Current management of femoro-acetabular impingement

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KEYWORDS
Femoro-acetabular impingement; Hip impingement; Cam impingement; Pincer impingement; Acetabular retroversion; Labral tear; Hip debridement

Summary
Femoro-acetabular impingement (FAI) is a common cause of hip pain in young adults. The condition can result in labral tears, articular cartilage lesions and eventual osteoarthritis of the hip. FAI results from an abnormal bony shape of the femoral head / neck or the acetabular rim or both, which causes contact (impingement) between the neck and acetabular rim during movement of the hip joint. Two different mechanisms are described, although a combination of the two mechanisms is frequent. Cam impingement is caused by an abnormality of the femoral head and neck; principally a reduction in offset between the head and the neck. Pincer impingement is caused by an abnormality on the acetabular side, with either excessive retroversion of the acetabulum or an unduly prominent anterior wall. Either problem is associated with the development of chondral lesions (especially in the acetabulum) and labral pathology.

Patients with FAI usually present with deep groin pain exacerbated by hip flexion. X-rays typically show an anterior impingement bump on the anterior femoral neck on a horizontal beam lateral, abnormalities of head/neck offset or an excessively prominent anterior acetabular wall. Surgery is the treatment of choice and this involves open or arthroscopic bony resection to improve femoral head-neck clearance with either resection or refixation of the damaged labrum. Both the femoral head/neck junction and the acetabular rim may require bony resection. Such surgery yields good symptomatic relief, but whether surgery prevents the development of osteoarthritis in the hip in the long term is currently unknown.

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Introduction
Hip pain in young adults can present a diagnostic challenge. Some patients will have a clear history of recognised predisposing factors. Such factors include the various classic forms of developmental dysplasia of the hip, causes of avascular necrosis or a history of trauma. However, some shape abnormalities of the hip have been recognised for many years as being associated with hip pain (eg the “bullet shaped” femoral head and minor slip deformities on X ray). Up until recently there was no systematic understanding of the importance of these appearances, and no understanding of how they might be treated. Recently, principally due to the work of Ganz and his group, our
understanding of shape abnormalities has improved substantially. The condition of impingement at the hip margin (femoro-acetabular impingement) has been described and characterised. Femoro-acetabular impingement (FAI) Table 1 is now recognised as one of the common causes of hip pain in young adults (Table 1), many of whom do not have the classical features of hip dysplasia. It is now possible to identify and treat many patients with this condition (Table 2).

We will begin by reviewing the case history of a typical patient, who was initially referred to physiotherapy triage and then on to the orthopaedic clinic after he failed to make adequate progress with conservative treatment.

A 40-year-old fireman was referred by the physiotherapist with a long history of left groin pain. He also had pain in the left sacroiliac joint and the greater trochanteric area. It was felt initially that his problems were related to mechanical back pain. Although back rehabilitation improved the symptoms at all sites, he still had significant groin pain. The pain would start after a period of strenuous cycling. It was felt that his problems were related to mechanical back pain. Although back rehabilitation improved the symptoms at all sites, he still had significant groin pain. The pain would start after a period of strenuous cycling. It was particularly present on prolonged sitting and when he was pushing with his left leg. He reported occasional giving way of the hip. The hip had a full range of movement but there was a positive impingement test on deep flexion and adduction. This test also reproduced the pain about which he complained, in both site and character. He also complained of clicking of the involved hip but had a negative psoas snap test. His x-rays showed a positive cross-over sign in the left hip. The hip had a full range of movement but there was a positive impingement test on deep flexion and adduction. This test also reproduced the pain about which he complained, in both site and character. He also complained of clicking of the involved hip but had a negative psoas snap test. His x-rays showed a positive cross-over sign in the left hip and a fleck of labral ossification on the AP view, with a small impingement bump on a cross table lateral view. A diagnosis of FAI was made.

### Table 1 Causes of femoro-acetabular impingement

<table>
<thead>
<tr>
<th>Cam impingement:</th>
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<tr>
<td>Idiopathic</td>
<td>Developmental</td>
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<tr>
<td>• Non-spherical femoral head</td>
<td>• Coxa vara</td>
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<tr>
<td>• Traumatic</td>
<td>• Malunited femoral neck fracture</td>
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<tr>
<td>• Post-traumatic retro-torsion of femoral head</td>
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<td>Childhood disease:</td>
<td>• Perthes’ disease</td>
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<td>• Slipped capital femoral epiphysis</td>
<td>• Femoral osteotomy</td>
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<tr>
<td>Idiopathic</td>
<td>Latrogenic</td>
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<tr>
<td>• Post-traumatic deformity</td>
<td>• Over-correction for retroversion in dysplastic hips</td>
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<table>
<thead>
<tr>
<th>Pincer impingement:</th>
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<tbody>
<tr>
<td>Idiopathic</td>
<td>Developmental</td>
</tr>
<tr>
<td>• Retroverted acetabulum</td>
<td>• Coxa profunda</td>
</tr>
<tr>
<td>• Coxa vara</td>
<td>• Os acetabuli</td>
</tr>
<tr>
<td>• Protrusio acetabuli</td>
<td>• Chronic residual dysplasia of acetabulum</td>
</tr>
<tr>
<td>• Traumatic</td>
<td>• Post-traumatic deformity</td>
</tr>
<tr>
<td>• Latrogenic</td>
<td>• Over-correction for retroversion in dysplastic hips</td>
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This case history illustrates some of the issues around diagnosing this disorder. The patient initially presented with symptoms in a fairly widespread area, including the sacroiliac joint, and had some mechanical symptoms. His pain was worse with sports. He had features of FAI on X-ray, and his symptoms have been significantly improved by surgery.

### Historical perspective

When assessing a series of patients after periacetabular osteotomy for hip dysplasia, Reinhold Ganz’s group from Berne observed a sub-group of patients who returned with symptoms of anterior FAI and progressive pain after what appeared to be a successful acetabular re-orientation procedure. Subsequently, this group was the first to describe “femoro-acetabular impingement” as a dynamic pathology where mechanical abutment between the proximal femur and the acetabular rim during terminal range of hip movement resulted in labral and chondral damage. Other researchers had long suspected that pathologic alterations of bony morphology might have been a contributing factor behind “idiopathic” primary hip osteoarthritis. Stulberg et al was one of the first to recognise that an abnormal morphology of the proximal femur predisposed to degenerative joint disease. His team introduced the term “pistol grip deformity” to describe abnormal femoral head-neck clearance in patients with primary hip osteoarthritis. Harris also subsequently demonstrated the presence of subclinical childhood disease and abnormal bony morphology in 90% of patients with idiopathic primary osteoarthritis of the hip. There is now growing evidence that abnormal hip morphology precedes hip osteoarthritis.

Ganz and his group have developed methods for treating FAI, principally using open surgical dislocation to expose the hip. This followed detailed work to examine the femoral head blood supply, permitting dislocation with minimal risk of subsequent avascular necrosis. This open approach has yielded successful results with good pain relief and improvement of function, and was extremely helpful in confirming and understanding the pathology of FAI. However, open debridement is a substantial surgical undertaking and other surgeons are now exploring both arthroscopically assisted and arthroscopic hip debride ment. These latter approaches are less invasive but all
three techniques still require detailed assessment of outcomes and complications.

The anatomy of the hip

In broad outline, the hip may be described as consisting of:

- the femoral head, which forms slightly more than half of a sphere,
- the cylindrical femoral neck which attaches the head to the femoral shaft, and
- the cup shaped acetabulum.

However, this does not accurately describe the hip in detail. The femoral head is actually a conchoid shape. The neck is of variable shape but usually narrowest at the mid-part and widest laterally. The ratio between the width of the neck and the diameter of the head varies considerably. Furthermore, the head may be placed centrally on the neck (so the centre of the femoral head lies on the geometrical axis of the femoral neck in both AP and lateral planes), or it may be displaced (typically so the centre of the head lies inferior and particularly posterior to the neck axis). The upper margin of the neck is usually slightly concave. The head-neck clearance (both anteriorly and superiorly) allows free motion of the hip without impingement. The femoral head normally appears as a section of a circle in both AP and lateral views and the head-neck offset is normally more than 9 mm. Articular surfaces are not completely congruent. Articulating surfaces are covered by articular cartilage, which is thickest antero-superiorly in the acetabulum and antero-laterally on the femoral head.

The fibrocartilaginous acetabular labrum is triangular in cross-section. The base is attached to the acetabular rim and the free apex overlies the femoral head. The central arm of the labrum is covered by articular cartilage, which is continuous with the cartilage covering the lunate surface. The function of the acetabular labrum is controversial; it appears to act as a shock absorber and also as a fluid seal for the hip joint to improve lubrication. It also has nociceptive and proprioceptive functions. The fluid seal prevents fluid flow in and out of the joint and enhances joint stability. Disruption of the fluid seal may make the joint relatively unstable. The acetabulum has been recognised to vary in orientation for many years, and developmental hip dysplasia has been described in detail. Recently, several factors predisposing to FAI have been described in the acetabulum, X-rays of which would typically be dismissed as normal. These include acetabular retroversion, coxa profunda and minor degrees of protrusio acetabuli.

Impingement: a dynamic problem

Both the hip and the shoulder joints are ball and socket joints with three degrees of freedom. The shoulder enjoys greater mobility than the hip but has a higher risk of dislocation. The hip joint has to support the body’s weight and also propel the limb forward. There is accordingly greater bony constraint in the hip joint, and the acetabulum is much deeper than the glenoid cavity. However, this anatomical arrangement risks significant coaptation between the articulating bony parts at the extremes of movement. Essentially, all hips may experience femoro-acetabular impingement at the extremes of movement. It is more likely to be a problem if the anatomy of the hip leads to frequent impingement during activity. This depends both on the patient’s level of activity, including range of hip movement, and their hip anatomy.

In order to understand the mechanism of FAI it is important to consider the geometry of the hip joint. The acetabular axis forms an angle of 35° to 40° with the horizontal axis. The upper part of the acetabulum therefore overhangs the femoral head laterally on erect posture. The acetabulum is anteverted 15° to 25° in normal individuals, when measured on CT scan at the mid-part of the femoral head. Both the anterior and posterior margins of the acetabulum overlie the femoral head.

A maintained space between the femoral head-neck junction and the acetabular rim is essential for an unhindered range of hip motion. This requires that there is an offset between the anterior and superior surfaces of the femoral neck and the corresponding area of the femoral head. It is worth emphasising that this femoral neck offset does not describe the head/shaft offset, which is used to describe hip replacement prostheses. A deviation from normal femoro-acetabular spatial relationships may not affect the mid-range of motion but in the terminal range of motion the joint will be vulnerable to mechanical blockage (Fig. 1). In “pistol grip deformity” the normal concavity of the femoral head-neck junction is lost. The femoral head extends laterally in a convex shape. Femoral neck offset is reduced in the antero-lateral head-neck junction. These patients also have reduced femoral anteverision. Loss of sphericity or offset will result in mechanical blockage between the femoral head and the acetabular rim in terminal range of motion.

Alternatively, excessive acetabular coverage or retroversion of the cup will also affect normal spatial relationships between the femoral head and acetabulum. Retroversion of the acetabulum results in anteo-lateral over-coverage; the acetabular edge will restrict flexion of the femoral neck (Fig. 2). Coxa profunda will increase the relative depth of the acetabulum and predispose to mechanical blockade (coxa profunda is present when the floor of the acetabular fossa touches or overlaps the ilioischial line, cf. protrusio acetabuli, where the femoral head line crosses the ilio-ischial line). Ito et al found that the site of acetabular abnormality was mainly in the supero-medial region of the acetabular rim. Finally, patients with normal hip morphology but excessive range of hip movement could also be susceptible to FAI in terminal range of hip movement due to mechanical abutment. Such patients include those with excessive laxity or those engaging in activities such as dance.

Natural history of FAI

Two distinct mechanisms of femoro-acetabular impingement have been described, although both are present in most patients. The details of the pathological changes
caused in the hip may be distinct in the two types of impingement, but because of the frequent coexistence of the two types it is somewhat difficult to be certain about this. Cam impingement is caused by abnormalities on the femoral side (Fig. 3). Initially, the abnormality may arise due to a minor slip of the capital femoral epiphysis (although the evidence for this is weak—it is simply that the imaging appearances are strikingly similar to those following a slip), or an abnormal fusion of the head and trochanteric epiphyses at the antero-superior border of the neck. Due to absence or loss of the normal femoral head-neck offset, the femoral neck abuts the acetabular rim in hip flexion and internal rotation. Repeated impingement over a period of years leads to reactive new bone formation ("impingement bump") on the anterior and superior femoral neck, which in turn further reduces the offset and exacerbates the impingement (Fig. 4). This abutment may cause damage to the labrum, including labral tears or detachment. There is evidence that synovial fluid is pumped during this process, with paralabral cysts sometimes occurring (readily visible on MR arthrogram). At the same time, a delaminating chondral lesion may occur adjacent to the antero-superior labrum, where an area of articular cartilage becomes detached from both the acetabular and the underlying bone. The delaminating lesion of the articular cartilage leads to a posteriorly based chondral flap. It is thought that this articular cartilage lesion occurs principally due to shear from the area of the impingement

Figure 1  Top two images show the normal bony configuration of the hip joint, with sufficient joint clearance. The centre two images show pincer impingement due to excessive acetabular over-coverage. The bottom two images show cam impingement, with an aspherical portion of the femoral head–neck junction getting jammed into the acetabulum. © American Journal of Radiology, reproduced with kind permission.

Figure 2  AP X-ray of the pelvis showing acetabular retroversion with a positive cross-over sign. AW denotes the anterior wall and PW denotes the posterior wall.

Figure 3  Aspherical femoral head in cam impingement. Arrows denote the abnormal extension of the epiphyseal scar. © American Journal of Radiology, reproduced with kind permission.
bump, which is out of round. Labral pathology is thought to be less common in pure cam impingement than in pure pincer impingement, and the delamination lesion may occur with a normal labrum.

Pincer impingement occurs because the arc of available motion in the acetabular opening is too small, or because it is oriented in an unsatisfactory fashion (Fig. 1). The available arc will be reduced in coxa profunda and in protrusio. Conversely, the situation with relative retroversion of the acetabulum is that the available arc of motion is biased towards extension and flexion, which cause impingement. Persistent abutment between the femoral head-neck junction and the acetabular rim or the labrum in pincer impingement results in labral damage, intra-substance ganglion formation and labral degeneration, and may cause subsequent labral ossification on the anterior or lateral aspect of the joint (Fig. 5). Labral ossification will increase over-coverage of the cup and contribute to worsen the impingement (Fig. 6). Unrelieved impingement will eventually lever the femoral head posteriorly, resulting in a contre-coup cartilage lesion over the postero-medial aspect of the femoral head and the postero-inferior aspect of the acetabulum. Although circumferential, the initial articular cartilage lesion in pincer impingement is limited, as the mechanical contact between the femoral neck and the acetabulum is linear. Cartilage loss is also more superficial (mean cartilage loss 4 mm, compared to a mean loss of 11 mm in cam impingement). 

Regardless of the type of impingement the initial zone of impingement is the antero-superior quadrant of the acetabulum. Initial impingement is anterior but with chronicity posterior impingement also develops and is heralded by the presence of postero-inferior traction osteophytes. Isolated cam type impingement is more destructive although less symptomatic. This is possibly because of more severe damage to the labrum in pincer type impingement, and the labrum has nociceptive fibres. Cam FAI produces antero-superior OA while pincer FAI produces postero-inferior or central OA.

Who is at risk and when?

The true incidence of FAI is not known. A recent Scandinavian study found a 6% incidence of cam malformation in men and 2% in women on radiological assessment of standardised AP hip radiographs of patients randomly selected from the Copenhagen Osteoarthritis study. Cam type impingement is said to be more common in young active males (M:F 14:1, age range 21–51, mean 32) and pincer type impingement commoner in middle-aged active females (M:F 1:3, age range 40–57, mean 40). However, most patients actually have a mixed type of impingement. Beck et al reported less than 30% incidence of isolated type of impingement in their large series. Stulberg et al reported a 10% incidence of pistol grip deformity in their historical series of patients with frank hip arthritis. The incidence of acetabular retroversion, a recognised cause of pincer type impingement, in published series varies from 5% to 20%.

Clinical presentation of FAI

A young or middle aged patient typically presents with deep groin pain, frequently exacerbated by athletic activities that demand deep hip flexion, or by prolonged walking, sitting or driving. These symptoms overlap with those of labral tears where patients usually present with an insidious onset of deep groin pain, which is aggravated by walking, pivoting on the affected side, impact activities or prolonged sitting. Mechanical symptoms from the hip such as painful locking or giving way are common presenting feature if a labral tear is present. It is now recognised that many patients previously diagnosed to have an isolated labral tear may actually have had unrecognised FAI.
Pincer impingement

Under these circumstances the labral lesion was simply part of a more extensive problem, and resection of the labral lesion alone frequently led to disappointing results. Gait will not be affected but range of motion of the hip may be restricted, especially flexion, internal rotation and adduction.10

The impingement test is usually positive. The hip impingement test is analogous to the shoulder impingement test where the articulating surfaces are forcefully jammed against each other to reproduce the abnormal contact and resulting pain. Anterior impingement is much more common than posterior impingement, but both should be sought. With the patient supine, the hip and knee of the affected side are passively flexed to 90° and the hip then further flexed, adducted and internally rotated. The combination of deep flexion, adduction and internal rotation jams the edge of the femoral head/neck junction against the acetabular rim. The test is positive if

1. it elicits pain, and
2. this pain is similar to that complained of by the patient.

A positive provocation test indicates irritation of the nociceptors of the damaged acetabular rim.

Posterior impingement usually occurs late in impingement, with development of a postero-inferior osteophyte on the acetabular rim. To demonstrate postero-inferior impingement, the examiner hyperextends the lower limb of the affected side passively by hanging the leg over the end of the couch, while maintaining the opposite limb in a neutral position. The test is positive if passive external rotation of the extended leg produces pain.

Investigation of FAI

Radiographs may be normal or changes may be subtle. Both AP and lateral radiographs of the hip are essential. The AP film must be standardised and must avoid malrotation or pelvic tilt to be of value. It should be realised that pelvic flexion (tilt) will automatically increase the prominence of the anterior acetabular wall and result in a positive cross-over sign. The criteria for an acceptable X-ray have been defined.28 Neither the AP nor lateral views adequately visualise the shape of the antero-superior femoral neck, and some groups now use CT scans in a plane radial to the femoral neck to assess prominence in this area. Of the two plain film views, the lateral view is more valuable and may show milder deformities not apparent on the AP view, and may show the presence of an impingement bump (Fig. 7). The three lateral views found useful by different investigators include: the Dunn view in 45° or 90° hip flexion-neutral rotation–20° abduction, cross-table lateral view with 15° internal rotation of femur, and frog lateral view.14–16

The radiographic features of impingement Table 3 include: a short femoral neck, a non-spherical but congruent femoral head, a hump deformity of the femoral head/neck junction, reduced femoral head-neck offset, labral ossification, a positive cross-over sign of a retroverted acetabulum, and herniation pits on the antero-superior aspect of the femoral head. Herniation pits are thought to be cystic lesions on the femoral neck due to intraosseous ganglia. The cross-over sign is demonstrated by examining the line of the anterior and posterior acetabular rims (Fig. 2). This is readily seen, and in a normal hip the anterior rim is medial to the posterior rim at all points.

Various radiological indices have been proposed to measure the likelihood and severity of impingement. For cam impingement these include the alpha angle, head-neck offset and the triangular index (Fig. 8, Table 4).28,30,32 Although hump malformations have been measured by the alpha angle on coronal MR slices, others have claimed that the majority of hump malformations can be adequately assessed on AP pelvis radiographs alone, using a modified α angle.30 The alpha angle is defined as the angle formed by two lines drawn between the femoral neck axis and a line connecting the centre of femoral head with the point of commencement of femoral head asphericity.32 The average alpha angle is 65° to 74° for patients compared to 42° to 47°
in controls (Fig. 9).\textsuperscript{14,32} Measurement of the alpha angle has good inter-and intra-observer reliability and is useful in detecting femoral head asphericity.\textsuperscript{14} The head-neck offset can be measured on plain films or CT. This examines the distance between the anterior femoral head and the anterior cortex of the femoral neck.\textsuperscript{27} Normal anterior offset is 11.6 ± 0.7 mm. Patients with cam malformation have reduced anterior offset of 7.2 ± 0.7 mm.\textsuperscript{27}

It is not always necessary to obtain MRI investigation of patients with impingement, but MRI is useful in attempting to differentiate between a simple labral tear and one due to impingement. The triad of abnormal findings demonstrated in MR arthrography include abnormal head-neck morphology, antero-superior cartilage abnormality, and antero-superior labral abnormality.\textsuperscript{17} Contrast enhanced MR arthrograms are useful to detect labral tears, impingement cysts, and periarticular lesions. It is not always helpful in assessing the shape of the femoral head-neck junction, as typically the slice thickness may be too great to examine this properly. It will also show any alteration of labral substance and confirm the state of the articular cartilage,\textsuperscript{18} but may not show labral detachment or undetached chondral separation.\textsuperscript{9} 3-dimensional CT scanning has recently been found useful in assessing femoral offset and may have advantage over MR arthrography as it is non-invasive and gives better resolution and smaller slice thickness.\textsuperscript{19}

It is often necessary to confirm that the pain arises from within the hip joint and not from some other site. Possible alternative sources include psoas pain, sportsman’s hernia (”Gilmour’s groin”), or the lumbar spine. If the diagnosis is in doubt, diagnostic local anaesthetic blocks are invaluable. Injection of local anaesthetic into the hip should be done under X-ray control with an arthrogram to confirm that the needle is placed correctly. Patients should be warned that the procedure is purely diagnostic and any improvement in symptoms will only last for 12–24 hours.

### Treatment options

There is little role for non-operative treatment.\textsuperscript{20} It is sensible to advise activity modification to avoid the extremes of range of motion. A trial of non-steroidal anti-inflammatory (NSAID) medication may give temporary relief of pain. Physiotherapy to improve passive range of motion

### Table 3  Radiological features of FAI

<table>
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<th>Femoral features:</th>
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<tr>
<td>• short femoral neck</td>
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<td>• non-spherical but congruent femoral head</td>
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<tr>
<td>• hump deformity of femoral head</td>
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<tr>
<td>• reduced femoral head-neck offset</td>
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<tr>
<td>• herniation pits on antero-superior aspect of femoral head.</td>
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<th>Acetabular features:</th>
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<tr>
<td>• labral ossification</td>
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<td>• positive cross-over sign of retroverted acetabulum</td>
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<tr>
<td>• os acetabuli</td>
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<tr>
<td>• coxa profunda</td>
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Figure 7  Femoral asphericity, most apparent on the lateral view.

Figure 8  Alpha angle and normal head-neck offset in the lateral view. © American Journal of Radiology, reproduced with kind permission.
or stretching is not helpful. If the symptoms continue then the patient may be a candidate for surgery. During preoperative counselling, it should be emphasised that the surgery has been shown to improve symptoms, but thus far has not been shown to either delay or prevent the development of osteoarthritis.

The aim of operative treatment is to improve femoro-acetabular clearance and prevent recurrence of mechanical blockage at the limits of the desired range of hip motion. Both arthroscopic and open debridement of the joint has been attempted. A major advantage of the open approach is that it gives an unrestricted view of the hip joint. The surgical approach for open debridement as described by Ganz et al is also known as the trochanteric flip approach. This approach allows surgical dislocation of the joint and affords a 360° view of the acetabulum and the femoral head. The vascular supply to the head of the femur is at risk during hip dislocation, but detailed examination of the blood supply has demonstrated that the relevant vessels pursue a predictable course. Ganz’s group has shown that the predominant blood supply to the femoral head is via the deep branch of the medial circumflex femoral artery. One or two vessels pass obliquely along the posterior surface of the neck as the retinacular vessels, and eventually enter the femoral head at the upper surface of the head/neck junction, just posterior to the midline. They describe a technique to avoid damage to the medial circumflex femoral branch by keeping the short external rotators intact, performing an osteotomy which leaves the overhanging posterior tip of the trochanter in place with approximately 1 centimetre of the gluteus medius still attached. This splits the piriformis tendon. A Z-shaped capsulotomy is made antero-laterally along the femoral neck axis. The cut must remain anterior to the lesser trochanter to avoid damage to the medial circumflex femoral artery. The authors did not report any cases of avascular necrosis in their series from this approach. During the osteochondroplasty on the femoral neck, care must be taken to avoid straying too far posterior on the upper surface of the head/neck junction and risking damage to the retinacular vessels. There is a reported risk of avascular necrosis of less than 1:1000 with this approach. At the end of the procedure, the Z-capsulotomy is repaired with one or two sutures, and the greater trochanter reattached using two or three 4.5 mm lag screws.

Alternatively, a Smith-Petersen or Huetter anterior approach can also be used. It is important to undertake careful soft tissue dissection after skin incision to avoid injury to the lateral cutaneous nerve of the thigh if this approach is used. With this approach, excellent visualisation of the anterior and superior part of the head/neck junction is obtained, together with the anterior rim of the acetabulum. It is not necessary to dislocate the hip, as a good view of intra-articular structures can be obtained if the procedure is performed on a traction table with traction applied at the appropriate point to permit insertion of an arthroscope. Adequate visualisation of the acetabulum is important because of the prevalence of cartilage delamination lesions.

Hip arthroscopy is minimally invasive but because of limited space may not provide adequate visualisation. There is also a steep learning curve associated with hip arthroscopy. Hip joint distraction involves considerable force and leaves a few patients with persistent postoperative groin pain. The procedure can be performed with the patient in either the supine or lateral position, but increasingly it is performed supine. Image intensifier guidance is required. A 70° scope is the standard instrument for hip arthroscopy, and use of cannulated introducers and switching sticks is essential. Hip arthroscopists describe the hip joint as being divided into central and peripheral compartments. The central compartment includes the labrum, ligamentum teres, articular surfaces and medial structures. This compartment is viewed using hip joint distraction. The peripheral compartment is viewed without distraction, and includes all intra-capsular structures lateral to the labrum. Arthroscopy is useful to deal with labral tears and chondral damage. Achieving adequate space to provide visualisation at the front of the hip requires resection of a section of the anterior capsule and synovium with a shaver or radio-frequency probe; this may be time consuming. Reattachment of labral tears to bone is difficult (but possible) by arthroscopic means, requiring the use of suture anchors and being similar in principle to an arthroscopic Bankart repair. Resection of the acetabular rim may be performed arthroscopically. A combined arthroscopic followed by open approach is now preferred.

### Table 4 Measurements from the lateral shoot-through X-rays

**How to measure the alpha angle:**

A line is drawn along the axis of the femoral neck. Another line is drawn from the centre of the femoral head to the point of commencement of asphericity of the femoral head, superiorly. This point is identified by drawing a circle over the femoral head and taking the point where the anterior femoral head protrudes anterior to the circle. The alpha angle is the angle between these two lines.

**How to calculate femoral head-neck offset:**

Line 1 is drawn along the axis of the femoral neck. Line 2 is drawn parallel to line 1, but abuts the anterior margin of the femoral head. Line 3 is drawn parallel to lines 1 and 2, but transects the point of commencement of asphericity (as for measurement of the alpha angle). The femoral head-neck offset is the tangential distance between lines 2 and 3.
by some surgeons. Initial arthroscopy allows an assessment of the severity of any pathology that then dictates the extent of exposure. A focal cam impingement lesion may be suitable for limited open debridement without joint dislocation. Whichever approach to the problem is used, there are several goals during the operation. First, the surgeon aims to re-create the normal concave anatomy of the femoral head/neck junction by sequentially removing bone from the femoral neck. Second, labral and chondral damage must be identified and treated. Third, excessive anterior projection of the anterior acetabular rim should be corrected (so called “rim trim”). Finally, the surgeon should check that impingement has been adequately corrected.

The anterior impingement osteophyte is probably the most obvious radiological sign of impingement. Many or most patients prove to have a prominence at the anterior and superior femoral neck which requires trimming. This can be performed using gouges or a burr. It is surprising how much bone needs to be resected in many patients. Peroperatively in open surgery, a spherical template can be used to identify a non-spherical portion of the femoral head/neck junction. Osteochondroplasty can be performed at the point where the template abuts against the head. The area involved in FAI may be covered by frayed hyaline cartilage and be obvious to naked eye examination. In contrast to unblemished white hyaline cartilage the area will have a reddish or bluish hue. The surgeon needs to be careful while removing slices from the superior aspect of the neck in order to preserve the retinacular vessels. Excision osteoplasty is continued gradually until impingement free motion is confirmed intra-operatively. The risk of neck fracture can be avoided if the total amount resected remains less than 30% of the antero-lateral quadrant of the head/neck junction. Patients with reduced anteversion and a varus neck may also be helped by a flexion-valgus intertrochanteric osteotomy.

Acetabular over-coverage can be treated with acetabular rim resection after elevating the labrum. The aim of resection is to achieve a residual lateral centre-edge angle of 20° to 25°. Periacetabular osteotomy should be considered if the anterior acetabular over-coverage is associated with marked deficiency of posterior coverage, or if there is dysplasia identifiable on the AP X-ray. Acetabular cartilage must be relatively well preserved for peri-acetabular osteotomy to be the preferred procedure.

During acetabular rim resection, the anterior labrum is lifted from the underlying bone. An adequate amount of bone is then resected, together with the underlying acetabular cartilage. This may make a “rim trim” an attractive option if there is a small chondral delamination lesion in the acetabulum. Ossified labrum is excised. Degenerate labrum is resected but this should be limited to the area of definite degeneration, only to preserve as much intact labrum as possible for refixation. In the early stages of the disease labral tears result from localised chronic irritation and the tip remains uninvolved. Labral fixation following resection of a degenerate portion is a feasible option. Viable torn labrum can be reattached to the acetabular rim with suture anchors. The early results of labral refixation have proved better compared to labral resection alone.

At the end of the procedure the surgeon should assess the impingement-free range of motion available at the joint. Most surgeons use bone wax on the debrided area of the femoral neck to minimise the risk of ectopic bone formation, which is a common problem after this procedure. The use of NSAIDs to minimise this problem should also be considered. Weight-bearing is restricted postoperatively after open surgery, with crutches being used for 2 months to minimise the risk of detachment of the greater trochanter. In semi-open or arthroscopic surgery, the patient is asked to use crutches for 2 weeks to protect the femoral head. Physiotherapy to work on range of motion exercises may be helpful from about 2 to 3 weeks; abductor exercises should be avoided for 2 months in patients with a trochanteric osteotomy. Most patients are back to activities of daily living by 6 to 8 weeks, and back to sporting activities by 4 to 6 months.

Outcomes

Both arthroscopic and open debridement surgery for impingement provide good symptomatic relief. There is a high risk of heterotopic ossification following open a debridement, although the risk of avascular necrosis is low. We do not yet have long term longitudinal studies to assess the role of debridement surgery in eventual prevention of hip arthritis. It is important to have a detailed discussion with the patient pre-operatively so that expectations remain realistic. Although surgery will cure mechanical impingement it will not recreate normal joint anatomy. Patients with advanced chondral damage may be better off with replacement arthroplasty. The worst prognostic indicator for failure of FAI surgery is significant osteoarthritis. Hips with additional risk factors, like untreated dysplasia and subluxation, are also at risk of failure. Although early results are encouraging, we need...
larger series with longer term follow-up to determine if mechanical correction of pathomorphic abnormalities will prevent long term progression of osteoarthritis.

Practice points

- There is growing evidence that femoro-acetabular impingement results in osteoarthrosis of the hip joint.
- Patients with FAI usually present with deep groin pain exacerbated by deep hip flexion.
- Pincer impingement is more common in middle aged athletic females.
- Cam impingement (Fig. 10) is commoner in young active males.
- Labral damage rarely occurs alone and may signify ongoing impingement.
- Radiology may reveal a non-spherical femoral head and/or retroverted acetabulum.
- Contrast enhanced MRI is useful to visualise a damaged labrum.
- Surgery is the treatment of choice and is effective in alleviating symptoms of FAI.

Future research directions

- Long term studies with larger numbers of patients are needed to examine the effects of impingement surgery in the potential prevention of osteoarthrosis of the hip joint.
- Guidelines need to be developed covering how early specialist referral should be made and when surgery should be undertaken.
- Better and more predictive imaging modalities are needed, such as three-dimensional modelling, to assess the severity of joint degeneration and to help plan surgery.
- There is a need to develop appropriate patient orientated outcome measures and functional scores in relation to FAI surgery.

References


Further reading