MENTORS IN ORTHOPEDICS

FEMORO-ACETABULAR IMPINGEMENT (FAI): IS THERE STILL A PLACE FOR OPEN SURGERY?

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SUMMARY

Background: Femoroacetabular impingement (FAI) is a dynamic hip dysfunction caused by morphological alterations of the acetabulum, femoral head-neck junction, or femoral torsion. If left untreated, the resulting labral and chondral damage may progress to premature coxarthrosis in young, active populations.

Objective: This review evaluates the diagnostic imaging requirements for FAI and defines the specific clinical indications for arthroscopic versus open surgical interventions, including pelvic and femoral osteotomies.

Key Points: Diagnosis requires standardized pelvic radiographs and arthro-MRI to quantify acetabular coverage (Lateral Center Edge angle >33°), alpha angles, and torsional deformities. While conservative management is the initial approach, surgical intervention is indicated upon failure. Hip arthroscopy is effective for labral repair and focal osteochondroplasty but has limitations in addressing global acetabular retroversion or significant torsional abnormalities. Open surgical dislocation provides circumferential joint access for complex cam morphologies and focal retroversion (<30%). For global acetabular retroversion (>30%), periacetabular osteotomy (PAO) demonstrates superior long-term joint survivorship compared to rim trimming. Femoral derotation osteotomy is specifically indicated for impingement secondary to femoral retroversion (<0°) or excessive anteversion (>35°).

Conclusion: Surgical management of FAI must be tailored to the specific morphological deformity. While arthroscopy is a primary minimally invasive option, open surgical dislocation, PAO, and femoral osteotomy remain essential for correcting global version abnormalities and complex femoral deformities to optimize clinical outcomes and joint preservation.

KEYWORDS

Femoracetabular Impingement; Arthroscopy; Bone Retroversion; Osteotomy; Hip Joint

INTRODUCTION

Femoro-acetabular impingement (FAI), described by Ganz in 2003 (1), is a frequent cause of hip joint pain in young adult athletes. Morphological alterations of the acetabulum (pincer effect), of the head-neck junction (cam effect), or femoral torsional deformities are the main causes of this dynamic impingement (Figure 1).

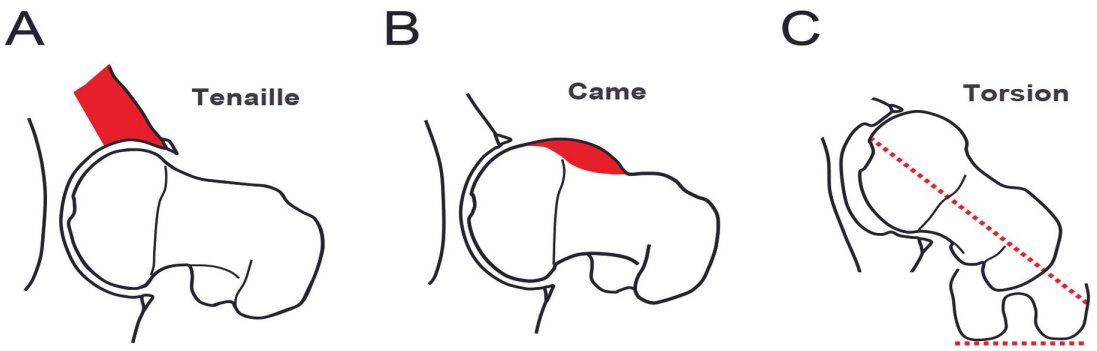

Figure 1: Type of femoro-acetabular impingement. Femoroacetabular impingement can be related to a pincer effect (A), a cam effect (B), or a femoral torsion disorder (retrotorsion femur or acetabular retroversion for anterior impingement) (C).

This leads to labrum and cartilage damage, which can progress in long-term to coxarthrosis, so early diagnosis and appropriate management are essential. The questions addressed in this article are the following:

1. What imaging modalities and measurements are needed for FAI assessment

2. With the advancement of hip arthroscopy, what is the place of open surgery in the treatment of FAI.

DIAGNOSIS OF FEMORO-ACETABULAR IMPINGEMENT

FAI is mainly diagnosed in young adults playing certain sports with repetitive hip movements, such as hockey, martial arts or football. More recently it has also been demonstrated in other sports such as table tennis or golf. While the pain is typically located in the groin, it can also occur in the region of the greater trochanter or in the thigh. No clinical test is specific for FAI, but pain for anterior impingement is often reproduced during a 90° flexion, adduction and internal rotation (FADIR) maneuver. Sometimes a posterior impingement can be demonstrated by flexion, abduction and external rotation (FABER) maneuver. Range of motion may be limited, especially in internal rotation. On clinical examination, hip rotations in extension and prone position allow estimation of femoral torsional deformities (2). Decreased internal rotation will point to femoral retroversion and increased internal rotation will point to exaggerated femoral anteversion.

The work-up should be completed with a standard X-ray and contrast Arthro-MRI to measure femoral torsion and acetabular version, and 3D reconstructions that can detect areas of FAI.

Standard radiographs with good quality are essential and represent the most important imaging modality. It should include a frontal view correctly centered on the pelvis and an axial view of the hip (3). These radiographs

allow assessment of acetabular coverage, acetabular orientation, cervical/cephalic junction deformity, and arthritic degeneration according to Tönnis classification.

Excessive coverage of the acetabulum can lead to a pincer-type FAI. This is seen with a Wiberg Lateral Center Edge (LCE) angle greater than 33° (4) (Figure 2). Pincer-type FAI may also occur in cases of acetabular protrusion (Figure 3) when the femoral head is medial to the ilio-ischial line.

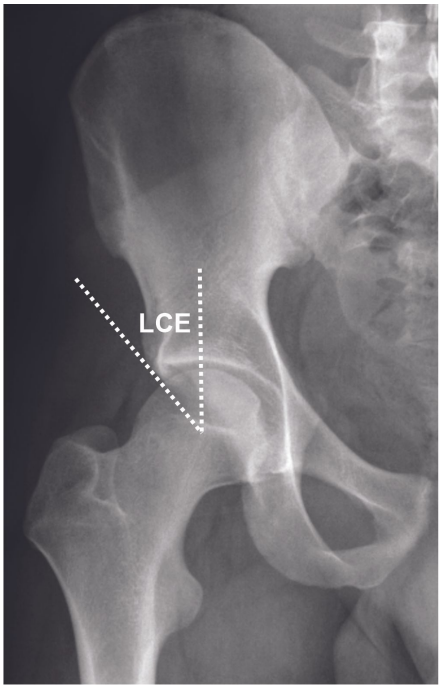

Figure 2: Lateral Center Edge Angle.A pincer-type femoro-acetabular impingement may be due to an increased Wiberg Lateral Center Edge (LCE) angle (>33°), which is assessed on the frontal pelvic radiograph.

Figure 3: Acetabular protrusion. A pincer-type femoro-acetabular impingement may be due to acetabular protrusion, where the femoral head (dotted line) protrudes medially over the ilio-ischial line (white line).

The orientation of the acetabulum is important to assess, as it can also be the source of a pincer-type FAI if the acetabulum is retroverted (Figure 4).

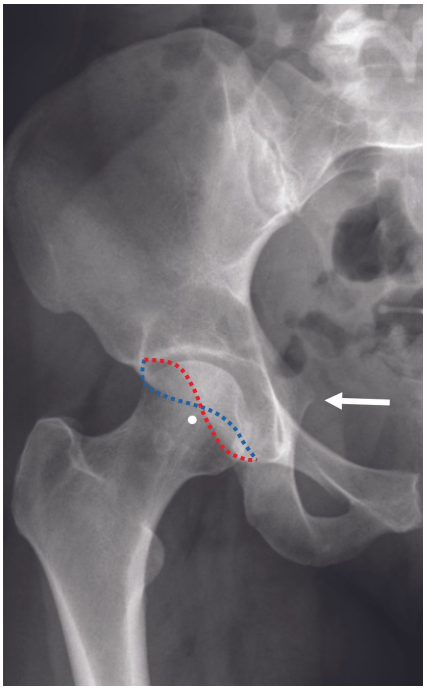

Figure 4: Global retroversion of the acetabulum. Retroversion of the acetabulum can lead to pincer-type femoro-acetabular impingement. Retroversion is observed by three radiological signs: the crossing sign (the anterior wall in blue crosses the posterior wall in red), the posterior wall sign (the posterior wall is medial to the head of the femur), and the ischiatic spine sign (white arrow: visibility of the ischiatic spine medial to the iliopectoral line).

The retroversion of the acetabulum may be focal (<30%) or global (>30%) depending on the crossing sign size. Posterior wall sign (posterior wall medial to the center of the femoral head), and ischiatic spine sign (visible on front pelvic film beyond the iliopubic line) are the two other signs for acetabulum retroversion. The filling of the cervico-cephalic junction can cause a cam effect (Figure 5), sometimes with a pistol grip appearance. The cam effect can be quantified using the alpha angle measured on the axial radiograph.

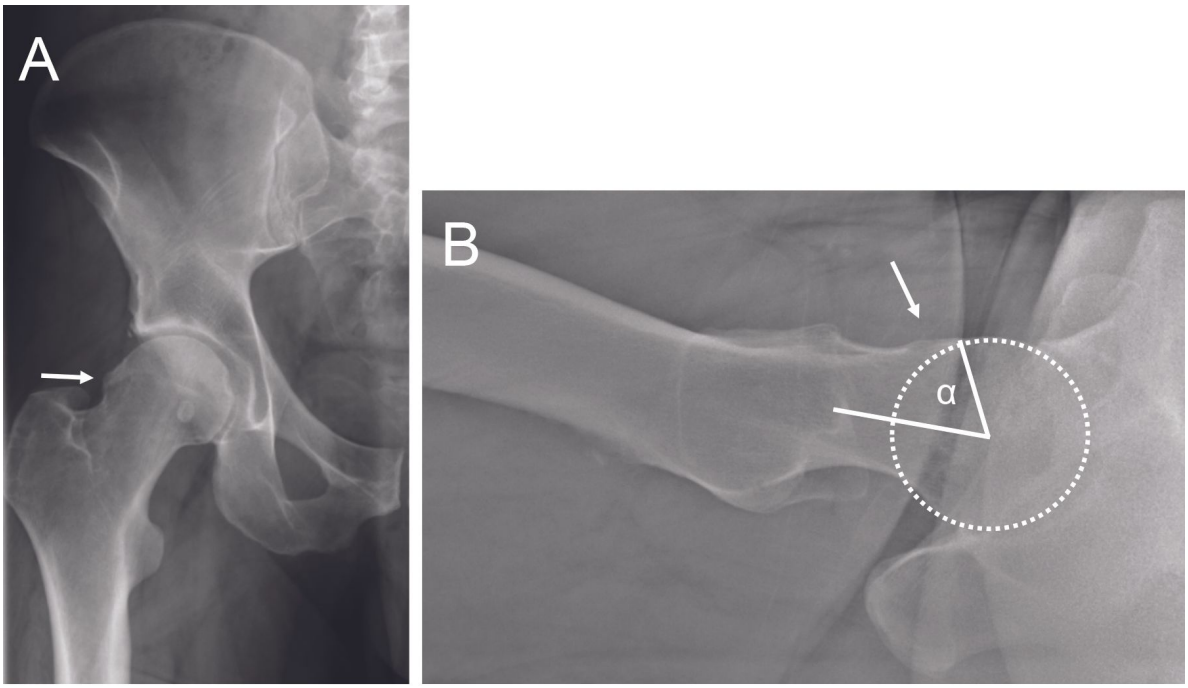

Figure 5: Cam effect The filling of the cervical-cephalic junction, which causes a cam-type femoro-acetabular impingement (white arrow), can be seen on the frontal (A) and axial (B) pelvis radiographs. The alpha angle can be measured on the axial view and is elevated in cam type impingement.

Finally, radiographs can exclude the presence of advanced arthritic changes, for which conservative hip surgery is no longer appropriate, and arthroplasty options should be considered. Arthro-MRI is the imaging procedure of choice for assessing the labrum and cartilage. Injection of contrast material into the hip joint allows better visualization of the labrum and cartilage. Lesions of the labrum (Figure 6) are most often found in the anterosuperior part of the joint. MRI with radial reconstructions allows better localization and quantification of the cam effect morphology (Figure 7). The alpha angle can also be measured on this imaging modality.

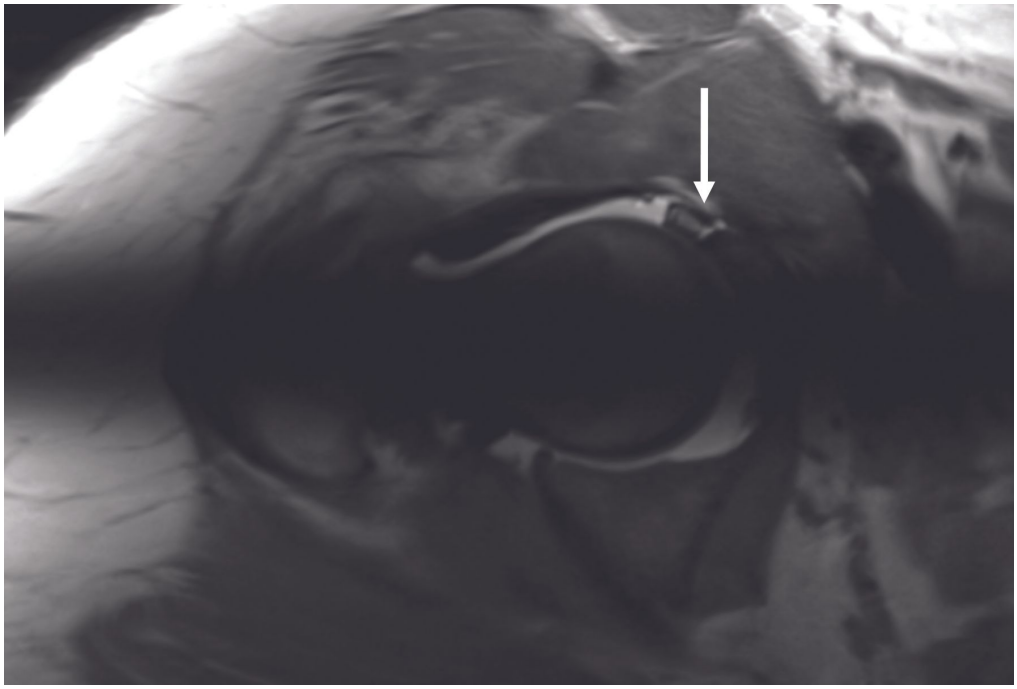

Figure 6: Lesions of the labrum. Arthro-MRI is the examination of choice for visualising labrum lesions, which are most often located anterosuperiorly in the joint (white arrow).

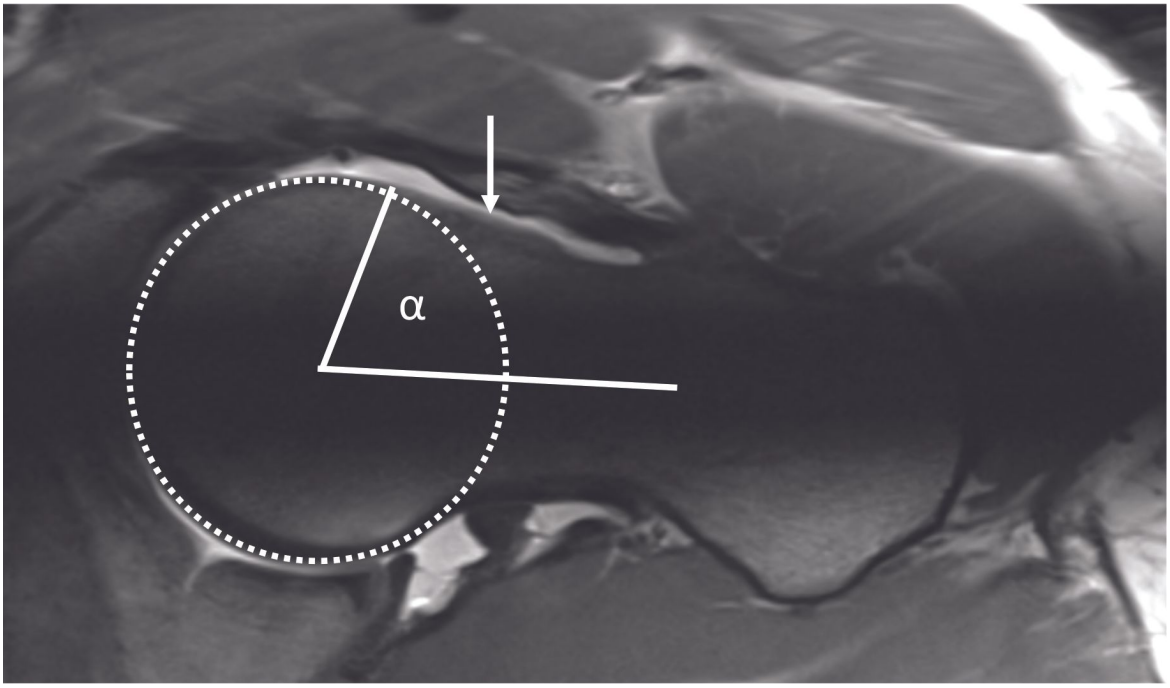

Figure 7: Cam effect. Arthro-MRI can be used to locate and quantify the filling of the cervico-cephalic junction that causes the cam effect. The alpha angle can also be measured on this modality.

Measurement of femoral torsions by MRI or CT scan is essential (Figure 8). There are many methods of calculating torsions (5), of which Murphy's method is the most reproducible. A femoral torsion problem can be a

cause of FAI (6). Femoral retroversion (<0°) may result in an anterior FAI, between the anterior-inferior iliac spine and the proximal femur. Increased femoral anteversion (>35°) may result in posterior ischiofemoral FAI between the lesser or greater trochanter and the ischial tuberosity.

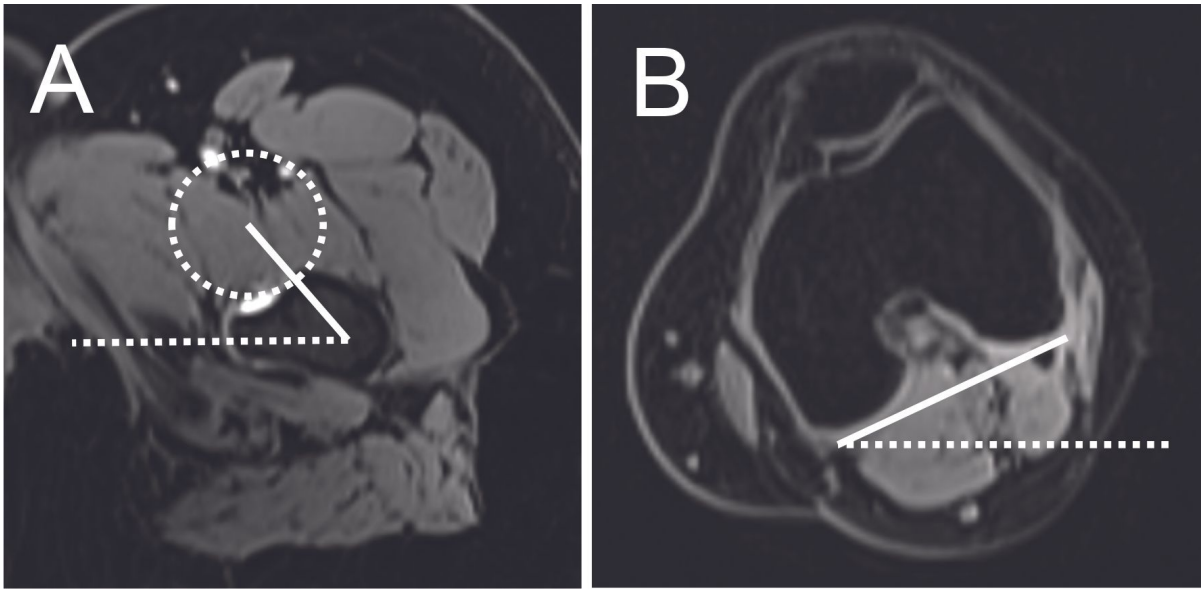

Figure 8: Measurement of femoral torsions. Femoral torsions can be measured by MRI or CT scan by coupling an axial section at the proximal (A) and distal (B) femur, using Murphy's method. These measurements are important because increased (>35°) or decreased (<0%) femoral torsions may be the cause of posterior or anterior femoro-acetabular impingement.

CONSERVATIVE TREATMENT

Conservative management of FAI should be offered before considering surgery (7). Treatment is multi-modal and includes patient education, activity modification, anti-inflammatory drugs, physiotherapy, and intra-articular injections. Conservative treatment is usually effective, and can relieve the pain of FAI, but not correct the existing deformity. Before considering surgery, an intraarticular injection is recommended for analgesic purposes but above all for diagnostic purposes to ensure the intra-articular origin of the pain. There are few studies that have compared conservative versus surgical treatment (8). A recent randomized clinical trial showed superior short-term clinical improvement with surgery compared to physiotherapy (9). However, there are no studies on long-term outcomes or osteoarthritic progression comparing these two treatments.

ARTHROSCOPIC TREATMENT

The treatment of FAI by hip arthroscopy is becoming more and more popular. Hip arthroscopy generally uses three portals, to access the joint compartment under traction and the peripheral compartment after release of traction. The intra-articular approach allows treatment of labrum lesions and to partially address the pincer effect by performing an acetabuloplasty. A protruding anterior-inferior iliac spine inserted near the acetabular rim (type 2 or 3 of Hestroni, 2013) is trimmed at its base. During the peripheral approach, the cam-type FAI can be treated by resecting the excess bone and fibrocartilage with a burr. Arthroscopy has the advantage of being less invasive

than open surgical hip dislocation surgery, with a shorter hospital stay and faster rehabilitation. It allows good visualization of the peripheral compartment to correct the cam effect (Figure 9).

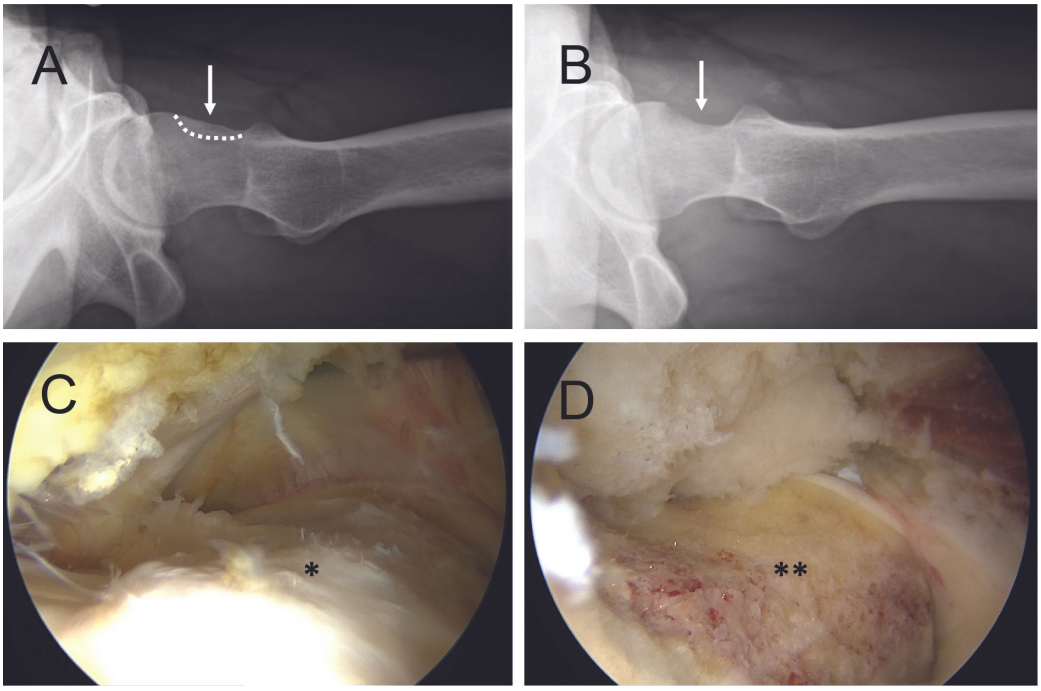

Figure 9: Hip arthroscopy. On the preoperative axial X-ray (A), the cam effect (white arrow) is seen. On the postoperative axial radiograph (B), the filling of the head-neck junction has been resected arthroscopically. The cam effect (*) is observed during arthroscopy (C) and a femoral osteochondroplasty (D) is performed with a burr to correct the neck/head junction (**).

The disadvantages include difficulty in accessing the ligamentum teres and the lower and posterior part of the joint, as well as the risk of damaging the retinacular vessels coming from the medial circumflex if the cam resection is extended posteriorly. In addition, there are some rare complications, such as pudendal neurapraxia related to traction, neurapraxia of the lateral femoral cutaneous nerve related to portals, and postoperative adhesions sometimes requiring a secondary operation with arthrolysis. Finally, hip arthroscopy is a technique that requires a long learning curve. The results of hip arthroscopy treatment of FAI (10) are good with an improvement in alpha angle and clinical scores, and a high return to sport rate (87%). The complication rate varies from series to series, ranging from 1.7% to 4% (11,12), with a major complication rate of 0.3%.

Although hip arthroscopy shows good results, this technique has limitations. Indeed, it cannot correct a global retroversion of the acetabulum and cannot address a problem of femoral torsion. Moreover, a large cam, particularly a posterior one, is difficult to access by arthroscopy. Thus, certain specific indications still leave an important place for open surgery.

OPEN SURGERY FOR SURGICAL DISLOCATION OF THE HIP

Open surgical hip dislocation (Figure 10) is used to address FAI (13). It consists of a lateral hip approach with an osteotomy of the greater trochanter, using an inter-nerve and inter-muscular interval, thus preserving muscle quality. After capsulotomy and resection of the ligamentum teres, the hip joint can be dislocated, allowing full access to the joint on both the femoral and acetabular sides.

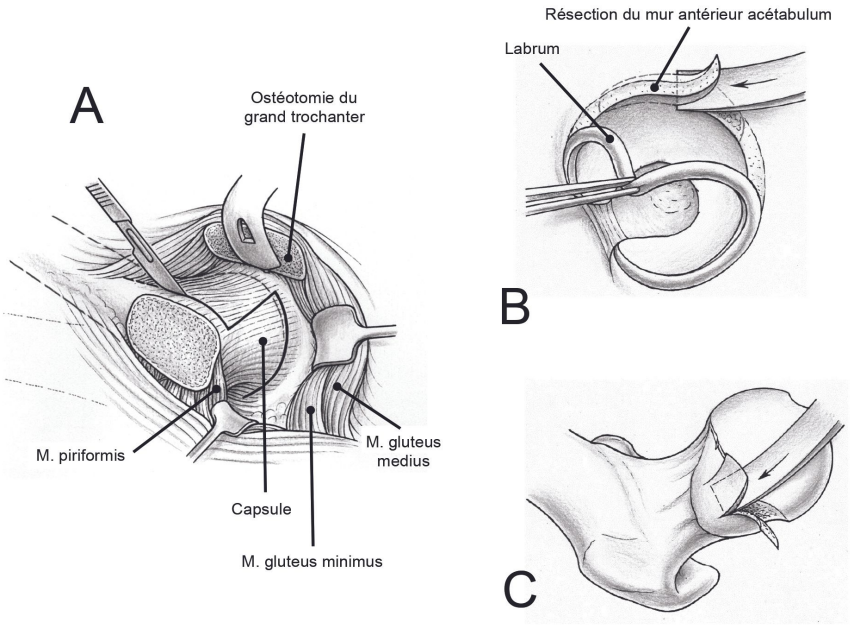

Figure 10: Surgical hip dislocation technique: This diagram illustrates open surgical hip dislocation. The approach is lateral by performing an osteotomy of the greater trochanter (A). Resection of the anterior wall of the acetabulum (B) and the cam (C) is performed using an osteotome and burr. Reprinted with permission of the authors (13).

Open hip dislocations allows visualization of the entire femoral neck, allowing correction of large cams or posterior cams that cannot be addressed arthroscopically. The sphericity of the head can be assessed using a spherical model, allowing the degree of severity of the cam to be judged. Furthermore excess coverage of the acetabulum can be addressed also (figure 11).

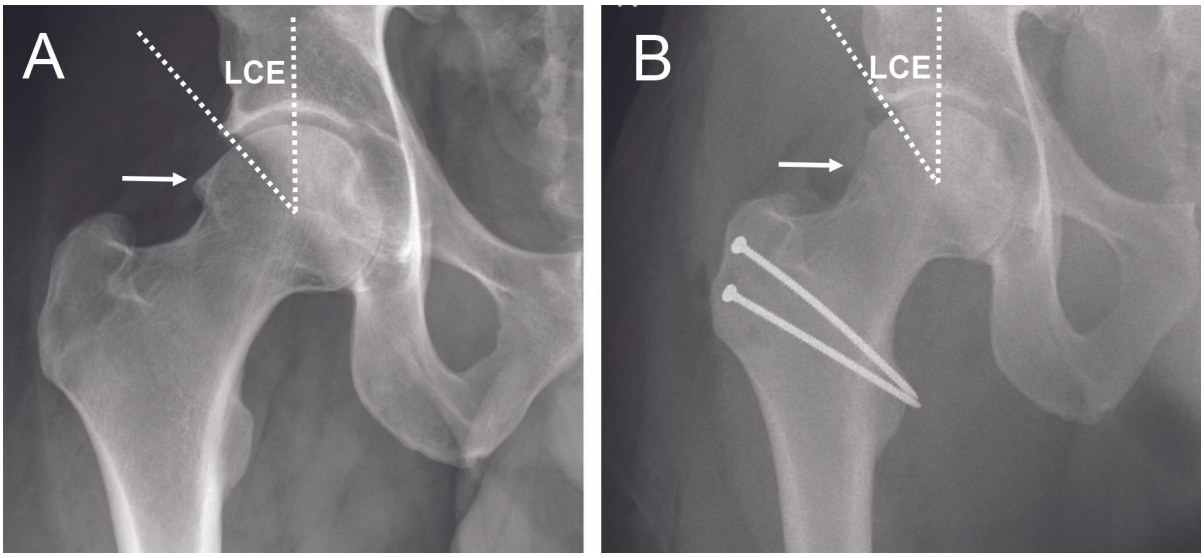

Figure 11: Surgical hip dislocation: imaging. On the preoperative radiograph (A) a cam effect (white arrow) and excessive coverage angle (LCE angle) can be seen. On the postoperative radiograph (B), the correction of the cam (white arrow), the correction of the coverage angle (LCE angle), and the presence of two screws to stabilize the osteotomy can be seen

In addition open dislocation allows treatment of pincer-type FAI in cases of proximal focal retroversion of the acetabulum (Figure 12), where the crossing sign is visualized with <30% retroversion. It can also be used to treat a pincer-type FAI in cases of excessive coverage of the anterior wall. Indeed, after disinsertion of the labrum, trimming of the anterior wall is easily accessible by this technique, followed by repair of the labrum. Furthermore,

it is possible to clinically test the mobility of the hip during the operation, before and after the correction of the FAI, to check the gain of joint range of motion.

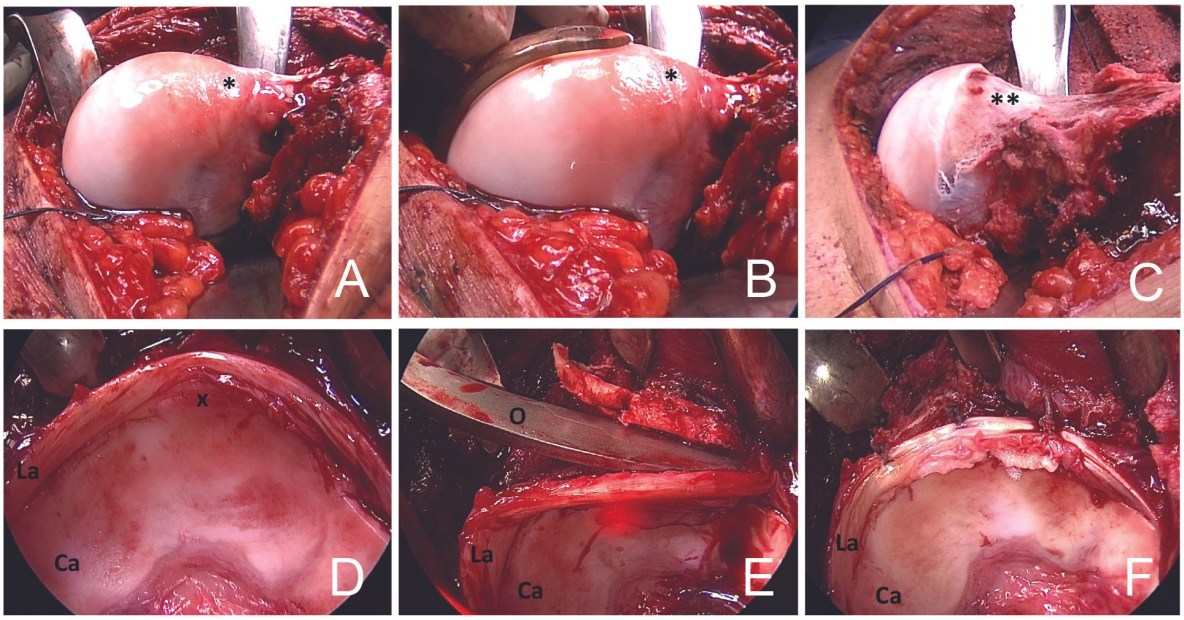

Figure 12: Surgical hip dislocation: surgery. During surgical hip dislocation, the proximal part of the femur is approached (A) with visualization of the cam (*). The extent of the cam is measured using a spherical model (B). After resection of the cam (C), a concave neck junction is found (**). The anterior part of the acetabulum can be treated (D) where an over-coverage of the acetabulum (x), a lesion of the labrum (La) with some focal cartilaginous lesions (Ca) is observed. After deinsertion of the labrum (E), the anterior part of the acetabulum is trimmed with an osteotome (O). Finally, the labrum is reinserted (F).

However, open dislocation is a more invasive surgery than arthroscopy and is reserved for young patients. The risk of nonunion of the greater trochanter has been reported but remains exceptional in young patients. The fixation hardware of the osteotomy may cause discomfort and a secondary operation to remove the hardware is usually necessary. With this approach, the ligamentum teres is sacrificed to dislocate the hip. Blood loss is greater with open surgery and rehabilitation is longer due to the greater trochanter osteotomy for which partial weight bearing is recommended for six weeks.

The results of open surgery are good and remain comparable to those of hip arthroscopy. Most studies comparing arthroscopic treatment and open surgery are reviews of the literature. There is an improvement in clinical scores, with comparable results between arthroscopic treatment and open surgery. There is only one prospective comparative study that has shown favorable results with both techniques (14). However, some studies report a higher complication rate with open surgery, but a greater alpha angle correction compared to arthroscopy (15).

While the results are comparable between these two techniques, there is probably a patient selection bias in studies comparing open treatment and arthroscopy. Indeed, both techniques offer advantages over each other. The indication for open or arthroscopic treatment should therefore be chosen carefully and adapted to the type of FAI, its morphology and severity.

FEMORAL DEROTATION OSTEOTOMY

The femoral derotation osteotomy is performed through a lateral hip approach with a subvascular passage. The femoral osteotomy is performed at the subtrochanteric or intertrochanteric level (in case of an associated varus

osteotomy) and stabilized with a plate (figure 13). Partial loading is recommended after surgery to protect the osteotomy.

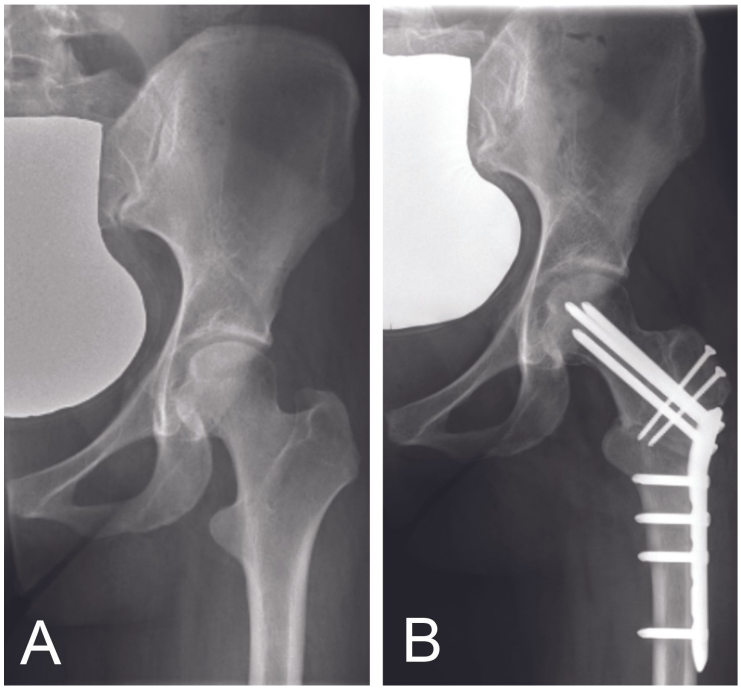

Figure 13. Femoral external derotation osteotomy. Preoperative (A) and postoperative (B) radiographs in a case of femoro-acetabular impingement related to a femoral torsion disorder with exaggerated anteversion, treated by femoral derotation and varus osteotomy.

A femoral internal derotation osteotomy may be proposed in cases of anterior FAI where there is femoral retroversion (<0°). In this case, the distal fragment will be internally derotated to increase internal rotation. A femoral external derotation osteotomy can also be proposed in cases of posterior FAI where, conversely, exaggerated femoral anteversion (>35) exists. The purpose of this external derotation osteotomy of the distal fragment is to increase external rotation. Imaging with torsion measurement is therefore essential, as well as a dynamic 3D examination to check for anterior or posterior FAI.

Some studies have found that correction of femoral torsion does not influence the outcome of arthroscopic surgery for the treatment of FAI (16). However, other studies (17) have shown good clinical results following internal femoral derotation osteotomy in anterior FAI with femoral retroversion. One study (18) also showed that external femoral derotation osteotomy in posterior FAI with exaggerated anteversion resulted in a gain in external rotation (16° to 44°), an improvement in symptomatology, and a satisfaction rate of 80% of patients who would repeat the surgery. Thus, femoral derotation osteotomy remains a treatment option to be considered in some patients with FAI with a femoral torsion disorder (retroversion or exaggerated anteversion).

ANTEVERSION PERIACETABULAR OSTEOTOMY

The periacetabular osteotomy (PAO) was initially described to treat dysplasia, and then the anteversion periacetabular osteotomy (19) was described to treat retroversion of the acetabulum that can lead to FAI (Figure 14).

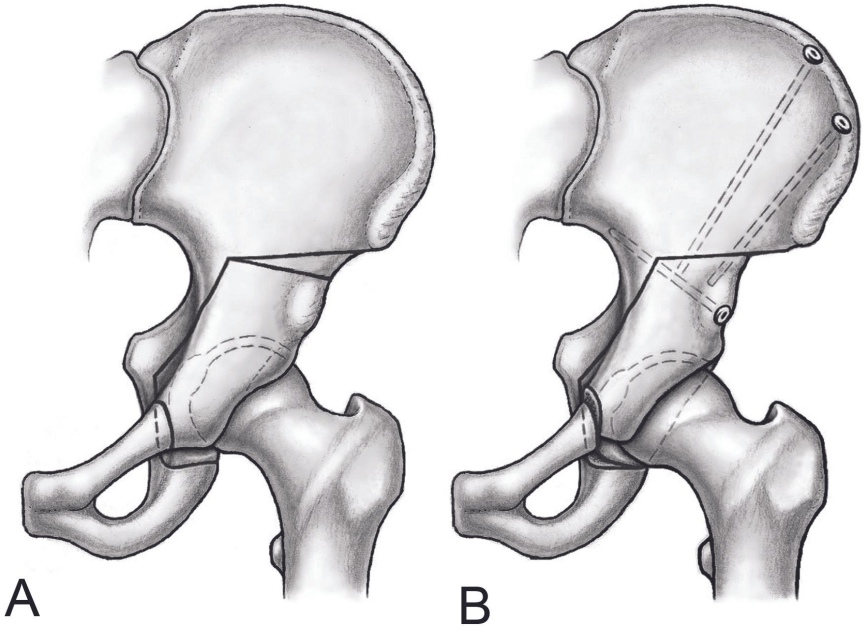

Figure 14: Anteversion periacetabular osteotomy: technique. The anteversion periacetabular osteotomy uses the modified Smith-Peterson approach. It consists of making several osteotomy cuts (A) at the level of the ischium, the superior ramus of the pubis, the supra-acetabular and retroacetabular region, while maintaining continuity of the posterior column. The fragment is then mobilised and stabilised with screws (B). Reprinted with permission of the authors (19).

The surgery is performed using a modified anterior Smith-Petersen approach. The principle is based on several osteotomy cuts, at the level of the ischium, the superior branch of the pubis, the supra-acetabular region and the retroacetabular region, while keeping the posterior column in continuity. Mobilization of the fragment comprising the acetabulum allows reorientation and thus correction of the version of the acetabulum. This fragment is then stabilized with screws.

This is a more extensive surgery, reserved for young patients under 40 years of age (20) in cases of global retroversion of the acetabulum with a retroversion >30% (Figure 15).

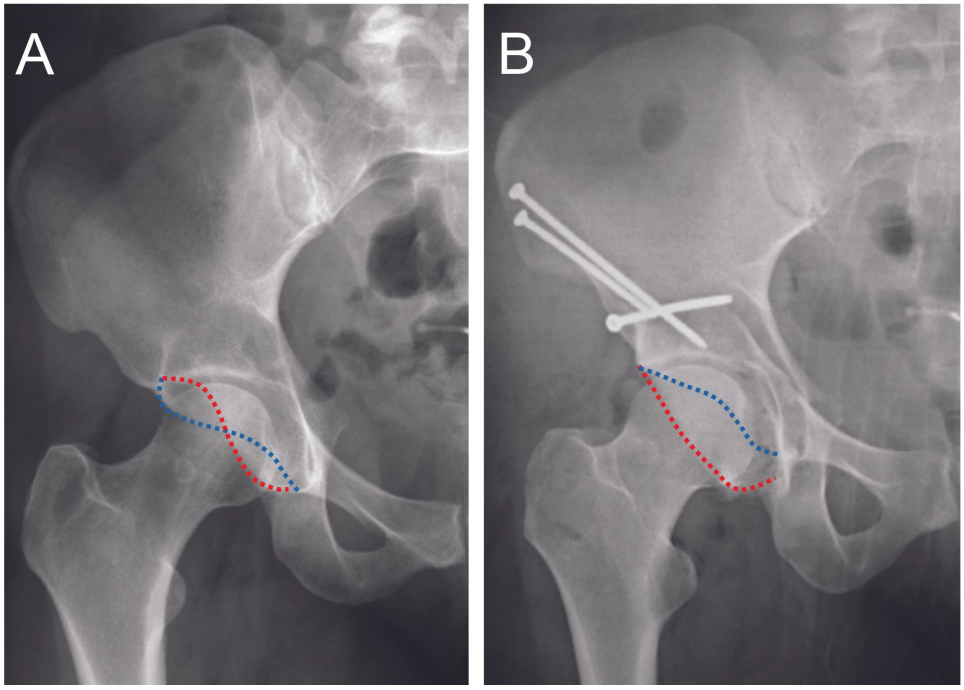

Figure 15: Peri-acetabular anteversion osteotomy: imaging. A femoro-acetabular impingement with excessive retroversion of the acetabulum (A) where the signs of retroversion are seen: the crossing sign where the anterior wall (blue line) crosses the posterior wall (red line), assessed at 50%. The anteversion periacetabular osteotomy (B) allows the correction of the version where there is no sign of crossing and the presence of screws to stabilise the fragment.

In the case of associated cam impingement, it is common to combine this with a procedure on the femur, either arthroscopically or by minimally invasive anterior approach. While short-term results seem promising, few studies have shown long-term results. Peters' 2011 study (21) proposed a decision algorithm between anteversion PAO or surgical hip dislocation for correction of acetabular retroversion. Anteversion PAO would be indicated in cases of acetabular retroversion with insufficient posterior and/or lateral coverage, associated with intact hyaline cartilage. A surgical hip dislocation with resection of the anterior part of the acetabulum would be indicated in cases of acetabular retroversion with excessive anterior coverage but sufficient posterior coverage. A recent study by Zurmühle in 2017 (22) showed a higher 10-year survival rate with PAO (86%) than with acetabular resection by surgical hip dislocation (23%) in cases of acetabular retroversion resulting in FAI. The failure is probably caused by the decreased surface area in case of retroversion with anterior wall resection, resulting in hip dysplasia and thus an increased risk of coxarthrosis (23).

This is a complex surgery that requires a well-trained surgical team to reorient the acetabulum in case of FAI. Patients must be carefully selected, and further research is needed to better define the indications.

CONCLUSION

FAI is a frequent source of hip joint and groin pain and involves a dynamic mechanism with abnormalities in the femur (cam type), acetabulum (pincer type) or femoral torsion. The diagnosis is based on clinical symptoms and radiological patterns. The standard X-ray is of primary importance. Arthro-MRI is used to complete the assessment to visualize the labrum and better define the morphology of the cam. The measurement of femoral torsions must also be an integral part of the radiological assessment, in order to detect a femoral anteversion pathology which could lead to a femoral derotation osteotomy.

Treatment should be conservative in the first instance, combining activity modification, physiotherapy measures and intra-articular infiltrations. Surgical treatment should be offered if conservative treatment fails. Several surgical modalities are possible. Hip arthroscopy remains a minimally invasive option that allows correction of certain cam or pincer type FAIs with retroversion of the upper part of the acetabulum only. Open surgery with surgical dislocation of the hip makes it possible to address certain cams that are not accessible by arthroscopy, and combine it with procedures on the anterior part of the acetabulum in the case of excessive coverage of the acetabulum (increased VCE angle or focal retroversion <30%). The femoral derotation osteotomy allows FAI to be addressed in cases of excessive femoral anteversion (>35°) or retroversion (<0°). Anteversion PAO allows correction of acetabular orientation in cases of global retroversion of the acetabulum (retroversion >30%). Thus, the surgical modalities must be carefully chosen, adapted to the morphology of the cam and the acetabular coverage and orientation. Open surgery therefore retains an important place in the management of FAI in well selected cases.

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