Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction

MINIMUM TWO-YEAR FOLLOW-UP

Over an eight-month period we prospectively enrolled 122 patients who underwent arthroscopic surgery of the hip for femoroacetabular impingement and met the inclusion criteria for this study. Patients with bilateral hip arthroscopy, avascular necrosis and previous hip surgery were excluded. Ten patients refused to participate leaving 112 in the study. There were 62 women and 50 men. The mean age of the patients was 40.6 yrs (95% confidence interval (CI) 37.7 to 43.5). At arthroscopy, 23 patients underwent osteoplasty only for cam impingement, three underwent rim trimming only for pincer impingement, and 86 underwent both procedures for mixed-type impingement. The mean follow-up was 2.3 years (2.0 to 2.9). The mean modified Harris hip score (HHS) improved from 58 to 84 (mean difference = 24 (95% CI 19 to 28)) and the median patient satisfaction was 9 (1 to 10). Ten patients underwent total hip replacement at a mean of 16 months (8 to 26) after arthroscopy.

The predictors of a better outcome were the pre-operative modified HHS (p = 0.018), joint space narrowing ≥ 2 mm (p = 0.005), and repair of labral pathology instead of debridement (p = 0.032).

Hip arthroscopy for femoroacetabular impingement, accompanied by suitable rehabilitation, gives a good short-term outcome and high patient satisfaction.

Femoroacetabular impingement (FAI) was first reported in 1936 by Smith-Petersen as an old slipped capital femoral epiphysis and intra-pelvic protrusion of the acetabulum. It was later described in 1968 as a bump in continuity with the profile of the femoral head creating an eccentric load. In 1971, Murray and Duncan described the athletic adolescent as being at risk of degenerative hip disease and Demarais and Lequesne in 1979, subsequently described hip pain associated with structural abnormalities of the proximal femoral neck in athletes. In 2001, Ganz et al., described an open surgical dislocation technique and this has been used for the treatment of FAI with encouraging early clinical results.

Increased diagnosis of acetabular labral tears and articular cartilage injury, in association with local bony abnormalities have encouraged alternative, less invasive forms of treatment such as arthroscopy. The indications and technique for the arthroscopic treatment of FAI and associated pathologies have been extensively described. The literature outlining factors that might influence the outcome after hip arthroscopy is, however, limited.

The purpose of this study was to report two-year outcomes after hip arthroscopy for the treatment of FAI and associated labral and chondral pathology. We hypothesised that patients undergoing hip arthroscopy for FAI and chondrolabral dysfunction would have significant improvement in their function, and high satisfaction by the two-year follow-up.

Patients and Methods

Between March 2005 and October 2005, 209 consecutive patients underwent hip arthroscopy by a single surgeon (MJP). Of these patients, 122 met the inclusion criteria for the study. Patients were included if they underwent arthroscopic treatment for FAI and chondrolabral dysfunction. Exclusion criteria were patients with bilateral hip arthroscopy, avascular necrosis, and hips which had undergone previous surgery. The study had ethical approval and all patients were prospectively enrolled. Ten patients refused to complete the follow-up questionnaire and were excluded, leaving 112 patients in the study. Their details are shown in Table I. The indications for surgery were disabling pain and a radiographic diagnosis of FAI.
Physical examination. Physical examination specific to the hip with suspected FAI and chondrolabral dysfunction included measurements of range of movement and specific provocative tests. Flexion, adduction and abduction, as well as internal and external rotation, were evaluated by two physiotherapists using a goniometer. The anterior impingement test was performed by placing the hip in 90° of flexion and then applying adduction and internal rotation. This attempts to recreate the impingement position that may engage any labral and bony pathology, thereby eliciting a painful response from the patient. The FABER test (Flexion ABDuction External Rotation) was performed with the patient supine.

Imaging. Cross-table lateral radiographs were used to assess the anterior femoral head-neck offset (α angle). The α angle is the angle between a line through the centre of the shaft of the femur and a line that connects the centre of the femoral head to the point at which the sphericity of the femoral head is lost anteriorly. The acetabulum was evaluated for both the amount of cover of the femoral head and the degree of version on anteroposterior (AP) radiographs. Acetabular depth was evaluated by noting the relationship of the centre of the femoral head to the posterior acetabular wall. If the centre of the femoral head was medial to the posterior acetabular wall, this was indicative of coxa profunda. An additional diagnosis of coxa profunda was made if the medial wall of the acetabulum was seen to cross the ilioischial line. Acetabular version was evaluated by noting the position of the anterior acetabular wall with respect to the posterior acetabular wall. In a retroverted acetabulum, the anterior acetabular wall crossed over the posterior acetabular wall (the ‘cross-over sign’). Classifications of cam and pincer impingement were based on these radiographs. Hips with retroversion or coxa profunda were assessed for cam impingement. An α angle > 50° was considered positive for cam impingement. For mixed impingement, patients had an α angle > 50° and retroversion or coxa profunda.

The joint space was measured at three areas preoperatively on an AP pelvic radiograph using the digital caliper Office PACS system (Stryker, Flower Mound, Texas) at three locations: the lateral edge and middle of the sourcil and above the level of the fovea (Fig. 1).

**Table I** Patient demographics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (yrs)</td>
<td>40.6</td>
<td>37.7 to 43.5</td>
</tr>
<tr>
<td>Mean body mass index (kg/m²)</td>
<td>24</td>
<td>23.2 to 25.0</td>
</tr>
<tr>
<td>Mean time from injury to surgery (mths)</td>
<td>34</td>
<td>26.2 to 42.8</td>
</tr>
<tr>
<td>Men (number)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Women (number)</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Mode of injury (%)</td>
<td></td>
<td></td>
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<tr>
<td>Sudden traumatic onset</td>
<td>24</td>
<td></td>
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<tr>
<td>Sudden with no trauma</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Gradual onset</td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1

Radiograph showing joint space measurements at three locations in the joint: lateral sourcil, middle sourcil and above the level of the fovea.

Surgical technique. The patient is placed in a modified supine position. A combination of general anaesthesia and a lumbar plexus block, with complete muscular paralysis is used. Both legs are positioned in 40° of abduction, 20° of flexion and neutral rotation. Fluoroscopy is used to obtain an AP view of the hip. Gentle traction is applied through the hip, with moderate counter-traction through the contralateral hip until a ‘vacuum sign’ is seen in the joint space. The leg is then adducted to neutral and the foot maximally internally rotated to bring the femoral neck parallel to the floor. Joint distraction is assessed with fluoroscopy and additional traction (usually 25 to 50 lb) is applied to achieve approximately 10 mm of distraction. The operating table is then tilted 10° toward the contralateral side. We use two portals, a lateral paratrochanteric and a mid-anterior portal, approximately 3 cm away from the lateral cutaneous femoral nerve and its branches. Portals are estab-
lished using a guide-wire. For pincer impingement, the long overhang is resected using a 5.5 mm round burr (or arthroscopic osteotome) (Fig. 2). Traction is then released and the peripheral compartment is examined. A dynamic arthroscopic examination confirms the pre-operative diagnosis of a cam lesion. Once the area of cam impingement is seen at the femoral head-neck junction, a 5.5 mm round burr is used to restore the normal anatomical bony architecture of the junction. The depth and width of the resection are determined by the native anatomy (i.e. retinacular vessels) and the amount of surface area of impingement. The resection is carried out between the superior 12 o’clock position and the inferior six o’clock position. Periodic dynamic assessment of the resection is performed and additional bone is removed if necessary.

Other pathologies including those of articular cartilage and of the labrum were also treated. The overall condition of the cartilage was rated by the surgeon as no changes, mild changes (Outerbridge grades 1 to 2 or small grade 4 lesions), moderate changes (Outerbridge grade 3 changes or isolated grade 4 changes) or poor cartilage (Outerbridge grade 3 diffuse changes or grade 4 changes). Depending on the size and severity of the lesion, the decision was made intra-operatively to perform gentle chondroplasty or microfracture. Outerbridge grades 2 and 3 chondral defects were treated with thermal and/or debridement chondroplasty. Outerbridge grade 4 chondral defects were treated with microfracture.

Degenerative labral tears were debrided using thermal and/or shaving techniques. Frayed, flap and small tears with enough viable healthy tissue remaining to provide function were also debrided. Anatomical function was defined as arthroscopic identification of the labrum providing a seal with the femoral head on dynamic examination. All other labral pathology was repaired (Fig. 3) using suture anchors with either circumferential or midsubstance capture. In the case of pincer impingement, it was sometimes necessary to extend the labral tear using an arthroscopic knife. The knife entered precisely at the chondrolabral junction; the labral tear was then carefully extended to allow adequate access for the 5.5 mm motorised burr to decompress the underlying pincer lesion. The labrum was then reattached and repaired using suture anchors to restore an anatomical labral seal and femoroacetabular labral articulation. At completion, the hip was dynamically tested to ensure normal anatomical tracking of the chondrolabral junction on the femoral head (Fig. 4). Figure 5 shows pre- and post-operative radiographs of adequate resection of both cam- and pincer-type FAI.
Post-operative rehabilitation. Our standard post-operative protocol after hip arthroscopy involving osteoplasty and acetabular rim trimming includes restrictions of weight-bearing, rotation and movement. Patients are kept at 20 lb of weight-bearing with eight to 12 hours per day of continuous passive movement (CPM) for four weeks. In the case of microfracture, partial weight-bearing and CPM are continued for six to eight weeks. An anti-rotation bolster to prevent external hip rotation of the hip is used for ten days after surgery.

Physiotherapy is used to first restore passive movements, followed by active movements and then strength.

Particular attention is paid first to restoring internal rotation then external rotation. We also recommend passive hip ‘pendulums’ or circumduction movements to prevent adhesion formation.

Functional outcome analysis. All patients completed a self-administered questionnaire pre-operatively and two years post-operatively. Data collected included the hip outcome score, the non-arthritic hip score, and the modified Harris hip score (HHS). Patient satisfaction with outcome was also collected (1 = unsatisfied, 10 = very satisfied).

Statistical analysis. The one-sample Kolmogorov-Smirnov test was used to test whether variables were normally
RESULTS

Pre-operative measurements for range of movement are shown in Table II. The operative hip had a significantly reduced range of movement in all directions. All patients had a positive impingement sign, either the anterior impingement test or a positive Faber test. The mean α angle was 72° (95% confidence interval (CI) 70.5 to 73.5) (Table III). A retroverted acetabulum was present in 63 hips, and coxa profunda in 19.

At arthroscopy, 23 patients underwent osteoplasty alone for cam impingement, three underwent only rim reduction for pincer impingement, and 86 underwent both for mixed-type impingement. The cartilage had mild changes in 66% (n = 74), moderate in 26% (n = 29) and was poor in 8% (n = 9). We treated 47 patients with microfracture, of whom eight underwent microfracture of the femoral head, 30 of the acetabular surface, and nine of both. For labral pathology, 55 hips had a detached labrum, 28 had a flap tear, 18 a degenerative labrum, two a mid-substance tear, five a bruised labrum, and four a frayed labrum. There were 58 patients who underwent a labral repair and 54 who had labral debridement. Of the repair group, 55 had a detached labrum, two a mid-substance tear, and one a degenerative labrum. Of the debridement group, 20 had a flap tear, 17 a degenerative tear, 12 a frayed labrum and five a bruised labrum. There was no association between the condition of the articular cartilage (mild, moderate or poor) and repair versus debridement (p = 0.053). In the debridement group, five (9%) had poor cartilage and eight (15%) had moderate changes. In the repair group, four (7%) had poor cartilage and 21 (36%) had moderate changes.

In terms of other pathology found at arthroscopy, 94 patients had a partial tear of the ligamentum teres, which was treated by debridement, 37 patients had loose bodies, and 31 had synovitis.

Ten patients underwent total hip replacement (THR) at a mean of 16 months (95% confidence interval (CI) 12.4 to 19.5) after arthroscopy. Patients who required a THR were significantly older at the time of arthroscopy (58 vs 39 years, mean difference = 18, 95% CI 8 to 28, p = 0.001). There was no difference with respect to gender, body mass index or pre-operative α angle. Patients who underwent THR had significantly less joint space on all three weight-bearing surfaces on their pre-operative radiographs (p = 0.001). Those with a joint space of less than 2.0 mm were 39 times (95% CI 5.5 to 263) more likely to progress to a THR. Patients requiring a THR had a significantly lower mean pre-operative modified HHS (47 vs 60, mean difference = 12, 95% CI 1.2 to 23, p = 0.026). Taken overall, cartilage changes were associated with THR (p = 0.001). Of the ten patients who underwent a THR six had poor cartilage and four had moderate changes. Patients with microfracture on both the femoral head and the acetabulum were also more likely to undergo a THR (p = 0.001).

Of the remaining 102 patients, 12 were lost to follow-up and two-year outcomes were thus obtained for 90 patients.

Table II. Mean pre-operative range of hip movements (*)

<table>
<thead>
<tr>
<th></th>
<th>Operative hip</th>
<th>Non-operative hip</th>
<th>Mean difference</th>
<th>95% confidence interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>116</td>
<td>126</td>
<td>-10</td>
<td>-13 to -7</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Internal rotation</td>
<td>33</td>
<td>38</td>
<td>-5</td>
<td>-7 to -3</td>
<td>&lt; 0.001</td>
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<tr>
<td>External rotation</td>
<td>43</td>
<td>46</td>
<td>-3</td>
<td>-1 to -3</td>
<td>0.001</td>
</tr>
<tr>
<td>Adduction</td>
<td>20</td>
<td>25</td>
<td>-4</td>
<td>-7 to -3</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Abduction</td>
<td>43</td>
<td>48</td>
<td>-5</td>
<td>6 to -3</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

* paired t-test

Table III. Measurements of the pre-operative joint space

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral joint space</td>
<td>3.4</td>
<td>3.1 to 3.7</td>
</tr>
<tr>
<td>Medial joint space</td>
<td>3.1</td>
<td>2.9 to 3.3</td>
</tr>
<tr>
<td>Foveal joint space</td>
<td>3.2</td>
<td>3.0 to 3.4</td>
</tr>
<tr>
<td>α angle (pre-arthroscopy)</td>
<td>72</td>
<td>70.5 to 73.5</td>
</tr>
<tr>
<td>α angle (post-arthroscopy)</td>
<td>46</td>
<td>44.6 to 47.4</td>
</tr>
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</table>
Mean follow-up was 2.3 years (2.0 to 2.9). The modified HHS improved from 58 to 84.3 (mean difference = 24, 95% CI 19 to 28) (Table IV). The median patient satisfaction with outcome was 9 (1 to 10). Of the 90 patients, 24 (27%) were retired or at school and all of the remaining patients (n = 66) returned to work. There were ten (15%) who returned to work within one week, 35 (53%) within one to five weeks, 12 (18%) within six to eight weeks, and nine (14%) who returned in two to six months. CPM was used at night although compliance with this was not recorded. There were eight patients who did not show any improvement in their modified HHS, with a mean pre-operative score of 66 and a mean post-operative score of 50. They had chosen not to undergo further surgery.

Factors associated with outcomes. The post-operative modified HHS correlated with the pre-operative α angle \( (r = 0.297, p = 0.008) \) and joint space measurements at the lateral \( (r = 0.402, p = 0.001) \) and middle sourcil joint spaces \( (r = 0.294, p = 0.011) \). Patients with any joint space < 2 mm had a mean post-operative modified HHS of 68, whereas patients with \( \geq 2 \) mm joint space had a mean of 87 (mean difference = 19, 95% CI 70 to 31, \( p = 0.002 \)). There was no difference in their pre-operative scores.

The time from onset of symptoms to surgery correlated with the post-operative modified HHS \( (r = 0.255, p = 0.022) \). There was no difference in modified HHS between patients who reported a sudden traumatic onset of pain \( (n = 18, \text{mean modified HHS} = 86) \), sudden with no trauma \( (n = 21, \text{mean modified HHS} = 81) \) or gradual onset \( (n = 51, \text{mean modified HHS} = 83) \). Patients with poor overall cartilage had a significantly lower post-operative modified HHS \( (n = 6, \text{mean modified HHS} = 62) \) compared to moderate \( (n = 10, \text{mean modified HHS} = 79) \) or mild changes \( (n = 74, \text{mean modified HHS} = 87, p = 0.011) \). The post-operative modified HHS was no different between those patients treated with microfracture \( (n = 25, \text{mean modified HHS} = 81) \) or no microfracture \( (n = 65, \text{mean modified HHS} = 86, p = 0.215) \). Patients with labral repair had a higher modified HHS than those who underwent a labral debridement but this was not significant \( (n = 46, \text{mean modified HHS} = 87 \text{ vs } n = 44, \text{mean modified HHS} = 81, p = 0.10) \).

Multivariable analysis showed three independent predictors of the post-operative modified HHS. The predictors of a higher post-operative modified HHS were the pre-operative score, joint space narrowing \( \geq 2 \) mm, and labral repair rather than debridement (Table V). Other factors included in the model that were not significant were age, months from onset of symptoms to surgery, α angle, overall cartilage condition and microfracture.

All patients with a cross-over sign or coxa profunda on the pre-operative AP pelvic radiographs had resolution of retroversion and adequate resection of the pincer lesion seen on their post-operative radiographs. The mean post-operative α angle decreased from 72° to 46° (mean difference = 25, 95% CI 22.7 to 28.2, \( p = 0.001 \)).

Complications. No patient had an infection, pulmonary embolism, deep-vein thrombosis, or fracture. No patient reported paraesthesiae.

Discussion

Hip arthroscopy for FAI accompanied by the prescribed rehabilitation allowed a return to excellent function and high satisfaction. The results support our hypothesis. Factors associated with a good outcome and increased satisfaction included a pre-operative joint space \( \geq 2 \) mm, and repair for treatment of labral pathology.

It has been suggested that FAI is a cause of labral and cartilage damage. The labrum and adjacent acetabular articular cartilage is damaged by both cam- and pincer-type FAI and this impingement is believed to be the genesis of idiopathic osteoarthritis. Ganz et al have recently reported on the association of osteoarthritis secondary only to primary FAI. Their study recommends intervention...
before major articular cartilage damage occurs in cases where the normal bony anatomy can be restored, thereby potentially slowing the progression of osteoarthritis. The association between the α angle and chondrolabral dysfunction has also been reported. Cam-type FAI as measured by an increased α angle correlates with articular cartilage injury, labral pathology, and reduced movement.

Several studies have described the open treatment of FAI. Murphy et al. described treatment with debridement: seven of their 22 patients required conversion to THR, and the remaining 15 were doing well at two to 12 years. Beck et al. reported on the open surgical dislocation of 19 hips with FAI, with a mean follow-up of 4.7 years; five deteriorated and 13 improved. Peters and Erickson reported on the use of the trochanteric flip osteotomy and dislocation in 30 hips. There was an improvement in the mean HHS from 70 to 88 at 32 months of follow-up, and conversion of four hips to THR. The patients’ mean pre-operative modified HHS was much higher than those in our study (70 vs 58). However, the mean post-operative modified HHS was similar (88 vs 84), indicating greater improvement in our cohort. The rate of progression to THR was much higher than in the Peters and Erickson study (4 of 30, 13.3%) than in our study (10 of 114, 8.7%).

There are few reports on the outcome after arthroscopic treatment of FAI. Philippon et al. reported on the return to sport in 45 professional athletes who underwent arthroscopic treatment for FAI and associated pathologies; 93% returned to the professional level, 78% remaining active at this level at a mean of 1.6 years follow-up. The limitation of this study was the lack of outcome measures used to report on this cohort. Our current study used four outcome measures and patient satisfaction to report the outcome after hip arthroscopy at a mean of two years of follow-up. Another study recently reported on the six-month outcome after arthroscopic treatment of FAI for 22 patients with a mean age of 42 years. The non-arthritic hip score improved and there were no complications. However, the change in α angle did not correlate with outcome.

In our study we excluded patients who had undergone previous hip surgery. Patients undergoing revision hip arthroscopy have already been treated with some type of surgical procedure. The outcome of the arthroscopy may be because of the earlier surgical procedure, or the technique. Thus, we only reported the outcome after primary arthroscopy. Further studies are needed to determine the predictors of outcome after revision hip arthroscopy for FAI. We also excluded patients who had undergone bilateral hip surgery. Previous work by Charnley described three types of hip patients. Charnley A includes patients with only one hip involved and for whom no other condition interferes with walking. Charnley B denotes a patient with both hips involved but for whom no other condition interferes with walking. Charnley C denotes a patient with other factors contributing to poor mobility, such as polyarthritis, senility, hemiplegia, and cardiovascular or respiratory disability. We chose to include only Charnley ‘A’ patients in this study, again to provide a clear picture of outcomes.

One predictor of outcome was the repair of labral pathology. We recommend labral repair rather than debridement, based on earlier work and previously reported outcomes in the literature. In a systematic review of the literature, Robertson, Kadmas, and Kelly found that patients with labral tears and no arthritis, who were treated with labral debridement, had a satisfaction rate of 67% at 3.5 years. Espinosa et al. reported on labral refixation versus labral excision in 149 hips undergoing open surgical dislocation. At two years post-operatively, labral refixation was superior both clinically and radiographically. Anatomical studies have shown a small group of blood vessels in the circumferential synovial layer surrounding the labrum, but that the labrum is predominantly vascularised by the capsule of the hip. In Espinosa el al’s study, a bleeding cancellous bed was necessary for labral refixation because of the relatively avascular nature of the labrum. This has also been shown in animal studies.

Joint space was also a predictor of outcome, confirming previous findings by Jacobsen et al., who reported that joint space < 2 mm in both men and women correlated significantly with pain in the hip joint caused by degenerative changes. In our study, those with a joint space < 2 mm were 39 times more likely to progress to a THR.

One limitation to our study was the determination of the appropriate outcome score. Although many scores have been thoroughly studied, there have been few reports of outcome scores after hip arthroscopy for FAI. We used four different scores in order to provide comparison with other studies. As it is widely used, we used the modified HHS to determine predictors of outcomes. It is unclear which score has the best validity and responsiveness in this population. Another limitation to our study is the referral nature of our population. The majority of the patients were seen by other practitioners and referred to the senior author (MJP) for surgery. This limited our ability to perform objective post-operative follow-up examinations. Although we present a minimum of two years’ follow-up, it is unclear how this procedure will affect the long-term outcome of the hip joint.

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References

OUTCOMES FOLLOWING HIP ARTHROSCOPY FOR FEMOROACETABULAR IMPINGEMENT WITH ASSOCIATED CHONDROLABRAL DYSFUNCTION


