

Hip Arthroscopy With Fluoroscopy-Free Technique for the Treatment of Femoroacetabular Impingement



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Abstract: Hip arthroscopy is the predominant surgical procedure for the treatment of femoroacetabular impingement syndrome (FAI). Usually, hip arthroscopy requires intraoperative fluoroscopic guidance for portal establishment, acetabuloplasty, suture anchor placement, and femoroplasty, which has disadvantages such as radiation exposure and prolonged operative time. This article presents a technique of hip arthroscopy without fluoroscopy throughout. By establishing portals through a semiopen hollow guide bar, “one-line trimming” for pincer deformity removal, modified distal anterolateral portal for anchor placement, “triangular abrasion” for cam deformity resection, and intraoperative dynamic examination to ensure adequate relief of impingement, we provide a safe and effective surgical procedure for hip arthroscopy to treat FAI without fluoroscopy.

As the most prominent treatment for femoroacetabular impingement, hip arthroscopy technique has been rapidly developed in the past 20 years and has achieved good results.^{1,2} Intraoperative fluoroscopy is an important adjunct technique in hip arthroscopy that is commonly used to assess the effectiveness of traction, guide the establishment of portals, and assess the amount of cam and pincer deformity removal.³ Although intraoperative fluoroscopy is a valuable aid to surgery, it can also increase radiation exposure for both patient and surgeon,⁴ as well as increase operative time and equipment requirements. Because of these drawbacks, we have

improved the surgical technique to eliminate the use of fluoroscopic equipment throughout the procedure. This technique is described in detail in this article, and to our knowledge, this is the first article to propose a similar surgical technique.

Surgical Techniques

Preoperative Planning

A detailed preoperative evaluation is important for the intraoperative fluoroscopy-free technique. In our experience, an anteroposterior view, 60° Dunn view, and false profile view of the pelvis are usually required. Measurements of the lateral central marginal angle (LCEA), Tonnis angle, cervical stem angle, alpha angle, and offset are performed to assess the extent of cam and pincer deformity. Computed tomography (CT) 3-dimensional reconstruction can be used to preoperatively evaluate the degree of cam and pincer deformity and type of anterior inferior iliac spine (AIIS) to guide intraoperative removal of the overgrown bone (Fig 1). Unilateral hip magnetic resonance imaging can provide enriched imaging detail to assess damage to the labrum, cartilage, and other soft tissue lesions.

Position and Anesthesia

The patient is placed under general anesthesia and given muscle relaxants to achieve good traction. The traction technique without perineal post is then performed in the Trendelenburg supine position with a large sponge pad placed under the patient to increase

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friction. The patient is placed in a 15° to 20° head-down position with mild antagonistic traction on the contralateral thigh and with traction on the affected limb in a straightened, internal rotation of 15° to achieve good traction.

Portals and Transverse Capsulotomy

A self-designed semiopen hollow guide bar is used to create the anterolateral (AL) portal (Fig 2A). This tool combines the functions of a guide bar and a slide for the creation of the AL portal without fluoroscopy. The skin is incised at the location of the conventional AL portal. The fascia, muscles, and soft tissues outside the joint capsule are bluntly separated using a straight clamp, and the semiopen guide bar is inserted into the incision at an angle of approximately 15° cephalad and 15° posterior until its tip contacts the surface of the hip capsule (Fig 2B). Slide the guide bar distally on the bony slope of the acetabular rim, during which the operator can clearly feel the soft spot in the joint space, and there is an obvious feeling of indentation in the gap. The width of the joint space and the location of the joint capsule puncture are assessed at this time. If the feeling of indentation is not obvious, it indicates that the joint gap is too narrow, and the traction needs to be increased. A long puncture needle is then placed along the slide in the center of the guide bar to penetrate the joint capsule and into the joint. When performing the portal expansion, care needs to be taken to stop once the expander has passed through the joint capsule to prevent damage to the labrum. Then, the 30° arthroscope (Smith & Nephew) is placed to confirm that the lens has passed through the portal into the joint (Video 1).

The mid-anterior (MA) portal can be established in 2 ways: if only a periportal capsulotomy is performed, the MA portal can be established in the same way as the AL portal. However, in most cases, we perform an interportal transverse capsulotomy using an outside-in technique for better visualization. In this case, the MA portal is established in the following pattern (Video 1).

The 30° arthroscope is entered into the joint through the AL portal with the lens oriented anteriorly. The skin is incised at the location of the conventional MA portal and the fascia, muscle, and soft tissue of the joint capsule surface are bluntly separated using a straight clamp. The 45° radiofrequency (Smith & Nephew) is then placed into the MA portal, which is intersected with the outer sheath of the lens at the point where the arthroscope penetrates the joint capsule. The lens is then slowly withdrawn from the joint capsule along with the outer sheath. The head end of the radiofrequency can be seen just as the lens exits the joint capsule (Fig 3A). At this point, the anterior and anterolateral joint capsule can be incised in its entirety from outside to inside using the radiofrequency in the direction of the joint space (Fig 3C), which can be made

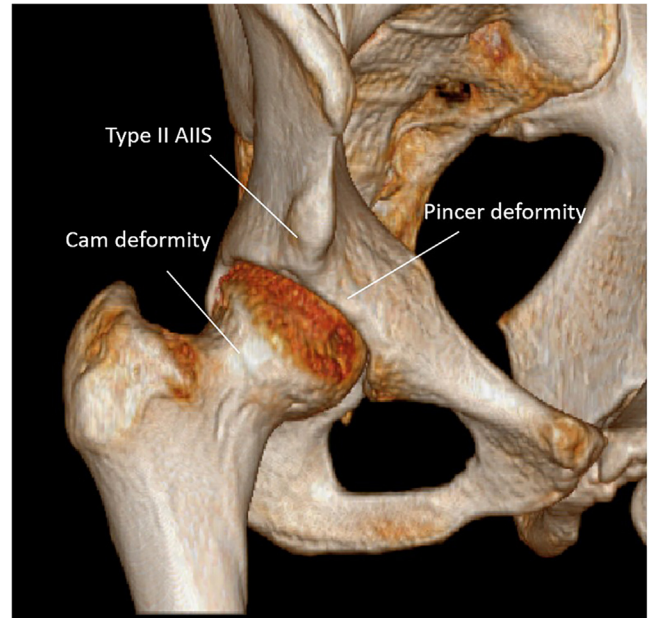


Fig. 1. Preoperative 3-dimensional computed tomography reconstruction of the right hip. Pincer, cam deformity, and type II anterior inferior iliac spine (AIIS) can be assessed in the imaging.

all the way to the 3-o'clock position. Care is taken not to damage the labrum on the deep side of the capsule during the incision. This method allows for effective exposure of the central compartment while minimizing iatrogenic damage to the labrum and cartilage (Fig 3B).

Acetabuloplasty and AIISplasty

After placement of the arthroscope, cartilage of the femoral head, labrum, acetabular fossa, and the ligamentum teres are first examined. Based on the degree and extent of the labral injury and preoperative imaging, the range of pincer deformity can be initially determined. Subsequently, the adhesions between the acetabular rim and the joint capsule should be separated sufficiently to fully reveal the overgrown bone of the pincer deformity behind the injured labrum.

Based on the characteristics of the local protrusion of the overcovered pincer deformity, we propose the "one-line trimming method" to guide the uniform abrasion of the pincer deformity. Use the AL portal as the viewing portal, with the arthroscopic lens placed close to the anterolateral edge of the acetabulum; the viewing field is then oriented anteriorly or posteriorly so that it can be observed in the direction of the acetabular rim, where the pincer deformity has an irregularly curved edge (Fig 4A). By moving the arthroscope in the direction of the acetabular rim, the border between the pincer deformity and the normal acetabular bone can also be observed (Fig 4B), which allows visual evaluation of the size and extent of the pincer deformity.

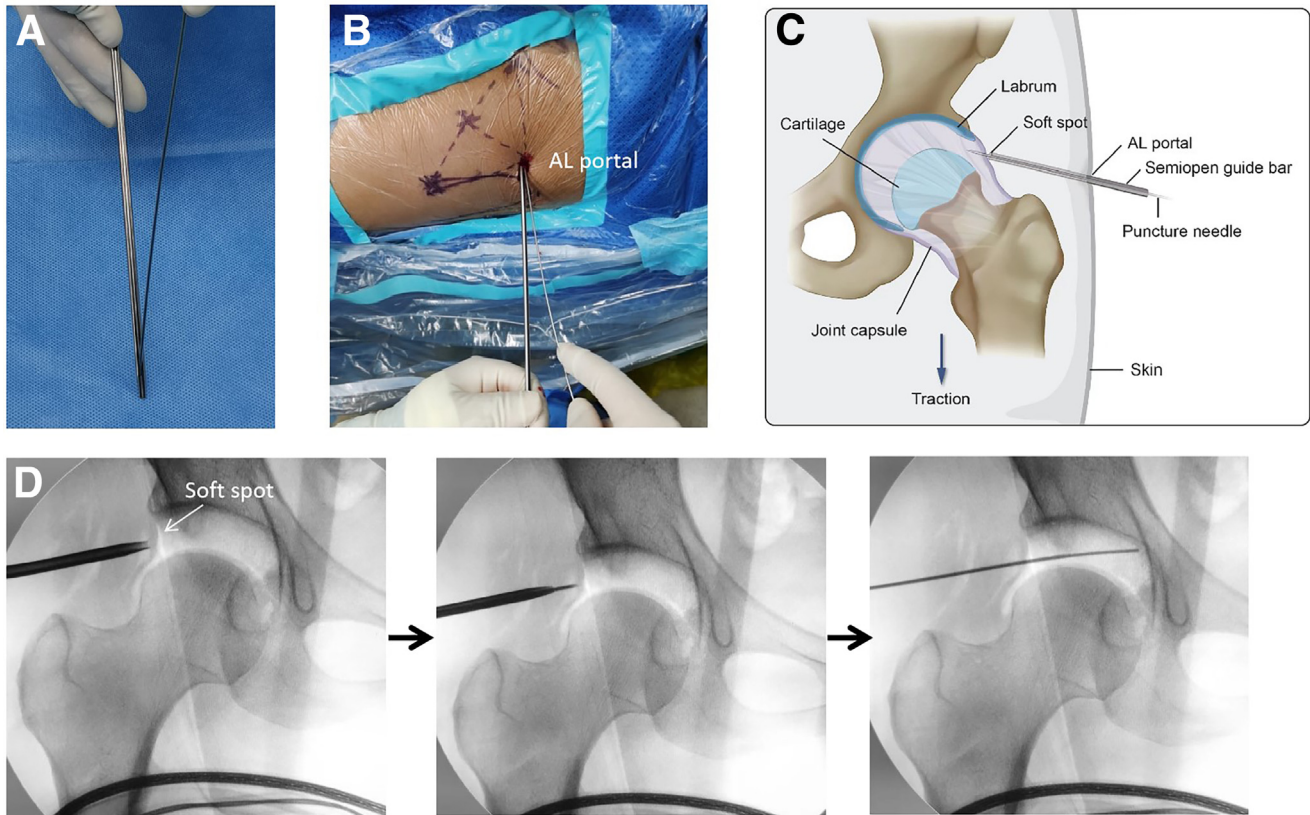


Fig. 2. (A) The self-designed semiopen hollow guide bar. This tool combines the functions of a guide bar and a slide. (B) Patient in supine position, left hip. The bar is inserted into the incision at the location of the conventional anterolateral (AL) portal and its anterior tip contacts the soft spot of the hip capsule. A long puncture needle is then placed along the slide in the center of the guide bar to penetrate the joint capsule. (C) Schematic diagram of the AL portal establishment by the guide bar. (D) Fluoroscopic view showing the establishment procedure of the AL portal using the semiopen guide bar. The key point is the identification of the soft spot location by the use of the guide bar.

Acetabuloplasty generally requires the removal of sclerotic bone and grinding to the junction of sclerotic bone and cancellous bone, so that the surface of the bone is uniform and mildly bleeding. The amount of trimming depends on the degree of the pincer deformity. Usually, the LCEA is reduced by about 1° for every 1 mm of bone removed, and it is sufficient when the LCEA returns to the normal range.⁵ Care must be taken not to remove too much bone to avoid post-operative hip instability. When the acetabular rim is flush anteriorly and posteriorly and in the shape of “1,” it indicates that the pincer deformity has been sufficiently abraded and the normal acetabular rim has been reached (Fig 4C, Video 1).

The main purpose of AIISplasty is to correct type II or type III AIIS to type I AIIS. The AIIS is usually ground medially by 1 to 1.5 cm using the abraded acetabular rim as a localization reference (Fig 5).

Management of Labral Injury

There are three options for the management of labral injuries: labral debridement, repair, and reconstruction.

Our principles and methods are similar to those of most surgeons. When the labral injury is irreparable, debridement or reconstruction may be chosen depending on the age of the patient. When the labral injury is repairable, a vertical mattress suture at the base is used in patients with a good-quality labrum, and a looped-type suture can be used when the labrum is significantly worn (Fig 6).

We prefer to create a modified distal anterolateral (mDALA) portal for anchor placement, which is located approximately 2 cm proximal to the traditional DALA portal. The orientation of the anchor through the mDALA portal is more parallel to the acetabular rim (Fig 7), thus greatly reducing the possibility of anchor penetration outside the bone and making it more suitable for anchor placement at the anterior (3- to 4-o'clock) or posterior (8- to 9-o'clock) acetabular rim.

T-Shaped Capsulotomy

When a cam deformity is present, we routinely perform a T-shaped capsulotomy for better visualization and management of the deformity. First, withdraw

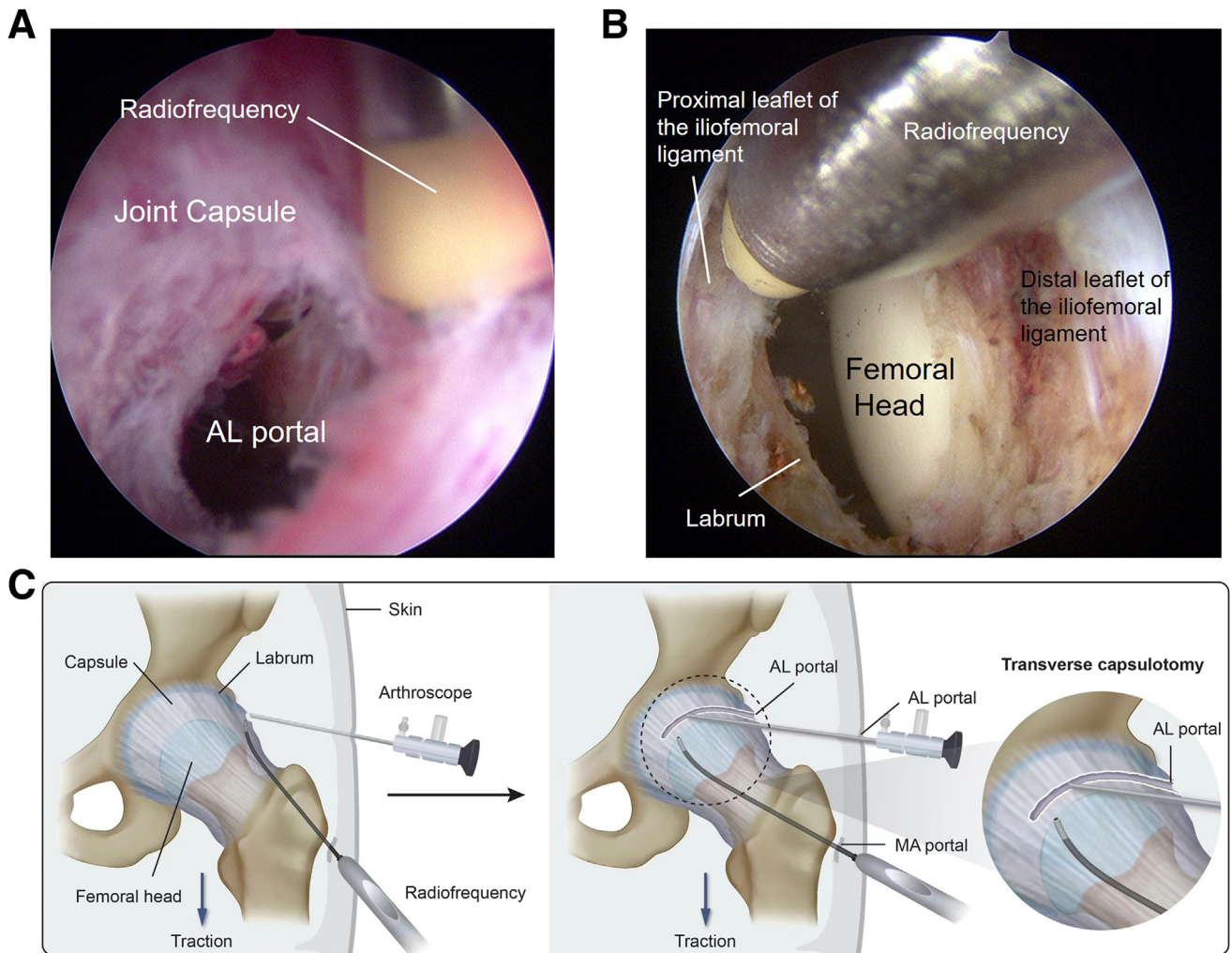


Fig. 3. Patient in supine position, right hip. Arthroscopic view from the anterolateral portal. (A) The head end of the radiofrequency can be seen just as the lens exits the joint capsule. (B) Transverse capsulotomy is made by outside-in technique for effective exposure of the central compartment. (C) Schematic diagram of the outside-in technique. (AL, anterolateral; MA, mid-anterior.)

traction and flex the hip to 30°, and then move the arthroscope to the peripheral compartment and incise the iliofemoral ligament starting from the middle of the femoral neck anteriorly to the middle of the base of the anterior femoral neck (Fig 8A). The cam deformity is well visualized at this site (Fig 8B).

Femoroplasty

We propose the “triangle abrasion method” for the resection of the cam deformity. Based on clinical observation, the cam deformity is generally triangular in shape and relatively localized in the anterolateral femoral head-neck junction area. The bottom edge of the triangle is the cartilaginous side of the head-neck junction near the femoral head, the top angle is

located at the anterolateral distal end of the femoral neck base, and the other 2 edges are located near the medial synovial fold and lateral synovial fold, respectively (Fig 9A).

The soft tissue on the surface of the cam deformity is first removed using a 45° radiofrequency (Smith & Nephew) or a curette to expose the bony deformity, and the bottom, inner, and outer edges of the “triangle” are defined in turn (Fig 9 B and C). After delineation by a 5.5-mm arthroscopic abrador burr (Smith & Nephew), the bony deformity can be removed with confidence. This method facilitates the beginner to control the size and extent of the cam deformity and to avoid residual deformity. The depth of abrasion is the junction of sclerotic cortical bone and cancellous bone, and when

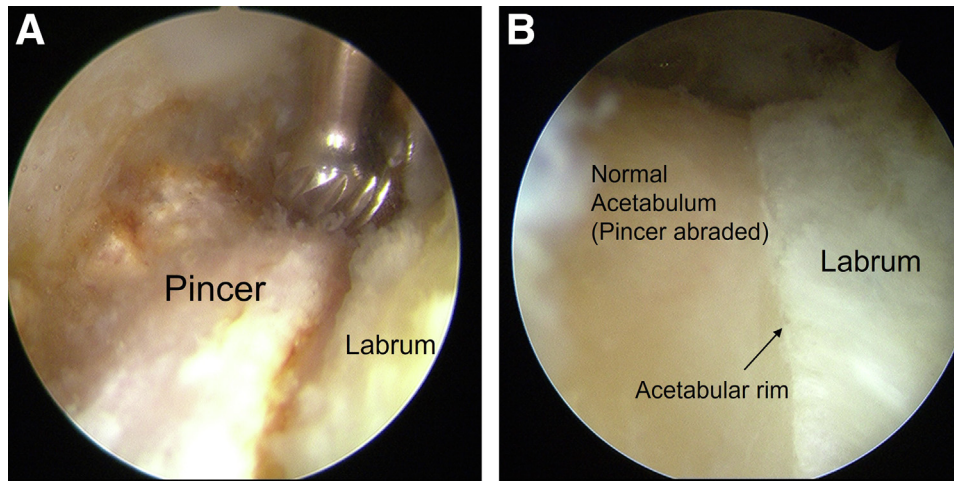


Fig. 4. “One-line trimming method” to manage the pincer deformity. Patient in supine position, right hip. Arthroscopic view from the anterolateral portal. (A) The pincer deformity has an irregularly curved edge. (B) The pincer deformity has been sufficiently abraded, and the acetabular rim is flush and in the shape of “1.”

the junction is reached, a change in the bone color can be clearly seen (Fig 9D, Video 1). The grinding depth should not be too deep, as biomechanical studies have shown that grinding more than 10 mm or one-third of the femoral neck diameter significantly increases the risk of postoperative femoral neck fracture.⁶

The joint is sufficiently flushed after cam resection to remove the remaining bone debris to minimize the formation of heterotopic ossification and the influence on the articular cartilage.

Intraoperative Dynamic Examination

The intraoperative dynamic examination can be used to determine whether there is residual bony deformity

and impingement after the grinding is completed. The superior posterior edge of the cam deformity can be seen in hip extension and internal rotation (Fig 10A), while the anterior inferior edge is most easily seen in flexion at 30° to 45° and neutral position (Fig 10B). From these 2 views, the margins of the bony deformity can be observed, and if it remains, further grinding is required.

Dynamic impingement test is performed by flexion, extension, and rotation of the hip joint under arthroscopic surveillance to simulate the impingement process of the acetabulum and femur to determine whether impingement is still present (Fig 10C). The criterion for relief of the impingement is when the hip is

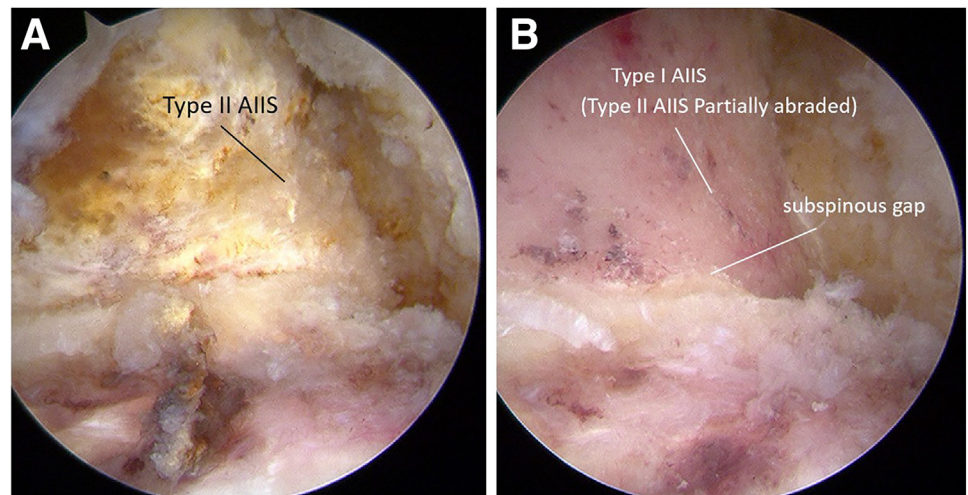


Fig. 5. Management of the anterior inferior iliac spine (AIIS). Patient in supine position, left hip. Arthroscopic view from the mid-anterior portal. (A) Typical type II AIIS. (B) Type II AIIS has been corrected to type I AIIS (the subspinous gap can be visualized).

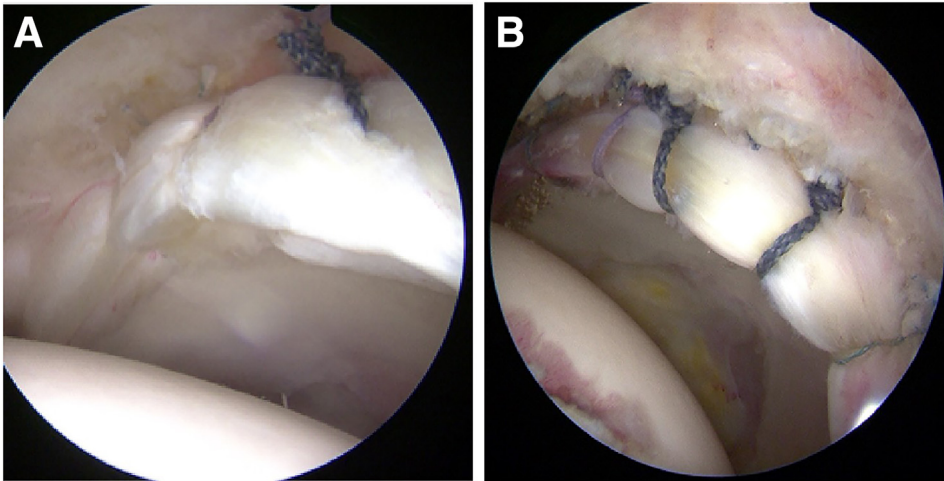


Fig. 6. Management of labral injury. Patient in supine position, left hip. Arthroscopic view from the anterolateral portal. (A) Vertical mattress suture. (B) Looped type suture.

flexed to 90°, internally rotated or externally rotated beyond 60°, and the labrum is able to pass through the femoral head-neck junction area without impingement (Video 1).

Capsule Closure

Capsule closure is routinely performed at the end of the procedure. Suturing is made using 1-0 high-strength wire, starting from the distal end of the T-shaped incision toward the proximal end and spaced

approximately 1 cm apart, with a total of 3 sutures. Then the transverse incision between the portals is sutured from medial to lateral with a total of 2 sutures (Fig 11).

Discussion

Since the beginning of the 21st century, with the development of hip arthroscopy, more and more patients with femoroacetabular impingement syndrome (FAI) have been able to undergo minimally invasive surgical treatment arthroscopically,⁷ with encouraging mid- and long-term results.^{8,9} Intraoperative fluoroscopy is still considered an indispensable technical assistant in the surgical procedure of FAI. In a cross-sectional survey of 27 sports medicine experts specializing in hip arthroscopy, all chose to use intraoperative fluoroscopy to assist in accessing the central compartment during the initial steps of the procedure.¹⁰ However, intraoperative fluoroscopy inevitably results in radiation exposure, and a systematic review¹¹ showed that the mean intraoperative absorbed radiation dose for hip arthroscopy was 12.6 mGy, whereas the mean occupational exposure for surgeons was 0.0031 mSv. Intraoperative fluoroscopy also increases operation time and additional instrumentation and cost.¹²

In order to avoid radiation exposure and reduce operation time, a fluoroscopy-free hip arthroscopy technique was proposed in our center. The fluoroscopic technique is used in hip arthroscopy mainly in 3 steps, which are portal establishment, pincer deformity trimming, and cam deformity removal¹¹; therefore, we improved for each step and proposed our own method to achieve neither the use of intraoperative fluoroscopy nor an increased complication rate.

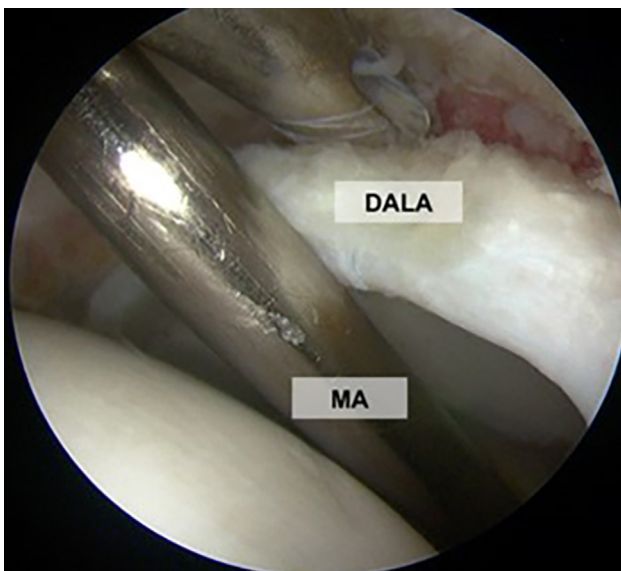


Fig. 7. Patient in supine position, left hip. Arthroscopic view from the anterolateral portal. Anchor placement direction from the modified distal anterolateral (mDALA) portal and mid-anterior (MA) portal. The orientation of the anchor through the mDALA portal is more parallel to the acetabular rim than the MA portal.

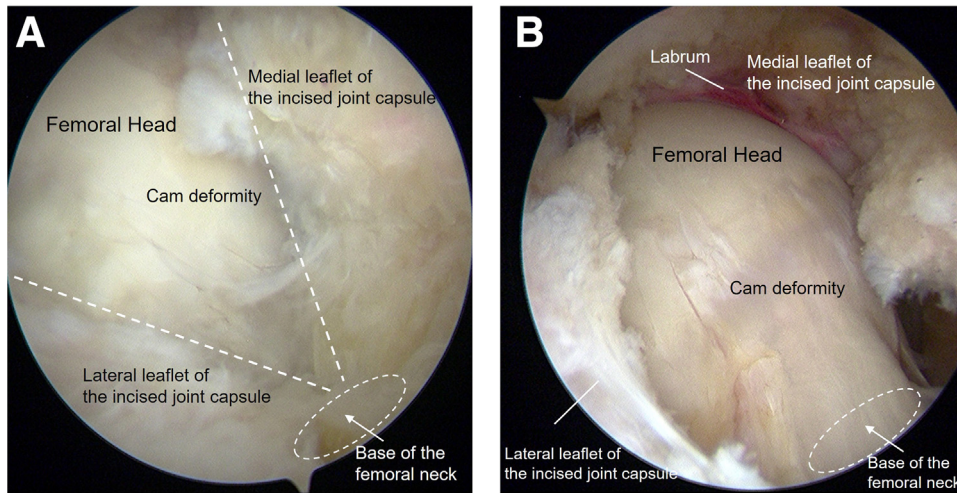


Fig. 8. Patient in supine position, right hip. Arthroscopic view from the anterolateral portal. (A) Incise the iliofemoral ligament starting from the middle of the femoral neck anteriorly to the middle of the base of the anterior femoral neck. (B) The cam deformity is well visualized after T-shaped capsulotomy.

At the time of portal establishment, we incise the skin at the conventional location of the AL portal, bluntly separate the subcutaneous tissue, and insert a semiopen hollow guide bar, which can clearly touch the “soft spot” of the capsule in the joint space. The width of the joint space and the location of the capsule puncture should be assessed here. If the joint space is believed to be narrow, the traction should be increased to widen

the joint space. For the establishment of the MA portal, we usually perform a transverse capsulotomy using the outside-in technique. When mastered, this method allows for a good view of the central compartment while avoiding direct puncture of the joint space, and the manipulation from outside to inside minimizes iatrogenic damage to the labrum and cartilage. Howse et al.¹³ described a method of establishing portals

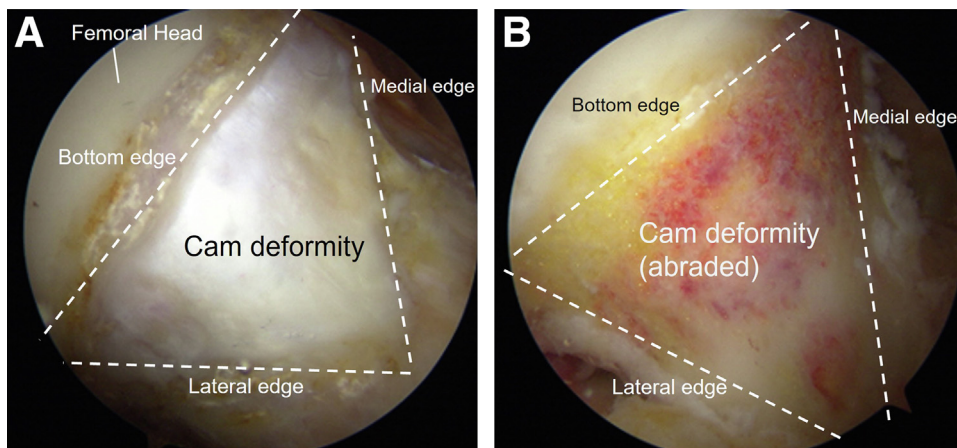


Fig. 9. The “triangle abrasion method”. Patient in supine position, right hip. Arthroscopic view from the anterolateral portal. (A) The cam deformity is generally triangular in shape. Delineation of the bottom, lateral and medial edge of the cam deformity by radiofrequency (dashed line). (B) The cam deformity has been abraded. The depth of abrasion is the junction of sclerotic cortical bone and cancellous bone. A change in the bone color can be clearly seen.

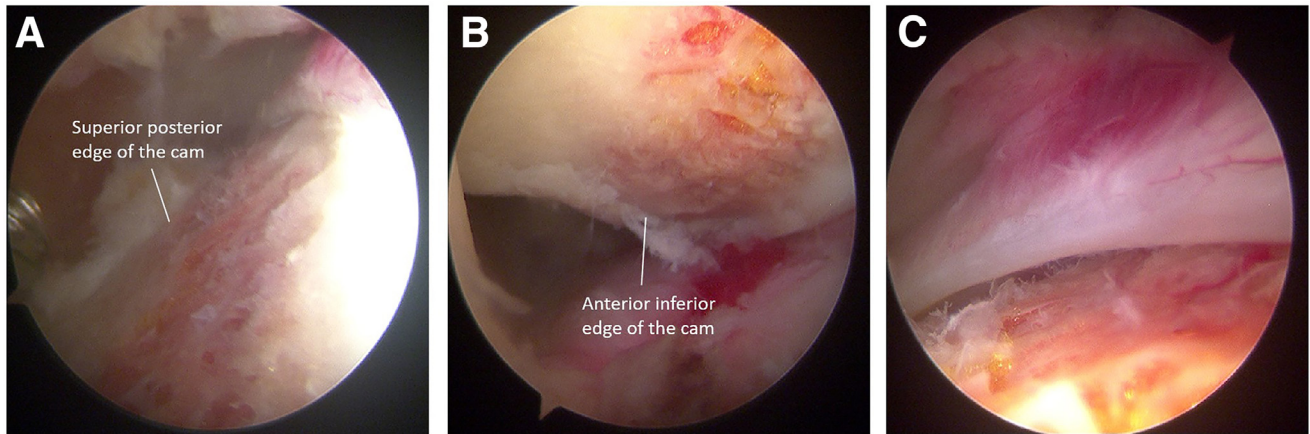


Fig. 10. Patient in supine position, left hip. Arthroscopic view from the anterolateral portal. (A) The intraoperative dynamic examination. The superior posterior edge can be seen in hip extension and internal rotation. (B) The anterior inferior edge is most easily seen in flexion at 30° to 45° and neutral position. (C) The labrum is able to pass through the femoral neck junction area without impingement while the hip is flexed to 90° and internally rotated to 60° .

without the use of fluoroscopic assistance, relying on the surgeon's palpation and anatomic experience, which we believe requires more experience on the part of the operator. Weinrauch and Kermeci¹⁴ described a technique for establishing portals using ultrasound assistance, which is simple and accurate but requires the assistance of ultrasound instruments and diagnostic experience.

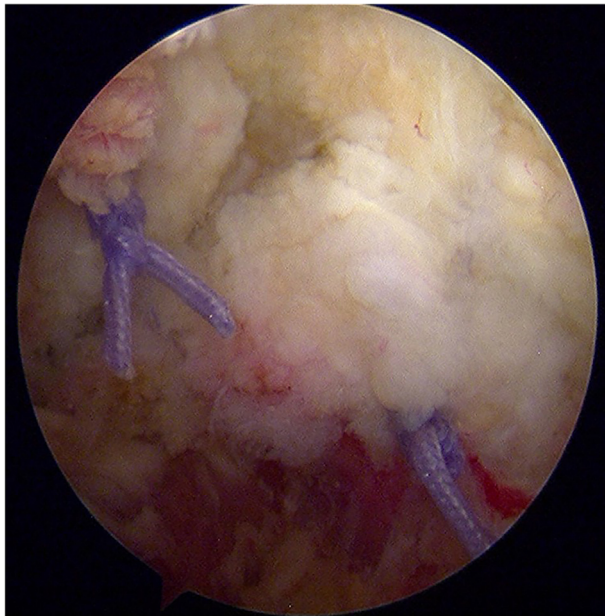


Fig. 11. Patient in supine position, left hip. Arthroscopic view from the anterolateral portal. Capsule closure is routinely performed at the end of the procedure to increase joint stability.

Adequate correction of cam and pincer deformity is important in the treatment of FAI. Insufficient removal can lead to residual impingement, while excessive grinding may lead to the complication of joint instability.¹⁵ A systematic review showed that 81% of hip arthroscopic revision surgeries were due to residual femoroacetabular impingement.¹⁶ Therefore, another role of intraoperative fluoroscopy is for assessing the abrasion degree of the pincer deformity and cam deformity.

In order to more accurately remove cam and pincer deformity without fluoroscopy, we propose the "one-line trimming method" for pincer deformity and the "triangle abrasion method" for cam deformity. These 2 methods can identify the extent and degree of the pincer and cam deformity more accurately under direct intraoperative visualization, so as to guide their reasonable grinding. The preoperative LCEA, alpha angle, and offset, as well as CT 3D reconstruction, are also used to fine-tune the extent of bone removal. At the end of the procedure, a dynamic examination is necessary, which simulates the presence of residual impingement and checks for any remnant bony deformity, thus ensuring the efficacy of the abrasion without fluoroscopy (Table 1).

In our opinion, the fluoroscopy-free hip arthroscopy technique for FAI is a very practical surgical technique. We have been using this technique for 3 years and have had good results in the postoperative follow-up of patients. Its main disadvantage is that it has a certain learning curve and is more suitable for surgeons with some experience in hip arthroscopy (Table 2). In the early stage of learning, it is recommended to still use intraoperative fluoroscopic surveillance and gradually

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Preoperative planning of the removal extent of the pincer and cam deformity according to the imaging	Improper planning may result in under- or overabrasion
Palpation of the “soft spot” of the capsule at the joint space using a semiopen hollow guide bar	Direct puncture with a needle increases the risk of iatrogenic damage
The width of the joint space and the position of the joint capsule puncture are assessed at the soft spot and adjusted appropriately	Traction needs to be increased when the joint gap is too narrow; otherwise, it is likely to cause damage to the labrum and cartilage. The location of the joint capsule puncture should not be too close to the acetabular side
Perform a transverse capsulotomy with radiofrequency using an outside-in technique	Inadequate incision may interfere with observation and manipulation
The “one-line trimming method” guides the removal of pincer deformity	Poor observation angle may result in misjudgment of the extent of the pincer deformity, which may be prone to residual deformity and affect labrum healing
T-shaped capsulotomy to ensure adequate visualization of the cam deformity	Insufficient visual field may lead to residual cam deformity and impingement
The “triangular abrasion method” guides the grinding of cam deformity and is less likely to leave excess bone	Insufficient grinding will result in residual cam deformity
Intraoperative dynamic examination of determining residual bony deformity and impingement	Adequate motion in all ranges of the hip joint is required; otherwise, the assessment is insufficient. Residual bony deformity and impingement will likely lead to poor outcomes and revision surgery
Routine joint capsule closure to increase joint stability	No suturing of the joint capsule may result in the complication of joint instability

Table 2. Advantages and Limitations of the Technique

Advantages	Limitations
Avoid radiation exposure to patients and surgeons	Require skill and experience from the operator
Reduce operation and anesthesia time	Unskilled manipulation may increase the risk of iatrogenic injury
Decrease in medical equipment and costs	
Intraoperative dynamic assessment is more straightforward, and the technique is safe and effective when mastered	

reduce the use of it. We believe that in the near future, fluoroscopy-free hip arthroscopy will become more and more popular.

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