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

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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/m^2 (range, 14.5 to 36.2 kg/m^2). 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.[12] 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.,[2] 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