Hip Arthroscopy: Anatomy and Techniques

3

Leandro Ejnisman and Marc Safran

3.1 Introduction

The first description of hip arthroscopy was in 1931 by Burman [1]. In this classic paper, the author investigates the feasibility of arthroscopic examination in multiple joints. With respect to the hip, the paper states "it is manifestly impossible to insert a needle between the head of the femur and the acetabulum." However, the author was able to visualize a portion of the anterior femoral neck and the femoral head and neck transition. At that time, this was not considered an important region because femoroacetabular impingement (FAI) and cam lesions were yet to be described, and the relative infrequency of rheumatologic disorders affecting the hip only diminished its need as well.

The past two decades have seen an explosion on the number of hip arthroscopies performed per year. Development of techniques to access the hip joint reproducibly and safely, better instrumentation, and improving understanding of surgical indications are the main reasons for this growth. However, even with this advancement in knowledge, hip arthroscopy is still a skillful procedure with a very prolonged learning curve. It is recommended that surgeons attend hip arthroscopy courses and observe experts performing hip arthroscopy before starting their own cases. Cadaveric training is worthwhile and extremely helpful to orthopedic surgeons, especially in their early technical stages. Adequate knowledge of arthroscopic

L. Ejnisman
Stanford University, Redwood City, CA, USA

Instituto de Ortopedia e Traumatologia, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de Sao Paulo, Sao Paulo, SP, Brazil
e-mail: ejnisman@stanford.edu

M. Safran (✉)
Stanford University, Redwood City, CA, USA
e-mail: msafran@stanford.edu

M. Safran, M. Karahan (eds.), *Hip and Groin Pain in the Athlete*,
https://doi.org/10.1007/978-3-662-58699-0_3

anatomy and technique is paramount to successful outcomes and keeping complications rates low.

3.2 Surgical Technique

In hip arthroscopy, the hip joint is divided into central and peripheral compartments [2]. The division of the compartments is determined by the outer edge of the acetabular labrum. The central compartment contains the acetabular articular cartilage, the labrum, the medial part of the femoral head, and the cotyloid fossa. In cases of pincer FAI, the pincer lesion is also often considered to be in the central compartment. The peripheral compartment contains the non-weight-bearing area of the femoral head, the femoral neck, the zona orbicularis, and the medial and lateral synovial folds – essentially the rest of the intracapsular joint outside of the acetabular articular surface and labrum. In cases of cam FAI, the cam lesion will be in the peripheral compartment. This division is important because each compartment will be visualized at different times during the surgery, so the surgeon should know when to address each anatomical structure. In basic terms, the central compartment is visualized with traction applied, to distract the joint, while the peripheral compartment is visualized with traction off to relax the capsule, often in conjunction with hip flexion to relax the anterior capsule to see more anteriorly and medially.

Traction is used to obtain a separation between the femoral head and the acetabulum in order to access the central compartment. This is most commonly performed using a fracture table, though other techniques to separate the femoral head from the acetabulum may be used, including using femoral distractor. Some variation in patient positioning and arthroscopic techniques can be found in the literature. First, the patient can be positioned supine or lateral [3, 4]. Second, some surgeons start hip arthroscopy from the central compartment first, while others start in the peripheral compartment. Studies have shown there is no clear advantages to any of the aforementioned techniques, and the decision will mainly depend on surgeon's preference and experience. This chapter will focus on the supine technique with the central compartment being addressed first, as this is the senior author's preferred technique. Other considerations include some surgeons doing hip arthroscopy with only two portals for the whole surgery, or just for the central compartment, and accessory portals at other times, such as for peripheral compartment surgery and/or labral repair. The senior author's preferred technique involves three portals for the central compartment and occasionally one or two accessory portals for labral repair and an additional portal for peripheral compartment arthroscopy.

The patient is positioned supine on the fracture table. Extra padding is used to protect the perineum and the dorsum of the feet. The perineal post should be larger than the normal post used for trauma, should be well padded, and is lateralized toward the affected hip. This facilitates the creation of a lateral distraction force (in addition to distally) when the leg is being pulled distally. Body weight traction is applied to both feet in order to approximate the perineum to the post, starting with slight body weight traction being applied to the non-operative leg first, as this

assures lateralization. At this moment, a fluoroscopy image is obtained. In some patients there will be some distraction of the femur just from the application of body weight, and this finding strongly suggests hip instability. Then, fine traction is applied until a distraction of 10 mm is obtained. The number of turns of the distraction device on the fracture table may be used to estimate ease of distractibility, which may be suggestive of hip laxity or microinstability. Few turns to get the hip adequately distracted suggest instability of the joint.

After adequate distraction of the joint is established, the joint should be vented to remove the negative intra-articular pressure. The anterolateral hip region is prepped, and a spinal needle is inserted inside the joint guided by fluoroscopy. An air arthrogram of the hip can be seen after venting (Fig. 3.1). After removal of the needle, the traction is then released and another fluoroscopic image is obtained. It is important to note if the hip has completely reduced, because incomplete reduction after joint venting may be another sign of hip microinstability.

Next the patient is prepped and draped, and all the arthroscopic equipment is set up. It is preferred to re-establish traction only once all the equipment is ready and tested to avoid unnecessary traction time. The first portal is the anterolateral portal, and it is done under fluoroscopic visualization (Fig. 3.2). The starting point is usually 1–2 cm medial and proximal to the anterior superior greater trochanter edge. A spinal needle is introduced into the hip joint aiming at the most medial aspect of the acetabular sourcil (Fig. 3.3). A long nitinol wire is introduced through the spinal needle, and the needle is removed. A small skin incision is performed, and an arthroscopic cannula is introduced using the nitinol wire as a guide. The cannula is introduced slowly while gently twisting. The cannula will encounter resistance when it reaches the capsule. Caution must be taken to rotate the bevel of the cannula away from the femoral head, with the objective of decreasing the risk of injury to the femoral articular cartilage. The same guided technique using the spinal needle and the nitinol wire is used for the subsequent portals. Once the cannula is inside the joint, the trocar is

Fig. 3.1 Fluoroscopic view of a left hip under traction. A spinal needle is inserted between the acetabulum and the femoral head. The goal is for the needle to be as close to the femoral head as possible, to reduce the likelihood of penetrating the labrum. It is possible to observe an arthrogram demonstrating the elimination of negative intra-articular pressure

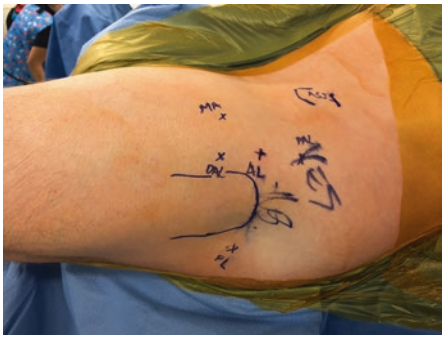

Fig. 3.2 Left hip after patient is prepped and draped. Picture demonstrates portal positioning in relationship to the anterosuperior iliac spine (ASIS) and the greater trochanter *MA* mid-anterior portal, *DAL* distal anterolateral portal, *AL* anterolateral portal, *PAL* proximal anterolateral portal, *PL* posterolateral portal

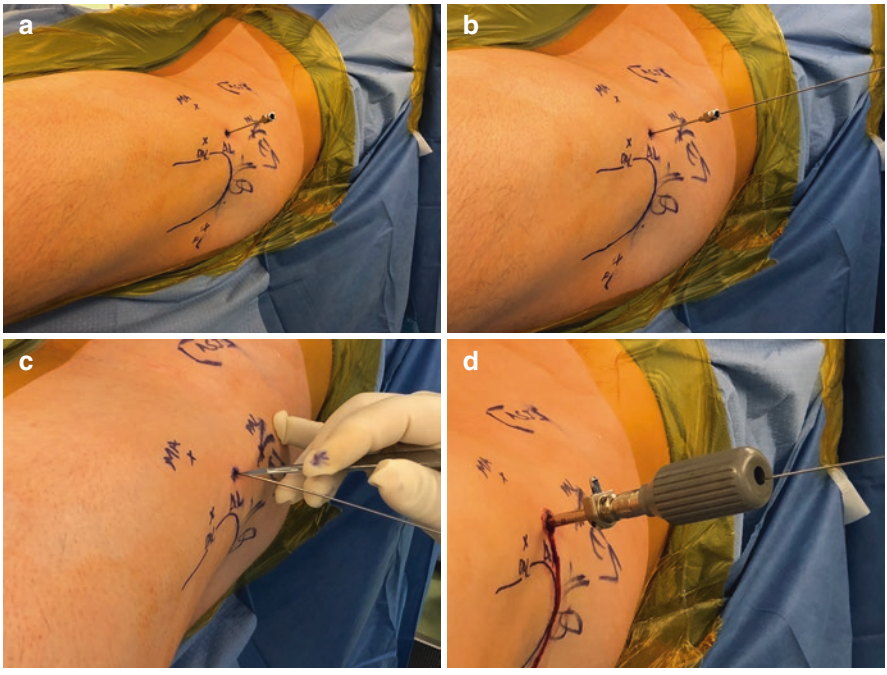

Fig. 3.3 Sequential pictures of the guided portal technique. (**a**) Spinal needle through the proposed anterolateral (AL) portal (first portal). (**b**) Nitinol wire inserted through the spinal needle. (**c**) Incision adjacent to the nitinol wire after retrieval of the spinal needle. (**d**) Cannula insertion guided over the nitinol wire

exchanged for the camera. Commonly a 70° lens will be used for the central compartment, and a 30° lens will be used for the peripheral compartment. However, this may change according to surgeon's preference, specific patient anatomic variations, or the procedure being performed.

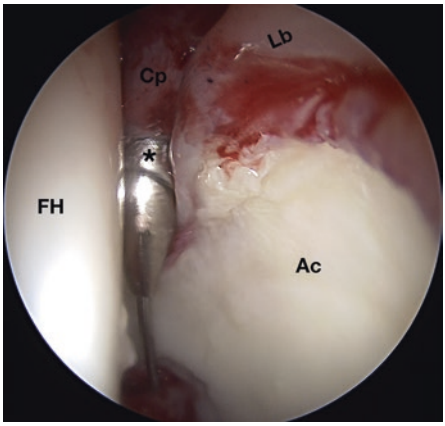

Fig. 3.4 Left hip, view from the anterolateral portal with a 70° arthroscope. The anterior portal cannula (black star) is inserted under arthroscopic visualization using the nitinol wire as a guide, aiming the triangular region formed by the femoral head, labrum, and the border of the lens. *FH* femoral head, *Cp* capsule, *Lb* labrum, *Ac* acetabulum

The next portals are established through direct arthroscopic visualization. Fluoroscopy may be used to help in difficult cases or at the beginning of the learning curve; however, it is important that the surgeon watches arthroscopically as the needle penetrates the joint so as to not injure the labrum or articular cartilage. Before the second portal, the surgeon visualizes the anterior capsule in a triangular shape. The triangle is formed by the acetabular labrum, the femoral head, and the border of the lens. The surgeon's goal is to perforate this triangle with the needle, avoiding injury to the femoral head and labrum, establishing the mid-anterior portal (Fig. 3.4). The skin entry point for the mid-anterior portal is 5–7 cm from the anterior portal on a line 45° distal and medial to the anterior portal, being sure to stay lateral to a line draw distal to the ASIS. Then, the camera is exchanged to the mid-anterior portal to assess the position of the anterolateral cannula, assuring that the cannula has not penetrated the labrum, as the anterolateral portal was performed using fluoroscopic visualization only, and the labrum may be perforated by the cannula. If this happens, the cannula needs to be repositioned. In some cases it is possible to back the cannula and simply readvance it avoiding the labrum. However, it may be necessary to take the cannula out and start again with the needle.

At this moment, another variation of the arthroscopic technique is possible. An interportal capsulotomy can be performed connecting the anterolateral and mid-anterior portals. The interportal capsulotomy has the advantage of performing the entire surgery (peripheral and central compartments) with only two portals. Its main disadvantage is that joining these two portals necessitates cutting the iliofemoral ligament, which is one of the main stabilizers of the hip joint. Another possible technique is to dilate the portals to pass the cannulas and not perform a capsulotomy. The main advantage of this latter technique is not injuring the iliofemoral ligament, while its main disadvantage is the need for multiple portals in order to reach and visualize the entire joint. No technique has been proven superior in the literature, and capsular management is a controversial, and currently frequently discussed, topic in hip arthroscopy. This chapter will focus on the technique without interportal capsulotomy [5].

Until the first two portals are established, the arthroscopy is performed dry without injecting fluid in the joint, as the second portal allows for outflow. If fluid is put into the joint without an outflow portal, mixture with blood will obscure visualization, making it difficult to visualize the second portal being made. After the second portal, fluid flow is instituted, which improves visualization. The posterolateral portal is performed third, looking posteriorly from the anterolateral portal. The starting point is 2 cm posterior to the posterior edge of the greater trochanter, just distal to a line drawn straight posterior from the anterolateral portal. It is important that the foot is in neutral rotation while establishing the posterolateral portal—external rotation or internal rotation will increase the risk of injury to the sciatic nerve when making this portal. Moving the camera lens' direction is more common in hip arthroscopy than in arthroscopy of another joints and can be helpful to achieve proper visualization.

3.3 Arthroscopic Anatomy

3.3.1 Central Compartment

After all portals are in place, an inventory of the joint can be performed. Each surgeon must have his/her own protocol to analyze the whole joint. Being systematic will avoid missing injuries and skipping steps. During most of central compartment arthroscopy, the posterolateral portal will be used as the camera portal, while the anterolateral and mid-anterior portal are used as working portals. However, exchanging viewing portals can aid in visualization. Also, for less experienced surgeons, exchanging portals will help to better understand the anatomy and localization of the structures.

First, the capsule is evaluated in regard to synovitis, which is common in FAI patients. It is possible to observe the capsule all around the acetabular rim and close to the labrum. The acetabular labrum is a fibrocartilage structure that runs around the acetabular rim. It is visible through all three portals and is important to evaluate all labral regions (Fig. 3.5). A clockface system is commonly used to facilitate location of tears. Twelve o'clock is directly lateral/superior, 3 o'clock is anterior, and 9 o'clock is posterior. Noting the aspect of the labrum is important to understand possible causes of tearing and determine treatment [6]. Tears caused by cam impingement are typically anterosuperior, the labral tissue is healthy, and a separation between the cartilage and the labrum is observed. In pincer impingement a more diffuse tear will be found, and the labral substance will be degenerated. The most anterior portion of the labrum can be visualized both from the anterolateral and posterolateral portals, while the posterior labrum will be better visualized from the anterolateral portal.

The acetabular cartilage is visualized from the central compartment. Similar to the labrum, its anterior portion will be better seen from the anterolateral and posterolateral portals, while the posterior region will be better seen from the anterolateral portal. A thorough examination of the cartilage is paramount, and the surgeon

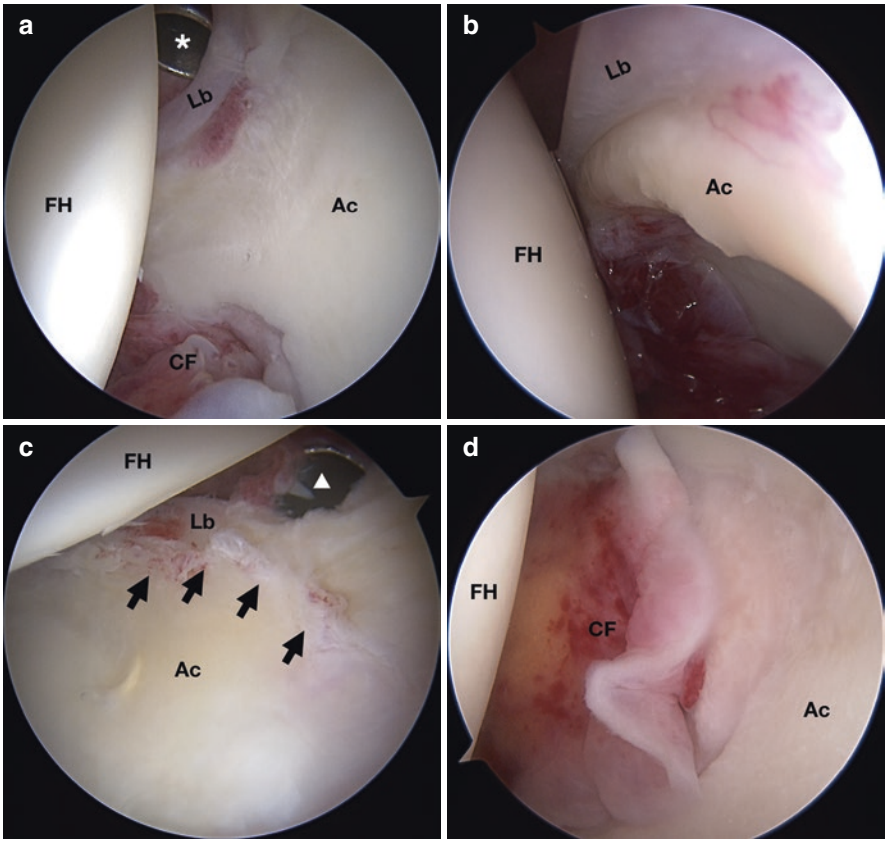

Fig. 3.5 Different views of the central compartment in a left hip. (**a**) View from the anterolateral portal with a 70° arthroscope. (**b**) View from the mid-anterior portal with a 30° arthroscope. (**c**). View from the posterolateral portal with a 70° arthroscope demonstrating the superior labrum and acetabular chondral damage (black arrows). (**d**) View from the posterolateral portal with a 30° arthroscope demonstrating the ligamentum teres and the cotyloid fossa with moderate synovitis *FH* femoral head, *Lb* labrum, *Ac* acetabulum, CF cotyloid fossa, *white star* cannula in the mid-anterior portal, *white triangle* cannula in the anterolateral portal)

has to be meticulous in probing the entire surface because carpet delamination may be underappreciated. Carpet lesions happen most commonly in association with cam lesions and are characterized by detachment of the articular cartilage from the labrum and subchondral bone (Fig. 3.6). Bubble lesions can also occur, and they are characterized by a detachment of the subchondral bone in a circumscript area without "opening" of the pocket to the joint. Areas of chondromalacia, noted as softening of the cartilage, can also be observed and should be recorded. The clockface system can also be used to localize acetabular cartilage injuries. However, another system has been described where the acetabulum is divided in geographic zones [7]. Two vertical lines and one horizontal line divide the acetabulum in six regions. The authors suggest this method is more reproducible than the clockface method.

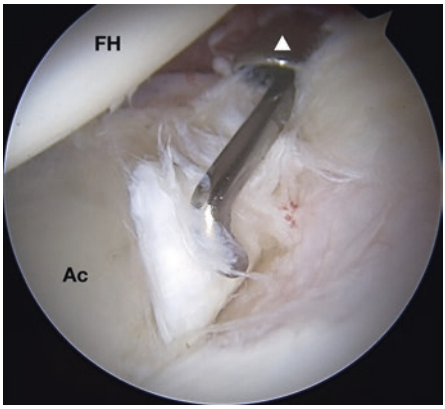

Fig. 3.6 View from the posterolateral portal with a 70° arthroscope demonstrating a carpet lesion of the acetabular cartilage being probed *FH* femoral head, *Ac* acetabulum, *white triangle* cannula in the anterolateral portal

Regardless of the location system used, it is essential to document all chondral damage in a systematic manner, as it may have treatment and prognostic consequences.

Attention is then turned to the cotyloid fossa and the ligamentum teres. This region is usually evaluated from the posterolateral portal. The anterolateral portal may also be used for visualization of the superior portion of the ligamentum teres. It is helpful to exchange to a 30° lens to facilitate a direct visualization of this region. Possible tears to the ligamentum teres are noted which may be partial or complete. The ligamentum teres and cotyloid fossa are also evaluated for synovitis, which is frequently observed in this area.

Finally, the femoral head is evaluated. From the central compartment, it is possible to observe the medial portion of the femoral head and the superior weight-bearing zone. The same geographic method can be used to record lesions on the femoral head [7]. Cartilage lesions on the femoral head are less common than acetabular lesions, and they are considered to have worse prognosis. Medial cartilage wear can be seen in cases of microinstability and appear to have a better prognosis. This damage is thought to occur during episodes of femoral head subluxation and is often accompanied by ligamentum teres tears and direct anterior acetabular labrum tears [8].

Two possible caveats in the central compartment anatomy are the psoas-U and the stellate crease. The psoas-U is a recess in the anterior margin of the acetabulum, where the psoas tendon crosses just anterior to the acetabular labrum. It can be used as a landmark for the 3 o'clock position [9]. A psoas tenotomy can be performed in this region [10]. The stellate crease is a reminiscent of the triradiate cartilage and can be seen both on MRI and arthroscopically [11]. During surgery it will appear as an area devoid of cartilage above the cotyloid fossa and should not be confused with chondral damage. It is more common in younger patients.

The pincer lesion is observed in the central compartment. In order to appreciate its location it is possible to use fluoroscopic guidance and direct observation. The labral and chondral damage will be markers of the impingement area, and will help to guide osseous resection. In cases of subspine impingement, the anteroinferior

iliac spine (AIIS) may be visible from the central compartment. It can be seen in the anterosuperior acetabular region, approximately between 1 and 2 o'clock, behind the labrum.

Correction of the pincer lesion and labral treatment are performed from the central compartment. Accessory portals may be necessary to achieve this goal. Common portals used include the anterior portal and the distal anterolateral accessory portal. The decision on which portals will be used should be tailored to each patient's anatomy and pathology.

3.3.2 Peripheral Compartment

When the central compartment portion of the surgery is finished, attention is turned to the peripheral compartment. Ideally, traction time should be kept less than 2 h to decrease the risk of traction-related complications. All cannulas are removed from the central compartment, and traction is released from both legs. A fluoroscopic image should confirm the hip is completely reduced. The cannula and trochar are inserted in the anterolateral portal and are introduced to the femoral head-neck junction or site of maximal deformity of the femoral head. A 30° lens is used for the peripheral compartment. An auxiliary portal is made approximately 3–4 cm proximal and 1 cm posterior to the anterolateral portal. This portal will be used as a working portal in the peripheral compartment. Fluoroscopy is used to aim the cannula and trochar toward the apex of the femoral head deformity, holding the cannula against the capsule. The trochar is exchanged for the 30 degree arthroscope, and a shaver is brought to the tip of the camera from the proximal anterolateral portal (Fig. 3.7). In this region, a partial small capsulectomy (up to 6–8 mm in width and 15 mm in length for capsular plications) is performed using the shaver. This area is considered the "bare area" of the hip capsule, between the iliofemoral and ischiofemoral ligaments. The capsulectomy is continued until proper

Fig. 3.7 Fluoroscopy image of a left hip. The arthroscope and the shaver are placed against the capsule at the femoral head-neck junction

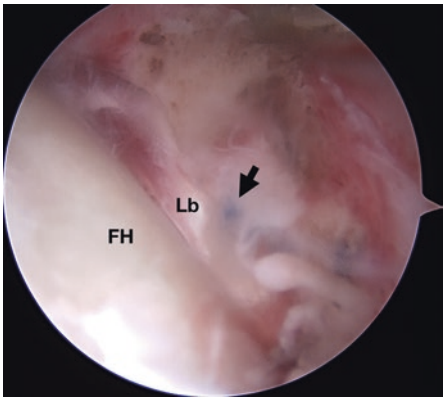

Fig. 3.8 View from the anterolateral portal with a 30° arthroscope in the peripheral compartment. The labrum sits nicely on top of the femoral head restoring the suction seal. It is possible to observe one stitch from the labral repair (arrow). *FH* femoral head, *Lb* labrum

visualization of the head-neck junction is observed. Observing the width of the capsule and if it is patulous may help in hip microinstability investigation.

In patients presenting cam impingement, the cam lesion should be visualized right upon entering the peripheral compartment. It is possible to observe the labrum (and its repair if it was performed) from the peripheral compartment (Fig. 3.8). Observing the relationship between the femoral head and the labrum is essential to confirm the suction seal was restored. The anterior portion of the femoral head is visible in its area not covered by the acetabulum. All the anterior neck is observed as distal as the intertrochanteric ridge.

When addressing the peripheral compartment, moving the leg can be extremely helpful to navigate the joint (Fig. 3.9). Hip flexion will relax the anterior capsule and make instrument maneuverability easier, and straight flexion brings the more distal and medial femoral neck into view. Likewise, hip rotation may facilitate access to the medial or lateral region. For example, internal rotation is useful to access the posterolateral portion of the femoral head-neck junction.

The anterior capsule can be noted, and similar to the central compartment, synovitis can be observed and treated. In the midportion of the capsule, the zona orbicularis can be seen as a transverse band going around the base of the femoral neck (Fig. 3.10). It is critical not to violate the zona orbicularis, as previous biomechanical work has demonstrated its importance in hip stability [12]. It is also possible to observe the impression of the psoas tendon on the anterior capsule, and a psoas tenotomy can be performed in this region (Fig. 3.10).

The medial synovial fold can be found on the medial portion of the femoral neck, which serves as an important landmark in the peripheral compartment. Flexion or external rotation may facilitate its visualization. The lateral synovial fold can be

Fig. 3.9 The operated leg is freed from the operating table and hold by the assistant. This allows flexion and rotation of the leg to help adequate visualization

found on the lateral portion of the femoral neck. Sometimes the pulsation of the lateral retinacular vessels is visible along the posterior and posterolateral femoral neck. One can also see the reflection and insertion of the proximal capsule on the acetabulum, above the labrum.

After a proper inventory of the peripheral compartment, a femoral osteoplasty can be performed in cases of cam FAI. A dynamic assessment of impingement should be performed at the end of the case to check for possible residual deformities and impingement. At the end of the procedure, the capsule may be closed or plicated if the patient presented hip laxity or microinstability. A bulky dressing is used after skin closure because liquid extravasation is common in the first 24 h. Hip arthroscopy can be safely performed as an outpatient procedure.

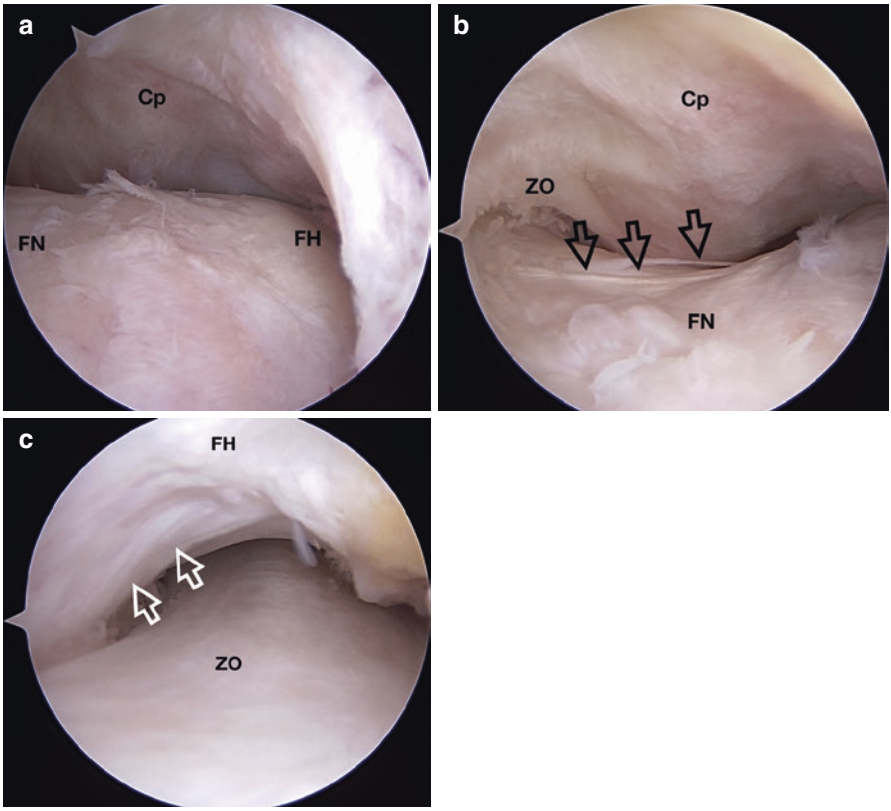

Fig. 3.10 View from the anterolateral portal with a 30° arthroscope in the peripheral compartment. (**a**) The cam lesion is observed in the femoral head-neck transition. (**b**) Medial synovial fold (black arrows) and the zona orbicularis. The back of the black arrow furthest to the right is where the iliopsoas tendon is indenting the capsule. Cutting the capsule at this point can expose the iliopsoas tendon for a psoas tenotomy. (**c**) Lateral synovial fold (white arrows) and the zona orbicularis posteriorly. *FH* femoral head, *FN* femoral neck, *Cp* anterior capsule, *ZO* zona orbicularis

3.4 Conclusion

Hip arthroscopy is a difficult procedure with a prolonged learning curve. Understanding the local anatomy is crucial to obtain satisfactory results and decrease the number of complications. A systematic approach for evaluation of the anatomic structures should be used by surgeons performing hip arthroscopy.

References

1. Burman MS. Arthroscopy or the direct visualization of joints. J Bone Joint Surg. 1931;13(4):669–95.
2. Dorfmann H, Boyer T. Arthroscopy of the hip: 12 years of experience. Arthroscopy. 1999;15(1):67–72.

3. Byrd JW. Hip arthroscopy utilizing the supine position. Arthroscopy. 1994;10(3):275–80.
4. Glick JM, Sampson TG, Gordon RB, Behr JT, Schmidt E. Hip arthroscopy by the lateral approach. Arthroscopy. 1987;3(1):4–12.
5. Kalisvaart MM, Safran MR. Hip instability treated with arthroscopic capsular plication. Knee Surg Sports Traumatol Arthrosc. 2017;25(1):24–30.
6. Beck M, Kalhor M, Leunig M, Ganz R. Hip morphology influences the pattern of damage to the acetabular cartilage femoroacetabular impingement as a cause of early osteoarthritis of the hip. J Bone Joint Surg Br. 2005;87(7):1012–8.
7. Ilizaliturri VM Jr, Byrd JWT, Sampson TG, et al. A geographic zone method to describe intra-articular pathology in hip arthroscopy: cadaveric study and preliminary report. Arthroscopy. 2008;24(5):534–9.
8. Shibata KR, Matsuda S, Safran MR. Is there a distinct pattern to the acetabular labrum and articular cartilage damage in the non-dysplastic hip with instability? Knee Surg Sports Traumatol Arthrosc. 2017;25(1):84–93.
9. Telleria JJM, Lindsey DP, Giori NJ, Safran MR. An anatomic arthroscopic description of the hip capsular ligaments for the hip arthroscopist. Arthroscopy. 2011;27(5):628–36.
10. Ejnisman L, Philippon MJ, Lertwanich P, et al. Relationship between femoral anteversion and findings in hips with femoroacetabular impingement. Orthopedics. 2013;36(3):e293–300.
11. Philippon MJ, Ejnisman L, Ellis HB, Briggs KK. Outcomes 2 to 5 years following hip arthroscopy for femoroacetabular impingement in the patient aged 11 to 16 years. Arthroscopy. 2012;28(9):1255–61.
12. 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):989–95.