Current concepts in the diagnosis and management of femoroacetabular impingement

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Abstract Femoroacetabular impingement is becoming increasingly recognised as a cause of hip pain in the young adult. It is thought that the condition may lead to acetabular labral tears, chondro-labral separation, chondral delamination and eventually predispose to osteoarthritis of the hip. Efforts have thus been directed to diagnosing and treating the underlying pathology and subsequent sequelae. This article presents the relevant literature with regards to the aetiology of femoroacetabular impingement, its clinical features, investigations and options of management. Finally outcomes relating to both open and arthroscopic approaches to treatment are discussed.

Introduction

Femoroacetabular impingement (FAI) is being increasingly thought of as an aetiological factor for osteoarthritis of the hip [1, 2]. The basic pathology is one of an abnormal abutment of the femoral head or neck on the acetabular rim and was first reported over a decade ago by the Swiss group [3]. In recent years, the condition has been linked with a number of other pathologies including slipped upper capital epiphysis (SUCE) [4] and fractures of the femoral neck [5]. A recent magnetic resonance imaging (MRI) study investigating 200 asymptomatic volunteers found 14% of the study population to have at least one hip with a cam-type FAI, whilst 3.5% were found to have bilateral deformities.

The majority of the deformities were found in men (79%) [6].

Pathophysiology

Two distinct types of impingement have been described, the cam and the pincer [2, 7, 8]. A third type combining morphological features of the preceding two also exists and is termed mixed [1].

Cam impingement is seen more commonly in the young athletic male and occurs as a result of an abnormally shaped femoral head repeatedly impinging upon an acetabulum that cannot accommodate the increased radius of the femoral head. It typically occurs with flexion of the hip joint [1, 2]. The repeated abutment of this abnormally shaped femoral head on the labro-chondral junction generates shear forces in this region which in turn may lead to a labral tear, labro-chondral separation, articular cartilage peeling off the bone and in the longer term osteoarthritis [8]. This morphological abnormality is usually situated in the anterior aspect of the head-neck junction of the femur and therefore the corresponding labral and chondral lesions produced are seen in the anterosuperior aspect of the acetabulum [1, 2, 9].

Pincer-type impingement on the other hand is more commonly seen in athletic middle-aged women [1, 2]. The primary pathology here is of the acetabulum with a resultant over coverage of the femoral head leading to abutment of the femoral head-neck junction on the acetabular rim in flexion. This over coverage could be global as in coxa profunda and acetabular retroversion or localised as in an anterior osteophyte [1, 2]. The anterior labrum is the most commonly affected region although a contrecoup phenomenon has been described with chondral injury seen in the posteroinferior region of the acetabulum [1, 2].

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Mixed impingement, as the name implies, incorporates both mechanisms and is thought to be the commonest form of impingement [1]. Regardless of the type of impingement the end point appears to be similar with damage to the surrounding soft tissues and eventually osteoarthritis [2, 10].

Aetiology

Genetics

Studies have shown that the sibling of a patient with a cam deformity has a relative risk of 2.8, whilst the siblings of those patients with a pincer deformity have a relative risk of 2.0 of having the same deformity when compared with a control group [11]. Bilateral deformities were also found to occur more often in the related group.

Slipped upper femoral epiphysis

Slipped upper femoral epiphysis (SUFE) is more common in boys than girls and typically occurs in obese children [12]. Plain radiographs show a posterior slip of the epiphysis relative to the metaphysis that is best seen on the lateral radiographs [12, 13]. A 15-year follow-up study of patients with previously treated SUFE has revealed the presence of FAI [14]. It is thought that even a mild slip may lead to early damage of the acetabular labrum and the adjacent cartilage by the repetitive trauma of a prominent femoral metaphysis impinging upon the acetabular rim [4].

Femoral neck fracture

Ganz et al. [15] reported six cases in which femoral neck fractures had subsequently led to FAI. More recently, it has been shown that malunion at the fracture site can also lead to impingement [5].

Perthes' disease

Perthes' disease belongs to the class of aseptic osteochondroses of childhood. It is characterised by avascular necrosis of the epiphysis, which, in turn, impairs the enchondral ossification of the femoral head [16]. At arthroscopy these patients have been shown to have evidence of articular surface damage with osteochondral projections at the area of anterior impingement [17].

Geographical variation

FAI seems to be more prevalent in the Western world and is proving to be a major cause of primary osteoarthritis. However, the prevalence is low in the Eastern world.

Takeyama et al. from Japan, in a retrospective study of 946 primary total hip replacements, observed FAI as a preoperative diagnosis only in six hips [79].

Clinical features

Typically, patients with FAI present with a history of groin pain especially on deep flexion [1]. In the initial stages, the pain may be intermittent, but as the condition progresses and surrounding structures become involved, pain becomes more constant [2]. Moderate to severe hip pain is a common finding with 86% of patients in one study presenting with such a pain in the groin [18]. Pain is exacerbated by prolonged walking, athletic activities or even from prolonged sitting [1, 2, 19, 20]. Clicking and catching within the joint is also an important clue to the diagnosis as this may represent a secondary labral tear [21, 22]. Acetabular labral tears should be considered in active patients with a history of groin pain that is exacerbated by activity without radiological evidence of other hip pathology [18]. Clinical examination yields the most diagnostic information with limited internal rotation in 90° of flexion seen in the majority of patients as well as a positive impingement test. The impingement test involves flexing the patient's hip to 90°, adducting and internally rotating it simultaneously. A positive test is indicated by reproduction of the patient's pain. A posterior impingement test is elicited similarly with the hip in extension and external rotation [20]. Provocative tests for the anterior and posterior labral tears exist and include moving the hip from flexion, external rotation and abduction into extension with internal rotation and adduction for anterior [23–25] and moving the hip from flexion, adduction and internal rotation to extension, abduction and external rotation [23, 24] for posterior tears. However, some authors feel that a positive impingement test is suggestive enough of a torn labrum [26, 27].

Investigations

Investigation of this condition requires a combination of plain radiographs and MRI scans. An anteroposterior pelvic view and a cross-table lateral view of the proximal femur are first-line investigations and may be augmented by a Dunn/Rippstein view in 45° of flexion [28]. These films will reveal the presence of a flattened femoral head or a pistol grip deformity both of which are associated with a cam-type impingement [1]. Acetabular version can be assessed on anteroposterior radiographs where a "crossover" sign may be evident. This refers to the radiographic appearance of the anterior acetabular wall beginning superolaterally, intersecting the posterior wall and ending inferomedially [29]. Lateral

X-rays also allow for the measurement of the alpha angle [3]. Two lines are drawn from the centre of rotation of the femoral head. One runs parallel to the femoral neck and the other to the anterior head-neck junction. The angle that these lines subtend should be less than 55° [3].

Whilst X-ray evaluation can help diagnose FAI, MRI scanning allows for labral and chondral damage to be assessed [1, 30]. Kassarian et al. [31] describe a triad of MR findings comprising abnormal head and neck morphology, anterosuperior cartilage abnormalities and anterosuperior labral abnormalities. Other authors have similarly found that the predominant site of involvement is at the anterosuperior labrum [32, 33], and at this site acetabular and femoral articular cartilage abnormalities are identified in 94 and 100% of the cases, respectively, an abnormally shaped femoral head in 39% of the patients and acetabular retroversion in 11% of the patients [32].

Sequelae

Labral tears and Chondral Damage

The pathomechanics of FAI resulting in labral tears has already been discussed. The majority of labral tears are situated anteriorly [34–36] and are associated with chondral damage usually in the same zone as the tear [37, 38]. MRI aids diagnosis. The sensitivity of an MR arthrogram is estimated to be 90% with a specificity of 91% [10, 39].

Osteoarthritis

It is estimated that one third of patients with mild osteoarthritis in the presence of FAI will take more than ten years to develop end-stage osteoarthritis. [3].

Management

Treatment of FAI involves an initial trial of non-operative measures. This includes activity modification and pain medication. However, conservative measures usually fail as the population that suffers from this condition is typically young and active and the problem is mechanical in nature [2]. Surgical management can be achieved either arthroscopically or via an open approach. Surgical treatment for FAI is directed towards the anatomical lesion and is tempered by the presence of any associated pathology. Advanced osteoarthritis typically necessitates joint replacement, whilst with symptomatic disease the aim is to improve the head-neck offset and treat any concomitant labral or chondral pathology, thus preventing impingement and possibly development of osteoarthritis [1, 3, 40].

Open treatment—surgical dislocation of the hip

The surgical approach for open debridement was described by Ganz et al. and termed as the trochanter flip approach [41]. An open approach allows dislocation of the hip and therefore for an unrestricted view of the femoral head and acetabulum. The vascular supply to the head of the femur is at risk during surgical dislocation of the hip, but Ganz et al. have shown that the predominant blood supply to the femoral head is via the deep branch of the medial circumflex femoral artery and that keeping the short external rotators intact prevents damage to this artery. Safe dislocation of the hip is accomplished by performing an osteotomy leaving part of the greater trochanter in place with its gluteus medius attachment intact. A capsulotomy is made anterolaterally along the femoral neck ensuring it remains anterior to the lesser trochanter, thus avoiding damage to the medial circumflex femoral artery. There is a reported risk of avascular necrosis of less than 1 in 1,000 with this approach [40, 42]. Following the surgical dislocation, the femoral head-neck junction osteoplasty can be performed to address the cam deformity, and then the labrum can be repaired and any chondral damage addressed at the same time. In cases of pincer impingement, an acetabular rim recession to decrease over coverage is carried out followed by refixation of the labrum. If, however, there is a significant amount of over coverage secondary to a retroverted acetabulum then a pelvic osteotomy to correct the version may be essential.

Arthroscopic treatment

The benefits of arthroscopic treatment include a minimally invasive procedure with a subsequent decrease in rehabilitation time. However, there is a steep learning curve, training is essential and it is certainly not a procedure for the occasional operator. But, in expert hands and centres which deal with this condition regularly, the results of arthroscopic treatment appear promising with one series reporting a 93% return to high-level competition for athletes following arthroscopic treatment for FAI [44].

Arthroscopies are typically performed under general anaesthesia with the patients either in a lateral or supine position [42, 45, 46, 80]. Both traction and fluoroscopic guidance are required. Applying traction under fluoroscopy until a vacuum sign secondary to the negative intra-articular pressure is evident accesses the central compartment of the hip. The joint capsule is then distended with normal saline, a 17 G needle is inserted into the joint avoiding the labrum and then a flexible nitinol guide wire is inserted into the joint over which the arthroscopic cannula is passed. A 70° arthroscope is typically used for the procedure [42, 45]. The labrum and chondral damage and the pincer lesion can be

Fig. 1 Labral tear in the anterosuperior region of the acetabulum

addressed via the central compartment (Fig. 1 and Fig. 2). The impingement lesion or the asphericity of the femoral head on the other hand is addressed via the peripheral compartment (Fig. 3 and Fig. 4). The peripheral compartment is accessed with the hip in flexion and no traction.

Labral tears can be effectively treated with hip arthroscopy. However, the issue of whether to remove and refix or debride labral tears remains unresolved [47, 48]. The acetabular labrum acts to enhance joint stability [38] and debridement, therefore has implications with regard to hypermobility and ongoing subluxation of the hip [48]. Kelly et al. compare the labrum of the hip with the menisci of the knee and note the healing capacity for both to be greatest at the peripheral capsular attachment. The authors recommend that repair be the management option of choice rather than debridement [48]. More recent work by Larson and Giveans [49] corroborates these findings.

Complications of hip arthroscopy can be attributed to either those caused by traction or those by instruments [45] and have been reported in 0.5–5% of patients [46]. The majority are related to transient neuropraxia secondary to distraction of the joint [45, 46]. Injuries to the sciatic nerve (posterior portal), lateral femoral cutaneous nerve (anterolateral portal) and femoral nerves have all been reported [45]. Traction may have a detrimental effect on the joint

Fig. 2 Chondral lesion in the anterosuperior region of the acetabulum

Fig. 3 Large impingement lesion viewed via the peripheral compartment at hip arthroscopy

capsule, the ligamentum teres or the acetabular labrum; however, this has yet to be proven [46].

In an attempt to prevent some of these complications, one cadaveric study evaluated the use of only anterior and anterolateral portals for the treatment of pincer-type FAI. The authors found that this method was a feasible option in treating anterosuperior pincer-type FAI but that there was a significant risk of underestimating the amount of resection required for posterosuperior pincer lesions [43, 50].

Combined open and arthroscopic approaches

A Smith-Petersen or Hueter anterior approach can also be used [42] to address FAI. The lateral cutaneous nerve of the thigh is at risk with this approach; however, it can provide an excellent view of the anterior and superior part of the head-neck junction and the anterior rim of the acetabulum. Clohisy and McClure [51] have reported good early results with this combined approach.

Outcomes

Both open and arthroscopic treatments of FAI have proven to be beneficial at short- to mid-term follow-up. Philippon et al. [52] prospectively evaluated 112 patients treated with

Fig. 4 View of the femoral head-neck junction via the peripheral compartment following excision of the cam impingement lesion

Table 1 Outcome studies on FAI

Study	Level of evidence	Number of hips	Average age (years)	Average follow-up (months)	Outcome measure	Approach	Result	Conclusion
Peters et al. (2010) [55]	4	96	28	26 (18–96)	HHS	Open	Statistically significant improvement in hip score; 6% failure rate	Improvement in function and pain at short-term follow-up if no evidence of preoperative arthritis
Ribas et al. (2010) [56]	4	117		36	Merle d'Aubigné, WOMAC	Mini-open (Tönnis 0 vs 1 vs 2)	Improvement in scores for Tönnis 0 & 1; no improvement Tönnis 2	Surgery influenced by preoperative degeneration
Graves and Mast (2009) [57]	4	48	33	38 (6–67)	Merle d'Aubigné-Postel score	Open	Mean increase in score of 3.8	Surgical dislocation improves symptoms in patients with limited radiographic signs of arthritis
Yun et al. (2009) [58]	4	15	35.8	27 (12–120)	HHS	Open	Mean improvement HHS 17	Surgical dislocation can be used to treat FAI
Beaulé et al. (2007) [59]	4	37	40.5	37	WOMAC, UCLA activity score, SF-12	Open	Statistically significant improvement in all scores; 6/34 patients dissatisfied	Open surgery is safe and effective and can provide a significant improvement in the overall quality of life of most patients
Beck et al. (2004) [33]	4	19	36	55	Merle d'Aubigné	Open	13 hips good to excellent; 5 required THA	Dislocation yields good results; not suitable in advanced degenerative disease
Bizzini et al. (2007) [60]	4	5	21.4	31	Return to play, time to regain symmetrical hip rotation	Open	3 athletes returned to highest level; 2 returned to minor league	Return to high-level play possible with open treatment
Ribas et al. (2007) [61]	4	35		29.2	Merle d'Aubigné, ROM	Mini-open	Significant improvement in ROM and Merle d'Aubigné	Anterior surgical approach allows early return to sport
Espinosa et al. (2006) [62]	3	60	30	24	Merle d'Aubigné	Open (labral resection vs reattachment)	Statistically significant improvement in both groups; better outcome if labral reattachment	Labral reattachment had superior clinical and radiographic results
Peters et al. (2006) [63]	4	30	31	32	HHS	Open	Statistically significant improvement HHS	Surgical dislocation can lead to improved pain and function in those without substantial damage to articular cartilage
Siebenrock et al. (2003) [64]	4	29	23	30	Merle d'Aubigné	Open	Statistically significant improvement in score; 3 required reoperation	Periacetabular osteotomy is an effective way to reorient the acetabulum
Gedouin et al. (2010) [54]	4	111	31	10	WOMAC	Arthroscopic	Statistically significant increase WOMAC; one conversion to open surgery; 4% reoperation rate, 6% complication rate	Arthroscopy is efficacious and associated with low morbidity
Gédouin et al. (2010) [65]	4	38	36	15	WOMAC, Merle d'Aubigné	Arthroscopic	WOMAC increased 20 points; Merle d'Aubigné increased 2.1 points; overall satisfaction 79%	Arthroscopy is safe and effective
Horisberger et al. (2010) [66]	4	20	47.3	36	NAHS, VAS	Arthroscopy	50% planned to or had undergone THA; other 50% showed improvement	Arthroscopy is not indicated in advanced osteoarthritis
Philippon et al. (2010) [67]	4	28	27	24	HHS, patient satisfaction, return to sport	Arthroscopic	HHS increase 25 points; patient score 10; 2 reoperated	Arthroscopic treatment leads to successful outcomes and high patient satisfaction

Table 1 (continued)

Study	Level of evidence	Number of hips	Average age (years)	Average follow-up (months)	Outcome measure	Approach	Result	Conclusion
Singh and O'Donnell (2010) [68]	4	27	22	22	HHS, NAHS	Arthroscopic	Improvements in all scores; 1 failed to return to sport	High satisfaction with arthroscopy both in short and medium term
Brunner et al. (2009) [69]	4	53	45	26	NAHS, sports frequency score, VAS	Arthroscopic	All scores significantly improved; 31/53 returned to pre-morbid level of sport	Arthroscopic osteoplasty can significantly improve the rate and level of popular sports activities in patients with FAI
Byrd and Jones (2009) [70]	4	207	33	16 (12–24)	HHS	Arthroscopic	83% had improvement in HHS	Short-term outcomes comparable to open procedure
Kang et al. (2009) [71]	4	41	26	27	HHS, HOS	Arthroscopic	Improvement HHS 31 points; HOS improvement from 43 to 75%; 71% return to sports	Patients with a diagnosis of labral tear should undergo arthroscopic examination
Larson and Giveans (2009) [49]	3	75	31(group 1), 27 (group 2)	21.4 (group 1), 16.5 (group 2)	HHS, SF-12, VAS	Arthroscopy (labral debridement vs reattachment)	HHS significantly better for reattachment	Labral reattachment results in better outcomes
Neppele et al. (2009) [72]	3	48	37.4 (arthroscopy alone), 33 (combined)	27 (group 1), 19 (group 2)	MMHS	Arthroscopic vs combined	Significant improvement in scores for both groups; at 1 year combined group exhibited better results	Improved clinical outcomes with combined procedure
Philippon et al. (2009) [52]	4	112	40.6	27 (24–33)	HHS, patient satisfaction score	Arthroscopic	Mean improvement HHS 26; median patient satisfaction 9	Arthroscopy with suitable rehabilitation gives good short-term outcome and high patient satisfaction
Bardakos et al. (2008) [73]	3	71	35 (control) vs 33 (treatment)	12	MMHS	Arthroscopic (debridement of impingement lesion vs leaving in situ)	83% excellent/good results with osteoplasty (vs 60%); improvement in HHS	Addition of osteoplasty improves results of arthroscopy
Larson and Giveans (2008) [74]	4	100	34.7	9.9	MMHS, SF-12, VAS	Arthroscopic	Improvement in all scores; good to excellent results in 75%; 3 hips went on to THA	Arthroscopy results in significant improvement in outcome measures
Philippon et al. (2008) [75]	4	17	15	15 (12–24)	MMHS, HOS, patient satisfaction, HOS sport subscale	Arthroscopic	MMHS increased 35 points; HOS sport score up 56 points; patient satisfaction score 9	Arthroscopy in the adolescent population produces excellent improvement in function and high levels of patient satisfaction in the short term
Philippon et al. (2007) [44]		45	31	18	Return to play	Arthroscopic	93% return to play	Arthroscopic treatment allows professional athletes to return to professional sport
Byrd and Jones (2000) [76]	4	38	38	24	HHS	Arthroscopic	10/38 subsequent procedure; improvement in median score 28	Can be performed with reasonable expectations of success
Laude et al. (2009) [77]	2	94	33.4	58.3 (28.6–104.4)	NAHS	Combined	Mean increase NAHS 29.1 points; 11/94 required THA	Allows direct visualisation, avoids dislocation and leads to improved function
Lincoln et al. (2009) [78]	4	16	37	24	HHS	Combined	Statistically significant improvement HHS; 1 required THA	Combined approach is a useful technique for cam impingement

HHS Harris hip score, THA total hip arthroplasty, ROM range of motion, NAHS nonarthritic hip score, VAS visual analogue scale, HOS hip outcome score, MMHS modified Harris hip score

hip arthroscopy. At the time of surgery, 23 patients underwent head/neck resection for cam impingement, three underwent acetabular trimming for pincer impingement, and 86 underwent both procedures. At 2.3 years, Harris hip scores had improved from 58 to 84, although ten patients needed to undergo total joint arthroplasty. The authors concluded that hip arthroscopy followed by rehabilitation resulted in good short-term outcomes and high patient satisfaction. Philippon et al. are not alone in their findings. Both Byrd and Jones and Gedouin et al. draw similar conclusions. Byrd and Jones prospectively analysed a cohort of 29 patients over a ten year period. All patients were evaluated preoperatively and postoperatively with a modified Harris hip score and all patients underwent hip arthroscopy for acetabular labral tears. At the time of the procedure eight patients were found to have arthritis. The vast majority of these patients required total hip arthroplasty. Of the remaining 18 patients, 83% continued to show a significant improvement in symptoms at 10 years. Byrd and Jones concluded that symptomatic tears treated with hip arthroscopy can result in good long-term outcomes, but the presence of arthritis at the initial procedure was a poor prognostic indicator. [53]

Gedouin et al. evaluated 111 arthroscopic procedures for FAI. Follow-up is short, at only a mean of ten months, but the group's findings of high satisfaction rates, improved Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores and a low level of associated morbidity appear to concur with the literature. Once again the authors show that patients with early arthritis had uniformly poorer results. [54]

Beck et al. [33] evaluated open surgical dislocation of the hip; 14 men and five women were followed up for an average of 4.7 years. There were no instances of avascular necrosis of the femoral head, although five of the 19 patients required subsequent total hip arthroplasty. The authors concluded that with surgical dislocation and subsequent treatment good results can be expected in patients with FAI. A detailed record of the outcome studies on FAI is shown in Table 1.

Conclusion

Femoroacetabular impingement is a relatively newly recognised. It presents with an insidious onset of groin pain that becomes more and more intrusive as the condition progresses. Two distinct forms have been identified and have been termed cam and pincer although combination of the two exists. The anatomical malformations themselves do not cause any symptom, but instead, the sequelae of repetitive impingement damages surrounding structures most notably the labrum and the adjacent chondral surface

leading to pain. It is therefore implicated in the aetiology of osteoarthritis of the hip. Diagnosis can be made clinically and can be augmented with plain radiographs and MRI scans. Treatment, be it via an open, arthroscopic or combined approach, is directed towards correction of the anatomical malformation and then to the resultant effect on the surrounding soft tissues. Short- to mid-term follow-up has thus far been promising, but there are limited data at present evaluating long-term outcomes.

Conflict of interest None.

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