22

The Young Adult With Hip Impingement: Deciding on the Optimal Intervention

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Abstract

Femoroacetabular impingement is a recognized cause of hip pain and osteoarthritis in young adults. The clinical presentation of this pathology is quite varied in terms of the underlying deformity, patient age, and the degree of cartilage damage. Open hip surgery with surgical dislocation is the gold standard for treating femoral deformities and the damaged acetabular labral complex; however, less invasive techniques such as hip arthroscopy and arthroscopy combined with limited anterior hip arthrotomy may provide comparable outcomes with less surgical morbidity. Unresolved issues include the indications for acetabular rim trimming with labral refixation in the presence of acetabular retroversion and/or delaminated acetabular cartilage. Other issues involve the use of arthroplasty in older patients and/or in those with significant cartilage damage.

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Femoroacetabular impingement is a relatively recently described condition in which an abnormally shaped proximal part of the femur causes interference between the femoral head-neck junction and the acetabular rim.[1,2] Although this can occur in normal hips with an increased range of movement, the condition is usually caused by abnormal morphology of the hip. Two mechanisms have been described.[1]

Cam-type impingement is caused by insufficient concavity of the femoral head-neck junction anterolaterally. This has been referred to as a pistol grip deformity or a head tilt deformity.[3,4] As a consequence, this region of the femoral head has an increased radius of curvature that is too large for the tightly congruent acetabulum. The repeated movement of the deformed femoral head in and out of the acetabulum produces shearing of the labrum and the adjacent acetabular cartilage. This can cause the labrum and articular cartilage to delaminate from the subchondral bone.[5,6] This damage is consistently seen at the anterosuperior aspect of the acetabular rim. The deformity may be secondary to Legg-Calvé-Perthes disease or slipped capital femoral epiphysis; however, most patients do not have a history of childhood hip disorders.[7-10]

Pincer-type impingement is caused by overcoverage of the femoral head by the acetabulum. This leads to contact of the labrum against the femoral neck during physiologic hip motion.[11,12] The labrum eventually fails, but damage to the articular cartilage is initially limited to the acetabular rim.[2] Heterotopic bone growth can occur at the base of the

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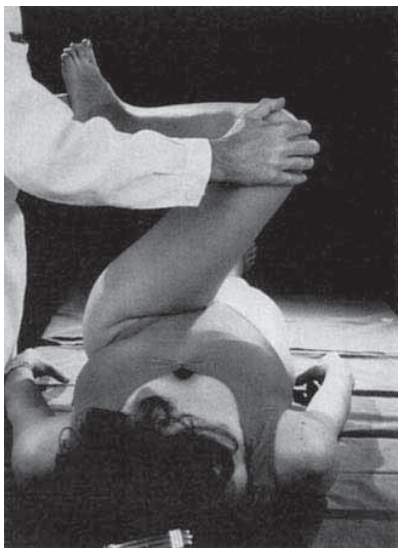

Figure 1 Impingement sign of the hip elicited by forced flexion, adduction, and internal rotation. (Reproduced with permission from Klaue K, Durnin CW, Ganz R: The acetabular rim syndrome: A clinical presentation of dysplasia of the hip. *J Bone Joint Surg Br* 1991;73:423-429.)

labrum in response to the repeated microtrauma. Pincer-type impingement may be associated with hip dysplasia or may be created by overcorrection after periacetabular osteotomy; more commonly, however, it is caused by a retroverted acetabulum producing impingement anteriorly or coxa profunda producing global impingement.[13,14] These two classic forms of impingement (cam and pincer) were shown by Beck and associates[2] to coexist in a large percentage of cases. In their study, 27 of 57 hips (47%) with cam impingement had an associated acetabular deformity, and 34 of 54 (63%) of hips with pincer impingement had an abnormally shaped femoral head. However, to what degree each coexisting deformity contributes to the intra-articular cartilage damage has yet to be clearly defined.

Diagnosis

Patients typically present with groin pain, which is usually of insidious onset and sometimes exacerbated by activity. The pain may be felt as the patient starts to walk after rising from a sitting position, or it may be a dull groin ache while the patient has the hip in a flexed position. The latter type can cause difficulty with sitting at a desk for a prolonged period or with traveling a long distance by automobile or airplane.[1,2,15] Patients with cam-type impingement most often have the onset of symptoms between ages 30 and 39 years, although the symptoms may occur earlier. Men are more commonly affected. Although the deformity is often bilateral, patients usually have symptoms on only one side. Pincer-type impingement is more common in women and often presents as groin pain after activity in patients between ages 40 and 49 years.[16]

The results of the physical examination may be normal, but most patients have a slightly antalgic gait. Typically, the patient has less than 20° of internal rotation with the hip in 90° of flexion and a positive impingement sign, which is groin pain with internal rotation combined with adduction of the lower limb with the hip in 90° of flexion[17] (Figure 1). Wyss and associates[18] found a strong correlation between a lack of internal rotation of the flexed hip and a lack of space between the acetabular rim and the femoral head-neck junction on MRI. The abdomen and low back should be examined to exclude referred pain, and an injection of bupivacaine into the hip joint may help to establish that the pain is from the joint.

Investigations

Cam-type impingement is characterized by asphericity of the femoral head. As the abnormality is typically in the anterolateral portion of the head-neck junction, it may not be seen on an AP pelvic radiograph or a simple lateral radiograph of the hip.[19,20] A cross-table lateral view (with the hip in 10° of internal rotation) or a Dunn view is required[21] (Figure 2). The authors of most studies have used an α angle (the angle between the axis of the neck and the point where the bone of the head-neck junction crosses outside the radius of curvature of the head) of greater than 50.5° to diagnose the abnormality.[20,22,23] In addition, a head-neck offset ratio[21] of 0.15 or less on the cross-table lateral radiograph has been reported to have a sensitivity and specificity of 68% and 82%, respectively, for diagnosing cam impingement.[19,21] The offset ratio is measured by dividing the anterior offset by the femoral head diameter. The anterior offset is the distance between two parallel lines, one adjacent to the anterior aspect of the neck and the other touching the most anterior part of the femoral head, with both parallel to the femoral neck axis. In a comparison of four different lateral radiographic views used to detect femoral head asphericity, Meyer and associates[20] found that the modified Dunn view (an AP radiograph of the hip in neutral rotation, 20° of abduction, and 45° of flexion) was the most sensitive, and the cross-table lateral view (with the hip in 10° of internal rotation) and the standard Dunn view (an AP radiograph of the hip in neutral rotation, 20° of abduction, and 90° of flexion) were quite satisfactory.

The AP pelvic radiograph is the most valuable study for confirming retroversion or coxa profunda in a patient suspected of having pincer-type impingement.[2,11] Pelvic posi-

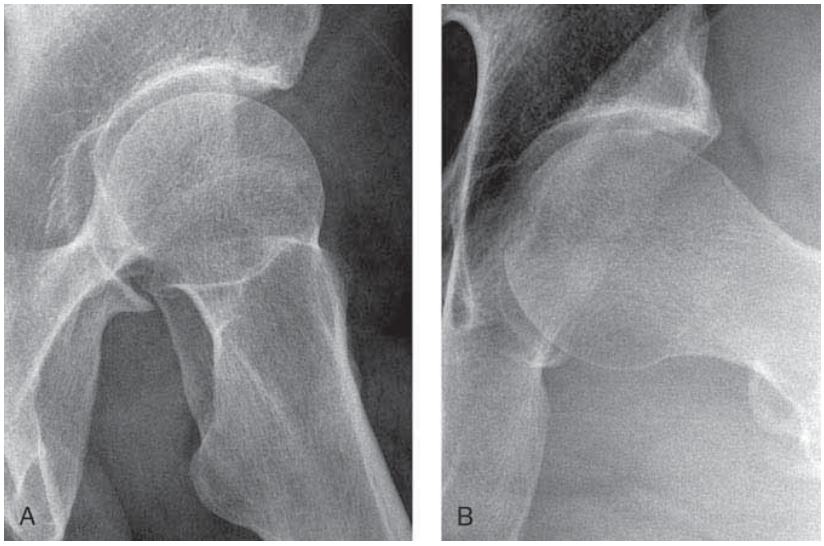

Figure 2 **A,** The impinging lesion can be underestimated on the basis of a standard lateral radiograph. **B,** The Dunn radiograph is more accurate for the assessment of the abnormality.

Figure 3 AP pelvic radiograph of a 24-year-old woman with evidence of acetabular retroversion. The crossover sign can be seen on both sides (where the anterior wall of the acetabulum crosses the posterior wall) and the ischial sign is present on both sides (as the ischial spine is visible).

tioning must be considered when interpreting the radiographic signs associated with pincer impingement. With the coccyx and symphysis pubis aligned, the pelvis should be in neutral flexion-extension, which means that the distance between the top of the pubic symphysis and the sacrococcygeal junction should be 32 mm for men and 47 mm for women.[24] The retroverted acetabulum is recognized on the basis of one of three findings: the anterior wall of the acetabulum crossing the posterior wall (the so-called crossover sign), the center of the femoral head lying lateral to the posterior wall (the so-called posterior wall sign), or the ischial spine projecting into the pelvic cavity on the AP pelvic radiograph (the so-called ischial sign)[11,12,25] (Figure 3). Coxa profunda is recognized on the AP pelvic radiograph when the medial wall of the acetabulum lies on or medial to the ilioischial line. Protrusio, which represents the more severe form of coxa profunda, is diagnosed when the femoral head crosses the ilioischial line.[2]

CT and MRI with gadolinium arthrography are useful as additional studies to confirm the impingement deformity, identify associated pathologic changes, and facilitate surgical planning.[23,26] CT scans provide three-dimensional surface renderings of the impingement deformity and aid in determining the area of resection to correct femoral head asphericity.[23] MRI with gadolinium arthrography can demonstrate abnormalities of the acetabular rim, such as labral tears, paralabral cysts, and cartilage delamination.[6,27] It has been demonstrated that MRI is useful for distinguishing dysplasia from impingement.[28] When there is impingement, the labrum may be normal in size or small, in contrast to the hypertrophied labrum associated with a dysplastic acetabulum.[28] Fibrocystic changes at the femoral head-neck junction (also known as Pitt's pit), which are often visible on plain radiographs but are more easily seen on CT or MRI studies, have been reported to be 91% specific and to have a positive predictive value of 71% for the diagnosis of femoroacetabular impingement.[26] When the plain radiographic examination is inconclusive, both MRI and CT scans provide radial images of the anatomy of the femoral head-neck junction that are more sensitive in detecting abnormal α angles as well as acetabular version.[19]

Management

Although we are not aware of any longitudinal studies on the issue, there is evidence that femoroacetabular impingement is a leading cause of so-called primary osteoarthritis of the hip.[1,2,16] Therefore, early intervention is aimed not only at providing pain relief and improving function but also at delaying and/or preventing subsequent osteoarthritis. Although we are not aware of any long-term follow-up studies demonstrating that the onset of osteoarthritis can be prevented and/or delayed with surgery, Beck and associates[5] reported no progression of joint-space narrowing in 19 hips at

4.7 years after surgical treatment of femoroacetabular impingement. However, it is becoming more apparent that one of the greatest challenges in treating femoroacetabular impingement is dealing with the associated damage to the acetabular labral chondral complex, which can range from fraying or irritation of the labral tip to large delaminated flaps of cartilage and/or chondral defects of the acetabulum.[2,29,30] In addition, the treatment of delamination of acetabular cartilage is still evolving. Localized débridement may be sufficient for small acetabular cartilage flaps, whereas larger lesions may require rim trimming to restore a stable cartilage edge.[30] Consideration is needed for the underlying morphologic abnormality causing the impingement (cam or pincer, or both); the presence or absence of deformity of the proximal part of the femur; and the physiologic age of the patient, especially one with early arthritic changes (1 to 2 mm of joint space narrowing), in whom a joint arthroplasty may offer a more predictable outcome. In contrast to a patient with advanced hip arthritis, joint-preserving surgeries may be inappropriate for a patient with relatively mild symptoms and/or advanced age. For young patients, joint preservation to delay and/or prevent arthritis may make even an open approach and femoral head dislocation appropriate. The following clinical factors should most strongly influence the treatment of a patient with femoroacetabular impingement: (1) the physiologic age of the patient; (2) joint space narrowing of 1 to 2 mm; (3) the extent of damage to the acetabular labral chondral complex; (4) in patients with pincer-type impingement, the severity of acetabular retroversion with or without the presence of cam-type impingement; and (5) in those with cam-type impingement, the absence or presence of proximal femoral deformity (for example, a high-riding greater trochanter) and the extent of head asphericity.

The best time for surgery is unknown. Symptoms are usually not as severe as those in patients requiring a joint arthroplasty, and delaying surgery may lead to irreversible cartilage damage. Nevertheless, a course of nonsurgical management, consisting of activity modification, anti-inflammatory medication, and range-of-motion exercises, is advisable for most patients. It is not clear that patients benefit substantially from such a regimen, however.[31]

There are three categories of surgical techniques for the treatment of femoroacetabular impingement: (1) a fully open surgical procedure in which the femoral head is dislocated, providing full access for the correction of cam impingement and trimming the acetabular rim as needed; (2) an arthroscopic technique, wherein the correction is done either arthroscopically only or combined with an arthrotomy (but the femoral head is not dislocated); and (3) a periacetabular osteotomy performed for certain forms of pincer-type impingement. Most patients with femoroacetabular impingement have a mixed type of impingement, and as yet there is no clear information about how to establish the predominant impingement type or if treatment of the cam or pincer-type deformity in isolation is sufficient.

Open Hip Surgery With Dislocation of the Femoral Head

The indications for this approach include (1) cam-type impingement with or without proximal femoral deformity, (2) pincer-type impingement associated with cam-type deformity, and (3) cam-type impingement with 1 mm of joint-space narrowing because this approach would allow possible conversion to arthroplasty.

Dislocation of the femoral head allows complete access to both the femoral head-neck junction and the acetabular rim.[32] The recommended technique for surgical dislocation was developed by Ganz and associates[33] for the treatment of intra-articular hip pathology. With this technique, the femoral head vascularity is protected, and osteonecrosis is avoided. In brief, the patient is placed in the lateral decubitus position, and the incision is centered over the greater trochanter and angulated slightly posteriorly. After the iliotibial band is released, the posterior border of the gluteus medius and minimus is marked. A trochanteric slide osteotomy is performed with a small sleeve of the gluteus medius left attached and with the vastus lateralis left attached to the trochanteric fragment. The osteotomy must be extracapsular and lateral to the piriformis fossa to avoid damage to the blood supply.[34] The trochanteric slide osteotomy is mobilized anteriorly, and the femoral head is dislocated anteriorly. This allows a complete view of the femoral head.

Both Beck and associates[5] and Murphy and associates[32] reported that, in their early experience with the treatment of femoroacetabular impingement with the surgical dislocation technique of Ganz and associates,[33] the results were good to excellent in more than 65% of patients. In a subsequent study, Espinosa and associates[35] reported significantly better outcomes (a 94%

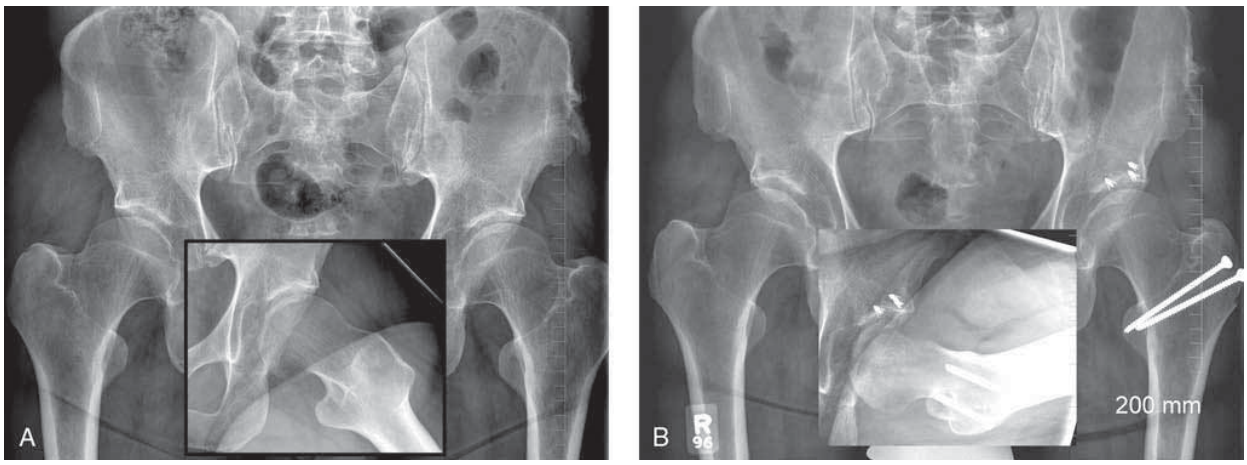

Figure 4 **A,** A 51-year-old man presented with bilateral hip and groin pain, which was worse on the left. The left hip had caused him discomfort for approximately 20 years, affecting his activities of daily living and limiting the distance that he was able to walk. The asphericity of the femoral heads and the short acetabular roofs are seen on the AP radiograph. The diminished anterior concavity of the femoral head is seen on the Dunn radiograph (inset). **B,** The patient was treated with surgical dislocation with osteochondroplasty of the femoral head-neck junction. Labral refixation was performed after the rim was trimmed to remove exposed subchondral bone and perform microfracture of the damaged articular surface. The restored head-neck offset is seen on the Dunn radiograph (inset).

rate of good to excellent results) when the labrum had been preserved as compared with when it had been resected ($P = 0.01$ Figure 4). After following the principles of labral preservation through partial débridement or refixation, Peters and Erickson[29] and Beaulé and associates[30] reported good to excellent clinical scores in more than 80% of patients, which was an improvement compared with the results in the initial series reported by Beck and assoicates[5] and Murphy and associates.[32] On the basis of these results, surgical dislocation appears to be a safe and effective technique for joint preservation that does not lead to osteonecrosis.[8] However, this technique has risks. Ganz and associates[33] reported 2 cases of sciatic neurapraxia, 3 trochanteric nonunions, and 11 cases of clinically relevant heterotopic ossification in a series of 213 hips. In addition, Beaulé and associates[30] reported 10 revisions directly related to the approach (such as screw removal or trochanteric nonunion).

Periacetabular Osteotomy

The indication for periacetabular osteotomy is acetabular retroversion with an associated posterior wall sign. A retroverted acetabulum is caused by external rotation of the entire acetabulum.[36] This produces overcoverage of the anterior aspect of the femoral head and less-than-normal coverage of the posterior part of the femoral head. This altered relationship between the anterior and posterior aspects of the hip leads to the posterior wall sign. This abnormality can be corrected with a periacetabular osteotomy (Figure 5), which also can be used to correct a retroverted acetabulum associated with a dysplastic hip.[37] The cartilage in the anterosuperior aspect of the acetabulum must be intact for a periacetabular osteotomy to be recommended; if it is not intact, acetabular reorientation will place poor cartilage in the main weight-bearing area. Siebenrock and associates[12] reported the results of periacetabular osteotomy in the treatment of femoroacetabular impingement secondary to a retroverted acetabulum in 29 hips in 22 patients. In conjunction with the periacetabular osteotomy, an anterior hip arthrotomy was performed in 26 hips to reshape the femoral head-neck junction. The result was good or excellent for 26 hips, and the average Merle d'Aubigné score improved from 14.0 points preoperatively to 16.9 postoperatively. Three patients required a revision, one each because of loss of correction, posteroinferior impingement, and recurrent signs of anterior impingement (caused by insufficient correction and lack of a head-neck offset). Pincer impingement caused by the relative prominence of the anterior

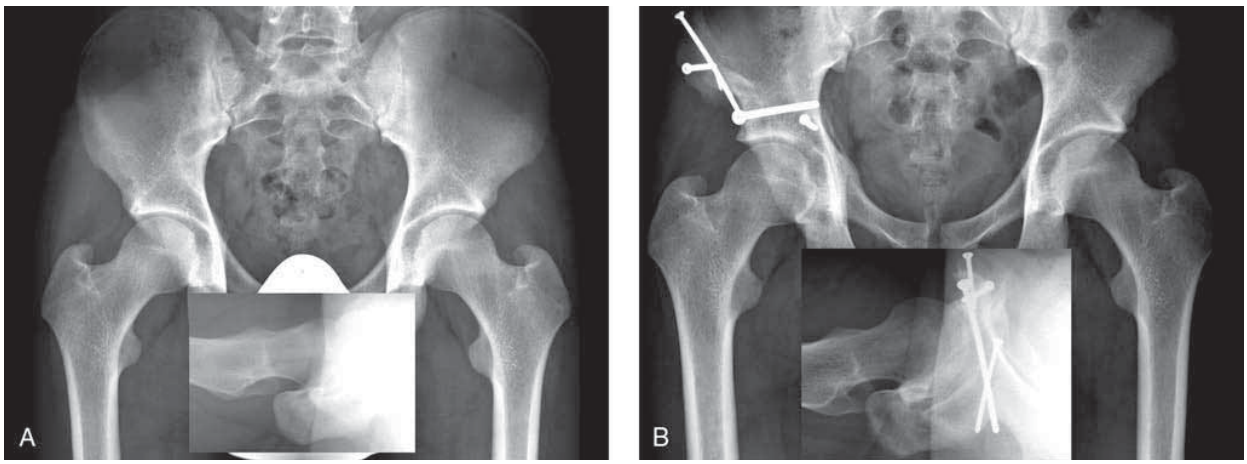

Figure 5 **A,** An 18-year-old male professional ice hockey player reported persistent pain in the right hip. Retroversion of the acetabulum with deficiency of the posterior acetabular wall (the lateral edge of the posterior wall lying medial to the femoral head center) is seen on the AP radiograph. Diminished anterior concavity of the femoral neck is seen on the cross-table lateral radiograph (inset). **B,** One year after a periacetabular osteotomy, the AP radiograph showed that the crossover sign has been corrected. The anterior concavity of the femoral neck has been restored (inset).

Figure 6 The extent of the deformity of a cam-type impingement is seen on this intraoperative photograph of a dislocated femoral head.

wall (the crossover sign) with an absent posterior wall sign (for example, with the lateral aspect of the posterior wall lateral to the center of the femoral head) is best treated with localized trimming of the rim, whereas coxa profunda requires global rim trimming; both procedures are best done with open surgery by means of surgical dislocation.

Hip Arthroscopy Combined With a Miniopen Anterior (Hueter) Hip Arthrotomy

Hip arthroscopy can be combined with a miniopen anterior (Hueter) arthrotomy as described by Frederic Laude (personal communication, 1999). The arthroscopy is performed first to inspect the joint as well as to treat labral and chondral pathology. Then the anterior hip arthrotomy is performed to correct a cam deformity, which is most commonly located on the anterior aspect of the femoral head-neck junction. In addition, it is possible to detach the labrum anteriorly to trim the acetabular rim. The direct anterior approach involves a dissection within the fascial sheath of the tensor fasciae latae to minimize the risk of damage to the lateral femoral cutaneous nerve. The fascia over the rectus femoris is then released, the rectus femoris is retracted medially, and a T-shaped capsulotomy is performed. Clohisy and McClure[37] argued that performance of the anterior hip arthrotomy allows a better exposure of the femoral head-neck junction than is possible with arthroscopy alone and that there is less potential for osseous debris to become trapped in the joint. Furthermore, the risk of an inadequate osseous correction is minimized. However, Ganz and associates[33] argued that the open technique with femoral head dislocation offers better inspection of the acetabulum than is possible with an anterior Smith-Petersen approach unless the tensor fasciae latae and gluteus medius are extensively detached from the pelvic brim. Clearly, the mini-anterior approach is not suitable for circumferential lesions of the femoral head or acetabulum (Figure 6). However, it may be appropriate for most patients in whom preoperative evaluation has demonstrated that the lesion is localized mainly anteriorly. Patients should be warned that there is a risk of injury to the lateral femoral cutaneous nerve with this approach. In addition, because the

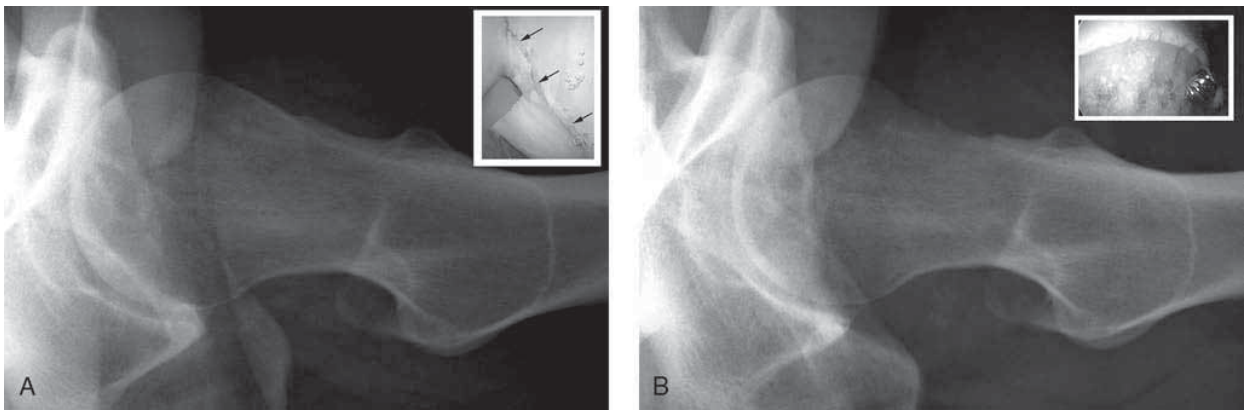

Figure 7 **A,** A cross-table lateral radiograph showing an insufficient anterior head-neck concavity. The inset shows the associated damage to the acetabular labral chondral complex (*arrows*). **B,** The concavity of the femoral head-neck junction has been restored by means of hip arthroscopy as seen on the postoperative radiograph. The resected head-neck area can be seen on the arthroscopic photograph (inset).

incision is not parallel to the tension lines of the skin, a hypertrophic scar may develop in some patients.

Hip Arthroscopy

The indications for hip arthroscopy include (1) cam-type impingement without proximal femoral deformity and (2) isolated acetabular retroversion with or without cam-type deformity. Arthroscopy is clearly an attractive alternative for patients because it involves smaller incisions, a shorter recovery time, and a lower morbidity rate. Today, the technique of arthroscopy of the hip can be divided into two approaches: one into the central compartment and one into the peripheral compartment. The central compartment includes the labrum and all parts medial to it. The peripheral compartment comprises everything lateral to the labrum within the capsule and includes the head-neck junction. Arthroscopy of the central compartment is typically performed with traction. The labrum can be inspected for tears that can be débrided or, in some cases, treated with refixation. Delaminated articular cartilage can be excised, and exposed acetabular subchondral bone can be treated with microfracture. With the traction released, the peripheral compartment can be entered through an anterolateral portal. A partial capsulectomy is then performed to facilitate instrument placement for reshaping of the femoral head-neck junction (Figure 7). In more advanced cases of osteoarthritis, peripheral osteophytes which can be removed. Incomplete visualization may lead to undertreatment, can lead to errors with defining the extent of rim trimming that is required, or can lead to excessive removal of bone at the femoral head-neck junction and subsequent fracture.[38] Neurovascular injury is rare but possible; it can be related either to the portals (the superior gluteal nerve can be damaged with creation of the anterolateral portal, and the lateral femoral cutaneous and femoral nerves can be damaged with creation of the anterior portal) or to the traction, which can especially affect the sciatic and pudendal nerves.

As with any new surgical technique, there is a risk of suboptimal results when arthroscopy is used for the treatment of femoroacetabular impingement.[39] With increasing clinical experience and training, arthroscopic treatment of femoroacetabular impingement will continue to expand. Ilizaliturri and associates[40] recently reported on 19 patients with pure cam impingement treated arthroscopically. Sixteen patients had significant improvement in their Western Ontario and McMaster Universities Osteoarthritis Index scores ($P = 0.001$), 2 had progression of arthritis, and 1 was advised to undergo total hip replacement. There were no major complications associated with this procedure. Other surgeons have reported on larger studies, but the duration of follow-up was short, and no validated scoring was provided.[38] More importantly, because the indications for and techniques of arthroscopic treatment of pincer-type impingement are still evolving, great caution should be exercised when considering trimming the acetabular rim, which is technically demanding and can create a dysplastic acetabulum if there is overcorrection.[41]

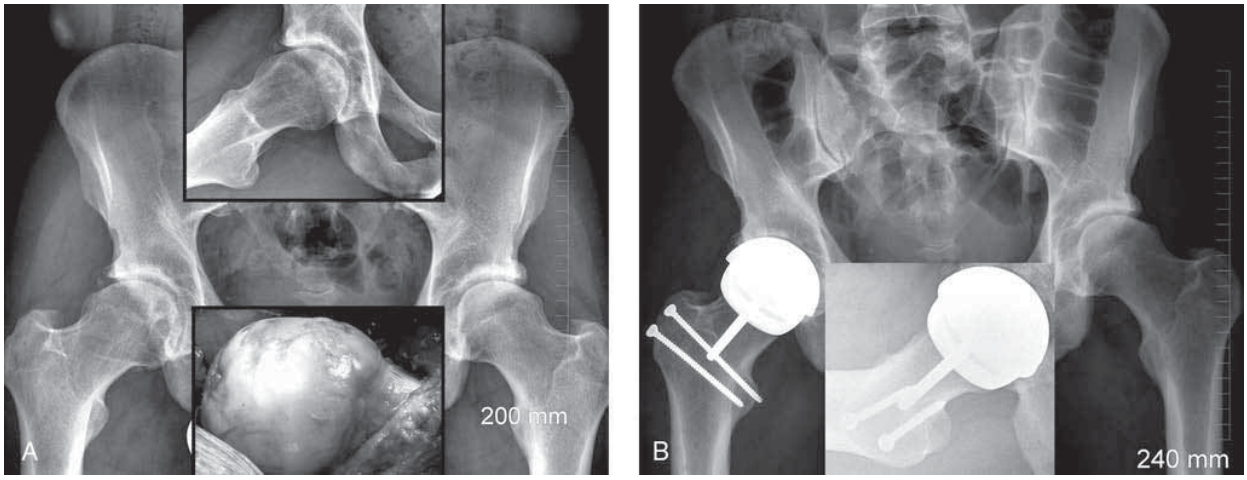

Figure 8 **A,** A 37-year-old man with pain in the right hip had cam-type impingement and joint-space narrowing. The Dunn radiograph (top inset) shows an insufficient head-neck concavity, and the intraoperative photograph (bottom inset) shows gross cartilage loss from the femoral head. **B,** Radiograph made following metal-on-metal hip resurfacing done through a surgical dislocation approach. The inset shows optimization of the femoral head-neck concavity.

Hip Arthroplasty

The presence of substantial cartilage damage at the time of surgery for the treatment of impingement has been associated with a poor outcome, with patients treated with joint arthroplasty in the short-term follow-up period.[5,40,42] However, it is often unclear whether joint preservation is still indicated or if arthroplasty is preferable to provide a more predictable outcome. One of the factors that has discouraged surgeons from proceeding with a total hip replacement is the large leap between joint preservation and resection of the femoral head-neck area to treat patients' symptoms. Hip resurfacing represents an attractive alternative bone-preserving option for a young patient with an arthritic hip.[43] When hip resurfacing is performed in a patient with osteoarthritis caused by femoroacetabular impingement, care must be taken to restore the femoral head-neck offset; otherwise, impingement can still occur.[19] In addition, restoration of the femoral head-neck offset allows optimization of the sizes of the femoral and acetabular components because the femoral head diameter drives the acetabular size.[44] It is recommended that anterior osteophytes be removed from the head-neck junction before the guide pin is placed.[44] One of the authors (P.E.B.) performed resurfacing arthroplasty in six patients, with a mean age of 42.4 years (range, 34 to 48 years), who had initially undergone surgery to treat impingement. All six patients had consented to both procedures because preoperative radiographs had demonstrated joint-space narrowing (Figure 8, *A*). All patients underwent hybrid metal-on-metal hip resurfacing with the Conserve Plus (Wright Medical Technology, Arlington, TN), and one patient also underwent a trochanteric advancement. All had substantial pain relief and improvement in function (Figure 8, *B*). Although there were no complications, two of the six patients required removal of the screws because of persistent bursitis.

Summary

Femoroacetabular impingement is a cause of hip pain in young adults, and there is evidence that it is a major cause of osteoarthritis. Treatment of femoroacetabular impingement has been reported to relieve symptoms and perhaps retard the progression of osteoarthritis. The optimal treatment strategies are determined by carefully correlating the patient's history and the findings of physical examination with detailed imaging studies. Surgery should be tailored to treat the individual patient's abnormal hip morphology and should address the major underlying impinging deformities. Future treatments may include cartilage grafting and computer-assisted surgery, further expanding the role of less invasive surgical techniques such as hip arthroscopy. Hip resurfacing is an additional tool for the treatment of young adults with hip pain and early stage osteoarthritis.

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