

Hip Capsulolabral Complex: Anatomy, Disease, MRI Features, and Postoperative Appearance

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The hip is a uniquely constrained joint with critical static stability provided by the labrum, capsule and capsular ligaments, and ligamentum teres. The labrum is a fibrocartilaginous structure along the acetabular rim that encircles most of the femoral head. Labral tears are localized based on the clock-face method, which determines the extent of the tear while providing consistent terminology for reporting. Normal labral variants can mimic labral disease and can be differentiated by assessment of thickness or width, shape, borders, location, and associated abnormalities. The Lage and Czerny classification systems are currently the most well-known arthroscopic and imaging systems, respectively. Femoroacetabular impingement is a risk factor for development of labral tears and is classified according to bone dysmorphisms of the femur (“cam”) or acetabulum (“pincer”) or combinations of both (mixed). The capsule consists of longitudinal fibers reinforced by ligaments (iliofemoral, pubofemoral, ischiofemoral) and circular fibers. Capsular injuries occur secondary to hip dislocation or iatrogenically after capsulotomy. Capsular repair improves hip stability at the expense of capsular overtightening and inadvertent chondral injury. The ligamentum teres is situated between the acetabular notch and the fovea of the femoral head. Initially considered to be inconsequential, recent studies have recognized its role in hip rotational stability. Existing classification systems of ligamentum teres tears account for injury mechanism, arthroscopic findings, and treatment options. Injuries to the labrum, capsule, and ligamentum teres are implicated in symptoms of hip instability. The authors discuss the labrum, capsule, and ligamentum teres, highlighting their anatomy, pathologic conditions, MRI features, and postoperative appearance.

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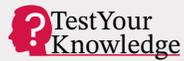
Introduction

The hip is a ball-and-socket joint consisting of the cuplike acetabulum, which receives the spherical femoral head. It is a uniquely constrained joint, in large part due to large-volume coverage of the femoral head by the acetabulum. Static stability is further provided by three important soft-tissue structures: the labrum, capsule and capsuloligamentous complex, and ligamentum teres (Fig 1).

The labrum and capsule are critical components of the joint’s strong suction mechanism, maintaining the intra-articular hydrostatic pressure necessary to contain the fluid within the central compartment (1). The capsule and capsular ligaments allow a full range of motion but restrict movements that predispose to subluxation and dislocation. The ligamentum teres is a secondary stabilizer of the hip, supplementing the capsular ligaments by acting as a “sling” to prevent subluxation of the femoral head at the extremes of motion.



Supplemental Material



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Abbreviations: FAI = femoroacetabular impingement, ILFL = iliofemoral ligament, ISFL = ischiofemoral ligament, MRA = MR arthrography, PDFS = proton density-weighted fat-suppressed, PFL = pubofemoral ligament, T1FS = T1-weighted fat-suppressed

TEACHING POINTS

- By convention, labral tears are localized based on the clock-face method, where 3 o'clock is anterior (demarcating the anterior superior and anterior inferior quadrants), 6 o'clock is the transverse ligament, and 12 o'clock is the superior apex of the acetabulum. This was shown to be an accurate method that matches the arthroscopist's localization and impression of the extent of labral tears, thereby providing a standardized method of reporting.
- In contradistinction to labral tears, which are irregular and extend into the labral substance, the margins of the labrum at the interface with a sulcus will be smooth. Other features that favor a sulcus over a tear are less than one-half labral width fluid signal intensity between the base of the labrum and the acetabular rim; linear shape; absence of regional paralabral, cartilage, or osseous abnormalities; and posterior inferior quadrant location.
- In contrast to the native labrum, increased signal intensity in the operated labrum that surfaces is not necessarily a re-tear and may represent granulation tissue or a healed tear. Increased fluid- or gadolinium-intensity signal within the labrum that surfaces, extension of labral abnormality beyond the suture anchor zone or beyond the margins of the original tear, paralabral cyst, and labral distortion are signs of a re-tear.
- Capsular lesions in the absence of traumatic hip dislocation may be related to open or arthroscopic capsulotomy or capsular dehiscence. In the absence of capsular repair, postoperative changes to the adjacent structures, capsular irregularity, edema, or a frank defect may indicate the site of arthroscopy trocar placement. Capsular dehiscence is a possible complication of capsular repair. It is appreciated at MRI as a disrupted or discontinuous pseudocapsule, often characterized by a fluid-filled gap with or without associated pseudocapsular thickening and hyperintensity.
- Iatrogenic instability is a rare postarthroscopy complication. Osseous risk factors include excessive bone removal during acetabular rim resection or femoral osteoplasty. Large capsulotomies without capsular repair and nonhealing capsular defects from previous arthroscopy are examples of soft-tissue risk factors.

The size, variable form, and orientation of these stabilizers, along with close apposition of the joint's articular surfaces, make imaging evaluation challenging. Furthermore, the advent of hip arthroscopy has increased recognition of numerous pathologic conditions affecting these structures, requiring careful scrutiny by the radiologist. This article discusses the labrum, capsule, and ligamentum teres, emphasizing their anatomy, pathologic conditions, MRI features, and postoperative appearance. Hip instability, a source of much controversy and debate, is also discussed, highlighting the terminology and classification.

Imaging Considerations

Conventional radiography remains the first line of imaging for investigation of all hip disorders. In the context of capsulolabral structures, it allows evaluation of osseous dysmorphisms that may predispose to labral tears or hip instability,

including "cam" and "pincer" femoroacetabular impingement (FAI), hip dysplasia, and osteoarthritis. US is useful in screening for tendon disease, muscle tears, joint effusion, and periarticular fluid collections. CT, with its cross-sectional capability and strong depiction of osseous morphology, allows characterization of hip dysplasia and cam or pincer deformities in multiplanar and three-dimensional forms (Fig S1). In patients who are candidates for joint-preservation surgery, it also enables calculation of important metrics such as acetabular and femoral version (2).

MRI remains the imaging tool of choice for direct evaluation of the labrum, capsular ligaments, and ligamentum teres (3). Optimized protocols include a dedicated surface coil, targeted field of view, thin section thickness, and high in-plane resolution to depict the anatomy and disease of these small structures. The addition of three-dimensional acquisitions that use isotropic voxels (voxels with the same dimensions in the x, y, and z planes) enables images to be reconstructed in any plane (4). Radial reconstructions, specifically, generate images oriented perpendicular to the curvature of the joint, hence providing true cross sections of all quadrants of the joint. They are unhindered by partial-volume effects, optimizing depiction of cartilage and the labrum, which is particularly important in investigation of FAI (5).

Visualization of capsulolabral structures is further improved by combining MRI with intra-articular contrast material or MR arthrography (MRA). Compared with the standard of reference of arthroscopy, MRA exhibits specificity, sensitivity, and accuracy of 100%, 92%–100%, and 93%–96%, respectively, for diagnosing labral tears (6–8). Recent studies have demonstrated that conventional or nonarthrographic 3-T MRI may be adequate for evaluation of the labrum (9–11).

A study of 38 patients with suspected FAI found a specificity of 50% but sensitivity, accuracy, positive predictive value, and negative predictive value of 98%–100% for nonarthrographic MRI with arthroscopy as a standard of reference (9). Another investigation of 68 patients with FAI also found that conventional 3-T MRI is equivalent to 1.5-T MRA for detecting labral tears (12). A recent meta-analysis found that the sensitivity of 3-T MRI was close to that of MRA (pooled sensitivity of 80% vs 89%) and its specificity was higher than that of MRA (pooled specificity of 77% vs 69%) (11).

At our institution, conventional 3-T MRI has replaced MRA as the workhorse for initial evaluation of hip internal derangement. We reserve MRA for evaluating a postoperative hip or young adults with persistent pain and normal results of 3-T MRI. MRA is the preferred technique for detecting hip capsular and ligamentum teres abnormalities (13,14). An investigation by Tomasevich et al (13) found that the sensitivity for detecting hip capsular defects after hip arthroscopy was significantly higher for MRA compared with MRI (87.5% vs 50%, respectively). MRA also shows sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for detection of ligamentum teres tears of 78%, 97%, 74%, 97%, and 95%, respectively (15). The axial oblique plane is particularly useful for differentiating grades of ligamentum teres injuries and improving specificity for differentiation of partial and complete tears (14).

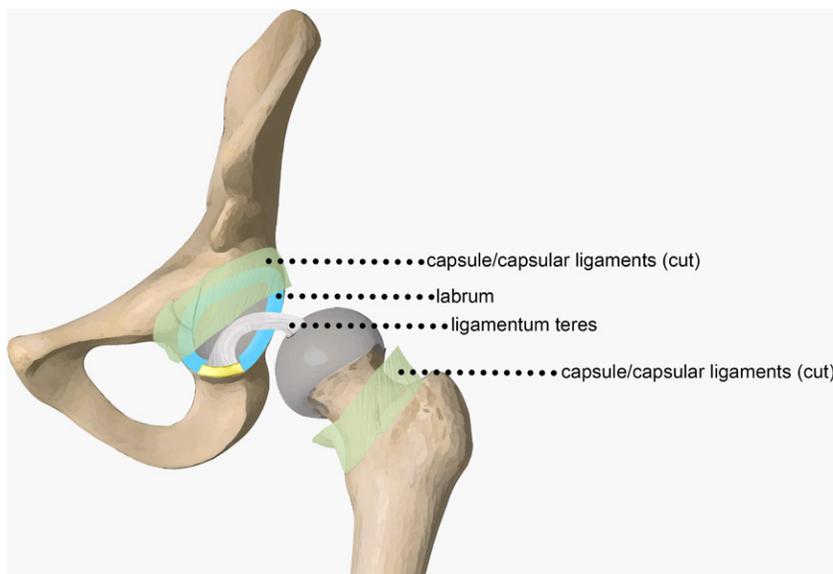


Figure 1. Graphic illustration depicts the capsulolabral complex of the hip.

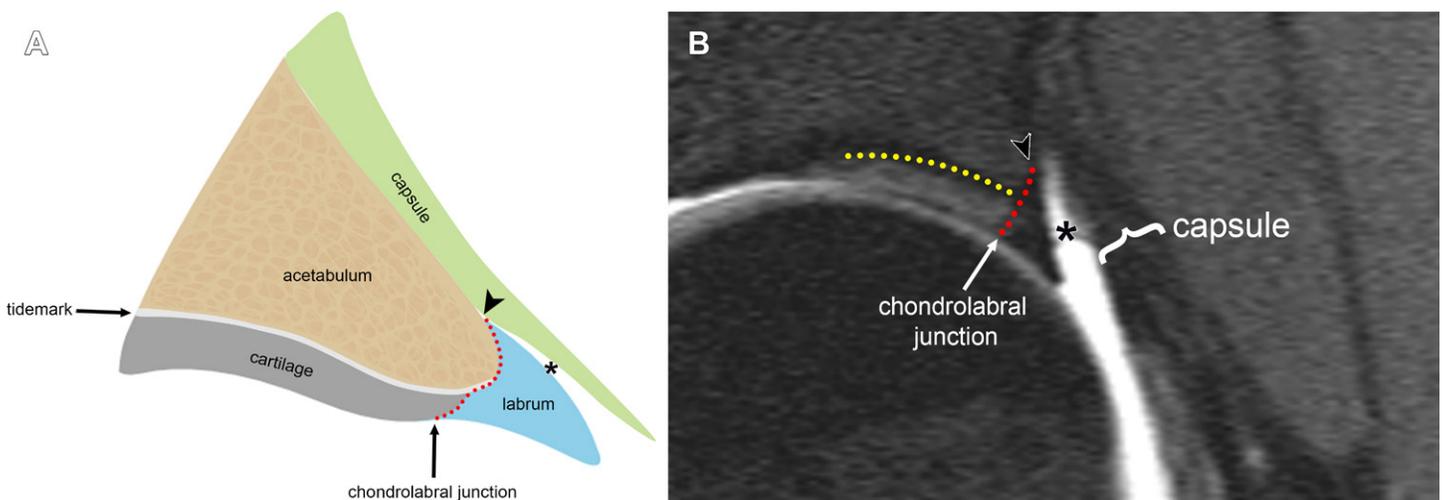


Figure 2. Normal labral anatomy. * = paralabral recess, arrowhead = osseolabral junction, red dotted line = labral base. **(A)** Graphic illustration shows normal labral anatomy. **(B)** Coronal T1-weighted fat-suppressed (T1FS) MR arthrogram in a 39-year-old healthy asymptomatic volunteer shows normal labral anatomy. Yellow dotted line = tidemark.

Acetabular Labrum

The labrum is typically triangular in cross section and is fixed to the acetabulum at its base (Fig 2). The base has dual attachment, spanning both the hyaline cartilage (chondrolabral) and the acetabular bone (osseolabral). At its chondral attachment, the labrum strongly adheres to the acetabular rim via a zone of calcified cartilage known as the tidemark (16).

The chondrolabral junction has a variable degree of blending and even overlap of the labrum with acetabular hyaline cartilage. The labrum terminates anteroinferiorly and posteroinferiorly, where it is bridged by the transverse acetabular ligament. Except for the region closest to the capsule, the labrum is poorly vascularized, limiting its ability to heal once torn (17).

MRI of the Labrum

The normal labrum typically has diffuse low signal intensity with all MRI sequences. Intrasubstance intermediate or high signal intensity can be seen in healthy individuals and may

represent mucoid degeneration, fibrovascular bundles, or magic angle artifact (3). The anterior superior labrum is most prone to signal intensity variations, including globular, linear, or curvilinear shapes (18).

The labrum is often triangular (66%–69%), although round (11%–16%) and flat (9%–13%) shapes have been reported (18). By convention, labral tears are localized based on the clock-face method, where 3 o'clock is anterior (demarcating the anterior superior and anterior inferior quadrants), 6 o'clock is the transverse ligament, and 12 o'clock is the superior apex of the acetabulum (Fig 3) (19). This was shown to be an accurate method that matches the arthroscopist's localization and impression of the extent of labral tears, thereby providing a standardized method of reporting (19).

Labral Variants

Aside from variations in shape and signal intensity, grooves or spaces formed by the labrum with either cartilage (sublabral

Figure 3. Clock-face localization of the acetabular labrum. Graphic illustration (A) and sagittal T1-weighted fat-suppressed MR image (B) show clock-face localization of the acetabular labrum. The transverse acetabular ligament (highlighted in yellow) is assigned as 6 o'clock, with the acetabulum divided into quadrants: 3 o'clock is anterior, 9 o'clock is posterior, and 12 o'clock is superior (apex of the acetabulum).

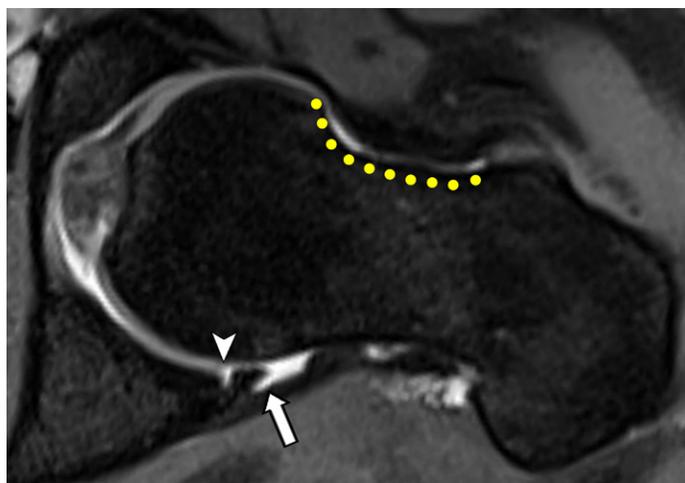
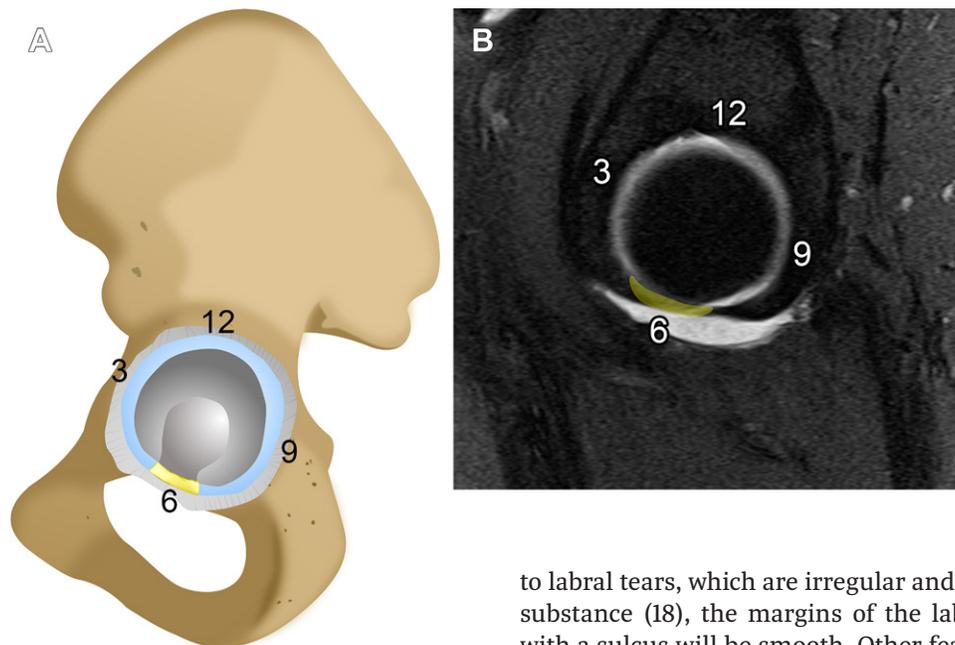


Figure 4. Sublabral sulcus. Axial oblique proton density-weighted fat-suppressed (PDFS) MR image in a 22-year-old woman with hip discomfort after anterosuperior labral repair and osteochondroplasty and with clinical concern for a retear shows a posterosuperior sublabyrinthic sulcus (arrowhead). There is also an adjacent paralabyrinthic recess (arrow). Yellow dotted line = osseous defect from prior osteochondroplasty. Results of arthroscopy were negative for a labral retear.

sulci) or the capsule (paralabyrinthic recess) can be confused with a labral tear (18,20); these are particularly conspicuous with the distention effect of MRA. Sublabral sulci are present in as many as 25% of patients and can be found in all anatomic positions, the most common being posterior superior (48%) (Fig 4) and anterior superior (44%) (18). In contradistinction

to labral tears, which are irregular and extend into the labral substance (18), the margins of the labrum at the interface with a sulcus will be smooth. Other features that favor a sulcus over a tear are less than one-half labral width fluid signal intensity between the base of the labrum and the acetabular rim; linear shape; absence of regional paralabyrinthic, cartilage, or osseous abnormalities; and posterior inferior quadrant location (20,21).

The junction of the transverse ligament overlapping with the acetabular labrum can also form a normal recess (Fig 5). It is more common anteriorly (33%) and can be confused with a labral tear or antero-inferior labral-ligamentous detachment (18). The paralabyrinthic recess refers to the space between the capsule and the labrum (Fig 6) and can be confused with a paralabyrinthic ganglion cyst. While the capsule inserts directly at the base of the labrum along the anterior and posterior margins of the labrum, it attaches several millimeters above the labrum along the superior margin, thereby making this recess most obvious on coronal sections (18).

Labral Abnormalities

Labral abnormalities are readily demonstrated at MRI. A degenerated labrum may manifest with increased size, increased intrasubstance signal intensity, or surface irregularity (22). Labral tears occur either through its substance or in the form of a detachment of the base from the adjacent acetabulum; up to 90% of cases represent labral detachments (23). Substance tear manifests with increased signal intensity or contrast material through the labral substance surfacing the articular surface, capsular surface, or both (22,23). Approximately 28% of tears may exhibit signal intensity less than that of gadolinium contrast material or fluid, possibly due to either granulation tissue or volume averaging (24).

With labral detachments, increased signal intensity or contrast material undercuts the base of the labrum, insinuating between the labral base and acetabular rim either partially or

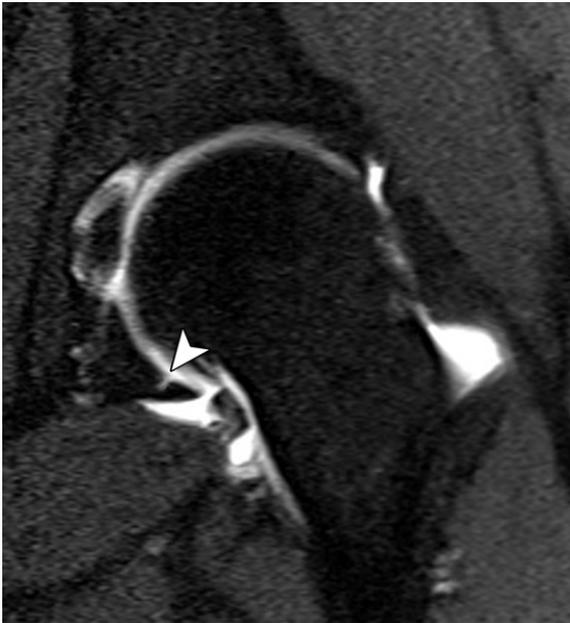


Figure 5. Transverse ligament–labral junction recess. Coronal T1FS MR arthrogram in a 38-year-old healthy asymptomatic volunteer shows contrast material (arrowhead) at the junction between the transverse ligament and labrum, consistent with a transverse ligament–labral junction recess.



Figure 6. Paralabral recess. Coronal T1FS MR arthrogram in a 26-year-old female asymptomatic volunteer shows contrast material (arrowhead) through the paralabral recess, an anatomic space created between the joint capsule and labrum.

completely (25). The evolution of labral detachment typically begins at the chondrolabral junction. In the earliest stages, there may be attrition of labral tissue in this region, with fluid imbibition between the labrum and hyaline cartilage—referred to as chondrolabral separation—or a partial labral detachment. The separation may extend peripherally toward the direction of the capsule, resulting in additional disruption of the osseolabral junction or a complete detachment of the labrum from the acetabular rim (26).

The chondrolabral junction is of particular interest in the context of cam-type impingement, as it serves as the first site of derangement secondary to shear force and compression injury of the hyaline cartilage (26). This may result in chondral delamination leading from the chondrolabral junction and coursing inward (26), the so-called carpet lesion (27).

Classification systems for labral disease exist in both the orthopedic and radiology literature. The Lage classification is the most well-known arthroscopic system and organizes labral tears as flap, fibrillated, longitudinal peripheral, or unstable (28). Czerny et al (29) devised an MRA classification for labral disease based on location: within the substance (types 1 and 2) or attachment (type 3) (Table, Fig 7). Labral tears can be substance type (type 2) or detachment type (type 3); the authors found that types 2 and 3 exhibit excellent correlation with arthroscopic findings. On the other hand, Blankenbaker and colleagues (19) found no correlation between the Czerny and Lage classifications. The authors also recommended describing the labral abnormality rather than attempting to correlate it directly with the Lage classification (19).

At our institution, labral disease is usually imaged using conventional 3-T MRI. Following this protocol and incorpo-

rating recommendations by previous authors (19), we use the following terminology for describing common labral pathologic conditions: (a) degeneration = increased intrasubstance signal intensity without surfacing, (b) substance tear = increased intrasubstance signal intensity extending to the capsular or articular surface of the labrum, (c) partial detachment tear = partial-width increased signal intensity extending between the base of the labrum and acetabular rim at the chondrolabral or osseolabral junction, (d) complete detachment tear = increased signal intensity between the labrum and acetabular rim extending across the full width of the labral base, and (e) complex tear = multidirectional or multiple increased-signal-intensity tear lines, extending to both the deep articular and capsular surfaces (Fig 8) (22).

Chronic labral tear and degeneration can result in labral ossification, which may exacerbate impingement symptoms. At MRI, ossification appears as a small focus of signal intensity similar to that of bone marrow (26)—although it may even be occult—and is therefore best evaluated on radiographs or T1-weighted images (Fig 9). The presence of ossification should be reported, as it may lead to a more difficult repair, making labral débridement the optimal approach (30).

Contrary to tears in its glenoid counterpart, acetabular labral tears most commonly occur in the anterior superior quadrant (23). Tears of the posterior superior quadrant (Fig 10) are usually seen in younger patients, in dysplastic hips, or after a posterior hip dislocation (19). Posterior inferior labral tears (Fig 11) are rare and should not be confused with the relatively common normal groove or sulcus, which is well depicted at MRA (31).

Classification of Labral Injuries at MRA

Stage 0	Homogeneous low signal intensity Triangular labrum Recess between the joint capsule and labrum is visible
Stage IA	Area of increased signal intensity within the labrum that did not extend to the margin of the labrum Triangular labrum Recess between the joint capsule and labrum is visible
Stage IB	Stage IA Thickened or deformed labrum Recess between the joint capsule and labrum is not visible
Stage IIA	Extension of contrast material into the labrum without detachment Recess between the joint capsule and labrum is visible
Stage IIB	Stage IIA Thickened or deformed labrum Recess between the joint capsule and labrum is not visible
Stage IIIA	Labral detachment Triangular labrum Recess between the joint capsule and labrum is visible
Stage IIIB	Stage IIIA plus thickened or deformed labrum Recess between the joint capsule and labrum is not visible

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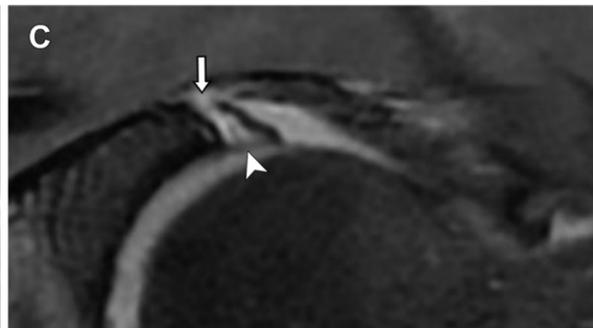
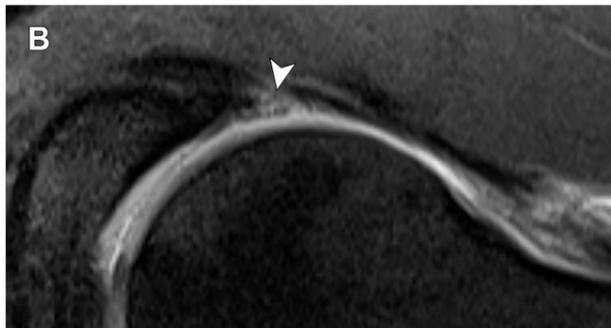
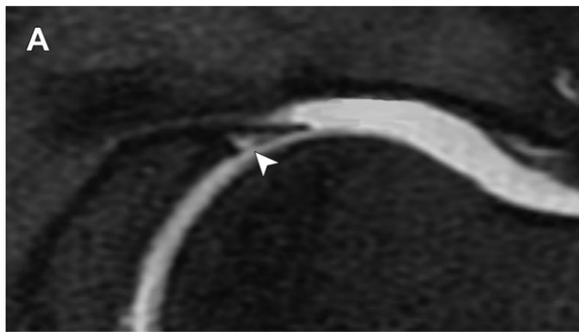


Figure 7. Representative anterior superior labral tears at MRA and their Czerny classifications. **(A)** Axial oblique T1FS MR arthrogram in a 20-year-old woman with daily and progressive left hip pain shows extension of contrast material into the labrum (arrowhead) without detachment, consistent with a Czerny stage IIA labral tear. **(B)** Axial oblique T1FS MR arthrogram in a 40-year-old woman with recalcitrant hip and groin pain shows imbibition of contrast material into the deformed labrum (arrowhead), consistent with a Czerny stage IIB labral tear. **(C)** Axial oblique T1FS MR arthrogram in a 33-year-old woman with clinical suspicion for labral tear shows contrast material-filled expansion of the labrum (arrowhead) with detachment at the osseolabral junction (arrow), consistent with a Czerny stage IIIB labral tear.

A paralabral cyst can arise when synovial fluid leaks through a labral tear cleft and into the periarticular soft-tissue space and becomes encapsulated. It aids in recognition of a labral tear and is often located in the anterior superior quadrant (32). Paralabral cysts usually have low to intermediate signal intensity on T1-weighted images and high signal intensity on T2-weighted images, although signal intensity can vary (33). Owing to their thick gelatinous content, they may not always fill with gadolinium contrast material at MRA (22). A vast majority of paralabral cysts are accompanied by full-thickness labral detachment tears (94%) (Fig 12); the lack of a labral tear thereby raises the possibility of another diag-

nosis, such as synovial cyst, focal synovitis, tumor, or psoas bursal fluid (33).

Femoroacetabular Impingement

FAI is a well-recognized risk factor in the development and evolution of labral tears and hip osteoarthritis. It is associated with anatomic alterations that impair interactions between the femur and acetabulum during motion of the hip joint, predisposing the labrum to tears and articular cartilage to premature degeneration. It is classified according to bone dysmorphism as cam (femoral side), pincer (acetabular side), or a combination of both types (mixed).

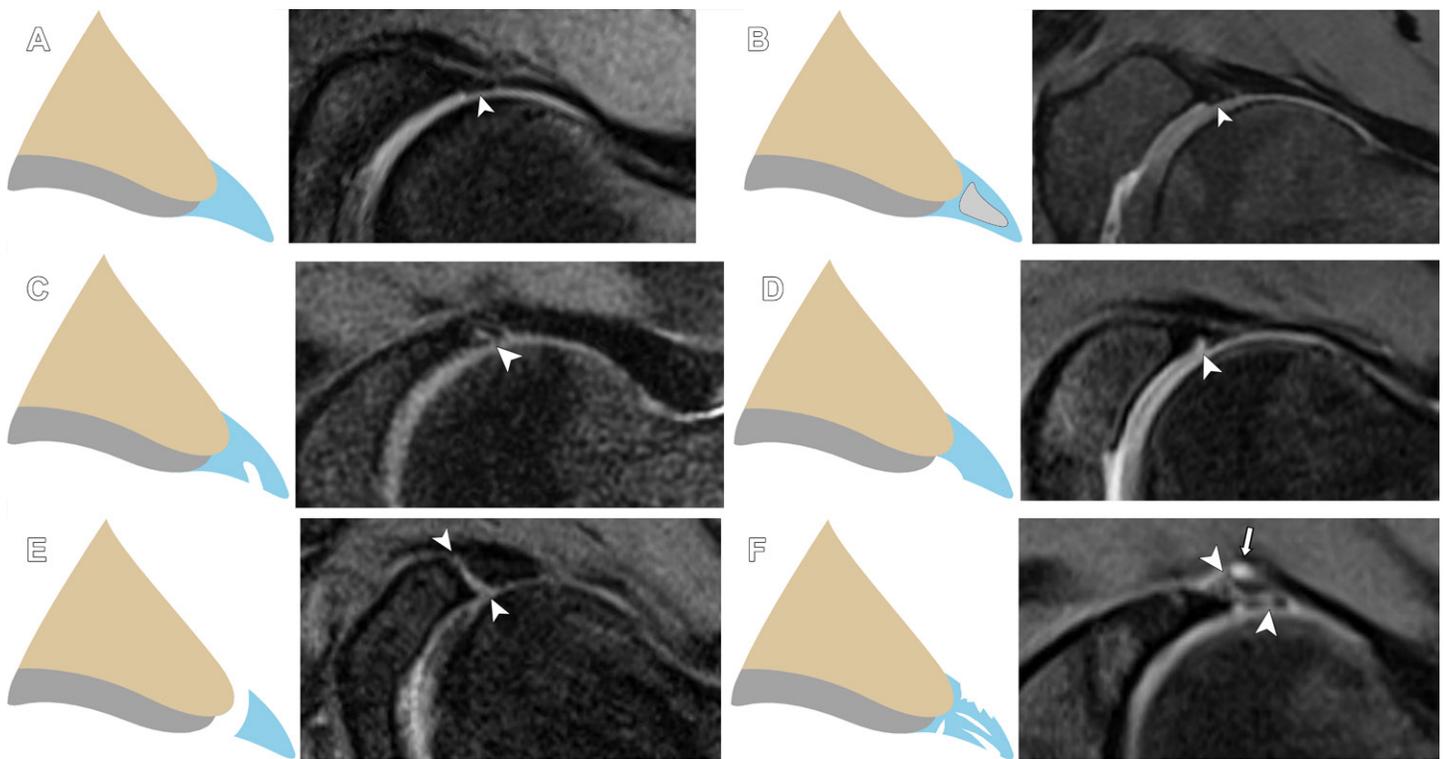


Figure 8. Normal and abnormal anterior superior labrum. **(A)** Graphic illustration (left) and axial oblique PDFS MR image (right) in a 27-year-old asymptomatic volunteer show a normal labrum with homogeneous low signal intensity (arrowhead), preserved triangular shape, and smooth borders. **(B)** Graphic illustration (left) and axial oblique PDFS MR image (right) in a 36-year-old woman with hip pain and clinical concern for labral tear show a small area of increased signal intensity (arrowhead) within the labral substance not reaching a surface, consistent with labral degeneration. **(C)** Graphic illustration (left) and axial oblique PDFS MR image (right) in a 43-year-old woman with symptoms of impingement show focal linear increased signal intensity (arrowhead) within the labral substance breaching the articular surface, consistent with a substance tear. **(D)** Graphic illustration (left) and axial oblique PDFS MR image (right) in a 37-year-old woman with persistent hip pain, query labral tear, show partial-width increased signal intensity (arrowhead) at the chondrolabral junction not extending past the chondrolabral junction, consistent with chondrolabral separation or partial labral detachment. **(E)** Graphic illustration (left) and axial oblique PDFS MR image (right) in a 78-year-old woman with symptoms of impingement show increased signal intensity (arrowheads) extending completely from the chondrolabral junction to the labral base, consistent with complete labral detachment. **(F)** Graphic illustration (left) and axial oblique PDFS MR image (right) in a 51-year-old woman with left hip pain worse with running show multiple increased-signal-intensity lines (arrowheads) extending to both deep articular and capsular surfaces, consistent with a complex tear. A small paralabral cyst (arrow) at the capsular surface is also present.

Cam morphology is characterized by excess bone or cartilage at the femoral head-neck junction, diminishing the femoral head sphericity and head-neck offset. Pincer morphology predisposes to impingement due to overcoverage of the femoral head by the acetabulum. It may be focal, as seen with acetabular retroversion, or global, as is seen with coxa profunda and acetabular protrusio. In cam morphology, labral and chondral disorders occur preferentially in the anterior superior quadrant of the joint. With pincer morphology, abutment of the anterior acetabular rim onto the femoral neck results in focal impaction and tearing of the anterior superior labrum, which eventually extends posteriorly and ultimately circumferentially (34).

Treatment and Postoperative Appearance

Labral disease can be managed with conservative or surgical options. In general, increased labral substance signal intensity that does not breach a surface (degenerative signal intensity) is conservatively managed. While the intraoperative appearance of the labrum (ie, labral quality) (35) is the most

important overall factor affecting surgical decision making, a survey by Herickhoff and Safran (36) showed that surgeons consider MRI or MRA findings to be the most important preoperative factor. Indications to repair a torn acetabular labrum and types of treatment are highly variable among hip arthroscopic surgeons (35,36).

There are three forms of labral surgery: débridement, re-fixation or repair, and reconstruction. Labral débridement involves trimming of frayed and unhealthy tissue, potentially leaving viable tissue with good healing capacity (37,38). Labral re-fixation or repair involves reattachment to the acetabular rim using suture anchors (38). Substance tears are treated with débridement with or without repair, while partial or complete detachments are managed with repair. In cases where there is insufficient labral tissue that precludes adequate repair, such as in a small or diminutive (hypotrophic) labrum less than 3 mm wide, complex tear, or macerated labrum, labrum reconstruction using an auto- or allograft can be performed (38).

A normal postoperative labrum should be firmly affixed to the acetabular rim and remain intact over the suture anchor



Figure 9. Complete labral detachment with ossification in a 32-year-old male cyclist. Coronal T1-weighted (**A**) and PDFS (**B**) MR images show a small focus of ossification (arrow in **A**) adjacent to the superolateral acetabulum with marrow-equivalent signal intensity, consistent with ossification. There is a fluid-filled cleft (arrowhead in **B**) extending completely from the chondrolabral junction to the labral base, consistent with complete labral detachment.



Figure 10. Posterior superior labral tear in a 46-year-old woman with locking and hip pain. Sagittal PDFS MR image shows increased signal intensity within the posterior superior labrum, consistent with a labral tear, with an adjacent small paralabral cyst (arrow).

zone (39). It is typically shorter and diminutive but should remain smooth (40). The sutures themselves should be positioned close to the acetabular rim but should not penetrate the subchondral bone or the articular cartilage (41,42).

Kim and colleagues (43) found obliteration of the paralabral recess in 94%–100% of hip arthroscopy procedures; this may be a normal postoperative finding related to adhesions or scarring (Fig 13) (43), although this finding may be worth reporting in the presence of symptoms (43). In contrast to the native labrum, increased signal intensity in the operated labrum that surfaces is not necessarily a retear and may represent granula-

tion tissue or a healed tear (Fig 14) (22,40). Increased fluid- or gadolinium-intensity signal within the labrum that surfaces, extension of labral abnormality beyond the suture anchor zone or beyond the margins of the original tear, paralabral cyst, and labral distortion are signs of a retear (Fig 15) (40).

The osseous dysmorphism responsible for FAI is usually treated along with the labral tear. The two most important factors to consider in choosing the technique are visualization of the entire lesion to achieve a thorough correction or repair while maintaining the biomechanical function of the joint (44). Osteochondroplasty is the most popular method for managing cam deformities and involves corrective resection of the cam morphology using a high-speed burr (Fig 16) (44). At MRI, the osteochondroplasty bed appears as a smooth defect of variable size at the femoral head-neck junction (45).

Pincer lesions are managed by a labral takedown and acetabular rim resection followed by reattachment of the labrum to the acetabulum with sutures (45). The resected portion appears as a defect or truncation of the acetabular rim with or without sutures from labral surgery (Fig 17). The appearance of labral procedures, osteochondroplasty, and acetabular resection defects may be subtle, at times even mimicking their normal preoperative counterparts, necessitating careful comparison with preprocedure images and operative notes when available.

Capsule and Capsular Ligaments of the Hip

The hip capsule is a critical static stabilizer of the hip and contains both longitudinal and circular fibers (Fig 18) (46). The longitudinal fibers are reinforced by three ligaments: iliofemoral (ILFL), pubofemoral (PFL), and ischiofemoral (ISFL). The ILFL or ligament of Bigelow is the strongest of the three (46), limiting external rotation in flexion and both internal and external rotation in extension. It consists of superior and inferior bands that extend from the lower part of the antero-inferior iliac spine and iliac margin of the acetabulum to the intertrochanteric line, forming a reverse-Y configuration (46).

The PFL stabilizes the joint most notably during abduction. It courses anteriorly from the obturator crest and superior

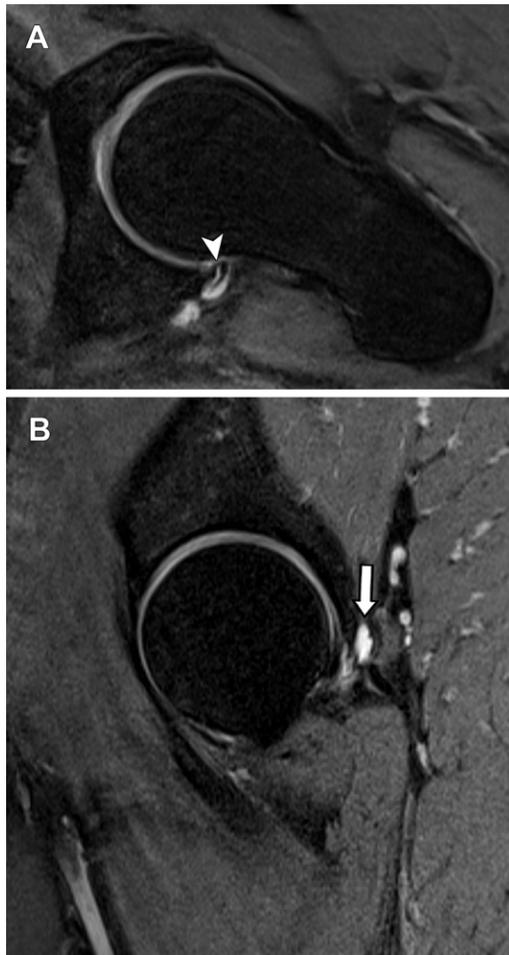


Figure 11. Posterior inferior labral tear in a 48-year-old man with deep left hip pain radiating to the groin. Axial oblique (**A**) and sagittal (**B**) PDFS MR images show a fluid-filled cleft (arrowhead in **A**) with an adjacent cyst (arrow in **B**), consistent with a labral tear with a small paralabral cyst.



Figure 12. Anterior superior labral tear with a paralabral cyst in a 68-year-old woman with right hip pain and an incidental soft-tissue mass at previous CT. Sagittal PDFS MR image shows a prominent fluid-filled cleft (arrowhead) in the anterior superior labrum with an adjacent large cystic mass (arrows), consistent with a complete labral detachment tear with a paralabral cyst.

pubic ramus to the femoral neck adjacent to the lesser trochanter, blending with the inferior fibers of the ILFL. The ISFL contributes to joint stability during extension. It courses from the ischial aspect of the acetabular rim to the greater trochanteric base posterior to the hip.

The zona orbicularis makes up the circular fibers and represents a circumferential capsular thickening attaching superiorly to the femur at the base of the greater trochanter before converging with the superior band of the ISFL (46). It ensheathes the posterior circumference of the femoral neck like a sling and forms the distal free border of the posterior portion of the articular capsule. While conventionally thought to be inconsequential to joint function and biomechanics, recent studies have postulated its roles in restraining joint distraction (47) and circulating synovial fluid between the central and peripheral compartments (46).

MRI of the Capsular Ligaments

At MRI, the capsular structures have homogeneously low signal intensity with all sequences. The ILFL bands and ISFL

are best identified in the axial and axial oblique planes (Fig 19). Coronal sections at the anterior capsule depict the ILFL, while sagittal sections demonstrate the PFL (Fig 20) (48). The zona orbicularis is depicted at both MRI and MRA; intra-articular gadolinium contrast material enhances visualization of the ligament and its synovial folds (49). Although often described as forming a collar around the femoral neck, it appears as a full circle in only 20% of cases (49).

Capsule and capsular ligament injuries usually follow definitive hip dislocations after high-energy contact sport injuries or impaction of the knee against a car dashboard with the hip flexed (50). The direction is frequently posterior, where the head of the femur lies posterior to the acetabulum and the injured lower extremity exhibits shortening, medial (internal) rotation, flexion, and adduction (51). On anteroposterior radiographs, anterior and posterior dislocations may appear similar. However, in a posterior dislocation, the femoral head is usually located posterior, superior, and lateral to the acetabulum (Fig S2).

The precise role of MRI in treatment algorithms for acute hip dislocation is not clearly defined, but it may be useful in early recognition of soft-tissue injuries (Fig 21) (52) and detection of intra-articular damage such as chondral injury, labral tear, or missed intra-articular body (53). The imaging triad of posterior acetabular lip fracture, ILFL disruption, and hemarthrosis was found to be pathognomonic of posterior hip dislocation in a case series of eight football players (54).

Anterior dislocation is far less common, occurring in less than 8% of traumatic hip dislocations (52). The mechanism of injury is forced hip abduction and external rotation; the femoral head dislocates anteroinferiorly when the hip is flexed

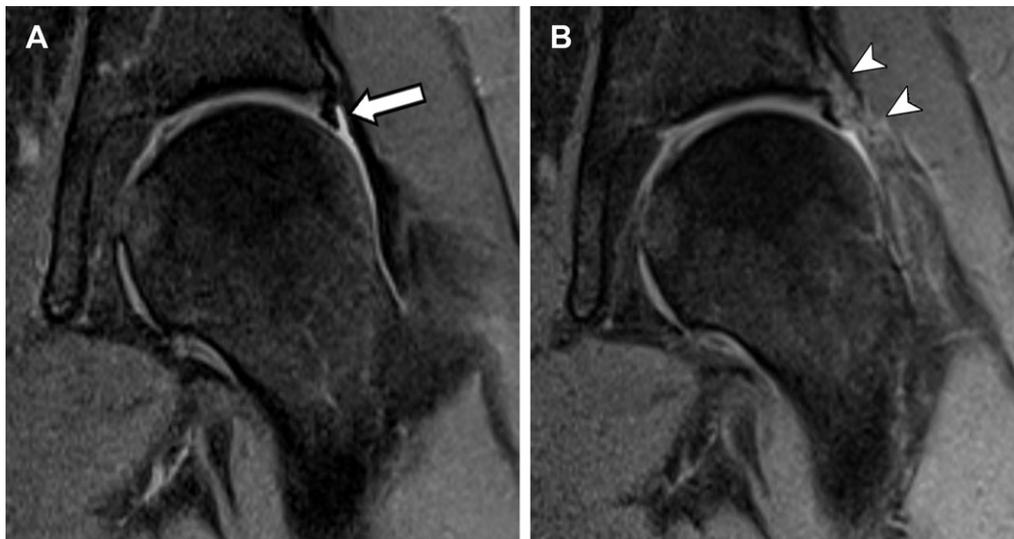


Figure 13. Postoperative obliteration of the paralabral recess in a 40-year-old woman with persistent limited range of motion after labral repair. Coronal PDFS MR images before (**A**) and 1 year after (**B**) arthroscopic labral repair show obliteration of the previously intact superior paralabral recess (arrow in **A**) and replacement with ill-defined intermediate-signal-intensity tissue (arrowheads in **B**), most in keeping with fibrosis or scarring.

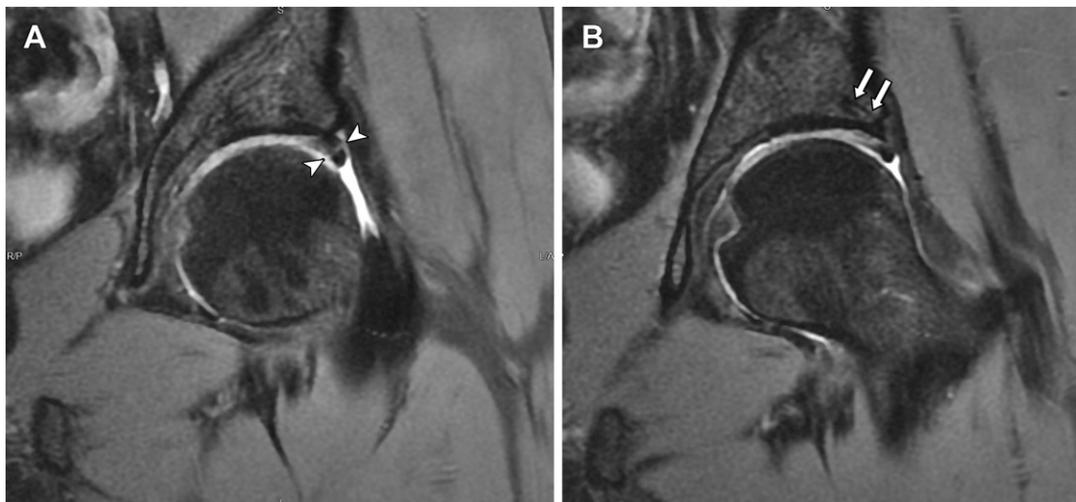


Figure 14. Normal postoperative labrum in a 48-year-old woman imaged for assessment of a retear. Sequential PDFS MR images at a more anterior (**A**) and posterior (**B**) level show signal intensity within the labrum that surfaces to both capsular and articular sides (arrowheads in **A**), which may be worrisome for a retear in a native labrum. The suture anchors are placed close to the acetabular rim (arrows in **B**) but do not breach the subchondral bone or articular cartilage. Arthroscopy demonstrated an intact posteroperative labrum.

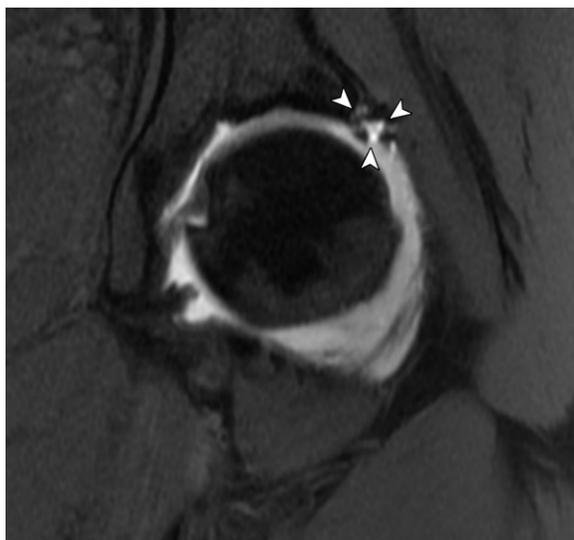


Figure 15. Labral retear in a 36-year-old woman. Coronal T1FS MR arthrogram shows distortion of the anterior superior labrum with imbition of contrast material (arrowheads), consistent with a labral retear.

and anterosuperiorly when the hip is extended (52). The transverse ligament, ligamentum teres, posterior capsule, and PFL may be injured in anterior inferior dislocations (52). Data on anterior superior dislocations are limited, although injuries to the ligamentum teres, ILFL, and superior capsule have been reported (52).

Postoperative Appearance

Capsular repair or tightening procedures have yet to gain universal acceptance among hip surgeons, even though a vast majority of high-volume arthroscopists recommend them for capsular redundancy or laxity or after arthroscopy (55). These procedures improve hip stability and decrease the risk of postoperative hip dislocation at the expense of iatrogenic femoral head chondral damage, capsule overtightening, and hip infection due to longer exposure time.

Capsular repair or plication uses sutures to close the capsular “bare area” at the site of prior arthroscopy. It is recommended for capsular redundancy, symptomatic capsular laxity, or generalized ligamentous laxity due to an underlying connective tissue disorder or after arthroscopy (56). At MRI, the repaired capsule is usually significantly thicker through

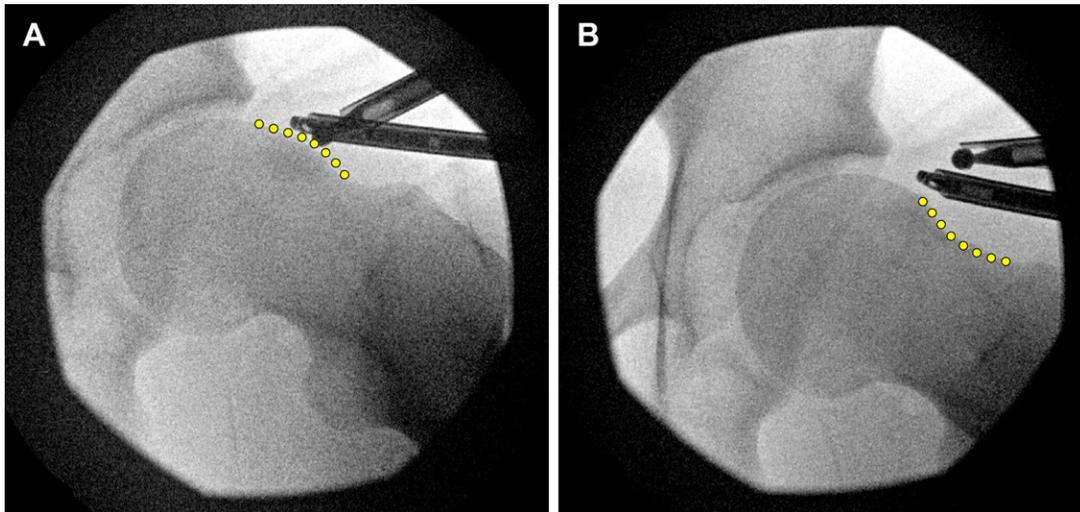


Figure 16. Labral repair with suture anchor in a 39-year-old woman with labral tear. **(A)** Intraoperative image before resection shows a prominent femoral head-neck junction (yellow dotted line), consistent with cam deformity. **(B)** Intraoperative image after the cam has been resected shows bony concavity of the femoral head-neck junction (yellow dotted line), consistent with postexcision changes.

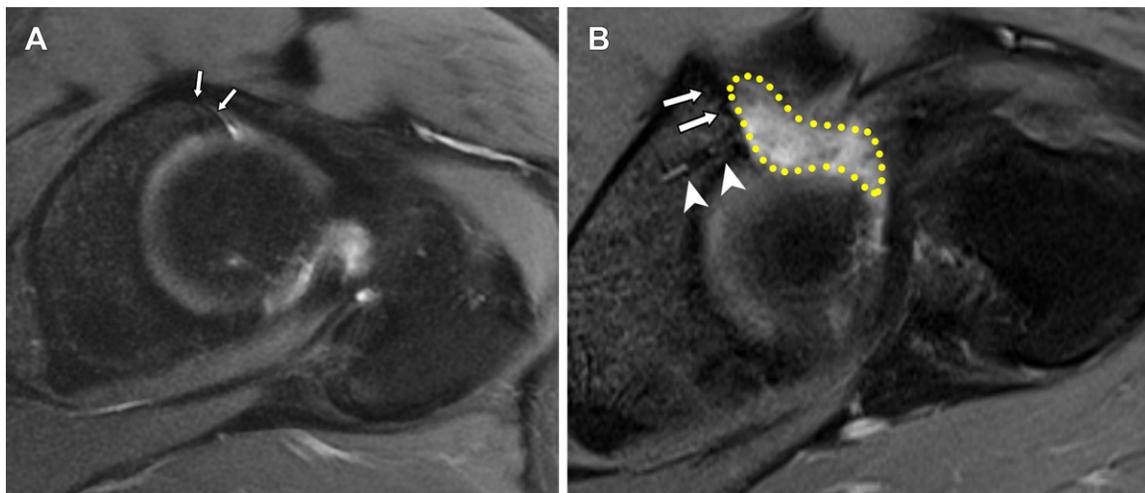


Figure 17. Acetabular rim resection and labral repair without capsular repair in a 36-year-old man with mixed-type left FAI. **(A)** Preoperative axial oblique PDFS MR image shows an intact anterior superior labrum attaching to a normal anterior superior acetabulum (arrows). **(B)** Postoperative axial oblique PDFS MR image shows bony truncation of the anterior superior acetabulum (arrows) and an adjacent fluid-filled defect in the anterior superior capsule (yellow dotted line) representing the arthroscopy portal. A labral suture is also shown (arrowheads).

the ILFL at the site of routine capsulotomy and closure compared with the contralateral nonoperative hip (57). Other capsular tightening procedures are thermal capsulorrhaphy and capsular reconstruction (50,56).

Capsular lesions in the absence of traumatic hip dislocation may be related to open or arthroscopic capsulotomy or capsular dehiscence. In the absence of capsular repair, postoperative changes to the adjacent structures, capsular irregularity, edema, or a frank defect may indicate the site of arthroscopy trocar placement (Fig 22). Capsular dehiscence is a possible complication of capsular repair. It is appreciated at MRI as a disrupted or discontinuous pseudocapsule, often characterized by a fluid-filled gap with or without associated pseudocapsular thickening and hyperintensity (58). Spontaneous

healing of the capsule can be seen as early as 6 weeks, depending on the arthroscopic approach (Fig 23) (59).

Ligamentum Teres

The ligamentum teres is a tubular ligament situated between the peripheral inferior acetabular notch and the fovea of the femoral head. It arises from the transverse acetabular ligament along the inferior margin of the acetabulum and attaches to the periosteum of the fovea by two bands: ischial and pubic. Awareness and interest in the ligamentum teres have increased with the expansion of hip arthroscopy. Initially considered an inconsequential vestigial structure, recent studies have recognized its role in femoral head vascularity, proprioception, nociception, and rotational stability of

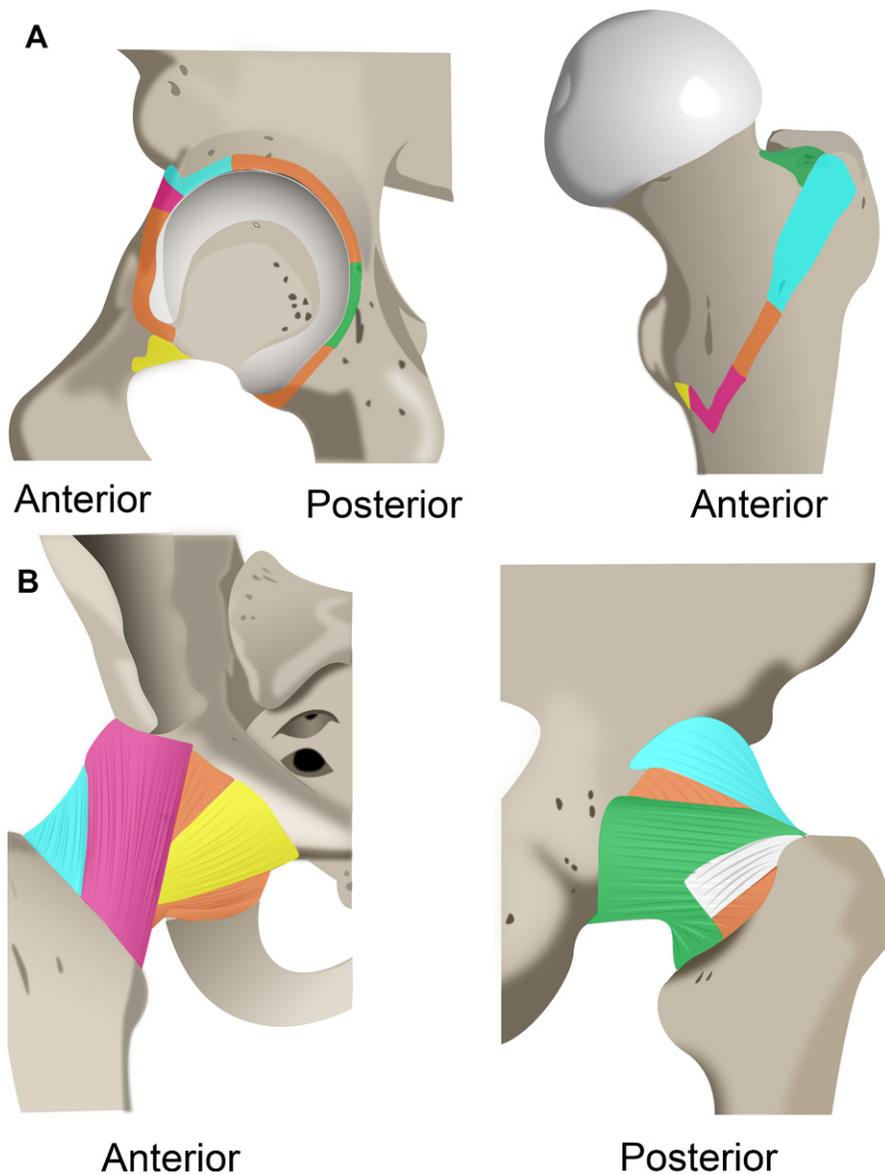


Figure 18. Graphic illustrations show the osseous footprints (**A**) and course (**B**) of the capsular fibers and ligaments. Light blue = superior band of the iliofemoral ligament (ILFL), pink = inferior band of the ILFL, green = ischiofemoral ligament (ISFL), yellow = pubofemoral ligament (PFL), orange = capsular fibers, white band in **B** = zona orbicularis.

the hip (14). Martin and colleagues (60) described its role in hip stability using a ball-and-string model (Fig 24).

MRI of the Ligamentum Teres

Ligamentum teres injuries are associated with hip dislocation, flexion-adduction stress (ie, fall on ipsilateral knee with the hip flexed), or abrupt external rotation of the hip such as in twisting (14). Various classification systems have been proposed (61). Gray and Villar (62) first classified injuries based on injury mechanism as well as arthroscopic findings. The Domb classification was developed to quantify the degree of ligament rupture in type 2 lesions or partial tears (63). Porthos Salas and O'Donnell (64) proposed a third classification to further delineate the cause of the tear and incorporate treatment options. Finally, O'Donnell and Arora (65) accounted for ligamentous laxity in addition to the ligament's appearance.

At MRI, the ligament appears as a smooth, predominantly homogeneous, and low-signal-intensity structure with all pulse sequences. It is best depicted on axial and coronal im-

ages, appearing as a bilobed slightly striated ligament comprised of one to three bundles (Fig 25) (14,66). It has an average overall length of 28 mm and measures approximately 3–4 mm in thickness, gradually tapering from proximal to distal (66). Slightly increased signal intensity near its curved attachment to the fovea capitis femoris on shorter time to echo (TE)-based images may be attributable to the “magic angle” artifact (14).

Partial and complete tears are most common in the fovea capitis; thorough inspection of this region is therefore important (14). While MRA has been shown to be accurate in diagnosing ligamentum teres tears, literature on the accuracy of conventional MRI is sparse. An intact ligament and a partially torn ligament can have similar imaging findings at MRA, making diagnosis of partial ligamentum teres tears difficult (66). High signal intensity within the substance of the fibers and peripheral irregularity are suggestive of a partial tear (Fig 26) (66). A complete tear manifests with full-thickness fiber discontinuity and ligament laxity.

A nondisplaced fracture fragment may accompany either a partial or complete tear but may be overlooked at MRI,

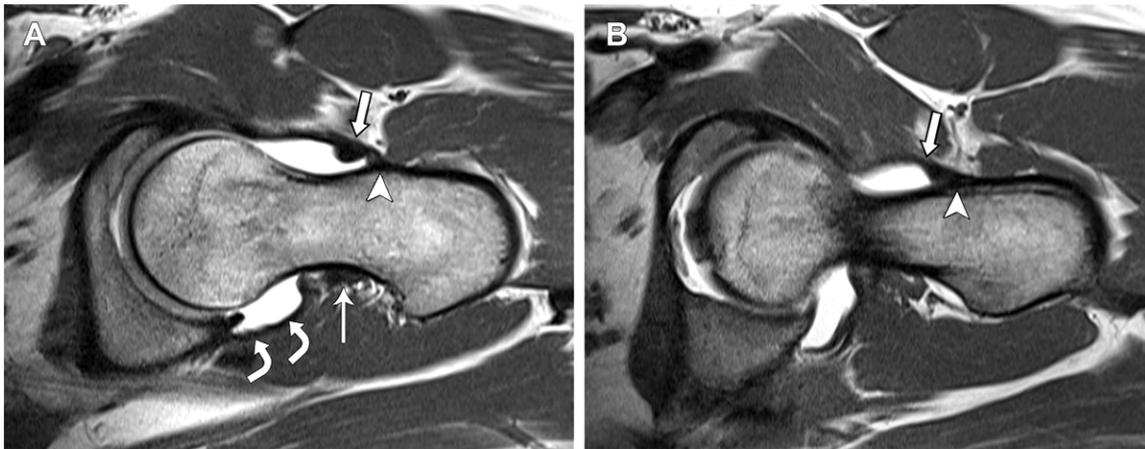


Figure 19. Normal MRI of the ILFL in a 26-year-old male asymptomatic volunteer. **(A)** Axial oblique T1-weighted MR arthrogram at a more superior level shows the superior band of the ILFL inserting onto the superior aspect of the intertrochanteric line (arrowhead). Medially, the inferior band of the ILFL (thick straight arrow) is seen as a distinct thickening on the anterior capsule. The ISFL appears as a thickening of the posterior capsule (curved arrows). The zona orbicularis (thin straight arrow) is a focal prominence that forms the distal free border of the posterior capsule. **(B)** Axial oblique T1-weighted MR arthrogram at a more inferior level shows the inferior band of the ILFL (arrow) inserting onto the inferior aspect of the intertrochanteric line (arrowhead).

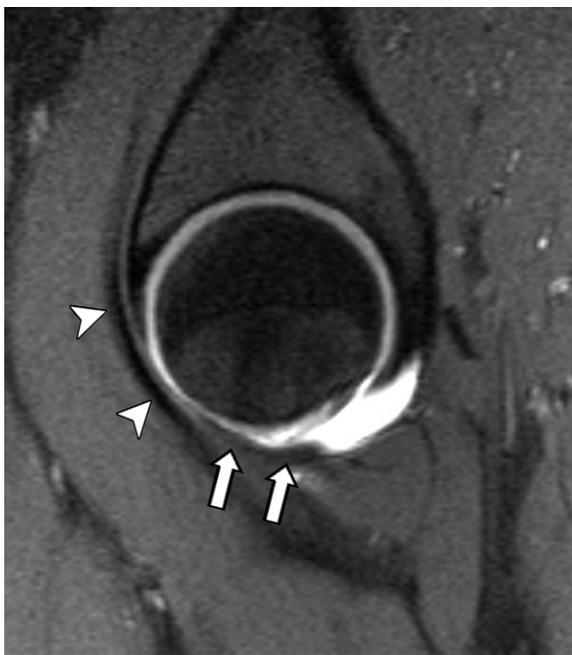


Figure 20. Normal MRI of the PFL in a 26-year-old male asymptomatic volunteer. Sagittal T1FS MR arthrogram shows an intact PFL (arrows). The iliopsoas tendon is seen in the anterior aspect of the joint (arrowheads).

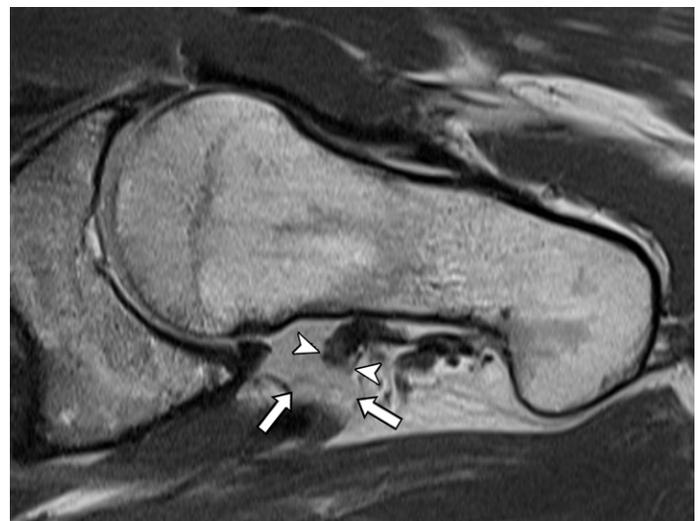


Figure 21. Hip dislocation at MRI. Axial T1FS MR arthrogram in a 23-year-old woman 3 days after a reported posterior hip dislocation shows a prominent defect in the ISFL (arrowheads) consistent with a complete tear, with extravasation of contrast material into the soft tissues (arrows).

Treatment

Compared with treatments for labral and capsule disease, there are limited data on management of ligamentum teres injuries. For most cases, conservative management is adequate. Tears are currently treated arthroscopically (67), and indications continue to evolve. Current indications are pain, instability, and mechanical symptoms with MRI findings of ligament thickening, partial or complete tears, or avulsion fracture of the ligament with intra-articular osteochondral fragments and edema in the acetabular fossa (14).

Treatment options are shrinkage, débridement, and most recently reconstruction. Shrinkage and débridement are

requiring careful evaluation of marrow signal intensity on proton density-weighted fat-suppressed (PDFS) or T2-weighted images (14). Conventional CT or CT arthrography may be more optimal for evaluating fragments compared with MRI or MRA (Fig 27). A chronically torn ligament is elongated, irregular, lax, or attenuated with fibers remaining contiguous. Absence of edema in the acetabular fossa, synovitis, and joint effusion allow distinction of chronic from acute tears (Fig 28) (14).

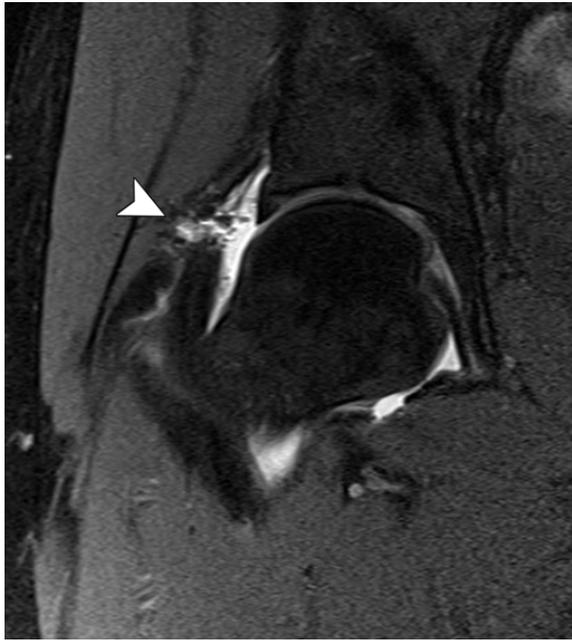


Figure 22. Postarthroscopy capsule defect in a 41-year-old woman who underwent recent labral repair without capsular repair 2 weeks earlier. Coronal T1FS MR arthrogram shows a well-demarcated contrast material-filled defect of the ILFL (arrowhead) with surrounding susceptibility artifacts, consistent with a postarthroscopy capsule defect.

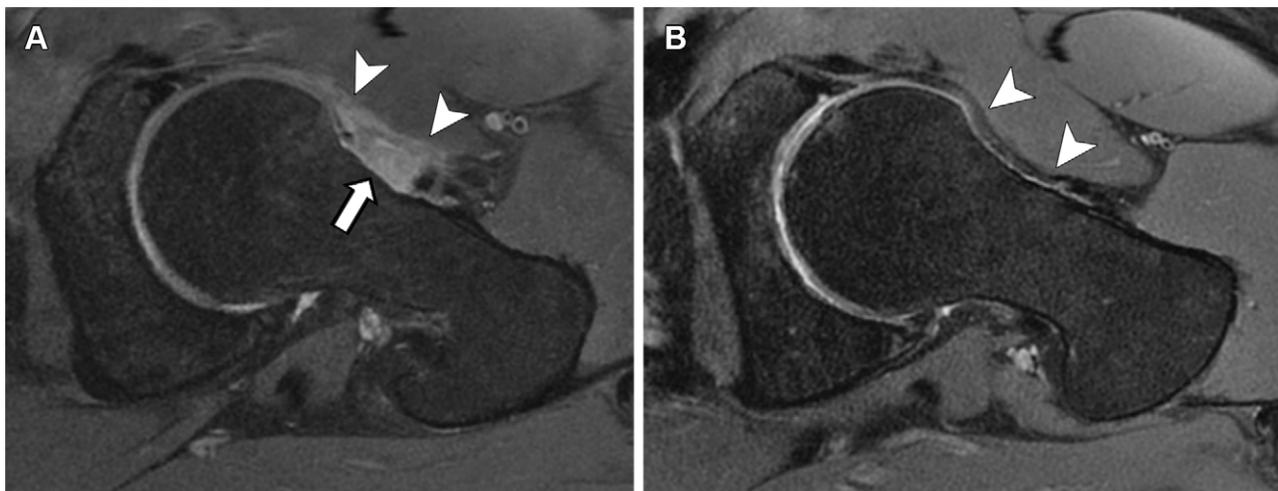


Figure 23. Capsular healing in a 46-year-old man with persistent impingement symptoms after surgery. **(A)** Postoperative PDFS MR image 2 weeks after capsulectomy and osteochondroplasty shows a newly excised femoral head-neck junction (arrow) with overlying ill-defined soft-tissue edema (arrowheads), consistent with capsulectomy changes. **(B)** Postoperative PDFS MR image 5.5 months after the procedure shows interval resolution of the edema and filling in of the capsule (arrowheads), consistent with capsular healing.

reserved for partial tears after failed conservative management. Fibroblastic response from thermal shrinkage improves the biomechanical strength of the remaining fibers, while débridement of frayed and the stump of torn fibers relieves mechanical symptoms and pain (14). Reconstruction with allografts, autografts, or synthetic grafts is indicated for complete tears that are considered reparable, cause instability, or failed previous débridement (67).

Hip Instability

Hip instability is a broad term used to describe various abnormalities manifesting with deep-seated pain around the hip, groin, or inguinal region. The term has been used interchangeably with *joint hyperlaxity* or *hypermobility* and *micro-*

instability (68). Awareness of the entity has increased recently, although its diagnosis and even its existence are still debated. Disorders of the capsulolabral structures have been implicated in symptoms of hip instability. An exhaustive discussion is beyond the scope of this article, but this section will emphasize current classification and terminology.

Hip instability may be (a) due to a single acute episode of trauma, (b) due to overuse or repetitive microtrauma in a young or athletic patient, (c) iatrogenic in the setting of prior arthroscopy and capsulotomy, (d) developmental or anatomic such as in hip dysplasia or connective tissue disorders (ie, hyperlaxity), or (e) idiopathic or microinstability when the clinical presentation is vague or in the absence of the previously mentioned criteria (68).

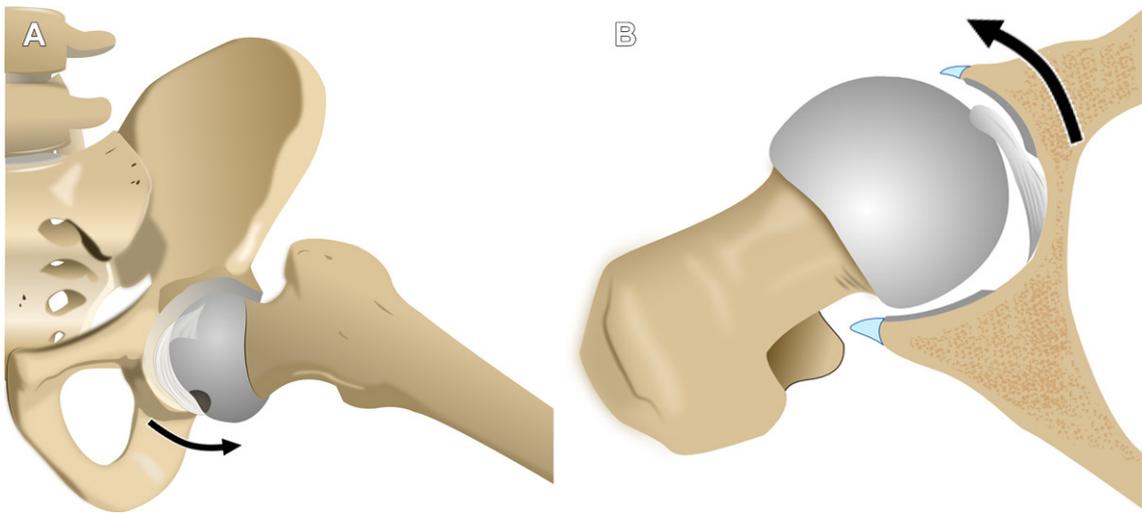


Figure 24. Graphic illustrations demonstrate the mechanism of hip stability provided by the ligamentum teres, according to the ball-and-string model. **(A)** As the hip joint is abducted, the ligamentum teres wraps under the femoral head while pulling it into the acetabulum, limiting inferior subluxation. **(B)** As the hip joint is externally rotated, the ligamentum teres wraps around the femoral head while pulling it into the acetabulum, limiting anterior subluxation.

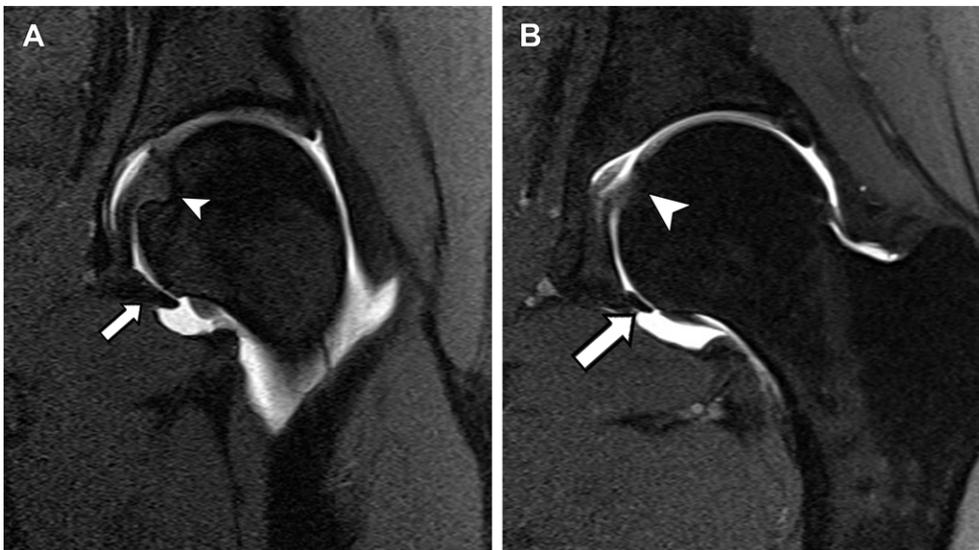


Figure 25. Normal MRI of the ligamentum teres in two patients. **(A)** Coronal T1FS MR arthrogram in a 24-year-old female asymptomatic volunteer shows a normal single bundle of the ligamentum teres coursing from the fovea capitis (arrowhead) to the transverse acetabular ligament (arrow). **(B)** Coronal T1FS MR arthrogram in a 30-year-old female asymptomatic volunteer shows a normal double bundle of the ligamentum teres coursing from the fovea capitis (arrowhead) to the transverse acetabular ligament (arrow).

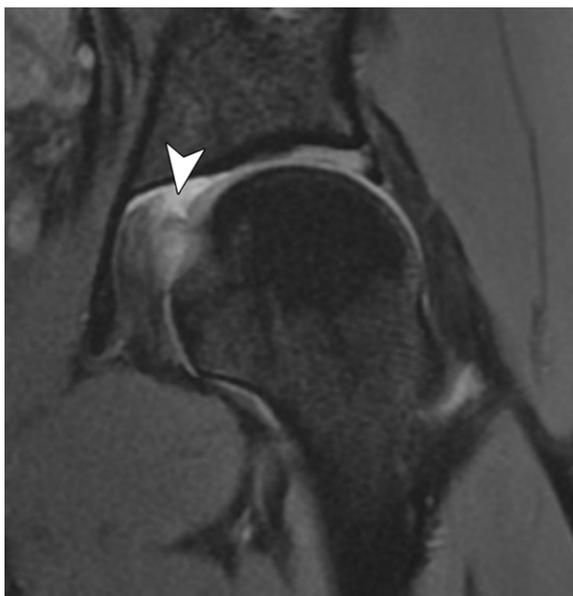


Figure 26. Partial tear of the ligamentum teres in a 29-year-old female sprinter with 4 weeks of groin pain. Coronal PDFS MR image shows focal discontinuity of the superior and medial fibers (arrowhead) of the ligamentum teres, consistent with a partial tear.

Traumatic instability secondary to an acute dislocation event may be distinguished from overuse instability only with a reliable clinical history and physical examination. Iatrogenic instability is a rare postarthroscopy complication. Osseous risk factors include excessive bone removal during acetabular rim resection or femoral osteoplasty (Fig S3). Large capsulotomies without capsular repair and nonhealing capsular defects from previous arthroscopy are examples of soft-tissue risk factors (56,69).

O'Neill et al (70) described a grading system for capsular changes at MRA in patients with symptomatic postsurgical hip instability. This system includes normal capsular appearance and volume, increased capsular redundancy (Fig 29), focal capsular rent or capsular irregularity, and gross capsular defect. In their cohort of 31 patients, no capsules appeared completely normal after the procedure (70). Contrary to traumatic

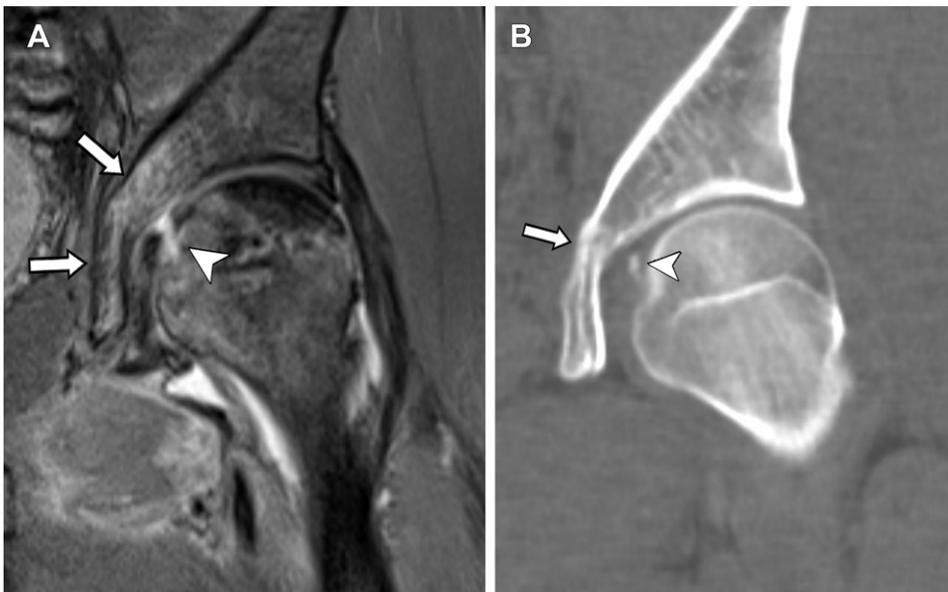


Figure 27. Acute avulsion fracture of the ligamentum teres in a 22-year-old man after left hip dislocation. **(A)** Coronal PDFS MR image shows an acute avulsion fracture of the foveal attachment of the ligamentum teres (arrowhead) and associated marrow edema in the acetabulum (arrows). **(B)** Coronal CT image shows a small avulsed fragment (arrowhead). There is also an undisplaced fracture of the adjacent medial wall of the acetabulum (arrow).



Figure 28. Chronic tear of the ligamentum teres in a 45-year-old former basketball player with 6 years of inguinal pain exacerbated by squatting. Coronal PDFS MR image shows marked thickening of the ligamentum teres at the fovea capitis (arrowheads) with preserved fiber contiguity, consistent with a chronic tear.



Figure 29. Capsular redundancy in a 33-year-old woman who underwent prior arthroscopy for labral débridement and who had persistent hip pain 3 years after the procedure. Axial oblique T1FS MR arthrogram shows capsular outpouching (arrowhead) at the previous site of capsulectomy. There is no frank capsular defect.

hip instability, postarthroscopic instability is most often anterior (the anterior lateral capsule being the most common portal for arthroscopy) and occurs with hip extension and external rotation (71).

Developmental or anatomic instability is seen in patients with dysplastic hip or FAI, connective tissue disorders, or hypermobility syndromes (Ehlers-Danlos or Marfan syndrome). The altered bone architecture in these conditions predisposes to early chondropathy and labral tears in the absence of trauma, athletic activity, or surgery.

Finally, idiopathic instability or microinstability refers to painful extraphysiologic hip motion without overt sublux-

ation or dislocation (42). While causes of microinstability can be the same as or overlap with those of the types mentioned earlier, it is often seen in patients who lack a definite underlying cause. As a result, diagnosis relies on a thorough clinical history, physical examination, and imaging evaluation. Currently, there are no pathognomonic imaging features of microinstability. A recent systematic review found that in the appropriate clinical context, hip dysplasia, anterior labral tears, and ligamentum teres tears may be suggestive of microinstability, although the authors recommend further studies (42).

Capsular laxity is implicated in microinstability but is not a diagnosis per se (72). It is a term used to describe the inability of the joint to deliver normal resistance to external forces (72). The terminology is often used in biomechanical and clinical studies, although a few investigations suggest imaging correlates. A prospective study of 100 consecutive patients showed lower hypermobility scores in subjects with a capsular thickness of greater than or equal to 10 mm (73). Another study by Magerkurth et al (74) concluded that a widened anterior hip joint recess (>5 mm) and a thinned anterior joint capsule (<3 mm) correlate with intraoperative findings of laxity.

Conclusion

The hip is a uniquely constrained joint with critical static stability provided by the labrum, capsule and capsular ligaments, and ligamentum teres. Understanding the anatomy, patterns of injury, MRI features, treatment, and postoperative appearance allows precise diagnosis and timely management.

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References

- Philippon MJ, Nepple JJ, Campbell KJ, et al. The hip fluid seal. I. The effect of an acetabular labral tear, repair, resection, and reconstruction on hip fluid pressurization. *Knee Surg Sports Traumatol Arthrosc* 2014;22(4):722–729.
- Scorcelletti M, Reeves ND, Rittweger J, Ireland A. Femoral anteversion: significance and measurement. *J Anat* 2020;237(5):811–826.
- Blankenbaker DG, Tuite MJ. Acetabular labrum. *Magn Reson Imaging Clin N Am* 2013;21(1):21–33.
- Mayer SW, Skelton A, Flug J, et al. Comparison of 2D, 3D, and radially reformatted MR images in the detection of labral tears and acetabular cartilage injury in young patients. *Skeletal Radiol* 2021;50(2):381–388.
- Petchprapa CN, Dunham KS, Lattanzi R, Recht MP. Demystifying radial imaging of the hip. *RadioGraphics* 2013;33(3):E97–E112.
- Chan YS, Lien LC, Hsu HL, et al. Evaluating hip labral tears using magnetic resonance arthrography: a prospective study comparing hip arthroscopy and magnetic resonance arthrography diagnosis. *Arthroscopy* 2005;21(10):1250.
- Toomayan GA, Holman WR, Major NM, Kozlowicz SM, Vail TP. Sensitivity of MR arthrography in the evaluation of acetabular labral tears. *AJR Am J Roentgenol* 2006;186(2):449–453.
- Freedman BA, Potter BK, Dinauer PA, et al. Prognostic value of magnetic resonance arthrography for Czerny stage II and III acetabular labral tears. *Arthroscopy* 2006;22(7):742–747.
- Linda DD, Naraghi A, Murnaghan L, Whelan D, White LM. Accuracy of non-arthrographic 3T MR imaging in evaluation of intra-articular pathology of the hip in femoroacetabular impingement. *Skeletal Radiol* 2017;46(3):299–308.
- Magee T. Comparison of 3.0-T MR vs 3.0-T MR arthrography of the hip for detection of acetabular labral tears and chondral defects in the same patient population. *Br J Radiol* 2015;88(1053):20140817.
- Zhang P, Li C, Wang W, et al. 3.0 T MRI is more recommended to detect acetabular labral tears than MR arthrography: an updated meta-analysis of diagnostic accuracy. *J Orthop Surg Res* 2022;17(1):126.
- Chopra A, Grainger AJ, Dube B, et al. Comparative reliability and diagnostic performance of conventional 3T magnetic resonance imaging and 1.5T magnetic resonance arthrography for the evaluation of internal derangement of the hip. *Eur Radiol* 2018;28(3):963–971.
- Tomasevich KM, Mills MK, Allen H, et al. Magnetic Resonance Arthrogram Improves Visualization of Hip Capsular Defects in Patients Undergoing Previous Hip Arthroscopy. *Arthrosc Sports Med Rehabil* 2021;4(2):e471–e478.
- Cerezal L, Kassrajian A, Canga A, et al. Anatomy, biomechanics, imaging, and management of ligamentum teres injuries. *RadioGraphics* 2010;30(6):1637–1651.
- Chang CY, Gill CM, Huang AJ, et al. Use of MR arthrography in detecting tears of the ligamentum teres with arthroscopic correlation. *Skeletal Radiol* 2015;44(3):361–367.
- Seldes RM, Tan V, Hunt J, et al. Anatomy, histologic features, and vascularity of the adult acetabular labrum. *Clin Orthop Relat Res* 2001;382(382):232–240.
- Kelly BT, Shapiro GS, Digiovanni CW, et al. Vascularity of the hip labrum: a cadaveric investigation. *Arthroscopy* 2005;21(1):3–11.
- Nguyen MS, Kheyfits V, Giordano BD, Dieudonne G, Monu JUV. Hip anatomic variants that may mimic abnormalities at MRI: labral variants. *AJR Am J Roentgenol* 2013;201(3):W394–W400.
- Blankenbaker DG, De Smet AA, Keene JS, Fine JP. Classification and localization of acetabular labral tears. *Skeletal Radiol* 2007;36(5):391–397.
- Chan BY, Allen H, Davis KW, Blankenbaker DG. MR Imaging of the hip: avoiding pitfalls, identifying normal variants. *Appl Radiol* 2018;47(12):8–14.
- Studler U, Kalberer F, Leunig M, et al. MR arthrography of the hip: differentiation between an anterior sublabral recess as a normal variant and a labral tear. *Radiology* 2008;249(3):947–954.
- Rakhra KS. Magnetic resonance imaging of acetabular labral tears. *J Bone Joint Surg Am* 2011;93(suppl 2):28–34.
- Petersilge CA. MR arthrography for evaluation of the acetabular labrum. *Skeletal Radiol* 2001;30(8):423–430.
- Ziegert AJ, Blankenbaker DG, De Smet AA, et al. Comparison of standard hip MR arthrographic imaging planes and sequences for detection of arthroscopically proven labral tear. *AJR Am J Roentgenol* 2009;192(5):1397–1400.
- Czerny C, Hofmann S, Urban M, et al. MR arthrography of the adult acetabular capsular-labral complex: correlation with surgery and anatomy. *AJR Am J Roentgenol* 1999;173(2):345–349.
- Li AE, Jawetz ST, Greditzer HG 4th, Burge AJ, Nawabi DH, Potter HG. MRI for the preoperative evaluation of femoroacetabular impingement. *Insights Imaging* 2016;7(2):187–198.
- Markhardt BK, Huang BK, Spiker AM, Chang EY. Interpretation of Cartilage Damage at Routine Clinical MRI: How to Match Arthroscopic Findings. *RadioGraphics* 2022;42(5):1457–1473.
- Lage LA, Patel JV, Villar RN. The acetabular labral tear: an arthroscopic classification. *Arthroscopy* 1996;12(3):269–272.
- Czerny C, Hofmann S, Neuhold A, et al. Lesions of the acetabular labrum: accuracy of MR imaging and MR arthrography in detection and staging. *Radiology* 1996;200(1):225–230.
- Hegazi TM, Belair JA, McCarthy EJ, Roedel JB, Morrison WB. Sports injuries about the hip: what the radiologist should know. *RadioGraphics* 2016;36(6):1717–1745.
- Dinauer PA, Murphy KP, Carroll JF. Sublabral sulcus at the posteroinferior acetabulum: a potential pitfall in MR arthrography diagnosis of acetabular labral tears. *AJR Am J Roentgenol* 2004;183(6):1745–1753.
- Blankenbaker DG, Tuite MJ. The painful hip: new concepts. *Skeletal Radiol* 2006;35(6):352–370.
- Magerkurth O, Jacobson JA, Girish G, Brigido MK, Bedi A, Fessell D. Paracapsular cysts in the hip joint: findings at MR arthrography. *Skeletal Radiol* 2012;41(10):1279–1285.
- Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res* 2003;417:112–120.
- Morgan P, Crawford A, Murette S, et al. Using a simplified version of a common surgical grading scale for acetabular labral tears improves the utility of preoperative hip MRI for femoroacetabular impingement. *Skeletal Radiol* 2020;49(12):1987–1994.
- Herickhoff PK, Safran MR. Surgical Decision Making for Acetabular Labral Tears: An International Perspective. *Orthop J Sports Med* 2018;6(9):2325967118797324.
- Domb BG, Hartigan DE, Perets I. Decision making for labral treatment in the hip: repair versus débridement versus reconstruction. *J Am Acad Orthop Surg* 2017;25(3):e53–e62.
- Philippon MJ, Peixoto LP, Goljan P. Acetabular Labral Tears: Debridement, Repair, Reconstruction. *Oper Tech Orthop* 2012;20(4):281–286.
- Woodward RM, Philippon MJ. Persistent or recurrent symptoms after arthroscopic surgery for femoroacetabular impingement: a review of imaging findings. *J Med Imaging Radiat Oncol* 2019;63(1):15–24.

40. Blankenbaker DG, De Smet AA, Keene JS. MR arthrographic appearance of the postoperative acetabular labrum in patients with suspected recurrent labral tears. *AJR Am J Roentgenol* 2011;197(6):W1118–W1122.
41. Matsuda DK, Bharam S, White BJ, Matsuda NA, Safran M. Anchor-induced chondral damage in the hip. *J Hip Preserv Surg* 2015;2(1):56–64.
42. Woodward RM, Vesey RM, Bacon CJ, White SG, Brick MJ, Blankenbaker DG. Microinstability of the hip: a systematic review of the imaging findings. *Skeletal Radiol* 2020;49(12):1903–1919.
43. Kim CO, Dietrich TJ, Zingg PO, Dora C, Pfirrmann CWA, Sutter R. Arthroscopic hip surgery: frequency of postoperative MR arthrographic findings in asymptomatic and symptomatic patients. *Radiology* 2017;283(3):779–788.
44. Mills MK, Strickland CD, Jesse MK, Lowry PA, Mei-Dan O, Flug JA. Postoperative imaging in the setting of hip preservation surgery. *RadioGraphics* 2016;36(6):1746–1758.
45. Li AE, Jawetz ST, Greditzer HG 4th, Burge AJ, Nawabi DH, Potter HG. MRI evaluation of femoroacetabular impingement after hip preservation surgery. *AJR Am J Roentgenol* 2016;207(2):392–400.
46. Ng KCG, Jeffers JRT, Beaulé PE. Hip Joint Capsular Anatomy, Mechanics, and Surgical Management. *J Bone Joint Surg Am* 2019;101(23):2141–2151.
47. Ito H, Song Y, Lindsey DP, Safran MR, Giori NJ. The proximal hip joint capsule and the zona orbicularis contribute to hip joint stability in distraction. *J Orthop Res* 2009;27(8):989–995.
48. Wagner FV, Negrao JR, Campos H, et al. Capsular Ligaments of the Hip: Anatomic, Histologic, and Positional Study in Cadaveric Specimens with MR Arthrography. *Radiology* 2012;263(1):189–198.
49. Malagelada F, Tayar R, Barke S, Stafford G, Field RE. Anatomy of the zona orbicularis of the hip: a magnetic resonance study. *Surg Radiol Anat* 2015;37(1):11–18.
50. Philippon MJ, Schenker ML. Athletic hip injuries and capsular laxity. *Oper Tech Orthop* 2005;15(3):261–266.
51. Şahin V, Karakaş ES, Aksu S, Atlihan D, Turk CY, Halici M. Traumatic dislocation and fracture-dislocation of the hip: a long-term follow-up study. *J Trauma* 2003;54(3):520–529.
52. Jia C, Crim J. Understanding a rare injury: an observational study of anterior-superior hip dislocations. *AJR Am J Roentgenol* 2020;214(3):624–629.
53. Mandell JC, Marshall RA, Banffy MB, Khurana B, Weaver MJ. Arthroscopy after Traumatic Hip Dislocation: A Systematic Review of Intra-articular Findings, Correlation with Magnetic Resonance Imaging and Computed Tomography, Treatments, and Outcomes. *Arthroscopy* 2018;34(3):917–927.
54. Moorman CT 3rd, Warren RF, Hershman EB, et al. Traumatic posterior hip subluxation in American football. *J Bone Joint Surg Am* 2003;85(7):1190–1196.
55. Gupta A, Suarez-Ahedo C, Redmond JM, et al. Best Practices during Hip Arthroscopy: Aggregate Recommendations of High-Volume Surgeons. *Arthroscopy* 2015;31(9):1722–1727.
56. Kalisvaart MM, Safran MR. Microinstability of the hip: it does exist—etiology, diagnosis and treatment. *J Hip Preserv Surg* 2015;2(2):123–135.
57. Weber AE, Kuhns BD, Cvetanovich GL, et al. Does the Hip Capsule Remain Closed after Hip Arthroscopy with Routine Capsular Closure for Femoroacetabular Impingement? A Magnetic Resonance Imaging Analysis in Symptomatic Postoperative Patients. *Arthroscopy* 2017;33(1):108–115.
58. Berkowitz JL, Potter HG. Advanced MRI Techniques for the Hip Joint: Focus on the Postoperative Hip. *AJR Am J Roentgenol* 2017;209(3):534–543.
59. Strickland CD, Kraeutler MJ, Brick MJ, et al. MRI evaluation of repaired versus unrepaired interportal capsulotomy in simultaneous bilateral hip arthroscopy: a double-blind, randomized controlled trial. *J Bone Joint Surg Am* 2018;100(2):91–98.
60. Martin RL, Kivlan BR, Clemente FR. A cadaveric model for ligamentum teres function: a pilot study. *Knee Surg Sports Traumatol Arthrosc* 2013;21(7):1689–1693.
61. Rosinsky PJ, Shapira J, Lall AC, Domb BG. All About the Ligamentum Teres: From Biomechanical Role to Surgical Reconstruction. *J Am Acad Orthop Surg* 2020;28(8):e328–e339.
62. Gray AJR, Villar RN. The ligamentum teres of the hip: an arthroscopic classification of its pathology. *Arthroscopy* 1997;13(5):575–578.
63. Botser IB, Martin DE, Stout CE, Domb BG. Tears of the ligamentum teres: prevalence in hip arthroscopy using 2 classification systems. *Am J Sports Med* 2011;39(1 Suppl):117S–125S.
64. Porthos Salas A, O'Donnell JM. Ligamentum teres injuries: an observational study of a proposed new arthroscopic classification. *J Hip Preserv Surg* 2015;2(3):258–264.
65. O'Donnell JM, Arora M. A novel and simple classification for ligamentum teres pathology based on joint hypermobility. *J Hip Preserv Surg* 2017;5(2):113–118.
66. Blankenbaker DG, De Smet AA, Keene JS, Del Rio AM. Imaging appearance of the normal and partially torn ligamentum teres on hip MR arthrography. *AJR Am J Roentgenol* 2012;199(5):1093–1098.
67. de SA D, Phillips M, Philippon MJ, Letkemann S, Simunovic N, Ayeni OR. Ligamentum teres injuries of the hip: a systematic review examining surgical indications, treatment options, and outcomes. *Arthroscopy* 2014;30(12):1634–1641.
68. Rosinsky PJ. Editorial Commentary: Hip Joint Laxity, Microinstability, or Instability Require Precise Definition—No Matter What You Call It, It's Here to Stay! *Arthroscopy* 2022;38(10):2850–2851.
69. Yeung M, Memon M, Simunovic N, Belzile E, Philippon MJ, Ayeni OR. Gross Instability after Hip Arthroscopy: An Analysis of Case Reports Evaluating Surgical and Patient Factors. *Arthroscopy* 2016;32(6):1196–1204.e1.
70. O'Neill DC, Mortensen AJ, Cannamela PC, Aoki SK. Clinical and Radiographic Presentation of Capsular Iatrogenic Hip Instability after Previous Hip Arthroscopy. *Am J Sports Med* 2020;48(12):2927–2932.
71. Aoki SK, Beckmann JT, Wylie JD. Hip arthroscopy and the anterolateral portal: avoiding labral penetration and femoral articular injuries. *Arthrosc Tech* 2012;1(2):e155–e160.
72. Han S, Alexander JW, Thomas VS, et al. Does Capsular Laxity Lead to Microinstability of the Native Hip? *Am J Sports Med* 2018;46(6):1315–1323.
73. Devitt BM, Smith BN, Stapf R, Tacey M, O'Donnell JM. Generalized joint hypermobility is predictive of hip capsular thickness. *Orthop J Sports Med* 2017;5(4):2325967117701882.
74. Magerkurth O, Jacobson JA, Morag Y, et al. Capsular Laxity of the Hip: Findings at Magnetic Resonance Arthrography. *Arthroscopy* 2013;29(10):1615–1622.