Introduction

Tears of the acetabular labrum are a recognised cause of hip pain. Possible causes of labral tears include trauma, hypolaxity of the anterior capsule, dysplasia, bony impingement and reduced biomechanical properties in the area most susceptible to tears.

Impingement of the proximal femur against or within the acetabular rim is a common underlying cause of a labral tear in the non-dysplastic hip.

Leunig et al. defined morphological abnormalities in the shape and orientation of the femur and acetabulum that characterised femoroacetabular impingement (FAI) and proposed a causative link between FAI and the development of osteoarthritis. Wagner et al. showed that the cartilage from the non-spherical portion of the femoral head in FAI showed histological changes similar to those of an arthritic hip, and different to a spherical head control group.

Chondral damage is associated with FAI in a predictable manner, and damage to the acetabular rim has been postulated as part of a sequence of events causing hip osteoarthritis.

Cam Impingement

The basic hypothesis is that cam impingement arises when the radius of curvature of the femoral head or neck profile exceeds the radius of curvature of the acetabulum, and can arise from a number of basic abnormalities. A key element of cam impingement is a reduced or absent offset between the femoral head and neck (Fig. 1). The degree of cam deformity has been defined...
by measurements of offset-ratio, alpha and beta angles on radiographs\textsuperscript{17,18} or MRI.\textsuperscript{19}

As the aspherical, expanded portion of the femoral head-neck complex encroaches on the acetabular rim, the labrum displaces outwards resulting in increased tensile stress at the labrochondral junction resulting in labral type-1 tear separation from the adjacent articular cartilage at the watershed.\textsuperscript{20} As the aspherical portion rotates further within the acetabular rim, compressive forces and shear stress at the osteochondral junction increase, resulting in delamination of the chondral surface from the underlying bone and producing the so called ‘wave sign’ visible at arthroscopy. Fissure fractures created by traction forces at the labrochondral junction expose the edge of the chondral surface to the advancing ‘front’ of the femoral cam lesion, and result in the creation of chondral flap tears or ‘carpet lesions’ (Fig. 2). This hypothesis is supported by McCarthy et al,\textsuperscript{21} who confirmed that 73% of hips with labral tears had adjacent acetabular chondral damage. Johnston et al\textsuperscript{15} confirmed that cam impingers with high alpha angles were associated with labral injury, chondral damage and decreased range of movement.

**Pincer Impingement**

The femoral neck of a hip with adequate head-neck offset can impinge on the rim of the acetabulum at the extremes of its range of movement. However, if the shape or orientation of the acetabular rim results in impingement before the hip has achieved its required functional range of movement, impact damage to the labrum will occur.

Radiographic features suggesting a susceptibility to pincer impingement include a deep socket (coxa profunda or protrusio), high centre-edge angle, low sourcil angle and signs of global or segmental retroversion or anteversion of the acetabular rim (Fig. 3).

Dynamic pincer impingement can occur in ‘normal’ hips if the required range of movement is large (e.g. dancers and gymnasts) or translated (e.g. hockey players\textsuperscript{22}).

Labral impact damage frequently manifests signs of a thickened, patulous labrum with ‘blunting’ of the labral edge and cystic change. Alternatively, the labrum may be almost non-existent as a result of intra-substance calcification,\textsuperscript{14} which compounds the problem of a reduced range of movement. Pincer impingement is associated with a lower incidence of anterior acetabular chondral damage than cam impingement, although it still occurs as a ‘contrecoup’ degeneration on the posterior aspect of the femoral head and acetabulum (Fig. 4).\textsuperscript{23}

While isolated cam and pincer impingement can occur, the majority of hips present with a mixed pattern.

**Presenting Symptoms**

FAI commonly presents in younger adults as a deep intermittent groin discomfort during or after activity.\textsuperscript{24}
The cam variety of impingement presents with intermittent discomfort in the groin during or after repetitive or persistent hip flexion. Sprinting or kicking sports, ascending hills or stairs, prolonged sitting in low chairs, driving or getting in and out of low vehicles are common exacerbating activities. Pain may be referred to the anterior thigh, to the region of the symphysis pubis and to the ipsilateral testicle in men.

Anterior pincer impingement presents with similar symptoms as cam impingement. However, symptoms of posterior impingement may be experienced in the buttock or sacro-iliac region. These symptoms are more common in women, occur when the hip is repeatedly hyperextended as in fast walking or walking downhill and are often difficult to differentiate from pain referred from the low back and sacro-iliac joint. Women with posterior impingement frequently complain of posterior hip pain during intercourse.

Mechanical symptoms of catching, clicking and a feeling of giving way are commonly associated with labral tears secondary to hip impingement.

**Examination**

The hip is examined in a methodical manner, which should include an assessment of rotational abnormalities in the femur. Hip flexion, adduction and internal rotation most commonly replicate the pain experienced during anterior hip impingement.\(^{25,26}\)

**Investigations**

**Radiology.** A systematic approach to the plain radiographic evaluation of these patients is essential. An anteroposterior (AP) pelvis film should be supported by a cross-table lateral or Dunn view.\(^{18}\)

Key acetabular features on the AP film include the presence of a deep or shallow socket (dysplasia, coxa profunda, protrusio) and an assessment of acetabular version (anteverted, retroverted, focal or global). Pattern recognition of subtle abnormalities takes a long time to develop and is fallible; modern Picture Archiving and Communications System (PACS) facilities allow accurate measurement of centre-edge and sourcil angles as a minimum. Key femoral measurements include head sphericity, neck-shaft angle, alpha angle and offset ratio. The Academic Network for Hip Outcomes Research (ANCHOR) study group\(^{27}\) has published an excellent systematic guide to evaluating plain images.

**MRI.** To identify the most subtle cam imperfections in proximal femoral anatomy, an MRI arthrogram with intra-articular contrast is required. This investigation should include radial sequence scans (Fig. 5) to allow a tangential view perpendicular to the acetabular rim and a detailed analysis of the proximal femoral morphology.\(^{28,29}\) Rakhra et al\(^{30}\) showed that the maximum alpha angles obtained on radial scanning were abnormal in 54% of patients with apparently normal alpha angles on conventional oblique axial scanning. We also recommend acquiring cuts through the distal femur to assess abnormalities of femoral torsion.
The use of 3D reconstruction of CT scans has proved useful in the recognition of subtle femoral deformities (Fig. 6) and in pre-operative planning during the management of complex deformities. It is particularly helpful in achieving appropriate orientation of the hip during arthroscopic femoral osteochondroplasty.

Management of FAI

Femoroacetabular impingement is a mechanical problem that requires a mechanical solution. A common presenting feature is failure to respond to analgesia and physiotherapy; stretching exercises and yoga may aggravate the condition. Reduction in the symptoms associated with pincer impingement might be amenable to sports therapy that focuses on modifying the dynamic hip flexion element of pincer impingement by maintaining core stability and a more upright stance during activity (e.g. skiing moguls or deep powder).

Surgical correction of the deformity remains the mainstay of management, and has been shown to be effective in the short term. Beaulé, Le Duff and Zaragoza showed that quality of life scores such as the Short Form (SF)-12 score or Western Ontario Mc masters Universities (WOMAC) index increase after FAI surgery.

FAI comprises a broad spectrum of disorders that require a wide range of surgical options. With increased understanding of the condition, and cross-fertilisation of surgical principles, it is clear that both hip arthroscopy and open surgery have a valuable role to play.

Surgical dislocation of the hip using the Ganz trochanteric flip approach is based on a thorough understanding of the vascular anatomy of the femoral head and allows unparalleled access to the femoral head and acetabulum. A full description of the technique has been summarised by Norton, Fern and Williams.

The technique facilitates the key elements of basic FAI surgery, namely femoral osteochondroplasty, labral repair or resection or replacement, reshaping of the acetabular rim and acetabular chondral debridement. With adequate experience, the versatility of the technique allows extremely complex hip reconstruction (Fig. 7) to be performed safely and predictably.

Clohisy and McClure reported good to excellent results in 24/25 patients at 1.5 years after an anterior exposure of the hip through a limited Smith-Petersen approach (Fig. 8) combined with hip arthroscopy, despite the restricted exposure compared with formal hip dislocation.

Although favourable long-term results can be achieved with simple arthroscopic labral resection, the early acceptance of the principles of FAI has resulted in considerable advances in both the techniques and equipment associated with arthroscopic hip surgery.
Labral refixation provides better results than simple excision, and correction of the underlying structural deformity produces a better result than dealing with the labrum in isolation. These results mirror those achieved by open surgery. Philippon et al reviewed the arthroscopic treatment of FAI and concluded that the technique had particular relevance to high-demand patients, particularly athletes seeking a return to high-level sport. It is apparent that the key elements of surgery for FAI which have been developed through open surgery are achievable by skilled hip arthroscopists. Avoiding the need for trochanteric osteotomies and prolonged periods of limited post-operative weight-bearing has obvious advantages. Zebala, Schoenecker and Clohisy summarised that FAI was a diverse disease with evolving treatment options; the understanding of the genetic elements of FAI might allow selective screening and earlier diagnosis of the condition. Long-term outcome studies showing a beneficial effect of peri-acetabular osteotomy after 20 years support the use of biological solutions. Although FAI surgery is effective in the short term, evidence is still required that early intervention prevents or delays the development of arthritis in the long term. Surgically induced acetabular dysplasia as a result of inappropriate acetabular rim trimming has been linked with a poor outcome after FAI surgery, and has prompted a change in management, emphasising femoral correction and minimal removal of the acetabular rim and/or labral calcification in our centre. Publication of definitive reference ranges for femoral cam lesions and acetabular rim morphology in the near future should allow surgeons to become more accurate with patient selection in the future.

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