest posteriorly
- Using extraarticular landmarks as a reference, the capsular origin was located approximately 13mm distal to the AIIS and 11mm lateral to the pectineal eminence
- The thickness of the capsular origin was greatest superiorly and least anteriorly

<table>
<thead>
<tr>
<th>Distance from Bony Acetabular Rim</th>
<th>Width of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>8.1 ± 2.8</td>
</tr>
<tr>
<td>Postero-Inferior</td>
<td>7.1 ± 1.0</td>
</tr>
<tr>
<td>Inferior</td>
<td>6.2 ± 4.2</td>
</tr>
<tr>
<td>Antero-Inferior</td>
<td>5.4 ± 2.9</td>
</tr>
<tr>
<td>Anterior</td>
<td>4.9 ± 1.5</td>
</tr>
<tr>
<td>Antero-Superior</td>
<td>5.5 ± 3.7</td>
</tr>
<tr>
<td>Superior</td>
<td>8.8 ± 3.3</td>
</tr>
<tr>
<td>Postero-Superior</td>
<td>8.2 ± 0.8</td>
</tr>
</tbody>
</table>

- Capsule origin at a mean of 5.1mm proximal to bony rim of acetabulum
- Created a small intracapsular recess between the outer rim and the inner capsule
- This distance was smallest anterosuperiorly and was largest posteriorly
- Using extraarticular landmarks as a reference, the capsular origin was located approximately 13mm distal to the AIIS and 11mm lateral to the pectineal eminence
- The thickness of the capsular origin was greatest superiorly and least anteriorly
RESULTS

Capsular Insertion

- The capsule inserted at a mean of 26.2 mm distal to the chondral head-neck junction of the proximal femur
  - Created a large distal intracapsular recess along the bony femoral neck
  - This distance was shortest posteriorly and was longest inferiorly along the femoral neck
- The thickness of the capsular insertion was greatest inferiorly and least posteriorly

<table>
<thead>
<tr>
<th>Distance from Femoral Head-Neck Junction (mm)</th>
<th>Width of Insertion (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance</strong></td>
<td><strong>Width</strong></td>
</tr>
<tr>
<td>Posterior</td>
<td>20.8 ± 5.6</td>
</tr>
<tr>
<td>Postero-Inferior</td>
<td>26.8 ± 7.1</td>
</tr>
<tr>
<td>Inferior</td>
<td>32.1 ± 8.0</td>
</tr>
<tr>
<td>Antero-Inferior</td>
<td>30.5 ± 6.3</td>
</tr>
<tr>
<td>Anterior</td>
<td>26.5 ± 5.9</td>
</tr>
<tr>
<td>Antero-Superior</td>
<td>26.1 ± 6.6</td>
</tr>
<tr>
<td>Superior</td>
<td>22.1 ± 5.8</td>
</tr>
<tr>
<td>Postero-Superior</td>
<td>24.4 ± 7.0</td>
</tr>
</tbody>
</table>
• A comprehensive qualitative and quantitative assessment of the capsular and pericapsular anatomy of the hip has not previously been performed.

• Previous authors have described capsular attachments of isolated muscles and tendons, including:
  • A consistent capsular attachment of the deep surface of the gluteus minimus tendon, which was postulated might retract the capsule during hip motion to prevent capsular entrapment.
  • A capsular origin of the iliocapsularis muscle which was postulated might tighten the anterior hip capsule, thereby helping to stabilize the femoral head within a dysplastic acetabulum.

• Unlike the capsular attachments of the iliocapsularis and gluteus minimus (both of which have been previously described) the quantitative and qualitative anatomic relationship of the conjoint tendon and the obturator externus to the posterior hip capsule has yet to be described.
  • Furthermore, although the supra-acetabular origin of the indirect head of the rectus femoris tendon is well-known, its proximal capsular attachment has not been documented to our knowledge.

• Hip arthroscopy requires specific capsular manipulation, release and repair. Knowledge of the surrounding capsular attachments, capsular thickness and the relationship of its origin and insertions to reproducible osseous landmarks will help perform these more precisely.
DISCUSSION

• Capsular thickness, as well as the footprints of its origin and insertion, are very important considerations for arthroscopic procedures, which often require manipulation and release of the capsule from inside-out with or without repair
  • Recent studies have examined the iliofemoral, ischiofemoral, and pubofemoral ligaments of the capsuloligamentous complex
  • Although the precise acetabular origin and insertion of the capsule has been documented, measurements of the thickness of the footprints were not provided, nor was the distance of these footprints from bony landmarks, both of which are relevant when performing hip arthroscopy
  • Furthermore, we are not aware of any studies that measure capsular thickness at various points throughout the capsule
  • Our anatomical findings regarding the various properties of the hip capsule including thickness, origin and insertion contributes critical quantitative information to the controversial debate surrounding how to address the hip capsule during hip arthroscopy and whether or not it should be repaired

• Study limitations:
  • Precise location and size of origins and insertions of the capsular and pericapsular structures were documented manually rather than digitally, albeit with a high degree of accuracy and excellent measurement reliability
  • Advanced age of the specimens may skew the anatomic results based on age-related changes
  • The anatomical findings described in this study may be altered in patients with various disorders of the hip, as these specimens did not have known hip pathology

• Conclusions:
  • The findings documented in this study are useful for hip arthroscopists in understanding the complex and intricate relationship between the hip capsule and surrounding pericapsular structures, thus allowing precise manipulation and releases of the capsule and surrounding soft tissue structures which are essential to obtain adequate surgical exposure and reduce unnecessary tissue trauma.
LITERATURE CITED


