



Hip arthroscopy for femoroacetabular impingement

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- The purpose of this article is to give a general overview of femoroacetabular impingement (FAI) and how it could be treated arthroscopically, with some details about indications, the procedure itself and some of the complications associated with the surgery.
- FAI is a dynamic condition of the hip that can be a source of pain and disability and could potentially lead to arthritis.
- When symptomatic, and if conservative treatment fails, FAI can be addressed surgically.
- The goal of surgical treatment for FAI is to recreate the spherical contour of the femoral head, improve femoral offset, normalize coverage of the acetabulum, repair/reconstruct chondral damage and repair/reconstruct the labrum to restore normal mechanics and joint sealing.
- Advances in equipment and technique have contributed to an increase in the number of hip arthroscopy procedures performed worldwide and have made it one of the more common treatment options for symptomatic FAI.
- Hip arthroscopy is a procedure with an extremely steep and long learning curve.

Keywords: hip; arthroscopy; FAI

Cite this article: *EFORT Open Rev* 2018;3:121-129.
DOI: 10.1302/2058-5241.3.170041

Introduction

FAI

The concept of femoroacetabular impingement (FAI) has been recognized as a source of hip pain since the early 1990s.¹ The actual term was coined by Ganz et al in 2003.² It is a dynamic conflict that occurs between the femoral head/neck junction and the acetabulum, eventually compromising the labrum and cartilage of the joint and possibly potentially leading to arthritis. The aetiology of FAI could be genetic or acquired, and many probable causes have been mentioned in the literature including paediatric hip disease and injury to the proximal femoral

physis due to heavy athletic activity during critical stages of development.^{3,4}

The ‘deformity’ consists of either an over-coverage of the acetabulum (pincer) that could be global or focal, and/or asphericity of the femoral head (cam) that could also be limited to a certain area or more circumferential (Fig. 1). Patients can have a combination of cam and pincer impingement, and a host of resultant pathologies including labral and cartilage damage. The impingement could also occur because of femoral version issues or in individuals with normal anatomy who are involved in activities that place their hips in extreme ranges of motion (ROM) repetitively.⁵ As with dysplasia, the damage in FAI usually first occurs peripherally in the anterolateral part of the acetabulum, where the mechanical overload is most commonly present.⁶ In an excellent review about the indications and limits of hip arthroscopy for FAI, Mella et al⁶ discuss the progression of the chondral injuries, explaining that: ‘In the “pincer” type of deformity, there is a direct impact on the labrum that causes an extensive degeneration of the labrum and the adjacent chondral surface. In the “cam” type of deformity, the impact leads to a chondrolabral disruption and a progressive chondral delamination.’ As the mechanical overload continues, the disruption of tissue which was limited to the labrum or the chondrolabral junction may reach the acetabular cartilaginous load-bearing surface. This process causes softening of the cartilage, then its dissociation from the subchondral bone and eventually delamination, full thickness defects and injury to the femoral head.⁶

In order to be comprehensive, and without confusing the issue, one must note that there are other types of hip impingement that have been described. These can involve the greater or lesser trochanters, extracapsular femoral neck, ischium or ilium.⁷ These ‘extra-articular’ impingements are different from the typical FAI and are not as common; however, they should be kept in mind as a potential source of pain in the hip and they have been dealt with endoscopically.

There are multiple reports of radiographic evidence of FAI in asymptomatic individuals,⁸⁻¹⁰ and that is why adequate history-taking and precise physical examination are

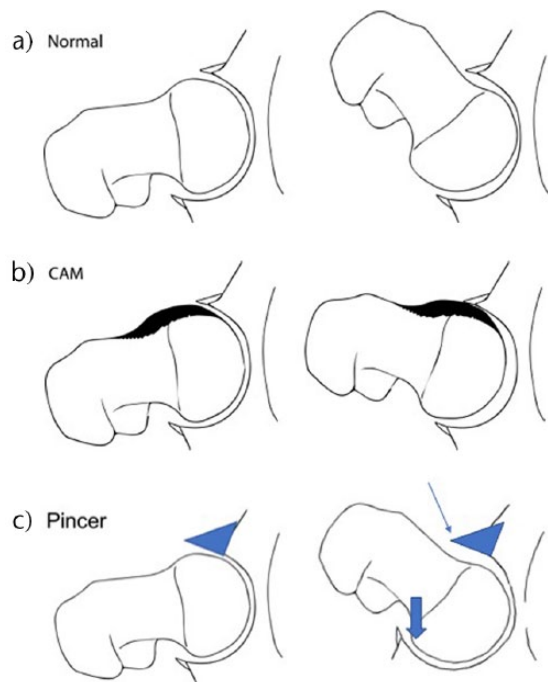


Fig. 1 a) Normal hip clearance. b) Cam type impingement with decreased head/neck offset. The cam enters the joint pushing the labrum aside and causing a shear injury to the chondrolabral junction. c) Pincer type impingement with excessive coverage of the acetabulum. Crush injury of the labrum on the femoral neck (thin arrow) and contre-coup lesion (thick arrow).

key in making the diagnosis. History should include the usual questions about pain onset, type and progression. There is usually stiffness in the hip, some limitation in the ROM, especially with flexion and internal rotation or external rotation. Specific symptoms of impingement are usually mechanical and include clicking, catching or locking if there is a labral tear.

The pain is usually brought about by extreme activity or prolonged sitting. A thorough exam of the hip should be performed in every patient presenting with hip pain, and that includes a gait evaluation, and then specific hip tests noting the ROM, both passive and active, log rolling, strength testing in flexion, extension, adduction, abduction, and internal and external rotation. If pain occurs during active motion or strength assessment, the pain may be related to a tendon or muscle injury and then the location of the pain and motion causing it may give a clue as to the source of the injury. Passive ROM testing partially negates the muscular component and could give more information about mechanical issues such as impingement. Although a review of the literature regarding the accuracy and validity of described physical exams for impingement did not show good reliability,¹¹ certain tests, such as the ‘anterior impingement test’ (FADIR: flexion, adduction, internal

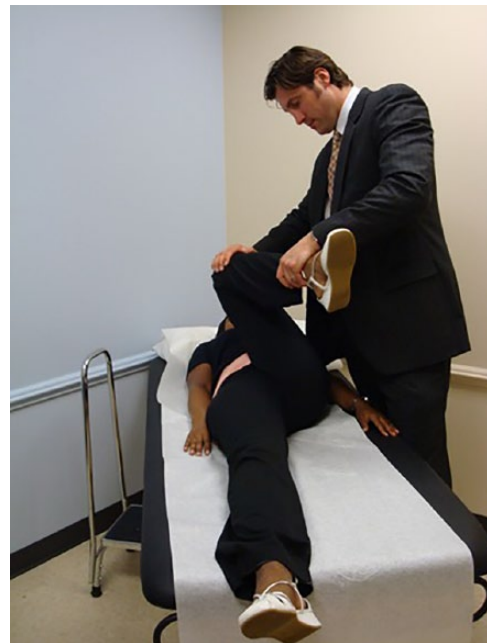


Fig. 2 Anterior impingement test: flexion to 90°, adduction and forced internal rotation. Reproduction of the pain in this position can indicate impingement. If there is no pain, then anterior impingement is extremely unlikely.

rotation) (Fig. 2), the FABER (flexion, abduction, external rotation) and the Fitzgerald test (hip starting position is flexed, abducted and externally rotated, the examiner then passively internally rotates, adducts and extends the leg) were found to be very sensitive.¹¹ If there is no evidence of impingement on physical exam, such as a positive FADIR or posterior or lateral impingement test, then the diagnosis of FAI should be questioned and further investigations performed to find the true source of the hip pain.

The differential diagnosis for FAI can be divided into other intra-articular sources of hip pain, extra-articular hip pain and referred pain from the back or sacroiliac joints. It includes tumoural conditions of the joint, stress fractures of the femoral head or neck, osteitis pubis, adductor tendon injuries, iliopsoas tendon problems, piriformis syndrome, gluteus medius or minimus injuries or tendonitis, greater trochanteric bursitis and radiculopathy.

The basic radiographs to obtain are an anteroposterior (AP) pelvis, Dunn lateral, cross-table lateral and, in some cases, a false-profile view (Fig. 3). It is important to ensure that the radiographs are adequately performed, as alterations in pelvic tilt or radiograph angle could give the impression of over-coverage. A cam may seem small or insignificant on a frog-leg lateral but quite large on a Dunn view. CT is helpful in better defining the cam and pincer lesions (Fig. 4).¹² MRI is more accurate in diagnosing labral and cartilage pathology when combined with an intra-articular gadolinium injection (Fig. 5)¹³ and that

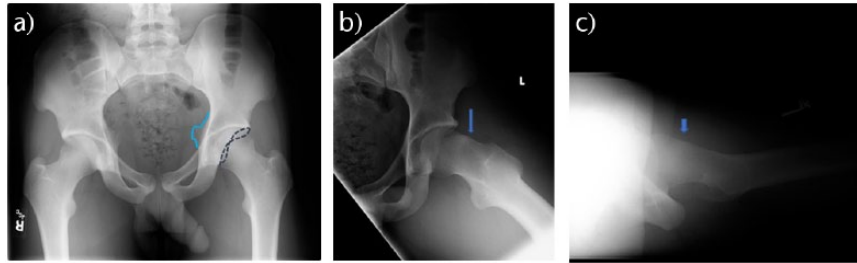


Fig. 3 a) AP pelvis. The dotted line shows the 'figure of 8' which is a marker of acetabular retroversion and over-coverage so long as the radiograph was taken adequately (i.e. with no excessive pelvic tilt or rotation). It outlines the anterior and posterior acetabular walls crossing at a certain point. In cases with no over-coverage, this point is at the top of the acetabulum. The dark blue line indicates the 'ischial spine sign' which is another marker for retroversion. b) Modified Dunn view, showing the cam (arrow). c) Cross-table lateral, with an apparently smaller cam (arrow).

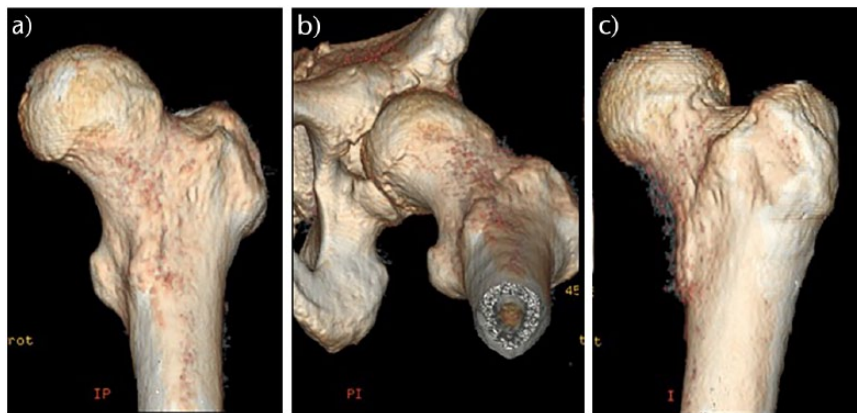


Fig. 4 CT scans showing an anterolateral cam lesion.



Fig. 5 MR arthrogram showing a labral tear with chondrolabral disruption.

could be combined with local anaesthetic to aid in the diagnosis. It has been shown that patients who obtain no temporary relief of pain with such injections have poor outcomes after arthroscopic surgical intervention.^{14,15} The

radiologist performing the procedure can note whether the patient's pain with impingement testing resolves after the injection and to what degree.

Conservative management of FAI is usually attempted first, and this includes activity modification and avoidance of certain positions, as well as hip stabilization and strengthening exercises.¹⁶ If that fails, and since impingement is a mechanical conflict, it can be resolved surgically. Its sequelae, such as labral tears and chondral damage, can also be repaired to a certain extent. Historically, an open approach to the hip with dislocation was used to correct the bony deformity and repair any labral or cartilaginous damage. Over the last ten years or so, hip arthroscopy has been successfully used as a less invasive treatment option.

Hip arthroscopy

Hip arthroscopy has been around for decades; however, this last decade has seen an exponential rise in the number of procedures performed worldwide. Thanks to technique and technological advances, most straightforward FAI cases can be dealt with adequately in a less invasive



Fig. 6 a) Supine position on special traction table with large padded post. The hip is initially fully abducted and slightly flexed. Both feet are in the traction boots, but traction is only applied to the operative leg. b) The hip is slightly internally rotated and the C-arm brought in to ensure adequate visualization. The C-arm is draped in this position, while ensuring that it does not obstruct the arthroscopy screen.

fashion. What must be kept in mind is that it is a procedure with a very steep learning curve.¹⁷ As with any surgical procedure, indications and contraindications must be abided by, planning and technique must be perfected, and anatomy and tissues respected, for it to be successful.

Indications, contraindications and outcomes

Hip arthroscopy for FAI has been shown to provide excellent outcomes, with pain relief and return to sports or activities comparable with, and even better than, open treatment.¹⁸ Although radiographic evidence of FAI is the most commonly used criterion for operative intervention,¹⁹ it is recommended that symptomatology and clinical tests be an integral part of the decision to operate. Not all patients with FAI need surgery and some deformities are not amenable to arthroscopic treatment. The ideal patient for arthroscopic treatment of FAI is a young non-arthritic patient who is symptomatic and has clinical and radiologic evidence of focal impingement. The prevalence of asymptomatic FAI was discussed in a review article by Frank et al,²⁰ which highlighted the importance of associating clinical history and physical exam with radiological findings before deciding to treat the impingement. Patients with arthritis have been shown to have poorer outcomes after hip arthroscopy; therefore, hip arthroscopy is not advisable in patients with < 2 mm of joint space in the weight-bearing area on an AP radiograph of the pelvis or Tönnis grade of 1 or greater.²¹ In summary, the current present indications for arthroscopic surgery in FAI are patients with a history and physical exam consistent with FAI, with radiographic evidence of focal impingement (cam, pincer or both, labral tears or chondrolabral disruptions) and minimal to no arthritic changes.

Depending on the surgeon's level of expertise, more complex cases, such as those with global acetabular over-coverage, posterior cams or borderline dysplasia, could

be tackled with adequate outcomes.^{22,23} Some authors report a lesser degree of improvement than in patients with focal impingement and otherwise normal anatomy,²⁴ while others have shown comparable outcomes.²⁵

Patients aged > 45 years, and particularly women aged > 45 years,²⁶ tend to have poorer results than younger patients, with a higher rate of conversion to total hip replacement in patients aged > 40 years.²⁷ Philippon's team evaluated the return to play for 44 professional baseball players after hip arthroscopy for impingement and found a 96% return to the same level of competition.²⁸ Hip arthroscopy has even been shown to have good outcomes with return to work in workers' compensation cases.²⁹ A recent study showed significantly improved patient-reported outcomes in patients aged < 60 years who underwent hip arthroscopy for FAI when compared with a cohort that was waitlisted.³⁰ Both groups had undergone three months of conservative treatment including community physiotherapy before either having the arthroscopy or being waitlisted. In another study evaluating high-level athletes, return to their high-level sport after hip arthroscopy was measured as 3/4 by one year post-operatively.³¹ Multiple other articles have been published citing a high rate of return to sports in athletes and excellent pain relief after arthroscopic surgery for FAI.³¹⁻³³ Further research should have better levels of evidence and address a discrepancy in hip arthroscopy outcome reporting methods between what is suggested as important in the literature and what is actually being reported.³⁴

The procedure

Positioning

Patient positioning (Fig. 6) can be either in lateral decubitus or supine, yet more recently, because of the increase of repair techniques and intra-articular procedures, the supine position is the most commonly used. Access can start in the



Fig. 7 Sequential compression devices are attached to the legs for deep vein thrombosis prophylaxis, the feet are well padded, attached to the traction boots and securely taped to them to safeguard against the feet coming out intra-operatively.

peripheral compartment (femoral neck) or in the central compartment (hip joint). Any work in the central compartment entails a certain amount of traction. In most cases, fluoroscopy is a necessary adjunct to a hip arthroscopy procedure, although that has recently been called into question by a group of ‘peripheral first’ surgeons.

The layout of the operating room, patient positioning and set-up are extremely important in ensuring that the procedure goes smoothly, and these are an integral part of the planning.

The patient’s lower extremities must be well padded and well secured to the boots (Fig. 7). Both legs are placed in traction around a large, extremely well-padded post and care is taken to protect the perineum. The hip should be flexed to relax the capsule and the leg abducted and internally rotated. The C-arm is positioned in a way to obtain an image that matches the hip on the AP pelvis.

Portals and visualization

Adequate portal placement is key for visualization and instrumentation. There are many described portals and all are within a safe zone lateral to a vertical line drawn down the anterior aspect of the thigh from the tip of the anterior superior iliac spine.³⁵ The most commonly used portals are anterolateral, mostly for viewing, and a modified anterior portal (Fig. 8). The anterolateral portal is the first one to be achieved and is located about 2 cm anterior and 2 cm superior to the anterosuperior border of the greater trochanter. The position of the anterior portal depends on the size of the patient and on the intra-articular pathology. Its position is guided by direct arthroscopic visualization and can be modified to allow for easier anchor placement without injury to the acetabular cartilage. There are multiple additional portals that can be used depending on the

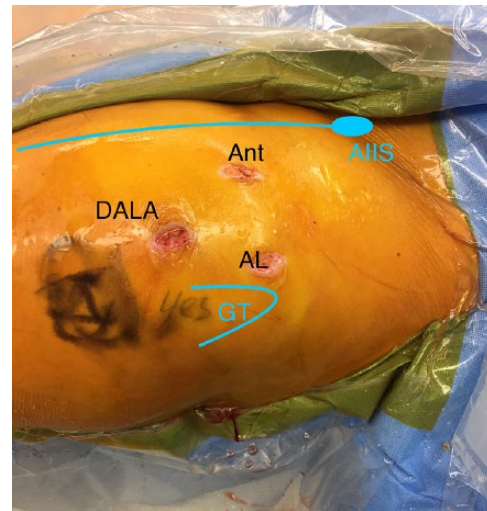


Fig. 8 Portals. AL: anterolateral portal, which is the initial portal achieved; Ant: anterior portal (working portal); DALA: distal anterolateral accessory portal; GT: greater trochanter; AIIS: anterior inferior iliac spine.

procedure that needs to be performed. There is a large amount of soft tissue between the skin incisions and the joint; regular cannulas are too restrictive, so special tools are used to exchange instruments within a portal.

One of the concerns during portal creation is injury to the labrum or femoral head cartilage. A ‘safe entry technique’, described by Domb et al,³⁶ can decrease that risk to < 0.67%. It involves using the bevel of the spinal needle used to enter the joint to the surgeon’s advantage. The metal spinal needle is first inserted just past the capsule. The guide is removed and air allowed into the joint, creating an air arthrogram and hopefully freeing up the labrum. The needle is then removed and reinserted with the bevel up until you move past the labrum. The needle is then turned 180° so the bevel faces down to avoid injuring the femoral head cartilage. The guidewire is then advanced under direct visualization until it touches the fossa. While inserting the expanders and the cannula for the scope, care is also taken to guide the tips away from the femoral head.

Once the joint is accessed and the portals secured, the next step is to perform a capsulotomy in order to facilitate visualization and navigation within the joint and in the peripheral compartment. Capsule management is one of the most debated topics in hip arthroscopy. Some authors recommend making large T-shaped capsulotomies,³⁷ while others opt for very small incisions in the capsule with special sutures or devices to help elevate it,³⁸ and others use a minimally invasive iliofemoral ligament-sparing capsulotomy.³⁹ Closure of the capsulotomy is also a matter of debate although most surgeons tend to repair large capsulotomies for fear of post-operative instability.

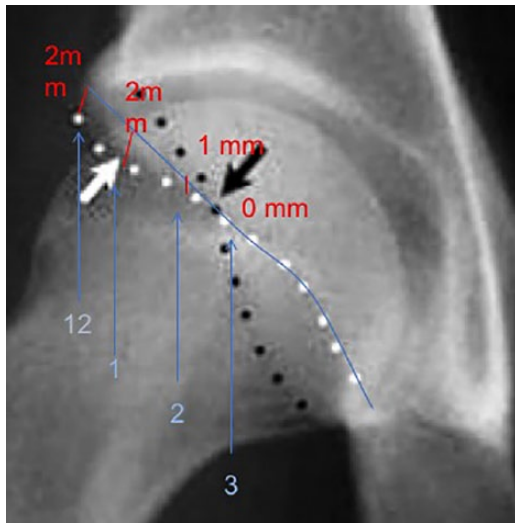


Fig. 9 Acetabuloplasty planning. Here we see the “figure of 8” again. The first step is to locate over-coverage on the ‘clock face’ of the acetabulum, in this case between 12:00 and 02:30 (thin blue arrows and blue numbers). Then the planned resection is pre-operatively templated (the red numbers). Intra-operatively the planned resection is carried out at sites of labral injury and a more conservative resection is performed at sites without injury. Care must be taken while positioning the C-arm so that the image on screen closely matches the position on the pre-operative film.

In the joint

A diagnostic arthroscopy is performed. The next steps depend on the disease process. Acetabuloplasty can be performed for pincer lesions, labral debridement/repair/reconstruction for tears, chondroplasty for articular damage and femoroplasty for cam lesions.

Any bony resection must be planned on the radiographs/CT pre-operatively (Fig. 9). Having the C-arm well positioned can help guide the osteoplasty and avoid complications. Adequate resection must be checked with the C-arm at all times in order to avoid removal of too much bone in both the acetabuloplasty and femoroplasty. If the chondrolabral junction is intact, the acetabuloplasty can be performed without detaching the labrum. Studies have shown that 5 mm of resection is grossly equivalent to 5° of change on the radiographs.⁴⁰ As the rim is trimmed back, care must be taken not to resect too much bone and not to injure the labrum or damage the cartilage (Supplemental Video 1). Focal chondral defects in the acetabulum or on the femoral head can then be addressed with microfracture, autologous chondrocyte implantation or autologous membrane-induced chondrogenesis, depending on availability and on the size of the defect.⁴¹

Repair (reinsertion) of the labrum should be performed if the tissue is viable, as labral preservation is one of the primary goals of hip arthroscopy.⁴² The labrum is brought

back to a bleeding bony edge with the help of suture anchors; careful placement of these anchors is critical in order to avoid chondral injury. The repair can be performed around the labrum or through the base of the labrum using a vertical mattress configuration, if there is enough tissue to grab (<https://www.youtube.com/watch?v=lr5anHqgrs>). This preserves the anatomy of the labrum and gives the best results biomechanically,⁴³ restoring the suction seal.⁴⁴ When the tissue is beyond repair, labral debridement or reconstruction can be performed depending on the case. Labral reconstructions have been performed using multiple types of grafts, such as the gracilis tendon⁴⁵ or the iliotibial band,⁴⁶ or the indirect head of the rectus femoris as a local graft⁴⁷ (Supplemental Video 2).

The next step would be taking care of the cam morphology if one is present. As with the acetabuloplasty, the femoroplasty requires accurate pre-operative planning with regards to the exact location of the excess bone and the amount of reshaping. This part of the procedure is performed with the leg out of traction. It will need to be flexed and extended and rotated so the entire head/neck junction can be visualized. The C-arm position is very important in this step as well. One must try to place the C-arm so that the image on the screen is as close as possible to the image on which the pre-operative planning was performed. The leg and C-arm may need to be rotated in order to ensure adequate and no over-resection. This is the part of the procedure where the capsule may obstruct the view and may need to be further opened, depending on the technique chosen. Some surgeons mark the area to be resected with a curette or cautery before using the burr to reshape the femoral head/neck junction (Supplemental Video 2). A ‘trough technique’ described by Aoki et al makes a trough where the resection should be deepest and contours around it proximally and distally to avoid resecting too much.⁴⁸ As FAI is a dynamic condition, an important part of assessing the adequacy of the bony work is putting the leg through a ROM to ensure that the impingement has been dealt with. During this dynamic evaluation, the labral repair, if one has been performed, can also be assessed. Thorough irrigation is important to decrease the debris and the chance of heterotopic ossification. At this point, a large capsulotomy would be repaired and the procedure completed with portal closure.

Complications and how to avoid them

Most complications related to hip arthroscopy for FAI can be avoided by choosing the right patient and with careful planning, positioning and execution. Recent studies have shown that complication rates, especially serious ones, are underestimated.⁴⁹ Nerve injuries due to portal placement, traction and compression from positioning are the

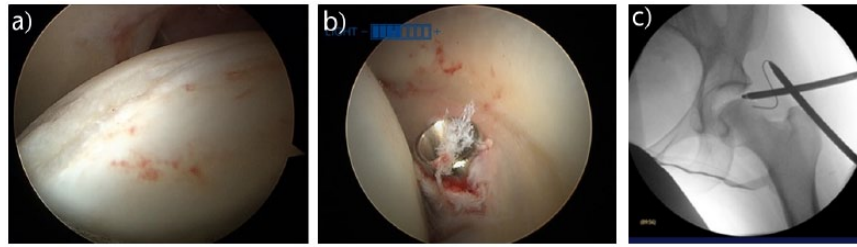


Fig. 10 a) Cartilage scuffing of the femoral head during cannula insertion. b) Labral penetration (anterolateral portal). This type of complication can be minimized with the safe entry technique. c) Kinking of the Nitinol wire which could lead to breakage within the joint.

most common complications. These are usually temporary and can be prevented with adequate padding and by respecting traction time limits.⁵⁰ Labral injury, cartilage scuffing and instrument breakage, which are more common at the onset of the learning curve (Fig. 10),⁴¹ are also avoidable with the safe technique mentioned above. Chondral damage can also occur due to poor anchor placement or careless instrument manipulation.

The most common reason for revision surgery, so long as the indications are correct, is inadequate bony resection. This could be due to inadequate visualization or planning and lack of experience. Under-resection can be treated with revision surgery, which has its own pitfalls and difficulties. Over-resection, on the other hand, can lead to permanent damage to the joint such as hip instability with gross dislocation if an overly aggressive rim trimming is performed. Over-resection of the cam will lead to abnormal hip mechanics and possible fracture.⁵¹ Post-operative hip instability may also occur due to capsular insufficiency and labral debridement in patients with borderline dysplasia.⁵² Other complications include heterotopic ossification and deep vein thrombosis, both preventable with prophylaxis if the patient is considered high risk.⁵³ Scarring has been reported and can be avoided with early onset of ROM.⁵⁴ Intra-abdominal fluid extravasation is quite rare but can be deadly, and can be prevented with careful monitoring by the surgeon and the anaesthesiologist.⁵⁵

Rehabilitation after hip arthroscopy for FAI

A recent study was performed to evaluate the need for a formal physiotherapy prescribed rehabilitation protocol after hip arthroscopy for FAI, and they found that it augmented improvements of patient-reported outcomes.⁵⁶ The type of rehabilitation will depend on what was done intra-operatively and on the patient's pre-operative activity level. Each surgeon has his/her own protocols and these are still being modified as we learn more about the procedure and have more follow-up. Some surgeons use hip braces to protect their repairs while others do not. Weight-bearing status depends on the performed

procedure and surgeon preference as well. From what is available in the literature and after discussion with peers, we can conclude that most use a four-phase system,⁵⁷ with the first phase concentrating on decreasing post-operative pain and inflammation and working on ROM while protecting any surgical repairs. This first phase is important as it should help prevent the development of anterior hip contractures and muscle inhibitions.⁵⁸ The second phase involves continuing the work on ROM, initiating weight-bearing if it was restricted and improving neuromuscular control. In the third phase, strengthening and further stabilization of the hip girdle musculature and the core are emphasized, with more dynamic exercises. The fourth phase includes training the athlete to return to their specific sport. Advancing to the next phase usually depends on the achievement of certain goals and timelines are better used as a guideline. Kraeutler et al⁵⁹ provide an excellent review and discussion of published protocols along with specific recommendations for patients who want to return to running or high-impact activities. They mention that return to sport is usually between 12 and 20 weeks post-operatively; however, it depends on the procedure performed and the sport.

Conclusion

In conclusion, hip arthroscopy for FAI can have excellent outcomes, as long as the indications are suitable and the surgeon has the required skills. In the wrong patient, and/or in the wrong hands, this can be a harmful surgery with severe complications, so each portion must be well planned and well executed. Recent studies have shown that patients who undergo total hip replacement after having had an ipsilateral arthroscopy may have poorer outcomes than those patients with no prior arthroscopy.⁶⁰ This is an issue to keep in mind when counselling and choosing your patients. If this is a procedure you would like to perform, it is recommended that you take the time to learn it and practise it well under expert supervision before applying it to your patient population.⁶¹

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ICMJE CONFLICT OF INTEREST STATEMENT

B. Domb declares board membership of American Hip Institute, AANA Learning Center Committee, Arthroscopy Journal; consultancy for Adventist Hinsdale Hospital, Amplitude, Arthrex, Medacta, Stryker; grants from Arthrex, Medacta, Stryker; royalties from DJO Global, Orthomerica, activities outside the submitted work.

FUNDING STATEMENT

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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