Arthroscopic management of anterior femoroacetabular impingement

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Background
Femoroacetabular impingement (FAI) is a recognized cause of intra-articular pathology and secondary osteoarthritis in young adults. Arthroscopy is reportedly useful in the treatment of selected hip abnormalities and has been proposed as a method for correcting underlying impingement. The aim of this study was to evaluate the early outcomes of arthroscopic management of FAI.

Patients and methods
Thirty-four consecutive patients with clinically and radiographically documented FAI were treated with hip arthroscopy, proximal femoral osteoplasty, labral debridement or repair/refixation, or acetabuloplasty or some combination. Outcomes were measured using the impingement test, Harris Hip Score, pain score on a visual analogue scale, and radiologically preoperatively and postoperatively at 6 weeks, 3 months, 6 months, 1 year, 2 years, and 3 years.

Results
There were 25 male patients and nine female patients with up to 3 years of follow-up (mean 20.6 months). The mean age of the patients was 34.2 years. Isolated cam impingement was identified in 16 hips, pincer impingement was found in six, and both types were noted in 12. Three hips were subjected to labral repair and fixation. A comparison of preoperative scores with those obtained at the most recent follow-up indicated a significant improvement ($P < 0.05$) for all outcomes measured: Harris Hip Score (59.7 vs. 82.9), visual analogue scale score for pain (6.81 vs. 1.81), and positive impingement test (100 vs. 11.76%). The α angle was also significantly improved after resection femoroplasty. Complications included heterotopic bone formation (one hip), four patients with nerve neuropraxia, and two hips have subsequently been subjected to total hip arthroplasty.

Conclusion
Arthroscopic management of patients with FAI results in a significant improvement in outcomes measures and is comparable with open techniques, with advantages of minimally invasive procedures.

Level of evidence
Level IV. Therapeutic study.

Keywords:
femoroacetabular impingement; hip arthroscopy; labrum; osteoplasty

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Introduction

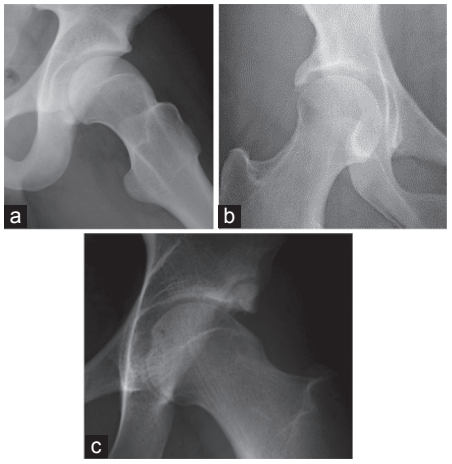
Femoroacetabular impingement (FAI) is not a new concept [1]. It has been described in conjunction with malunited femoral neck fractures, acetabular dysplasia, acetabular retroversion, and as a complication of periacetabular osteotomies [2,3]. Increasingly, it is being recognized as a cause of significant hip pain and disability and is strongly implicated as a cause of secondary osteoarthritis [4].

Stulberg *et al.* [5] described the pistol-grip deformity of the femoral head and observed its association with early-onset osteoarthritis. However, Ganz *et al.* (2003) were the first to describe it as an iatrogenic process in native hip and as a precursor to the development of osteoarthritis. They subgrouped FAI into pincer, cam, and combined types (Fig. 1) and described an open surgical approach for correction [3].

Cam impingement created by the prominent portion of a nonspherical femoral head engaging against the articular surface of the acetabulum, caused by a developmental disorder (premature eccentric closure of the growth plate at femoral head — neck junction) or reactive lesions, results in selective delamination and failure of the articular surface of the acetabulum with relative preservation of the labrum [6].

Pincer impingement may be the result of a variety of morphological changes of the acetabulum, including acetabular retroversion, coxa profunda, protrusio acetabuli, and post-traumatic deformities [7]. It results in anteroposterior acetabular overcoverage, creating an obstacle for flexion and internal rotation [8], and secondary changes of the labrum, the cartilage, and the head — neck shape, as well as fibrocystic changes at the femoral head–neck junction [9].

Figure 1



Different types of femoroacetabular impingement syndrome. (a) Cam impingement. (b) Pincer impingement. (c) Mixed impingement lesion.

FAI is not a cause of hip pain *per se* [1]. It is simply a morphologic variant predisposing the joint to intra-articular pathology that then becomes symptomatic [10]. Hips may have the morphologic feature of FAI without developing the cartilage failure associated with pathologic impingement. Thus, the arthroscopic findings are a determinant in the course of management for patients who have radiographic features of FAI [11].

Surgical treatment of FAI is mainly determined by the underlying morphologic abnormality to restore sphericity of the femoral head, thereby relieving the impingement, and to also address the pathologic changes in the labrum and articular cartilage [12]. A safe technique for surgical dislocation of the hip was described by Ganz *et al*. (2002) to address hip impingement surgically. This technique was based on the course of the blood supply to the femoral head [13]. Recent advances in arthroscopic techniques have allowed FAI to be addressed using a less invasive procedure [14,15].

The aim of the present study was to evaluate the role and effectiveness of arthroscopy in managing patients with FAI, the early results of arthroscopic management, and the frequency of complications.

Patients and methods

Between June 2008 and May 2012, a total of 34 patients with anterior FAI were treated with arthroscopic procedures and enrolled in the present prospective study. There were 25 men and nine women, with 24 right and 10 left hips. The cam patients tended to be slightly younger, with an average age of 32 versus 34 years for pincer or combined lesions.

The inclusion criteria were as follows:

(1) Moderate to severe persistent hip pain that limits activity, worsened by flexion activities (e.g. squatting and prolonged sitting), and unresponsive to medical management (e.g. restricted activity, nonsteroidal anti-inflammatory).
(2) Positive impingement sign (i.e. sudden pain on 90° hip flexion with adduction and internal rotation).
(3) Radiographic confirmation of FAI (i.e. pistol grip deformity, α angle >50°, head — neck offset <9 mm, offset ratio <0.17, coxa profunda, crossover sign, and/or posterior wall sign for acetabular retroversion).
(4) Do not have advanced osteoarthritis (Tonnis grade 2 or 3) and/or severe cartilage damage (outerbridge grade III or IV).

The exclusion criteria were as follows:

(1) Advanced osteoarthritis or bone-to-bone contact (absolute contraindication for hip arthroscopy).
(2) Unreasonable expectations of patients that could not be achieved practically.

The duration of symptoms before arthroscopic surgery averaged 31 months (range 17–49 months).

Arthroscopic technique

After the induction of general anesthesia, the patient is positioned on a standard fracture traction table. Both legs are positioned in 30° of abduction, and neutral rotation. Fluoroscopy is used to obtain an anteroposterior view of the operative hip. Gentle traction is applied through the operative hip under periodic fluoroscopic control. Once the vacuum sign (~8–10 mm of distraction between the acetabulum and the femoral head) has been visualized, the operative leg is adducted to neutral. The foot is internally rotated, bringing the femoral neck parallel to the floor.

Portals placement

The operative hip is prepared and draped. The anterolateral portal is 1 cm proximal and 1 cm anterior to the tip of the greater trochanter. Using a 6 inch, 18 G hip arthroscopy needle, 30 ml of sterile saline can be injected through the needle to assess for fluid rebound indicative of joint entry. The needle is threaded with a guide wire over which a 4.5-mm cannula is placed. A 70° arthroscope is introduced into the joint with fluid at 105 mmHg of pressure. Once within the joint, the intra-articular triangle can be viewed, formed by the borders of the anterior femoral head, labrum, and joint capsule. The anterior portal is placed directly distal to the anterior superior iliac spine and medial to the anterolateral portal. An arthroscopy needle

is introduced through the intra-articular triangle, followed by a guide wire and a 4.5-mm cannula. Care is taken to place the cannula through the synovial lining and not the labrum. The camera is placed through the anterior portal to visualize the anterolateral portal entry site and the portal is repositioned as needed.

Treatment of cam impingement: osteoplasty

The diagnosis of cam impingement can be confirmed using a dynamic arthroscopic examination for central and peripheral compartments of the hip. The area of cam impingement is visualized at the anterior femoral head — neck junction. The chondral surface in this area is convex and shows changes in color (purplish/gray) and texture (fibrillation/flap/fissure) that distinguish it from normal articular cartilage. Once the region of the cam impingement has been defined, a 5.5 mm round burr is used to restore the femoral head–neck offset by transforming the convexity of the lesion into a concave surface. The depth and width of the resection are determined by the native anatomy and the amount of surface area of impingement. The resection is performed from inferior (6-O'clock position) to superior (12-O'clock position). One should only resect enough bone to relieve the FAI as determined by periodic dynamic examination (Figs 2 and 3).

Treatment of pincer impingement: rim trimming

First, we assess the condition of the labrum. Severely degenerative labral tissue should be debrided. Labral tissue with some integrity should be preserved when possible. Then, we assess the amount of bone overhang. To better visualize the bony shelf, a shaver can be used to perform a limited synovectomy. In some patients with small pincer lesions and an intact, healthy labrum, an osteoplasty may be sufficient to relieve the impingement. A moderate-sized or large-sized pincer lesion, however, requires trimming of the acetabular rim. The pincer lesion can be resected (rim trimming) using a 5.5-mm round burr. The amount of bone resected is typically 5–7 mm. Once the pincer lesion has been resected, the next step is labral repair and reattachment using bioabsorbable anchors with polyester suture (Fig. 4).

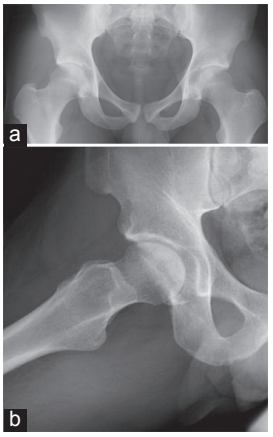
Postoperative treatment and rehabilitation

The use of a nonsteroidal anti-inflammatory drug is recommended for 2 weeks postoperatively to limit the risk of heterotopic ossification. Mechanical compression devices and pharmacotherapy are used for 4 weeks to limit the risk of DVT. Physical therapists should first restore passive motion, followed by active motion. Special attention is paid to restoring internal rotation first, followed by external rotation. Patients

Figure 2

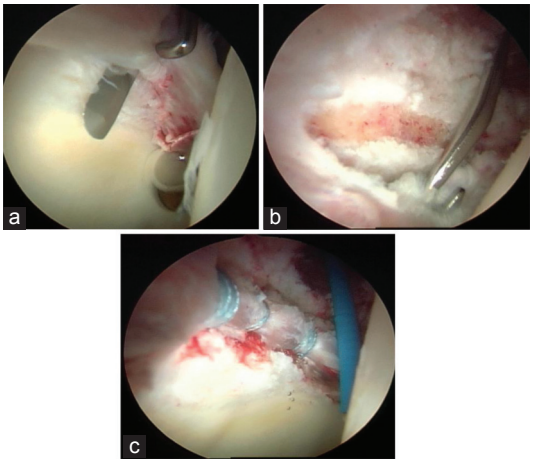
Preoperative anteroposterior and lateral views: male patient, 43 years old, with cam impingement lesion right hip.

Figure 3



Postoperative anteroposterior and lateral views: male patient, 43 years old, after arthroscopic osteoplasty for cam impingement lesion right hip.

Figure 4



Intraoperative labral lesion in patient with pincer impingement. (a) Labral degeneration and avulsion, (b) after acetabuloplasty, (c) after fixation of the labrum using three anchors.

should be allowed to weight bear as tolerated, but crutches should be used for 4 weeks as a precautionary measure to protect the femoroplasty site against any twisting episodes. Endurance strengthening is commenced after motion is maximized and full weight bearing begun.

Follow-up

No patients were lost to follow-up; there was 100% follow-up of the 34 patients at a minimum of 7 months (range 7–41 months; mean 20.6 months). Outcomes were measured using the impingement test, Harris Hip Score (HHS), and pain score on a visual analogue scale (VAS), and radiologically preoperatively and postoperatively at 6 weeks, 3 months, 6 months, 1 year, 2 years, and 3 years. Postoperative radiographic alpha angles were measured to evaluate the adequacy of proximal femoral osteoplasty.

Statistical analysis

For statistical analysis, preoperative, and follow-up VAS, HHS scores, and radiographic values were compared using Student's paired *t*-test using an SPSS program (SPSS Inc., Chicago, Illinois, USA). For all comparisons, a *P* value of less than 0.05 was considered significant.

Results

After careful inspection and dynamic arthroscopic examination of the joint, 16 (47.1%) patients had isolated cam impingement (managed by femoroplasty), six (17.6%) patients had isolated pincer impingement (managed by acetabuloplasty, but one patient needed biodegradable anchor labral fixation), and 12 (35.3%) patients had combined lesion (managed by femoroplasty, labral debridement, and acetabuloplasty, but two patients needed biodegradable anchor labral fixation). All patients were followed according to a prospective protocol, with HHSs, VAS, and plain radiographs obtained 6 weeks, 3months, 6 months, 1 year, and annually for 2 years postoperatively.

The mean HHS had significantly improved from 59.7 points preoperatively to 82.9 points postoperatively at the time of the final follow-up (mean improvement of 23.2; $P < 0.02$). The mean VAS improved from 6.81 point preoperatively to 1.81 points at the time of the final follow-up (mean improvement of 5 points; $P < 0.015$). At the final follow-up, the impingement test was positive in four (11.76%) patients. The α angles were also significantly improved after resection femoroplasty, with 76.2 ± 14.4° preoperatively and 51.5 ± 11.6° postoperatively ($P < 0.025$).

In terms of the complications in the present study, one (2.94%) patient developed heterotopic ossification, which did not affect the outcome. Two of these 34 (5.88%) hips were considered a clinical failure, with radiographic evidence of progression of the osteoarthritis, and required conversion to total hip arthroplasty. There were four (11.67%) patients with transient neuropraxia: one with transient neuropraxia of the sciatic nerve that resolved within 3 weeks, one transient neuropraxia of the pudendal nerve that resolved within 2 weeks, and two patients with transient neuropraxia of the femoral nerve that resolved within 3 weeks.

Twenty-six (76.47%) patients were satisfied and able to return to preinjury activities after hip arthroscopy at a mean of 9.4 ± 4.7 months (range 4–26 months). Six (17.65%) patients were satisfied, with questions. Only two (5.88%) patients were not satisfied and required a hip arthroplasty.

Discussion

FAI is the main cause of early damage to the acetabular labrum and articular cartilage of the hip, particularly in young, active patients and high-level athletes [16]. In patients with FAI, limitation of flexion and internal rotation occur at the hip joint as a result of premature pathologic contact between the skeletal prominences of the acetabulum and femur [17]. The possible causes of this deformity are subclinical slipped capital femoral epiphysis or secondary remodeling of the proximal femur. Goodman *et al.* [18] noted that the deformity was primary (anatomical variant in the shape of the adult femur) and not secondary to remodeling (because of unrecognized childhood disease).

Surgical treatment has been used to improve the clearance for motion at the hip joint and lessen the femoral thrust against the acetabular rim. If left untreated, FAI will lead to osteoarthritis of the hip [19]. Possible surgical options for anterior FAI include open treatment (hip dislocation, osteoplasty, and labral debridement or fixation) and less invasive arthroscopic management.

Compared with the generous exposure provided with open surgical dislocation of the hip, arthroscopic visualization and orientation of the cam lesion is more challenging. Meticulous soft tissue preparation and a capsular window as necessary to fully visualize the lesion are important. With good visualization, recontouring can then be performed in a comparable manner that approaches that of the open technique. We also believe that there may be many individuals with abnormally

shaped femoral heads who do not develop intra-articular failure because of cam impingement. Thus, it is possible to have cam morphology without cam pathology. The arthroscopic findings then become an important component in the decision to address the cam lesion. Frank or impending articular failure of the anterior acetabulum reflects the importance of performing an accompanying femoroplasty. The surgeon must weigh the risks of performing a potentially unnecessary procedure in an asymptomatic individual with cam morphology against the risks of allowing unchecked progression of the deleterious process [1,20].

Encouraging results after the open treatment of FAI have been reported. A retrospective study by Beaule *et al.* [17] evaluated the quality of life after open osteochondroplasty of the femoral head–neck junction for the treatment of FAI. Thirty-seven hips in 34 patients with persistent hip pain and a mean age of 40.5 years underwent surgical dislocation of the hip and osteochondroplasty of the femoral head–neck junction for the treatment of cam-type FAI. Ten patients required a reoperation that was directly related to the surgical dislocation approach (e.g. screw removal or a reoperation because of failed trochanteric fixation) [16].

Ng *et al.* [21] performed a systemic review of 23 reports (970 cases) to review the efficacy of surgical treatment for FAI and which patient will have best outcomes. The outcome scores reported improved after treatment in all studies. Despite these improvements, up to 30% of patients will eventually require total hip arthroplasty. Patients dissatisfied with the procedure or who experienced no improvement in their pain ranged from 0 to 31.2% [21]. In the present study, two patients underwent total hip replacement at least 17 months after arthroscopy because they did not show improvement in the HHS, with a preoperative score of 56.58 and a postoperative score of 53.58, respectively. In these patients, arthroscopic examination indicated an outerbridge grade IV lesion of the articular cartilage that was not proved with preoperative radiographic examination.

Hartmann [22] retrospectively evaluated 33 patients 15 months after an arthroscopically assisted mini-open anterior approach to compare it with the results after surgical dislocation for FAI. The mean HHS improved from 64 points preoperatively to 85 points at the time of follow-up ($P < 0.001$). Mean patient satisfaction on the VAS was 7 points (range 2–10 points). In two of the patients observed, a transient femoral nerve palsy (completely resolved at follow-up) was observed and 15 patients reported numbness in the area of the lateral cutaneous femoral nerve. The author concluded that treatment of anterior FAI through an arthroscopically assisted mini-open anterior approach can reduce pain and improve function in a short-term observation period [22]. In the present study, our results are comparable with the Hartmann study, but without numbness in the area of the lateral cutaneous femoral nerve that is related to the operative approach.

Horisberger *et al*. [23] prospectively followed a cohort of 105 hips (88 patients; 60 men and 28 women) who underwent arthroscopic surgery for symptomatic cam or mixed FAI. At a minimum follow-up of 1.3 years (average 2.3 years; range 1.3–4.1 years), all clinical outcome measures improved. Nine (8.6%) patients underwent THA during follow-up. The outcome measures after arthroscopic therapy for FAI seem comparable with those reported after open procedures, and also comparable with our results [23].

Palmer *et al.* [24] evaluated the mid-term outcomes of patients with cam-type FAI treated arthroscopically. Two hundred and one patients were available for the final assessment, with a minimum follow-up of 36 months (mean 46 months). Preoperative to postoperative satisfaction levels improved from 0.5 to 75%. Twelve (5.97%) patients required hip arthroplasty during the follow-up period. Patients with associated pincer pathology showed poorer results after arthroscopic acetabular rim resection [24]. The outcome measures of our study for all types of FAI seem comparable with those reported by Palmer and colleagues in terms of satisfaction and the need for hip arthroplasty.

There are two described risks associated with the femoroplasty operative technique: fracture and avascular necrosis. A study by Mardones *et al.* [25] has shown that up to 30% of the femoral neck can be resected before compromising its structural integrity. There is no known amount of the femoral neck that can be resected before vascular compromise occurs. However, care must be taken to avoid resection in the region of lateral epiphyseal vessel penetration [25]. The femoral neck is protected in the postoperative setting using the modified brace as well as protected weight bearing. In the current study, no femoral neck fracture was detected until the end of follow-up [26].

Adverse outcomes after hip arthroscopy can be associated with traction. The primary risk of traction is injury to the sciatic nerve. This traction risk can be reduced through gentle, controlled application of traction with the hip in a flexed and abducted position. The risk of pudendal traction neuropraxia can be reduced with the use of a padded perineal post [27]. Byrd and Jones [28] reported five cases of transient neuropraxia (all resolved) and one minor heterotopic

ossification. In the current study, the rate of neuropraxia was 11.76% (four cases) and it resolved completely within 3 weeks postoperatively [28].

Conclusion

Arthroscopic surgery for the treatment of FAI improves hip function and reduces pain. Arthroscopic surgery is less traumatic than open hip surgery, which reduces the time required for postoperative rehabilitation; however, as arthroscopic surgery is more difficult than open surgery, arthroscopic surgery may not be as beneficial as open surgery in the long term. Labral refixation has been suggested to be performed whenever possible to preserve the function of the tissue. Despite encouraging reports of the arthroscopic treatment of FAI, long-term follow-up is necessary.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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