New Findings in Hip Capsular Anatomy: Dimensions of Capsular Thickness and Pericapsular Contributions

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Purpose: The purpose of this investigation was to provide a detailed description of the anatomy of the hip capsule and pericapsular structures. Methods: Dissections were performed on 11 nonpaired, fresh-frozen cadaveric hips by 2 independent observers: 1 fellowship-trained orthopaedic total joint surgeon and 1 chief orthopaedic surgery resident. Documentation of capsular thickness, origins, insertions, and attachments to pericapsular structures including the abductors, rectus femoris, piriformis, short external rotators, and iliocapsularis muscles was performed. Tendinous insertions of the surrounding pericapsular muscles were measured according to size and distance from reproducible osseous landmarks. Results: The capsule is thickest near the acetabular origin at the posterosuperior and superior hemi-quadrants and is thinnest near the femoral insertion in the posterior and posteroinferior hemi-quadrants. The iliocapsularis, indirect head of the rectus, conjoint, obturator externus, and gluteus minimus tendons all show consistent capsular contributions, whereas the piriformis does not have a capsular attachment. Osseous landmarks for tendinous attachments are defined and illustrated. The inter-relation of these structures is complex, yet their relations to the anterior hip capsule and contributions to its thickness are predictable. Conclusions: The dynamic pericapsular structures pertinent to the hip arthroscopist include the iliocapsularis, gluteus minimus, and reflected head of the rectus femoris. At the acetabulum, the thickest region of the capsule is posterosuperior and superolateral. At the femoral insertion, the thickest region is anterior. Clinical Relevance: Knowledge of the intricate relation between the hip capsule and pericapsular structures presented here will be useful for surgeons as they perform the precise and specific capsular releases required during hip arthroscopy. Our anatomic findings contribute important qualitative data that build on the recent literature regarding the importance of capsular management during hip arthroscopy to postoperative hip stability.

A review of the literature shows that our understanding of the pericapsular anatomy and its contribution to hip stability is still evolving. It was not until the early 2000s that studies detailing the complex anatomy of the iliocapsularis, gluteus minimus, and medial femoral circumflex artery made essential contributions to our understanding of the pericapsular musculature and vascular anatomy.1-3 These studies paved the way for later studies that have sought to more clearly define the relation between the dynamic and static contributions of the pericapsular anatomy and hip stability.4-8 More recently, as hip arthroscopists have performed extensive capsular releases to address various pathologies in the peripheral compartment of the hip, there have been several case reports showing poor outcomes and complications related to postoperative hip instability.9,10 These case reports suggest that postoperative instability may be related to extensive capsulotomy without repair. Currently, research efforts are focused on determining the role the hip capsular ligaments and pericapsular musculature may play in hip stability and understanding how the preservation of their anatomy during hip arthroscopy may contribute to greater postoperative stability.5-8,11

It is now clear that an accurate anatomic description of the hip capsule and pericapsular structures is necessary not only to allow surgeons to clearly understand the relations among these structures but also to facilitate analysis of their functional roles in hip stability through biomechanical studies. Correspondingly, the purpose of this study was to provide a detailed description of the anatomy of the hip capsule and pericapsular structures. We hypothesized that the anatomy of the hip capsule...
may be more complex than previously realized and that its ligamentous and muscular contributions may contribute significantly to hip stability.

**Methods**

**Gross Anatomy Dissections**

Eleven nonpaired, fresh-frozen cadaveric hemipelvises were used for this study. The mean age of donors at the time of death was 72.3 years (range, 67 to 95 years), and the mean body mass index of donors was 24.6 kg/m² (range, 14.5 to 36.2 kg/m²). There was no history or evidence of previous injury or surgery in any hip. No institutional review board approval was required for this cadaveric study at our institution. Dissections were performed by 2 independent observers: 1 fellowship-trained orthopaedic total joint surgeon and 1 chief orthopaedic surgery resident. Dissections were typically performed without optical assistance, but 3.0× loupe magnification was used whenever it was thought to be beneficial. Dissections began with identification of the muscles and tendons that were intimately associated with the hip capsule, including the iliocapsularis, gluteus minimus, rectus femoris, piriformis, and obturator externus, as well as the conjoint tendon of the gemellus inferior, obturator internus, and gemellus superior muscles. Neurovascular structures and all superficial structures were removed from the specimens. The gluteus medius and psoas muscles were removed because they did not have any direct capsular contributions and because it was difficult to accurately identify and measure the relations among the structures of interest while these muscles were still present.

Each of the muscles was dissected off of its origin and reflected distally toward its insertion, with the exception of the rectus femoris, which was reflected in a distal-to-proximal direction to preserve the intimate relation between its 2 origins and the hip capsule. As the muscles were reflected, any contributions to the hip capsule were carefully noted with a fine marking pen. Capsular contributions were defined as adhesions between the muscle and the hip capsule that could not be freed by blunt dissection. The area and location of these capsular contributions were recorded. Tendinous insertions onto the hip capsule were dissected off of the capsule after the area of their contribution to the capsule was carefully marked. In addition, the size and location of the bony insertions of the various muscles were recorded, as was the distance of these insertions from bony and soft-tissue landmarks.

The hip capsule was divided circumferentially at its midpoint between the acetabular origin and femoral insertion. The thickness of the capsule at this midpoint was then measured at 8 different locations, using a modification of the quadrant system described by Wasielewski et al. as a reference for orientation (Fig 1A). In addition to measurement of the capsular thickness at the midpoint, it was also measured at points 5 mm from the acetabular origin and 5 mm from the femoral insertion. The aforementioned quadrant system was used for the acetabular-sided measurements, whereas a different quadrant system was devised for femoral-sided measurements using the coronal-oblique plane of the femur to define superior and inferior (Fig 1B). The width of the capsular origin along the acetabulum and the width of the insertion onto the proximal femur were also recorded, as were the intra-articular 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. All measurements were made to the nearest 0.1 mm with a digital caliper (Neiko Tools, Markham, Ontario, Canada) with measurement accuracy of ± 0.02 mm.

**Statistical Analysis**

The intraclass correlation coefficient (ICC), which measures reliability by comparing the variability of different ratings of the same entity with the total variation across all ratings and all entities, was selected to evaluate the reliability of the measurements between observers. The ICC for all measurements taken was greater than 0.90, where an ICC of 1.0 represents perfect agreement and an ICC of 0 suggests that measurements are entirely random.

**Results**

**Muscular Capsular Attachments**

The iliocapsularis, first described by Ward et al. had the largest capsular contribution. In all specimens, it was adherent to the entire length of the anteromedial capsule beginning at its origin at the inferior aspect of the anterior inferior iliac spine to its insertion just distal to the lesser trochanter (Figs 2 and 3). The rectus femoris had a consistent capsular contribution at the origin of the indirect (reflected) head over the anterosuperior acetabular rim. The gluteus minimus showed a large, broad capsular insertion laterally, which was proximal to its bony insertion onto the greater trochanter (Figs 2 and 4). Although this broad capsular insertion was present in all specimens, its shape and pattern was variable. The piriformis tendon did not have any capsular contributions in any of the specimens and could easily be dissected free of the capsule. The obturator externus tendon and the conjoint tendon of the obturator internus and gemellus muscles coursed along the posterior aspect of the hip capsule (Fig 5A). Each showed small but consistent capsular adhesions posteriorly near the posterior acetabular rim. The capsular contribution of the obturator externus tendon was on the posteroinferior aspect.
of the capsule while the capsular contribution of the conjoint tendon was on the posterosuperior aspect of the capsule (Fig 5B). Mean sizes of capsular contributions (in greatest dimensions) are provided in Table 1. A precapsular fat pad was encountered in every hip, between the gluteus minimus and the iliocapsularis, extending from the proximal origin of the vastus lateralis to the reflected head of the rectus.

**Capsular Thickness**

Near the acetabular origin, the capsule was thickest superiorly and posterosuperiorly (3.7 to 4.0 mm) but was thinnest anteriorly and anteroinferiorly (1.3 mm) (Fig 1A and Table 2). At its midpoint between the acetabular origin and femoral insertion, the hip capsule was thickest superolaterally underneath the gluteus minimus and the iliocapsularis, extending from the proximal origin of the vastus lateralis to the reflected head of the rectus. The quadrants were subdivided into hemi-quadrants (dashed lines) for additional data points. The large asterisk marks the thickest hemi-quadrant of capsular tissue posterosuperiorly at a distance of 5.0 mm from its acetabular origin. The 2 small asterisks mark the region of the acetabular origin that has the thinnest capsule. (B) View of a right femur as seen from a medial vantage point. The central axis of the femur was used to determine the superior (Sup)–to–inferior (Inf) axis, and a second line perpendicular to this axis was drawn from anterior (Ant) to posterior (Post) along the center of the femoral head, creating 4 equal quadrants. The quadrants were subdivided into hemi-quadrants (dashed lines) for additional data points.

**Capsular Origin and Insertion**

The hip capsule originated at a mean of 5.1 mm proximal and medial to the bony rim of the acetabulum, creating a small intracapsular recess. This recess was smallest anterosuperiorly and largest posteriorly (Table 2). By use of extra-articular landmarks as a reference, the capsular origin was located approximately 13.0 mm (±4.3 mm) distal to the anterior inferior iliac spine and approximately 11.1 mm (±5.0 mm) lateral to the pectineal eminence. The capsule inserted at a mean of 26.2 mm distal to the chondral head-neck junction of the proximal femur, creating a large distal intracapsular recess along the bony femoral neck. This distance was shortest posteriorly and longest inferiorly along the femoral neck (Table 4). By use of extra-articular landmarks as a reference, the capsular insertion was located approximately 12.2 mm (±4.1 mm) distal and medial.
to the tip of the greater trochanter and approximately 13.6 mm (±4.0 mm) proximal to the lesser trochanter. The thickness of the capsular insertion was greatest across all anterior quadrants and thinnest posteriorly (Table 4).

**Reflected Head of Rectus Fat Pad**

During our dissections of the peripheral compartment, a distinct and consistent fat pad overlying the reflected head of the rectus was present in every specimen. This reflected rectus fat pad was found between the capsular attachments of the gluteus minimus and iliocapsularis muscles directly overlying the reflected head of the rectus. Compared with the adjacent precapsular fat pad overlying the entire anterior hip capsule and found just deep to the deep layer of the tensor fascia, the reflected rectus fat pad was distinct in consistency (much less lobular) and location (directly overlying the reflected head of the rectus). It was also much less yellow or blander in color relative to the adjacent precapsular fat pad.

**Discussion**

Our study shows that the dynamic and static pericapsular structures of the hip are intimately associated and contribute to reproducible patterns of anterior capsular thickness. Several cadaveric and biomechanical studies have described the ligamentous anatomy of the hip capsule and established a foundation for the argument that the static stabilizers of the hip play critical roles in stability, particularly after hip arthroscopy. By use of our data, a greater understanding of these static and dynamic contributors to capsular thickness can be used to facilitate maximal surgical...
exposure through capsulotomy and restoration of functional anatomy through capsular repair.

Muscular Attachments: The Gluteus Minimus, Reflected Head of the Rectus Femoris, and Iliocapsularis Are Dynamic Stabilizers of the Hip

The dynamic capsular stabilizers relevant to the hip arthroscopist include the iliocapsularis, the reflected head of the rectus femoris, and the gluteus minimus. Each of these muscles has direct capsular contributions that are consistent and reproducible. To our knowledge, the location of these muscles has been previously described but the area of each muscular contribution to the capsule has never been documented. The reflected head of the rectus has a mean footprint on the anterosuperior capsule of 26.1 × 10 mm. The iliocapsularis has a narrow but long and consistent contribution along the anteromedial capsule (73 × 16 mm), whereas the gluteus minimus has a very broad and intimate relation with the capsule superolaterally (68 × 28 mm).

Hip Capsular Ligaments: The Iliofemoral, Ischiofemoral, and Pubofemoral Ligaments Are Static Stabilizers of the Hip

The capsular hip ligaments include the iliofemoral ligament (ILFL), ischiofemoral ligament, and pubofemoral ligament. These ligaments were neither identified nor dissected in our study, but several recent studies have described the details of these ligaments with respect to their origins, insertions, and overall capsular locale. Martin et al. sought to detail the specific anatomy of the ILFL with special attention paid to its 2 distinct arms: the lateral-horizontal (ILFL-h) and the medial-vertical (ILFL-v). They described the course of each arm as it spanned the capsule and inserted distally onto the intertrochanteric line of the femur. The lateral arm was found to originate superior to the medial arm, travel horizontally along the neck of the femur, and insert along the anterior greater trochanteric crest. The medial arm was noted to travel more vertically, with termination at the distal-medial aspect of the intertrochanteric crest. Whereas the ILFL’s general anatomy and course across the anterior capsule have been studied, the contribution of this ligament to anterior capsular thickness has not been described. Moreover, the intimate topographic relation that exists between the dynamic (gluteus minimus and iliocapsularis) and static (ILFL) stabilizers of the anterior hip capsule and their contributions to capsular thickness patterns have not been detailed.

Along the capsular origin, we know that the horizontal and vertical ILFL arms arise from a common origin that spans the superior to anterosuperior region. Our data show that some of the thickest capsular origin spans this region and this thickness reflects contributions from the common origin of the ILFL as previously described, as well as the reflected head of the rectus (Table 2). When viewed from the central compartment, we found this region of the capsular origin to have the smallest intracapsular recess and largest overall thickness (Table 2). Our data on this intracapsular recess are in agreement with an eloquent magnetic resonance imaging study recently performed that detailed the depth of the perilabral recess among patients with femoroacetabular impingement (FAI). The surgical implications of these anatomic findings are 2-fold. The small intracapsular recess and thickened confluence of the ILFL and reflected head of the rectus make this region of capsular tissue particularly difficult

Fig 4. Anterior view of right hip capsule after dissection of precapsular and reflected fat pads. For orientation, the greater trochanter (GT), anterior superior iliac spine (ASIS), anterior inferior iliac spine (AIIS), lesser trochanter (LT), and anterior capsule (c) are labeled. The iliocapsularis (ic) is seen originating from the anterior aspect of the hip capsule, beginning just inferior to the AIIS, and inserting just distal to the LT (arrows). An Aufranc retractor has been placed underneath the rectus femoris (asterisks) to more clearly show the broad capsular attachment of the iliocapsularis, and the gluteus minimus muscle (gm) is visualized laterally with a broad capsular attachment (arrows).
to mobilize without release. Consequently, an interportal capsulotomy that releases a portion of this thickened confluence is performed in the majority of cases as the first step in achieving mobility within the central compartment. Despite its common use, a literature search for iatrogenic dislocation after hip arthroscopy performed in the setting of limited interportal capsulotomies turned up just a few isolated reports, all of which occurred in dysplastic “at-risk” patients.\(^{19,20}\) This suggests that in an individual with normal anatomy, a limited interportal capsulotomy alone does not contribute to the gross instability that has been observed more recently among patients undergoing hip arthroscopy with extended lateral capsulotomies.\(^{7,10}\) Our data suggest that the broad muscular contributions of the gluteus minimus and iliocapsularis along the thickened medial capsular origin may be protective, especially in the setting of limited interportal capsulotomy performed without repair.

We found the thickness of the anterior half of the capsule to be in agreement with what has been previously observed.\(^{1,17}\) In all specimens, the capsule was significantly thinned in its direct anterior and anteroinferior quadrants along the midcapsular and acetabular quadrants (Tables 2 and 3). Whereas the horizontal limb of the ILFL contributes to anterosuperior capsular thickening, the vertical limb of the ILFL and iliocapsularis contribute to anteromedial and anteroinferior capsular thickening relative to the inferior quadrants that spans along the midcapsular and femoral insertion. This relative thickening of the anterior capsule has been observed elsewhere in the literature but has not been quantified.\(^{11,17,18}\) Our measurements of anterior capsular thickness along its insertion on the intertrochanteric line show regional thickenings corresponding to the lateral insertion points of the ILFL limbs. In fact, the capsule along the anterior half of the femoral insertion is nearly 2 times thicker than any other portion of the femoral insertion (Table 4).

**Table 1. Dimensions of Capsular Contributions From Pericapsular Muscles and Tendons**

<table>
<thead>
<tr>
<th>Muscle or Tendon</th>
<th>Dimensions (mm)*</th>
<th>Capsular Origin Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iliocapsularis</td>
<td>73.8 (±27.3) × 16.1 (±4.4)</td>
<td>Anteromedial</td>
</tr>
<tr>
<td>Indirect head of rectus</td>
<td>26.1 (±11.0) × 10.1 (±3.8)</td>
<td>Anterosuperior</td>
</tr>
<tr>
<td>Gluteus minimus</td>
<td>68.8 (±30.5) × 28.1 (±9.9)</td>
<td>Superolateral</td>
</tr>
<tr>
<td>Piriformis</td>
<td>No contribution</td>
<td></td>
</tr>
<tr>
<td>Conjoint tendon</td>
<td>18.6 (±5.6) × 9.4 (±2.9)</td>
<td>Posterosuperior</td>
</tr>
<tr>
<td>Obturator externus</td>
<td>20.8 (±8.1) × 14.5 (±5.7)</td>
<td>Posteroinferior</td>
</tr>
</tbody>
</table>

*Data are given as mean (±standard deviation).

**Table 2. Acetabular-Sided Capsular Measurements: Intra-Articular Distance of Hip Capsular Origin From Bony Acetabular Rim and Width and Thickness of Capsular Origin**

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance From Bony Acetabular Rim (mm)*</th>
<th>Capsular Thickness (mm)*</th>
<th>Width of Origin (mm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>6.0 (±3.3)</td>
<td>1.8 (±1.2)</td>
<td>8.1 (±2.8)</td>
</tr>
<tr>
<td>Posteroinferior</td>
<td>5.6 (±2.8)</td>
<td>1.7 (±0.9)</td>
<td>7.1 (±1.0)</td>
</tr>
<tr>
<td>Inferior</td>
<td>5.2 (±4.5)</td>
<td>1.5 (±0.6)</td>
<td>6.2 (±4.2)</td>
</tr>
<tr>
<td>Anteroinferior</td>
<td>4.8 (±3.8)</td>
<td>1.3 (±0.6)</td>
<td>5.4 (±2.9)</td>
</tr>
<tr>
<td>Anterior</td>
<td>5.3 (±3.3)</td>
<td>1.3 (±0.6)</td>
<td>4.9 (±1.5)</td>
</tr>
<tr>
<td>Anterosuperior</td>
<td>3.4 (±1.8)</td>
<td>2.2 (±1.6)</td>
<td>5.5 (±3.7)</td>
</tr>
<tr>
<td>Superior</td>
<td>4.6 (±3.1)</td>
<td>3.7 (±2.2)</td>
<td>8.8 (±3.3)</td>
</tr>
<tr>
<td>Posteroinferior</td>
<td>5.6 (±3.5)</td>
<td>4.0 (±3.0)</td>
<td>8.2 (±0.8)</td>
</tr>
</tbody>
</table>

*Data are given as mean (±standard deviation).

**Fig 5.** (A) Superior, or bird’s-eye, view of posterior aspect of a right hip specimen before dissection of pericapsular muscles and tendons. The greater trochanter (GT), lesser trochanter (LT), ischium, and capsule (asterisk) have been labeled for orientation. The gluteus minimus (gm), conjoint (cj), and obturator externus (oe) muscles all have consistent capsular attachments, whereas the piriformis (pf) runs along the posterior aspect of the capsule but does not have any capsular attachment. (B) Superior, or bird’s-eye, view of same specimen. The piriformis (pf), conjoint (cj), and obturator externus (oe) muscles have now been dissected off of the capsule and reflected laterally to expose the underlying capsule. The gluteus minimus (gm) muscle and tendon have been removed from the specimen. The capsular attachments of the gluteus minimus (gm), conjoint (cj), and obturator externus (oe) are outlined in green. The greater trochanter (GT) and ischium are labeled for orientation.
Capsular Origin and Insertion

We describe the origin and insertion of the capsule with respect to both intra- and extra-articular osseous landmarks. The average distance of the capsular origin to the bony acetabular rim of a right hip anteriorly, anterosuperiorly, and superiorly (3, 2, and 12 o’clock, respectively) is 5.3 mm, 3.4 mm, and 4.6 mm, respectively (Table 2). The 12-o’clock (superior) to 3-o’clock (anterior) positions in a right acetabulum or 9-o’clock to 12-o’clock positions in a left acetabulum encompass a large majority of pathology seen in the management of pincer-type FAI. In addressing these deformities, the distance that the bony acetabular rim can be resected before one can expect to encounter the capsular origin is between 3.4 mm at its closest anterosuperiorly and 5.3 mm at its farthest anteriorly.

Laterally, we describe the insertion points of the capsule along the intertrochanteric line of the femur with respect to its distance from the chondral head-neck junction. In agreement with other anatomic studies, we found the capsule to attach anteriorly to the intertrochanteric line, superiorly to the base of the femoral neck, posteriorly superomedial to the intertrochanteric crest, and inferiorly to the femoral neck near the lesser trochanter. Our data on the distance of the anterior capsular attachment along the intertrochanteric line from the chondral head-neck junction were consistent with those of the authors of a pilot study on FAI patients (Table 4). Knowledge of these dimensions may add intraoperative perspective when one is addressing the cam component of FAI from the peripheral compartment. Resections of large osteochondral deformities along the anterosuperior region of the head-neck junction may require extended lateral capsular release. Our data suggest that release along the anterolateral neck to a distance of 2 cm lateral to the head-neck junction can be performed without violating the distal femoral capsular insertion. Any lateral extension of capsular takedown beyond 2 cm in this region may damage the capsular insertion or endanger the terminal ascending branch of the lateral femoral circumflex artery, which traverses this region.

Capsular Thickness

The thickest portion of the capsular origin along the acetabulum lies between the posterosuperior and anterosuperior zones (Fig 1A, Table 2). Previous studies

<table>
<thead>
<tr>
<th>Location</th>
<th>Thickness of Femoral Insertion (mm)</th>
<th>Distance From Chondral Head-Neck Junction (mm)</th>
<th>Width of Capsular Insertion (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>0.7 (±0.5)</td>
<td>20.8 (±5.6)</td>
<td>2.1 (±1.0)</td>
</tr>
<tr>
<td>Posteroinferior</td>
<td>0.9 (±0.4)</td>
<td>26.8 (±7.1)</td>
<td>2.6 (±1.2)</td>
</tr>
<tr>
<td>Inferior</td>
<td>1.3 (±0.8)</td>
<td>32.1 (±8.0)</td>
<td>7.3 (±3.9)</td>
</tr>
<tr>
<td>Anteroinferior</td>
<td>2.2 (±1.4)</td>
<td>30.5 (±6.3)</td>
<td>6.6 (±2.9)</td>
</tr>
<tr>
<td>Anterior</td>
<td>2.4 (±1.3)</td>
<td>26.5 (±5.9)</td>
<td>5.6 (±3.0)</td>
</tr>
<tr>
<td>Anterosuperior</td>
<td>2.5 (±0.6)</td>
<td>26.1 (±6.6)</td>
<td>5.3 (±2.9)</td>
</tr>
<tr>
<td>Superior</td>
<td>1.3 (±0.7)</td>
<td>22.1 (±5.8)</td>
<td>3.7 (±0.7)</td>
</tr>
<tr>
<td>Posterosuperior</td>
<td>1.4 (±0.6)</td>
<td>24.4 (±7.0)</td>
<td>2.6 (±1.2)</td>
</tr>
</tbody>
</table>

NOTE. For these measurements, the capsule was divided into hemi-quadrants as described in Fig 1B. *Data are given as mean (±standard deviation).

Table 3. Capsular Thickness at Its Midpoint

<table>
<thead>
<tr>
<th>Location</th>
<th>Center of Capsule (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>2.0 (±0.6)</td>
</tr>
<tr>
<td>Posteroinferior</td>
<td>1.6 (±0.5)</td>
</tr>
<tr>
<td>Inferior</td>
<td>1.7 (±0.7)</td>
</tr>
<tr>
<td>Anteroinferior</td>
<td>2.0 (±1.2)</td>
</tr>
<tr>
<td>Anterior</td>
<td>2.3 (±1.0)</td>
</tr>
<tr>
<td>Anterosuperior</td>
<td>3.6 (±1.6)</td>
</tr>
<tr>
<td>Superior</td>
<td>3.5 (±1.4)</td>
</tr>
<tr>
<td>Posterosuperior</td>
<td>4.2 (±1.4)</td>
</tr>
</tbody>
</table>

NOTE. For these measurements, the capsule was divided into hemi-quadrants as described in Fig 1A and viewed by the observer from the medial aspect as pictured in Fig 6. *Data are given as mean (±standard deviation).
confirmed that this region corresponds to the common origin of the ILFLs. We found the reflected head of the rectus to consistently insert onto this thick region of the capsular origin from superior to anterosuperior as well. Taken together, these findings suggest an important confluence of static and dynamic stabilizers of the hip capsule, and its location can be precisely determined by using the central or peripheral compartment landmarks we have described.

Finally, in contradistinction to the femoral-sided capsular insertions, some of the thinnest regions of the capsule origin exist along the anterior and anteroinferior acetabulum. It is in this very region that a thickened and inflamed psoas tendon can be found in cases involving internal snapping hip or hip dysplasia. In a healthy hip, anterior capsular contributions to stability and anterior restraint are less important, and this explains the relative ease of anterior capsular resection in exposing the psoas tendon during capsular release and psoas takedown for psoas impingement. Conversely, in the dysplastic hip, the anterior capsule and pericapsular structures play a greater role in providing anterior restraint and are often thickened and hyperemic, making anterior release more difficult.

Traditional Capsulotomy and Repair

Strategies for achieving enhanced exposure through capsular release and repair must begin with an enlightened understanding of the local anatomy of the dynamic and static structures that contribute to the anterior hip capsule, as well as its overall thickness and potential role in hip stability. An elegant approach to these important considerations was recently published. Depending on the planned procedure, the capsulotomy may have lateral extension—beginning just lateral to the anterosuperior labral quadrant and traversing laterally along the femoral neck—or may begin at the anterolateral portal and traverse parallel to the labrum toward the anterior portal. Generally speaking, a parallel, or “interportal,” capsulotomy that connects the anterolateral and anterior portals is used to gain adequate exposure of the periacetabular region during pincer resection and labral repair, whereas lateral capsulotomies are more useful for large femoral head-neck osteochondroplasties or “cam”-type resections. Nearly 50% of FAI involves a mixture of cam- and pincer-type pathology, and to properly address both arthroscopically, many surgeons will use some combination of both interportal and lateral capsular releases to achieve adequate exposure. Previous authors have described their techniques for capsular incision and repair at length. On the basis of our dissections, we believe that larger capsulotomies—though often necessary—pose greater risk to the anterior hip structures and overall stability than previously understood. We believe the risk can be mitigated with careful attention to local anatomy and capsular repair.

Stability Arc

In our dissections, after we cleanly dissected the reflected head of the rectus and precapsular fat pads off of the anterior capsule, the consistent dynamic (muscular) and static (ligamentous) contributions to the anterior capsular region could be appreciated. The ILFL’s horizontal and vertical limbs are the primary static stabilizers of the anterior capsule, and their location and course have been previously detailed. The dynamic capsular contributions include a broad superior and superolateral capsular contribution from the gluteus minimus, a smaller but consistent contribution by the reflected head of the rectus superomedially, and a direct anterior and medial contribution by the iliocapsularis. When viewed from the peripheral compartment, these dynamic and static pericapsular structures, taken together with the inherent capsular thickness itself, form the contents of an arc that we have deemed the “stability arc” (Fig 7). The stability arc lies directly anterior to the femoral head and spans the anterior hip capsule from its acetabular apex to its lateral insertion along the intertrochanteric line. The borders of this arc are outlined by the dynamic (iliocapsularis, reflected head of rectus, and minimus) and static (ILFL’s horizontal and vertical limbs) contributions to the anterior hip capsule as they course parallel to one another from origin to insertion (Fig 7). The stability arc may function similarly to a hammock by cradling the femoral head in at-risk positions and providing restraint to anterior subluxation or dislocation. Persistent dynamic tensioning across the thin anterior capsule that lies within the arc is achieved by the broad capsular thickenings that exist along the insertions of the minimus and iliocapsularis (Fig 7). Of note, the course of the muscular attachment of the gluteus minimus overlies the course of the lateral-horizontal limb of the ILFL (ILFL-h), whereas the muscular attachment of the iliocapsularis runs a similar course to the medial-vertical limb of the ILFL (ILFL-v). Because the ILFL is a primary stabilizer of the hip in extension and external rotation, the duplication of its course by the gluteus minimus and iliocapsularis strengthens the argument that these muscles are dynamic contributors to hip stability. We speculate that a small interportal capsulotomy that runs parallel to the labrum poses little risk to the stability arc because it does not violate the arc complex, which consists of the long proximal and distal lateral arms of the arc and the thin anterior capsule that spans between them (Fig 7). A lateral capsulotomy, by virtue of its incision through a greater portion of the thin anterior capsule that lies within the stability arc, poses a greater risk of postoperative instability. This occurs because the lateral incision has effectively...
dissociated the proximal and distal limbs of the arc. In this case the dynamic muscular contributions of the proximal (gluteus minimus) and distal (iliocapsularis) limbs actually tension their respective superior and inferomedial capsular flaps away from one another, allowing the femoral head to subluxate anterolaterally as it moves into a position of extension and external rotation (Fig 8). This offers a functional explanation for the rise in case reports of postoperative instability that has occurred in the setting of large lateral capsulotomies.

Safe Capsulotomy

The importance of capsular repair has been brought into question following several observations of instability after hip arthroscopy in select patient populations. On the basis of our dissections, we believe the borders of the stability arc can be used as a guide to plan capsular incisions that minimize damage to local anatomy and facilitate repair that more closely restores functional anatomy.

We believe that capsular repair in the setting of a limited interportal capsulotomy may not be necessary in healthy individuals. As we have shown, the medial aspect of the anterior hip capsule is inherently stable because it contains the thickest regions of the capsular origin and receives large and broad contributions from a confluence of dynamic and static stabilizers. Conversely, our data on capsular thickness and its relation to the dynamic and static pericapsular structures provide evidence to suggest that extensive lateral capsulotomy without repair may significantly increase the risk of postoperative instability by dissociating the limbs of the stability arc and greatly diminishing its ability to provide dynamic restraint (Fig 8). When performed at the end of the procedure, capsular repair may function to restore the ability of the stability arc to provide persistent dynamic tensioning of the anterior capsule through the reassociation of its proximal and distal limbs. This is especially true when a
more extensive lateral capsulotomy or some form of combined interportal and lateral capsulotomy has been performed.

We believe that capsular repair should be considered when capsulotomies are performed in the setting of at-risk individuals: patients with dysplasia or laxity, high-level athletes, and cases requiring extensive lateral capsulotomies. Furthermore, any combination of capsulotomy that incorporates an interportal and far lateral component will almost certainly result in a greater risk of postoperative instability, and we believe that the capsule should be repaired in these instances as well.

Future studies are needed to determine the ease and accuracy with which capsulotomy and repair can be performed in a manner that preserves the capsular anatomy and restores function. This study builds on the results of recently published capsular anatomy studies by contributing new details on pericapsular anatomy, capsular thickness, and the potential combined roles of the dynamic and static stabilizers of the anterior hip in maintaining stability. The dynamic and static stabilizers of the anterior hip form an intimate relation with the hip capsule and may play a much more important role in hip stability than previously understood. We believe that our findings show that an intimate anatomic relation exists among the pericapsular structures of the anterior hip and that the functional role of the anterior capsule in hip stability relies on the integrity of these anatomic relations. The importance of capsular repair is becoming increasingly evident, and further biomechanical studies will need to determine whether capsular repair reliably leads to less postoperative instability.

**Limitations**

There are several limitations to our study. The mean age of our cadaveric specimens was 72.3 years. This specimen age does not adequately reflect the age of the average patient undergoing hip arthroscopy, and therefore our data do not account for any changes that the capsular and pericapsular anatomy may undergo as part of the normal aging process. None of the specimens had documentation of any hip pathology or bony evidence of FAI. The precise location and size of the origins and insertions of the capsular and pericapsular structures were documented manually with a digital caliper (Neiko Tools). Whereas 2 separate investigators performed the measurements, they were performed with a high degree of accuracy (±0.02 mm) and excellent measurement reliability (ICC > 0.90).

**Conclusions**

The dynamic pericapsular structures pertinent to the hip arthroscopist include the iliocapsularis, gluteus minimus, and reflected head of the rectus femoris. At the acetabulum, the thickest region of the capsule is posterosuperior and superolateral. At the femoral insertion, the thickest region is anterior.

**Acknowledgment**

The authors thank Sarah Slappey for providing the illustration found in Figure 6.

**References**


