Hip Arthroscopy: Central Compartment Access

19

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Contents

Abstract

Recently, the field and awareness of hip arthroscopy have significantly expanded amongst surgeons managing hip disorders. Pathologies arising from the intra-articular space of the hip joint, also referred to as the central compartment of the hip, remain the primary indications for this procedure. This chapter will focus on issues relevant to the arthroscopic access to the central compartment. These issues include the unique characteristics of the hip joint and surrounding tissues, relevant anatomical structures, the introduction of the standard portals used, their establishment and utilization, safety concerns and risks, the process of proper patient selection, and preoperative planning. This chapter provides the necessary base of knowledge needed prior to performing this procedure.

Introduction

Arthroscopic management of the hip has evolved significantly since hip arthroscopy was described in the early 1930s [1]. For many years, hip arthroscopy was primarily a diagnostic and therapeutic tool for pathology arising from the space within the hip joint. This space is commonly referred to as the central compartment of the hip. As hip arthroscopy evolved, two additional compartments for arthroscopic procedures were described: the peritrochanteric compartment [2]

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and the peripheral compartment, providing access to the femoral neck, outer acetabular rim, and peripheral labrum [3]. The advent of these compartments enabled the expansion of arthroscopic indications to treat a broader spectrum of pathologies within and around the hip joint.

Appropriate portal placement is fundamental to obtain adequate access to all compartments. Portal positioning is simultaneously a critical part of the procedure and, some might say, the most challenging part. Improper portal positioning has the potential to add complexity to the procedure as well as damage important and vital anatomical structures, hence compromising procedure safety and outcomes.

General Considerations

Hip arthroscopy can be performed with the patient positioned either in the supine or lateral decubitus position. The same portal placement is used in both positions [4–6]. The anterior superior iliac spine (ASIS) and tip of the greater trochanter are the most important superficial anatomical landmarks that serve as reference points in portal placement for the central compartment. Additional anatomical reference points include the symphysis pubis and femoral shaft.

Standard portals for the central compartment consist of the anterolateral (AL), anterior (AP), and posterolateral (PL) portals. More recently, the midanterior portal (MAP) is being increasingly utilized. The AL portal is the most commonly used introductory portal for hip arthroscopy and is the working portal for many arthroscopic hip procedures.

Portal placement is a demanding task that requires careful consideration of the unique anatomy of the hip joint and surrounding tissues. The hip joint is a constrained ball-and-socket joint with a relatively small intra-articular volume (normal range, 0.7–5.6 mL) [7]. Important intra-articular structures include the acetabular and femoral articular hyaline cartilage and the acetabular labrum, which effectively seals off the deep central part of the joint. Surrounding the hip joint are a thick soft-tissue mantle and the thickened hip joint capsule. Neurovascular structures in close proximity to the hip joint should also be taken into consideration. Important structures include the lateral femoral cutaneous nerve (LFCN), femoral nerve (the most lateral of the femoral neurovascular structures), sciatic nerve, superior gluteal nerve, and branches of the lateral circumflex femoral artery (LCFA) and medial circumflex femoral artery (MCFA) [8–12].

Initial entry into the central compartment of the hip carries a high risk of iatrogenic injury to the structures mentioned above. The intra-articular labrum is especially at risk due to its location directly along the path of the common initial portal placement. Scuffing the femoral head and/or acetabular articular cartilage is also possible when first entering the hip joint [8, 13–16].

Additional factors that might influence portal positioning and complicate access to the hip joint include coxa vara/valga, excessive bony abnormalities seen with femoroacetabular impingement, excessive version deformities, hip dysplasia, coxa profunda, hip joint arthritis with degenerative changes, and abnormal body habitus. These findings must be addressed and should be taken into consideration prior to arthroscopy.

Patient selection and preoperative planning are integral components to achieve successful outcomes in hip arthroscopy. Arthroscopic hip surgery should be advocated for patients with clinical and imaging findings suggestive of pathology amenable to arthroscopic intervention established by current evidence-based guidelines. It is imperative that the surgeon preoperatively plan the appropriate surgical procedure according to the underlying pathology and discuss with the patient the steps of the procedure and manage expectations in terms of outcomes [17].

Patient Setup

Hip arthroscopy is commonly performed under general anesthesia with muscle relaxation. Epidural anesthesia is an alternative option, but requires an adequate motor block to ensure optimal distractibility of the joint. Regional anesthesia can be used as an adjunct in postoperative pain

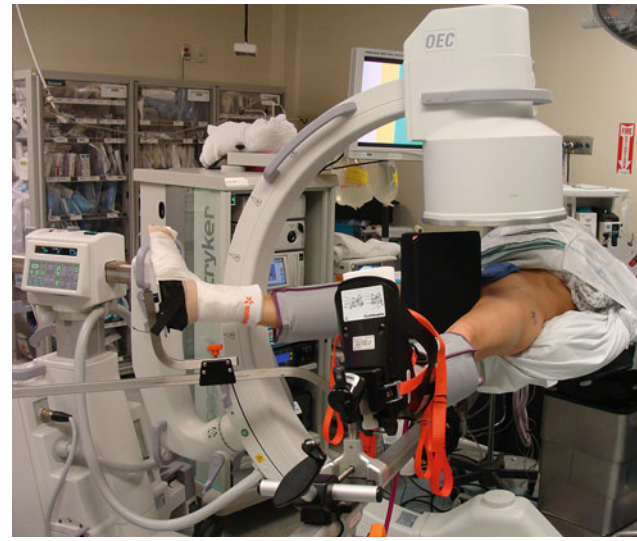

Fig. 1 Patient setup in the supine position for left hip arthroscopy

management [17, 18]. The patient can be placed either supine or in the lateral decubitus position for the procedure, according to surgeon preference. Both positions have been shown to yield comparable results. The supine position will be described, as it is perceived as simpler and more commonly utilized. The lateral approach may be preferable for patients with obesity or morbid obesity.

The arthroscopic and fluoroscopic towers are placed on the opposite side of the operative extremity, with the fluoroscopic monitor at the foot of the patient and the C-arm image intensifier centered over the operative hip. The patient is placed in the supine position on a fracture table or radiolucent table with traction capability. The feet are wrapped with padding and securely attached to the foot holders. A well-padded perineal post is attached to the operating table. The perineal post is positioned laterally against the proximal medial thigh of the surgical hip. This provides an optimal moment arm for distraction once traction forces are applied and reduces direct pressure on the perineum, minimizing the risk of neuropraxia of the pudendal nerve. Patient setup in the supine position is demonstrated in Fig. 1.

Gentle hip distraction is applied to obtain approximately 10 mm of joint distraction confirmed fluoroscopically (see Fig. 2a, b). The goal is to use the minimal force required to achieve adequate distraction and keep traction time as brief as possible (preferably less than 2 h). It is important that the distraction system employed allows for adequate mobility of the operative hip specifically in flexion, abduction, and/or adduction of the hip. Freedom of movement in these planes is essential to achieving sufficient visualization and optimal maneuverability during surgery [19, 20].

Portal Placement

After proper traction is applied, the operative extremity is placed in neutral abduction. Slight hip flexion can be added, as it may relax the anterior capsule and aid in portal placement. The principal landmarks are identified and marked including the greater trochanter, anterior superior iliac spine (ASIS), pubic symphysis, and femoral shaft. Arthroscopic access to the central compartment of the hip joint is based on two to three standard portals that are routinely established: anterolateral (AL), anterior, and/or posterolateral (PL) portals. A more commonly used portal in recent years is the midanterior portal (MAP). The AL portal is used as the introductory portal for virtually all routine hip arthroscopy. The anatomical landmarks and position of these portals are demonstrated in Fig. 3.

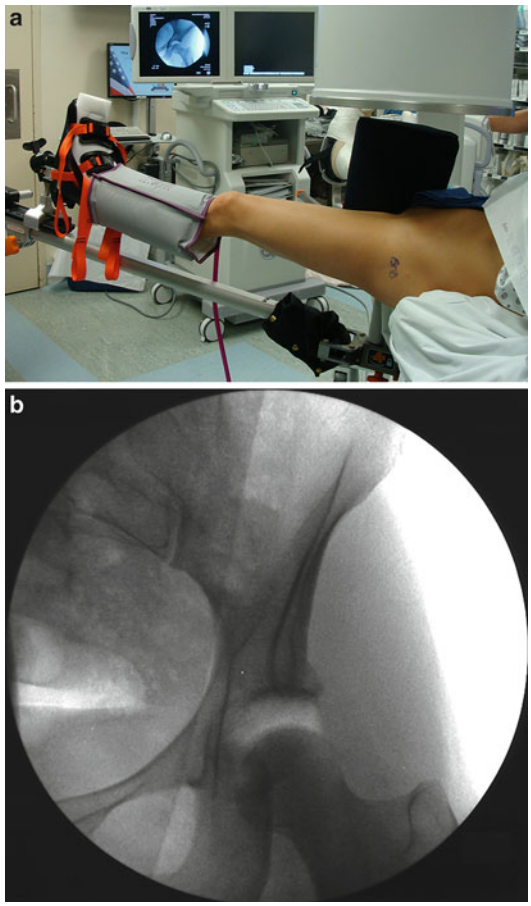

Fig. 2 (**a**) The left lower extremity is seen in approximately 10 mm of distraction and (**b**) confirmed fluoroscopically

Anterolateral Portal

The AL portal is usually established as the introductory portal. It is easier to access, reproducible, and presents relatively less risk to the surrounding neurovascular structures. The entry point on the skin is approximately 1 cm anterior and 1 cm superior to the anterosuperior tip of the greater trochanter. This portal was traditionally described as penetrating the gluteus medius muscle and entering the lateral capsule at its anterior margin [17]. Another well-described technique for establishing the AL portal is through the intermuscular interval between the abductors and the tensor fasciae latae. In some patients, when traction is applied to the operative extremity, a palpable ridge can be identified along the anterolateral thigh at the level of the AL portal insertion site. This palpable ridge is formed by the transition zone between the posterior border of the tensor fascia lata and the anterior border of the gluteus maximus fascia, which merge in line with the anterior aspect of the greater trochanter. When done properly, the portal will penetrate the gluteal fascia and then pass down to the joint capsule with minimal soft-tissue resistance as it passes atraumatically between the tensor fasciae latae anteriorly and the gluteus medius posteriorly [11].

The joint capsule is punctured with a large-gauge spinal needle (17 G or 16 G) under fluoroscopic guidance. The needle should be inserted through the AL portal insertion site with a slightly posterior (20–30°) and cephalad (10–20°) trajectory toward the hip joint and between the femoral head and acetabular labrum. A tactile feedback of a resistance felt when the needle penetrates the thick joint capsule with an immediate decrease of this resistance after penetration of the capsule can signify proper positioning of the needle without injury to the intra-articular structures at risk.

Successful entry into the central compartment of the hip joint is confirmed with an air arthrogram. This is performed by removal of the spinal needle stylus and breaking the vacuum seal of the joint. This should provide for additional distraction of the hip joint and often enables fluoroscopic visualization of a silhouette of the acetabular labrum. The joint can also be filled with saline at this time with observed backflow confirming the intra-articular position of the spinal needle. A nitinol guidewire is then placed through the spinal needle, and a stab incision is made through the skin adjacent to the needle. The needle is removed, leaving the nitinol wire and cannulated dilators placed over the guidewire to allow for easier passage of the final obturator. It is important to direct the various cannulas superiorly away from the convexity of the femoral head in order to avoid inadvertent scuffing of the articular cartilage [18].

A 70° arthroscope is then used to perform a diagnostic arthroscopic examination and to establish the other portal(s) under direct visualization.

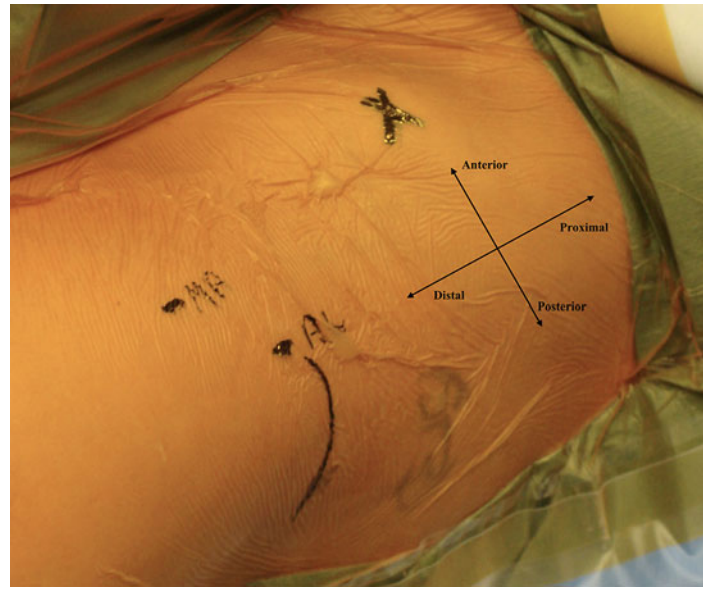

Fig. 3 Anatomical landmarks are outlined including the greater trochanter (*curved line*) and anterosuperior iliac spine (marked "X"); the anterolateral (*AL*) and midanterior (*MA*) portals are also labeled

This process of spinal needle, nitinol wire, dilators, and obturator placement is used for all subsequently portals and is an important aspect of safe portal placement. After placement of other portals, the arthroscope can be introduced into another portal in order to visualize the position of the anterolateral portal in relation to the acetabular labrum and make adjustments if necessary.

The anterolateral portal in the central compartment enables arthroscopic visualization of the following structures: cotyloid fossa, pulvinar, ligamentum teres, posterior medial acetabulum and labrum, anterior labrum, anterior capsule, paralabral sulcus, and the intra-articular portion of the psoas tendon and corresponding bursa. The anterior triangle, containing the anterior capsule, anterior labrum, and femoral head, is a very helpful landmark allowing for direct visualization of the spinal needle when establishing the anterior portal (see Fig. 4) [18].

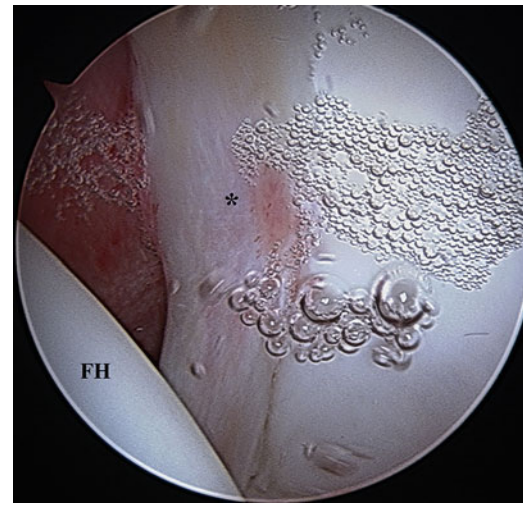

Fig. 4 Structures visualized through the anterolateral portal including the anterior triangle, anterior labrum/capsule (*asterisk*), and femoral head (*FH*)

Risks

The anterolateral portal is located centrally within the safe zone of access to the hip joint, minimizing the risk of damage to neurovascular structures. The superior gluteal nerve, coursing on the deep surface of the gluteus medius, and the sciatic nerve are the closest neurovascular structures to this portal located a mean distance of 64.1 and 40.2 mm, respectively, from the anterolateral portal [11].

The main concern when establishing the AL portal under solely fluoroscopic control is possible damage to the intra-articular structures such as scuffing the articular cartilage of the femoral head or perforating the acetabular labrum. A recent

study of 250 patients reported an iatrogenic labral puncture rate of up to 20 % [13]. Strategies to minimize labral injury include using adequate distraction, joint distention, tactile feedback, reintroducing the spinal needle after distention of the joint with saline, as well as spinal needle repositioning with or without arthroscopic visualization from other portals. Careful attention to detail and proper technique can reduce the likelihood of iatrogenic injury [10, 13, 18].

In addition, novel techniques for minimizing the risks while accessing the central compartment of the hip joint have been described and published in recent years. One technique describes placing the arthroscope first in the peripheral compartment through the anterolateral portal followed by placement of a spinal needle and guidewire into the central compartment via an anterior portal under direct arthroscopic visualization [3]. Another technique describes directing the AL portal needle slightly anteroinferior to the clear space of the distracted joint overlapping the superior part of the femoral head, thereby directing the needle away from the labrum [14].

Anterior Portal

Several variations of positioning the anterior portal have been described. The traditional location of the skin entry point of the anterior portal was at the intersection of a sagittal line drawn down from the anterior superior iliac spine (ASIS) and a transverse line from the superior border of the greater trochanter. Insertion of the spinal needle is aimed approximately 45° cephalad and 30° toward the midline. It was found that when positioned this way, in line with the ASIS, this portal penetrates the sartorius muscle and the rectus femoris muscle before entering the anterior joint capsule and passes in dangerously close proximity to branches of the lateral femoral cutaneous nerve (3 mm) and the ascending lateral circumflex femoral artery (3 mm) [11, 12, 17]. Some have advocated placing the AP portal 1 cm lateral to its traditionally described location (i.e., 1 cm lateral to the ASIS) reducing the risk of lateral femoral cutaneous nerve (LFCN) and lateral circumflex femoral artery (LCFA) iatrogenic injury. When positioned laterally, the portal penetrates the muscle belly of the tensor fasciae latae (TFL) and passes through an interval between the gluteus minimus and rectus femoris before entering the joint through the anterior capsule. It courses a mean distance of 15 mm lateral to the LFCN and its branches, 31 mm proximal to the ascending LCFA, and 15 mm lateral to the ascending LCFA terminal branch [11].

The anterior portal is established under direct visualization using a 70° arthroscope in the anterolateral portal. The spinal needle is directed toward the anterior triangle. The anterior portal in the central compartment enables arthroscopic visualization of the following structures: ligamentum teres, posterior transverse ligament, posteromedial labrum, anterior transverse ligament, anterior labrum, superior articular cartilage, lateral labrum, and posterolateral capsule.

Risks

Special care and attention should be taken when inserting the AP portal. As mentioned, branches of the lateral femoral cutaneous nerve and lateral circumflex femoral artery are in close proximity to the portal and most at risk. Positioning the skin entry point 1 cm laterally places the portal path further away from these structures and may mitigate this risk. An important consideration is the anatomical variation of the proximal LFCN branching site, present in nearly 25 % of patients [19]. In these cases, the most lateral branch of the LFCN might be even closer to the AP portal. Stab incisions should be avoided in the anterior portal in an effort to prevent iatrogenic injury to these branches. The femoral neurovascular bundle is normally located a safe mean distance of more than 3 cm from the portal, and the vertical line marked from the ASIS distally can be used as the medial border of the safe zone. Because this portal is established under direct visualization, the risk to intra-articular structures should be minimal.

Midanterior Portal (MAP)

The midanterior portal is becoming more popular in recent years. Some have adopted this portal and the AL portal as part of the standard two-portal hip arthroscopy technique. The MAP was described in several variations including halfway between the anterior and AL portals and either 2–7 cm distally at a distal angle of 45° from the AL portal or as the third vertex of an equilateral triangle with the AP and AL portal as the remaining two proximal vertices [11, 18]. The placement of the midanterior portal may slightly vary depending on patient body habitus. This portal is also established under direct arthroscopic visualization and allows for a better-angled placement of superior and anterior anchors for labral repair. The midanterior portal in the central compartment enables arthroscopic visualization of the same structures as the anterior portal with the addition of the peripheral compartment.

Risks

The midanterior portal has been associated with penetration of the TFL before passing through the gluteus minimus–rectus femoris interval. There is a decreased risk of LCFN injury because this portal is placed laterally and distally to the traditional and modified anterior portal. The terminal branch of the ascending LCFA was found to be the closest neurovascular structure to the MAP with a mean distance of 10 mm (range, 1–23 mm). There is no report in the literature of significant intraoperative or postoperative bleeding using this portal. However, this theoretical risk should still be taken to consideration.

Posterolateral Portal

The posterolateral portal is placed 1 cm superior and 1 cm posterior to the tip of the greater trochanter or the posterior superior border of the greater trochanter. It is established under direct visualization from either the anterior or the anterolateral portal. The portal enters the hip joint at the posterior margin of the lateral capsule [17]. When the hip is in slight internal rotation, compensating for femoral neck anteversion, the needle is aimed almost parallel to the floor for joint entry [20]. The posterolateral portal provides visualization of the following structures within the central compartment of the hip joint: the inferior gutter of the hip joint, the weight-bearing dome of the acetabulum, anterolateral labrum, and femoral head (Fig. 5).

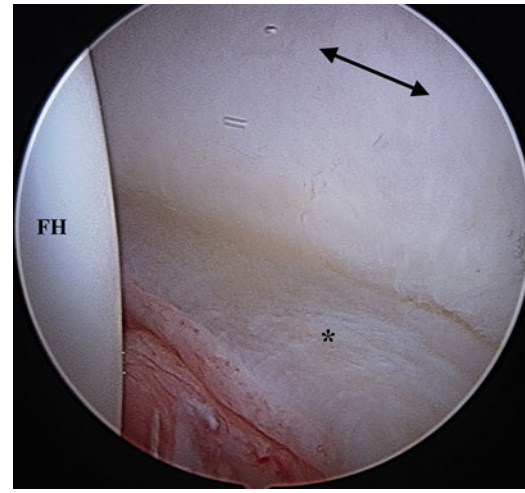

Fig. 5 Posterolateral compartment: the inferior gutter of the hip joint, the weight-bearing dome of the acetabulum (*two-sided arrow*), anterolateral labrum (*asterisk*), and femoral head (*FH*)

Risks

The sciatic nerve has been described as residing a safe mean distance of 22 mm from the PL portal to the central compartment [11, 12]. It is in closest proximity at the level of the joint capsule. The closest neurovascular structure to the PL portal was the deep branch of the medial circumflex femoral artery at a mean distance of 10.1 mm inferior to the PL portal as it passes through the piriformis tendon. The posterior tip of the greater trochanter seems to protect this important vessel, which is the main blood supplier to the femoral head, and functions as a bony boundary for the trocar. Any change of normal anatomy

(pathologic or iatrogenic) of the posterior aspect of the greater trochanter must be evaluated properly prior to the surgery and addressed during the surgery [20–22]. Risk to intra-articular structures should be minimal, as this portal is established under arthroscopic visualization.

Challenges to Central Compartment Access

Portal placement can be complicated by several patient-specific pathologies. Detached anterosuperior labral tears can make it difficult to establish the anterior portal (Fig. 6). Large pincer lesions and global overcoverage may increase the amount of distraction needed for visualization. Structural bony abnormalities such as coxa vara/valga and focal retroversion may slightly alter optimal portal placement. An alternative is to enter into the peripheral compartment first and perform a peripheral labrum takedown and rim trimming to allow access to the central compartment [23]. Patients with hip dysplasia and a hypertrophic labrum are especially at risk of iatrogenic labral injury. Surgeons should be mindful of these challenges, plan preoperatively, and make the appropriate adjustments in order to optimize patient outcomes.

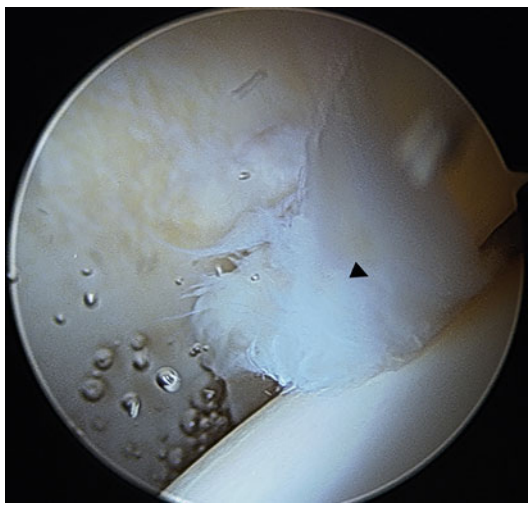

Fig. 6 Detached labral tear (*arrowhead*) obstructing visualization from the anterior portal

Capsulotomy

The strong fibrous capsule of the hip is a unique structure that provides stability, protection, and the blood supply for the hip joint. The capsule is composed of internal and external fibers. The internal fibers comprise the circular zona orbicularis, which forms a collar around the femoral neck. The external fibers run longitudinally and are made up of the iliofemoral, ischiofemoral, and pubofemoral ligaments. The anteriorly located and inverted "Y"-shaped iliofemoral ligament was found to be stiffer and more resilient to force than the ischiofemoral and pubofemoral ligaments [24]. This highlights the importance of preserving or restoring its anatomical and functional characteristics at the end of the procedure.

Capsular management during hip arthroscopy is critical to allow for better exposure without compromising hip stability, kinematics, and blood supply [25].

An anterior capsulotomy connecting the anterolateral and anterior portals can be very helpful in terms of visualization, exposure, instrument maneuverability, and safety. The interportal capsulotomy is created carefully within the plane between the labrum and femoral head. The length of the capsulotomy depends on findings in the central compartment and can be extended as posteriorly as the piriformis tendon and as anteromedially as the psoas tendon as needed. The interportal capsulotomy allows for arthroscopic visualization of the extra-articular side of the labrum, rim, and pathologic impingement lesions related to the anterior inferior iliac spine [6, 25].

There is no consensus on the optimal way to address the capsulotomy at the termination of the procedure. The capsule can either be repaired or left alone. Many hip surgeons traditionally have not repaired the capsulotomy with favorable results and no significant sequelae. Furthermore, it was suggested that when preoperative hip stiffness was encountered, the capsulotomy might even be therapeutic [6, 26]. Others believe that changing the anatomy of the capsule might result in instability, less restraint to external rotation of

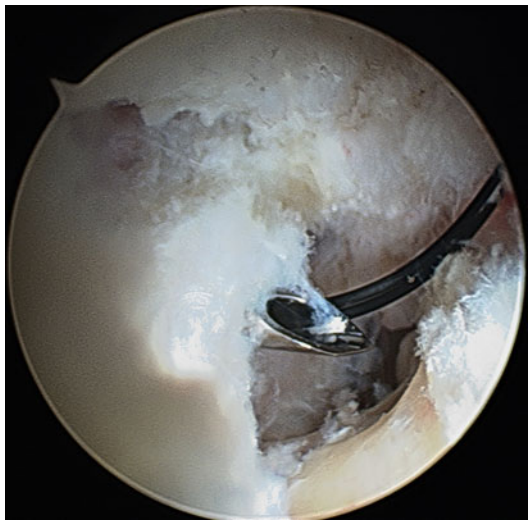

Fig. 7 Capsulotomy and repair

the hip, capsular scarring, and/or postoperative pain, particularly in patients with underlying hyperlaxity or dysplasia. Repair of the capsulotomy is done by anatomical reduction of the medial and lateral capsular flaps and repair with anatomical side-to-side stitches until a complete closure is achieved (Fig. 7).

Summary

Hip arthroscopy is becoming a more common treatment with encouraging outcomes for a wider range of pathologies within and around the hip joint. Pathologies arising from the intra-articular space of the hip joint, also referred to as the central compartment of the hip, remain the primary indications for this procedure. Access to the central compartment, as for other compartments as well, is based on proper portal positioning. Understanding the unique characteristics of the hip joint and surrounding tissues and anatomical structures is a key factor for a successful and safe procedure. Other pivotal components include proper patient selection and preoperative planning. The standard portals of the central compartment are the anterolateral (AL), anterior (AP), and posterolateral (PL) portals. The midanterior portal (MAP) is becoming a more frequently utilized portal. The AL portal is the most commonly used introductory portal for hip arthroscopy. Hip arthroscopy is considered a relatively safe procedure and surgeons should be cognizant of the possible sequelae and ways to mitigate the risk of complications.

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