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Arthroscopic Management of Femoroacetabular Impingement

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Abstract

Femoroacetabular impingement is a well-recognized cause of intra-articular pathology and secondary osteoarthritis among young adults. It has been proposed that femoroacetabular impingement that does not require periacetabular osteotomy sometimes can be managed by arthroscopic methods. Clinically relevant impingement is suspected based on the patient history, examination findings, and radiographic features. Pathologic impingement is then substantiated based on the arthroscopic parameters of characteristic intra-articular pathology. Early experience has shown that hip arthroscopy can achieve results that compare favorably to open methods in patients with femoroacetabular impingement.

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Impingement is not a new concept. As early as 1913, Vulpius and Stöffel[1] described a bony resection procedure for the deformity created by a slipped capital femoral epiphysis (Figure 1). In 1936, Smith-Petersen[2] described an operation with excision of the acetabular rim sometimes combined with a wedge resection of the femoral head/neck junction for protrusio, slipped epiphysis, and coxa plana. Although primitive, the technique bears a striking similarity to the recent descriptions of open surgical dislocation for pincer and cam impingement (Figure 2). This combined approach received no further mention in the literature, but osteoplasty for the femoral deformity associated with chronic slipped capital femoral epiphysis was popularized by Heyman and Herndon[3] and has similarly been described for the misshapen femoral head of coxa plana as a sequela of Legg-Calvé-Perthes disease.[4]

Other authors formulated the concept of femoroacetabular impingement (FAI) and described it as an iatrogenic process associated with overcorrection of periacetabular osteotomy done to correct hip dysplasia.[5] Subsequently, FAI in nonoperated hips was described as a precursor to the development of osteoarthritis.[6] FAI was classified into pincer, cam, and combined types, and an open surgical approach was described for correction.[7] Successful treatment with a goal of delaying the progression of osteoarthritis has been reported, but this technique has not been advocated for the resumption of an active lifestyle.[8]

FAI does not appear to be a cause of hip pain; it is simply a morphologic variant that predisposes the joint to intra-articular pathology that then becomes symptomatic. Pincer impingement, caused by an overhanging of the anterolateral rim of the acetabulum, results primarily in breakdown of the acetabular labrum and, over time, a variable amount of associated articular damage to the acetabulum (Figure 3). Cam impingement, created by the prominent portion of a nonspherical femoral head engaging against the articular surface of the acetabulum, results in selective delamination and

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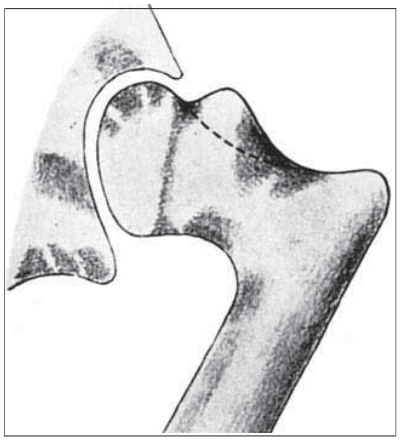

Figure 1 This illustration by Vulpius and Stöffel, published in 1913, illustrates cheilectomy for slipped capital femoral epiphysis. The bone above the curved dotted line is removed to relieve the obstruction to motion at the rim of the acetabulum.

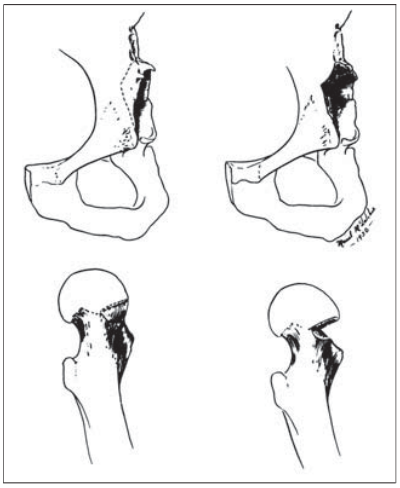

Figure 2 Diagrams illustrating early efforts at reshaping the acetabulum and femoral head for improved range of motion. (Reproduced with permission from Smith-Petersen MN: Treatment of malum coxae senilis, old slipped upper femoral epiphysis, intrapelvic protrusion of the acetabulum, and coxa plana by means of acetabuloplasty. *J Bone Joint Surg Am* 1936;18:869-880.)

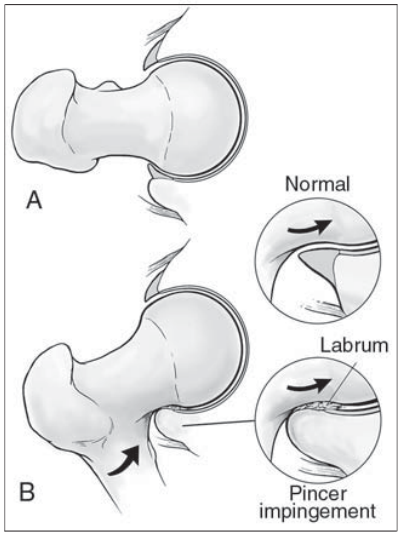

Figure 3 Pincer impingement occurs from a bony prominence of the anterior acetabulum crushing the labrum against the neck of the femur. Secondary articular failure occurs over time. (Courtesy of J. W. Thomas Byrd, MD, Nashville, TN.)

failure of the articular surface of the acetabulum with relative preservation of the labrum (Figure 4). These observations are important in the arthroscopic management of FAI because hips may have the morphologic features of FAI without developing the cartilage failure associated with pathologic impingement. Thus, the arthroscopic findings determine the course of management for patients who have radiographic features of FAI. Impingement is not the sole cause of intra-articular pathology and hip joint symptoms in active adults.

Arthroscopic Approach

Patient Selection

The indication for hip arthroscopy in our 220 patients (227 hips) was recalcitrant hip pain with imaging evidence of intra-articular pathology or clinical findings of persistent hip symptoms unresponsive to conservative measures, including activity modification and time. The indication for treating associated impingement was based partly on the radiographic findings and principally on arthroscopic findings.

The presence of a crossover sign suggested pincer impingement, which then was substantiated by three arthroscopic parameters. First, difficulty often was encountered establishing the anterior portal, despite adequate joint-space separation, because of the barrier imposed by the prominence of the anterolateral acetabulum. Second, associated labral damage was created by the pathologic pincer impingement process. Third, selective débridement of the damaged portion revealed the overhanging lip of bone characteristic of pincer impingement.

Cam impingement was suggested by the radiographic feature of loss of sphericity of the femoral head. If this was suspected, a three-dimensional CT scan helped to more clearly detail the bony architecture in anticipation of arthroscopic correction. Cam pathology associated with cam morphology was substantiated by the arthroscopic finding of articular surface failure with delamination of the anterolateral acetabulum.

Technique

Pincer Impingement

The basic principles developed in the early 1990s were the foundation for the subsequent development of methods of treating FAI.[9-11] Although corrective surgery has been done for impingement caused by posttraumatic osteophytes since early in the development of the technique, FAI as a formal indication has been incorporated only since 2003.[12-15]

Pincer impingement is treated from the central compartment using the standard supine three-portal technique[11,12] (anterior, anterolateral, and posterolateral) (Figures 5 through 7). After completely in-

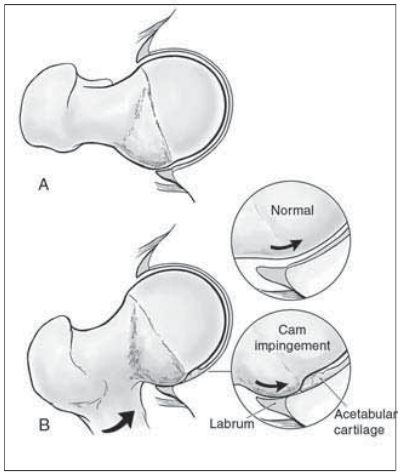

Figure 4 Cam impingement occurs with hip flexion as the bony prominence of the nonspherical portion of the femoral head (cam lesion) glides under the labrum, engaging the edge of the articular cartilage, and results in progressive delamination. Initially, the labrum is relatively preserved, but secondary failure occurs over time. (Courtesy of J. W. Thomas Byrd, MD.)

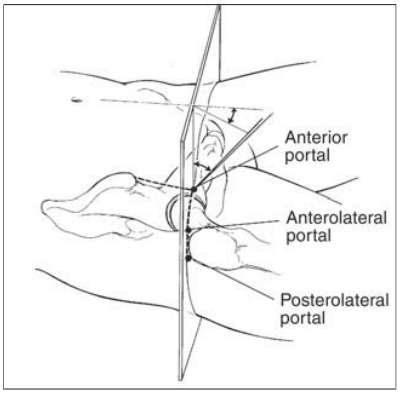

Figure 5 The site of the anterior portal coincides with the intersection of a sagittal line drawn distally from the anterior superior iliac spine and a transverse line across the superior margin of the greater trochanter. The direction of this portal courses approximately 45° cephalad and 30° toward the midline. The anterolateral and posterolateral portals are positioned directly over the superior aspect of the trochanter at its anterior and posterior borders. (Courtesy of Smith & Nephew Endoscopy, Andover, MA.)

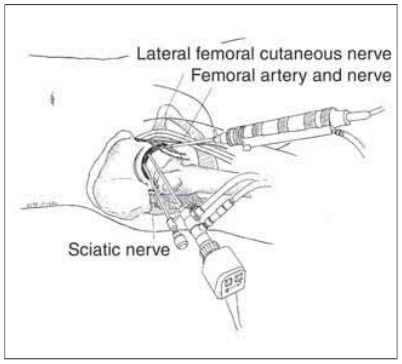

Figure 6 The relationship of the major neurovascular structures to the three standard portals is illustrated. The femoral artery and nerve lie well medial to the anterior portal. The sciatic nerve lies posterior to the posterolateral portal. The lateral femoral cutaneous nerve lies close to the anterior portal. Injury to this structure is avoided by using proper portal placement. The anterolateral portal is established first because it lies most centrally in the safe zone for arthroscopy. (Courtesy of J. W. Thomas Byrd, MD, Nashville, TN.)

specting the joint, attention is turned to the labral lesion. Selective débridement of the damaged portion reveals the overhanging lip of bone instead of the normal capsular reflection from the labrum. Once the damaged tissue has been removed, exposing the pincer lesion, the bone is then recontoured with a spherical burr. Generous capsulotomies around the portals facilitate maneuverability and access. The pincer lesion is accessed by switching the arthroscope and instrumentation between the anterior and anterolateral portals. Proximally, the bone is resected flush with the anterior column of the acetabulum. The anteromedial and lateral extent of the bony resection is dictated by the margin of healthy labrum. The bone is recontoured to create a smooth transition with the healthy portion of the labrum, which is preserved. A variable amount of associated secondary articular damage may be present, which is treated with a chondroplasty or microfracture for grade IV lesions.

Cam Impingement

Treatment of cam impingement begins with arthroscopic examination of the central compartment to document the presence of cam pathology (Figures 8 and 9). The characteristic feature is articular failure of the anterolateral acetabulum. Depending on the location of the cam lesion, the articular damage may be more anterior or lateral. The typical situation involves articular delamination beginning at the junction of the articular surface with the base of the labrum. Often this is a full-thickness, grade IV lesion, although it may be a deep grade III lesion. In early disease, a substantial area of closed grade I articular blistering may be present, but this must be distinguished from simple articular softening, which can be a normal variation in the consistency of the surface. Associated failure of the labrum at its base is frequent, but there is a disproportionate amount of articular abnormality relative to the labral pathology. The articular damage is treated with chondroplasty and microfracture, as dictated by its severity. The associated labral pathology is conservatively débrided, creating a stable edge. Débridement can be limited selectively to the articular side of the labrum, allowing preservation of its capsular surface and maintaining much of the labral substance.

Transition to Periphery

After completing arthroscopy of the central compartment, the cam lesion

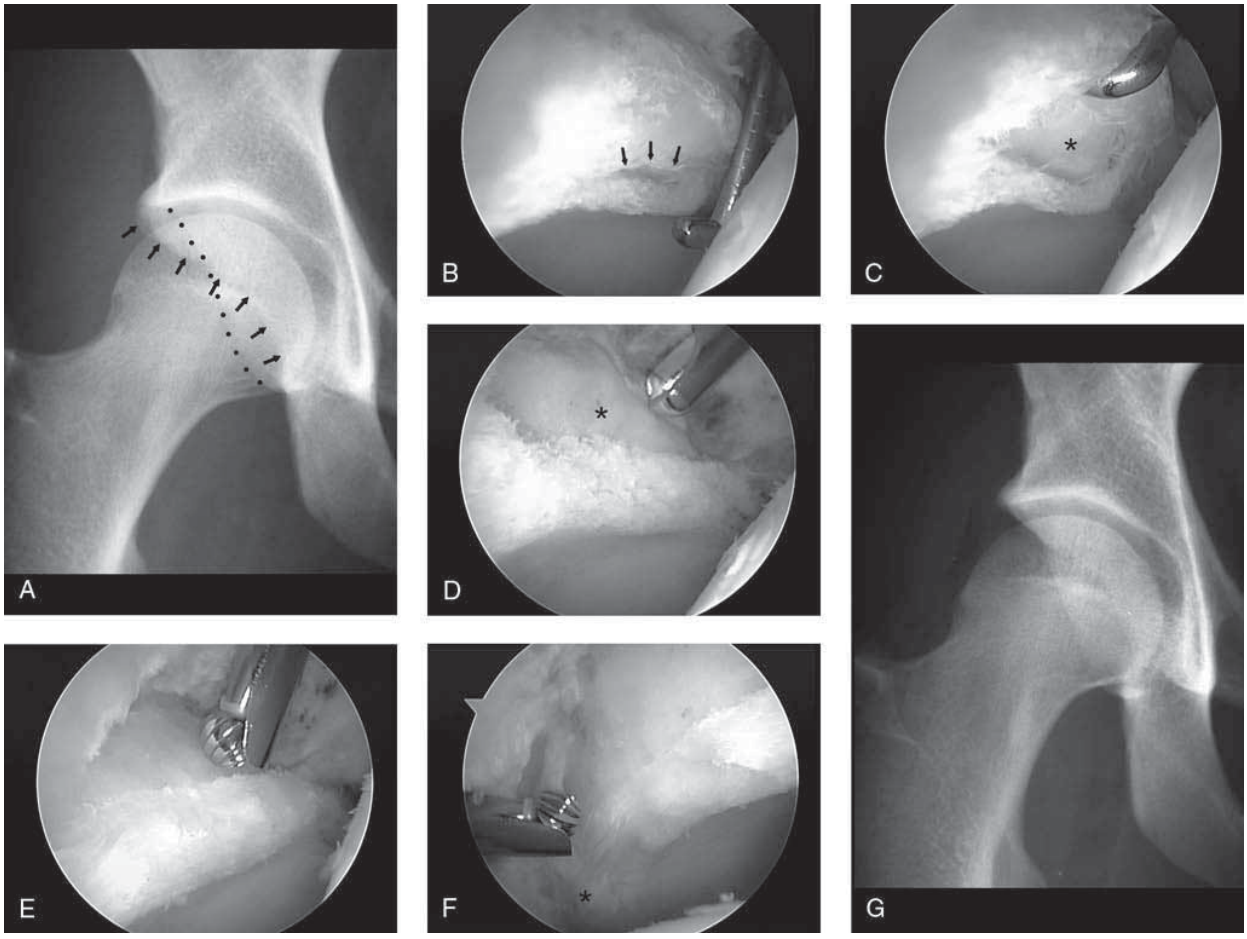

Figure 7 Imaging studies of the hip of a 20-year-old man who has persistent hip pain after an acute injury. **A,** AP radiograph demonstrates a positive crossover sign indicative of pincer impingement. Superiorly, the anterior wall (*arrows*) lies lateral to the posterior wall (*dotted line*), reflecting anterior acetabular impingement. Inferiorly, it lies medial to the posterior wall, creating the crossover sign. **B,** Viewing from the anterolateral portal, tearing of the anterior labrum is identified (*arrows*). The probe is introduced from the anterior portal. **C,** Retracting the torn portion of the labrum exposes the overhanging bony impingement (*). **D,** The damaged labrum has been resected, exposing the impinging lesion (*). **E,** Acetabuloplasty is performed, excising the bony impingement. **F,** The arthroscope has been switched to the anterior portal, completing the acetabuloplasty with the burr in the anterolateral portal. The healthy lateral labrum (*) demarcates the limit of the bony resection. **G,** Postoperative AP radiograph illustrates correction of the crossover sign. (Courtesy of J. W. Thomas Byrd, MD, Nashville, TN.)

is approached from the peripheral compartment. Numerous methods can allow access to the abnormal bone, but the goal is to establish working portals centered on the cam lesion to lessen the amount of soft-tissue dissection necessary to fully expose it. Simply connecting the capsulotomy between the anterior and anterolateral portals creates most of the capsular window necessary for accessing the cam lesion and situates the exposure directly over the abnormal bone. This capsulotomy also releases a portion of the reflected head of the rectus femoris. The posterolateral cannula can be removed, and the anterior and anterolateral cannulas are simply backed out of the central compartment but remain inside the capsule. The traction is released, and the hip is flexed approximately 35°. Failure to adequately create the capsulotomy before releasing the traction can tether the instrumentation proximally and hinders maneuverability in the periphery. As the hip is flexed under arthroscopic visualization, the line of demarcation between healthy cartilage and abnormal fibrocartilage that covers the cam lesion usually can be identified. Flexing the hip so

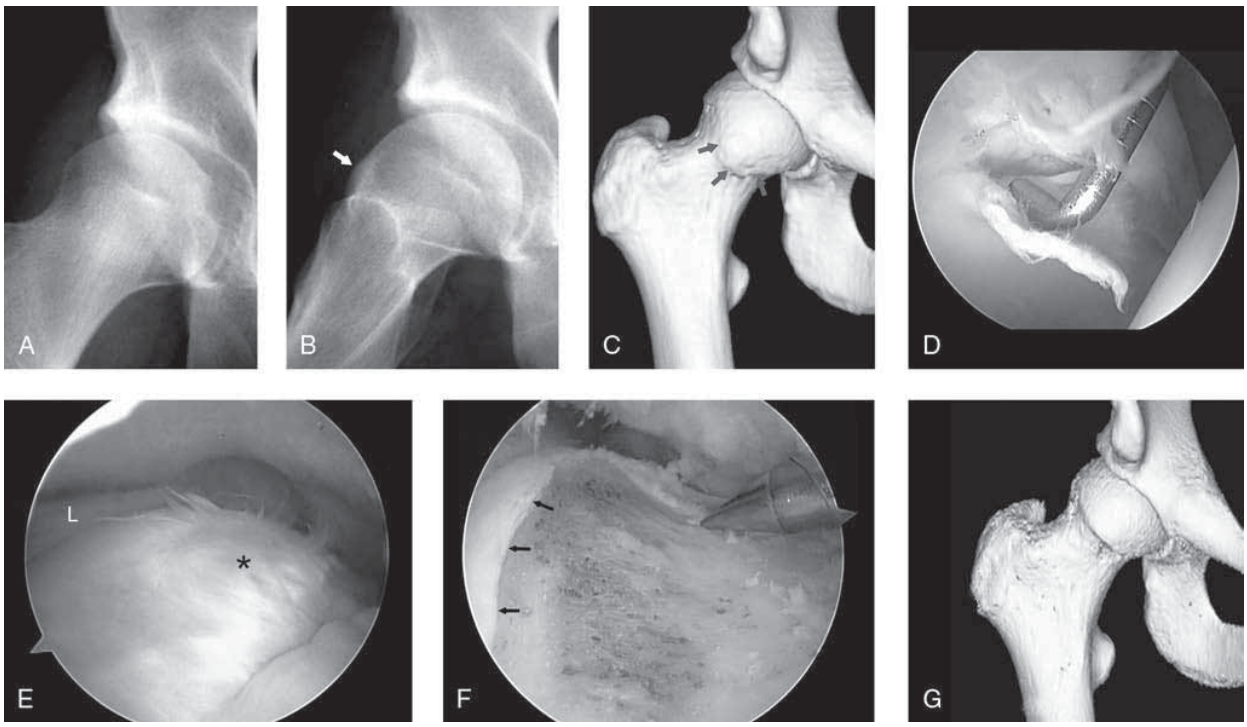

Figure 8 Imaging studies of the right hip of a 20-year-old man who plays hockey and has a 4-year history of pain. **A,** AP radiograph is unremarkable. **B,** Frog-leg lateral radiograph demonstrates a morphologic variant with bony buildup at the anterior femoral head/neck junction (*arrow*) characteristic of cam impingement. **C,** A three-dimensional CT scan further defines the extent of the bony lesion (*arrows*). **D,** Viewing from the anterolateral portal, the probe introduced anteriorly displaces an area of articular delamination from the anterolateral acetabulum, which is characteristic of the peel-back phenomenon created by the bony lesion shearing the articular surface during hip flexion. **E,** Viewing from the peripheral compartment, the bony lesion is identified (*) immediately below the free edge of the acetabular labrum (L). **F,** The lesion has been excised, re-creating the normal concave relationship of the femoral head/neck junction immediately adjacent to the articular surface (*arrows*). Posteriorly, resection is limited to the midportion of the lateral neck to avoid compromising the blood supply to the femoral head from the lateral retinacular vessels. **G,** Postoperative three-dimensional CT scan illustrates the extent of bony resection. (Courtesy of J. W. Thomas Byrd, MD, Nashville, TN.)

that this line of demarcation is just below the rim of the acetabulum allows the acetabulum to be partly used as a template in determining the circumferential line of resection adjacent to the articular surface. Excessive flexion will cause a portion of the cam lesion to disappear underneath the acetabulum and result in inadequate resection.

A cephalad anterolateral portal is established approximately 5 cm above the anterolateral portal, entering through the capsulotomy that has already been established. These proximal and distal anterolateral portals work well for accessing and treating the cam lesion. The anterior cannula can be removed or maintained if it is needed for better access to the medial side of the femoral neck.

Recontouring

Most of the work for recontouring the cam lesion (femoroplasty) lies in the soft-tissue preparation. This includes capsular débridement as necessary to ensure complete visualization of the lesion and then removal of the fibrocartilage and scar that covers the abnormal bone. With the hip flexed, the proximal portal provides better access to the lateral and posterior portion, whereas the distal portal is more anterior relative to the joint and provides the best access to the anterior part of the lesion. The lateral synovial fold is identified as the arthroscopic landmark for the retinacular vessels, and care is taken to preserve this structure during recontouring. Switching between the portals is important to fully appreciate the three-dimensional anatomy of the recon-

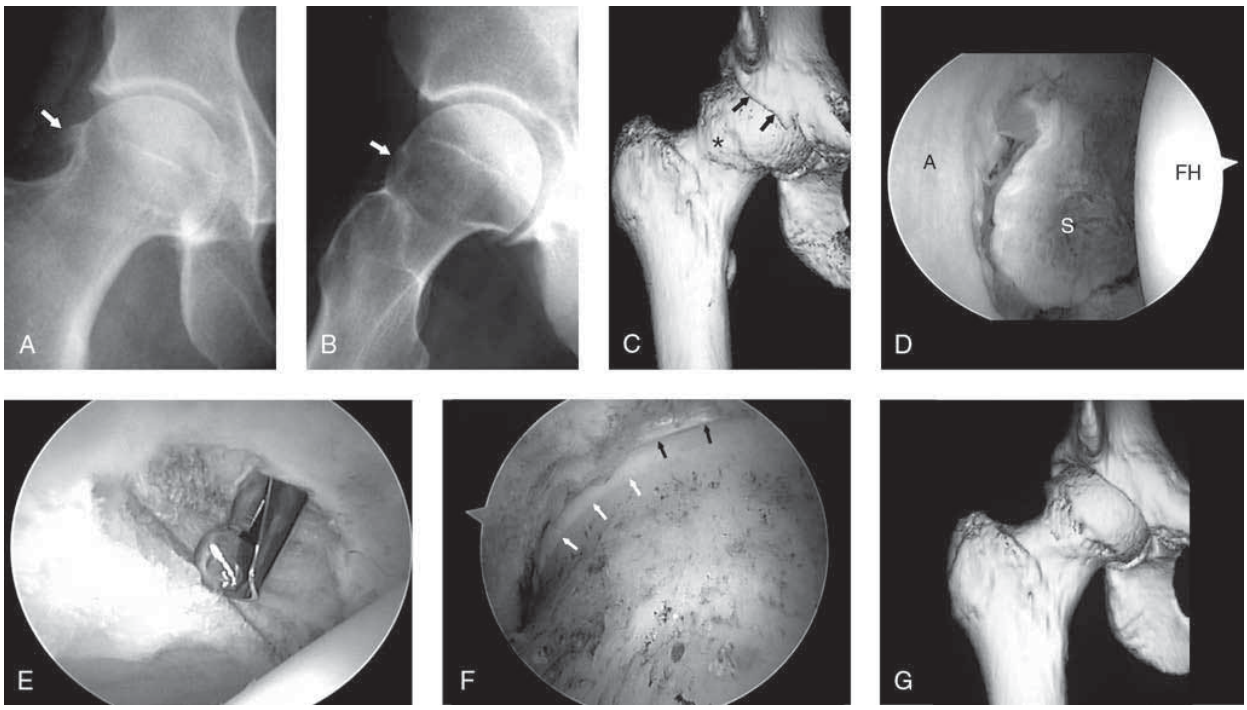

Figure 9 Imaging studies of the right hip of a 38-year-old woman with progressive pain and loss of motion. **A,** AP radiograph demonstrates acquired bony buildup/osteophyte formation on the lateral femoral head (*arrow*). **B,** A frog-leg lateral radiograph further defines the bony buildup on the anterior femoral head (*arrow*). **C,** A three-dimensional CT scan further defines the femoral head osteophyte (*) and the anterior acetabular lesion (*arrows*). **D,** Arthroscopy of the central weight-bearing surface of the joint demonstrates good articular preservation of both the acetabulum (A) and femoral head (FH), with some reactive synovitis within the fossa (S). **E,** The anterior acetabular osteophyte is excised. **F,** Viewing peripherally, the femoral head has been recontoured, showing the edge of the femoral articular surface (*white arrows*) and the labrum (*black arrows*). **G,** A postoperative three-dimensional CT scan demonstrates the extent of bony recontouring of both the acetabulum and femoral head. (Courtesy of J. W. Thomas Byrd, MD, Nashville, TN.)

touring. Trying to complete the work with the arthroscope in a single portal increases the risk of creating a planar resection and not re-creating the spherical anatomy.

Once the bone has been fully exposed, recontouring is done with a spherical burr. Initial bony resection is done at the articular junction to fully demarcate the line of resection as well as its depth. The resection is then tapered distally to make it flush with the natural neck of the femur. Particular attention is paid to ensure that the bony resection is adequate but does not notch the femoral neck or leave a potential stress riser. The resection begins at the posterolateral limit of the cam lesion, with the arthroscope in the more distal portal and instrumentation in the more proximal portal. The posterior extent of the resection usually is the most difficult and is the most critical procedure to avoid notching the tensile surface of the femoral neck; particular attention must be given to avoiding and preserving the lateral retinacular vessels. Then, switching the arthroscope to the proximal portal, the burr is introduced distally, and reshaping is completed along the anterior head and neck junction. All bone debris is removed as thoroughly as possible, to lessen the likelihood of heterotopic ossification.

Rehabilitation

Formal supervised physical therapy begins within 1 or 2 days following surgery. The protocol is variable, depending on the pathology encountered and the procedure done. In general, the emphasis is on optimizing range of motion with early implementation of closed-chain joint stabilization and core-strengthening exercises.

With acetabuloplasty, weight bearing is allowed as tolerated. Crutches are used for approximately 1 week until the gait pattern is normalized, as dictated by pain. With femoroplasty, the patient is allowed to bear weight as tolerated, but crutches are used for

4 weeks as a precautionary measure against any awkward twisting episodes. Once normal muscle tone and response patterns have been regained, these will adequately protect the joint for normal forces. Impact loading is avoided for 3 months while the bone fully remodels.

The rehabilitation protocol is modified for microfracture by keeping the patient on a strict protected weight-bearing status for 2 months. The patient is allowed to place the weight of the leg on the ground, which provides optimal neutralization of forces across the joint.

A formal structured rehabilitation protocol is continued for 3 months. For athletes, functional progression is then advanced as tolerated. Although some athletes may resume unrestricted activities quickly, usually another 1 to 3 months are necessary for full participation.

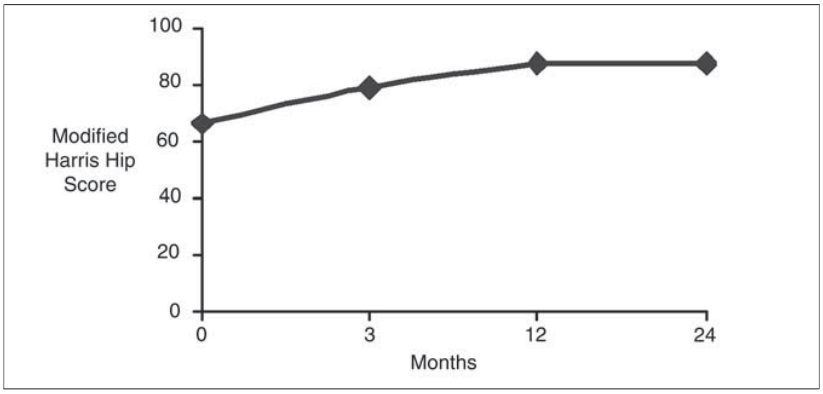

Figure 10 Results over time of arthroscopic treatment of FAI assessed using a modified Harris hip score.

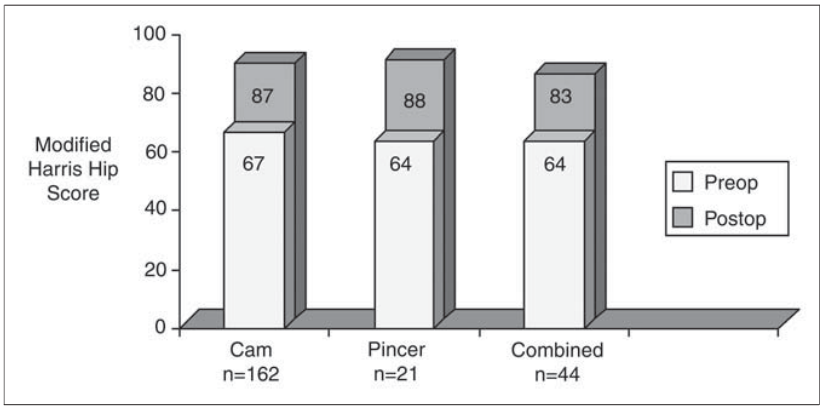

Figure 11 Results for cam, pincer, and combined impingement, assessed using a modified Harris hip score.

Results

Since 1993, all patients undergoing hip arthroscopy at the Nashville Sports Medicine and Orthopaedic Care Center have been prospectively assessed using a modified Harris hip score preoperatively and then postoperatively at 3, 12, 24, 60, and 120 months.[16-18] Arthroscopic treatment of FAI has been done in 227 hips in 220 patients, with a minimum 12-month follow up (average, 17 months) and 100% follow-up of all patients. The average age was 34 years (range, 13 to 77 years) in the 148 men and 72 women (130 right and 97 left hips). The average improvement was 21 points (preoperative, 66; postoperative, 87), with 85% of patients improved at the most recent follow-up. The results over time are outlined in Figure 10, with continued improvement noted throughout the first year and results maintained in those with 2-year follow-ups. Overall, using the Harris classification, there were 88 excellent, 99 good, 15 fair, and 18 poor results, with 7 hips requiring a subsequent procedure (1 total hip arthroplasty; 6 for repeat arthroscopy). Most had grade IV (115) or grade III (89) articular damage. A total of 162 hips had femoroplasty to correct cam impingement; 21 hips had acetabuloplasty to correct pincer impingement, and 44 hips had both procedures (Figure 11). There were three minor complications: one transient neurapraxia of the pudendal nerve and one of the lateral femoral cutaneous nerve, each of which resolved uneventfully, and development of heterotopic ossification within the capsule in one patient, which did not preclude a successful outcome.

Discussion

Arthroscopic management of impingement is not a new concept. Acetabular and femoral lesions have been treated arthroscopically at the Nashville Sports Medicine and Orthopaedic Care Center for two decades, but this was limited to posttraumatic osteophytes, avulsed fragments, and the occasional severely misshapen femoral head as a

sequela of Legg-Calvé-Perthes disease.[12,13] With the initial description of the concept of FAI, we were slow to adopt a role for arthroscopic management, but as the credence of FAI became more evident, we began to explore the potential value of a less invasive arthroscopic approach. The results of this study reflect this evolution. The current understanding of FAI and the arthroscopic strategies to treat it will continue to evolve.

In our study of FAI, there was a disproportionate prevalence of cam lesions, which probably was influenced by the criteria on which surgical correction was based. If the labrum is intact, the patient does not have pincer pathology. For a patient with a positive crossover sign and a healthy labrum, we have been hesitant to take down normal tissue to correct a radiographic variant based on the conceptual concern that this variant is bad, even in the absence of joint pathology. Although the labrum can be refixed, its appearance will never come close to that of the native uninjured tissue.

Radiographic indices of pincer morphology are questioned but not discounted. It is unclear what relevance the radiographic measures made on a properly centered supine view have in relationship to the individual orientation of the pelvis with functional weight-bearing activities. Many factors influence an individual's pelvic orientation; for example, variability of lumbar kyphosis or lordosis can accentuate pelvic flexion or extension and significantly alter functional overcoverage or undercoverage from the acetabulum. As difficult as it is to obtain a properly centered, standardized supine AP radiographic view of the pelvis, accomplishing this with a standing radiograph produces even greater inconsistencies and is unlikely to be better suited to assessing functionally relevant radiographic indices.

This report raises four important questions. First, does surgical correction (open or arthroscopic) of FAI result in successful outcomes? There are ample data that, using various outcomes instruments, a significant portion of patients have improvement with surgical intervention.

A second question is whether surgical correction of FAI alters the natural history of this disorder. Although successful results have been reported, in absence of a true control cohort in which the disorder is untreated, this question cannot be answered with scientific validity.

Third, how do the results of arthroscopic management compare with those of the open method? Clearly, arthroscopy offers a much less invasive technique, lower risks of complications, and an easier recovery without hospitalization. However, is it as effective? Although there are no single-institution studies that compare open and arthroscopic methods, the literature increasingly supports that, in properly selected patients, successful results can be accomplished with arthroscopic techniques. Although visualization and assessment of the adequacy of recontouring are more complete with an open approach, with proper patient selection and planning, it appears that the arthroscopic method can come close to accomplishing this recontouring with equal precision. Aided by three-dimensional CT, which serves as a road map for the arthroscopic surgeon, recontouring can be successfully accomplished.

Fourth, does arthroscopic correction of underlying impingement lead to better results than treatment of only the soft-tissue pathology? Clearly, correction of the underlying impingement represents a more extensive surgical undertaking with potentially greater complications. There are no randomized studies comparing the results of arthroscopy with and without correction of the impingement. However, in this center, there is ample historic data contained within a 15-year database from which to answer this question. Many patients had arthroscopy before recognition of FAI as an entity, and impingement was not corrected. A separate study is underway to compare results in patients with and without correction of bony impingement.

Early experience in the arthroscopic management of FAI has resulted in 83% good and excellent results. This cohort represents more advanced pathology, with 90% grade IV (115) and grade III (89) articular damage. Overall, 85% were improved, with only one patient (0.4%) requiring conversion to a total hip arthroplasty. These results compare favorably to outcomes reported with open surgical dislocation, including the series of Beck and associates,[8] who described 68% successful outcomes with 26% conversion to total hip arthroplasty, and Murphy and associates,[19] who described 65% successful outcomes with 30% conversion to arthroplasty.

Summary

Many patients with FAI can be appropriately treated arthroscopically. Successful outcomes can be expected in most patients, but meticulous attention to the details of the procedure is required. The arthroscopic method has several advantages over open methods. As a less invasive procedure, it is done on an outpatient basis, with few complications, and facilitates postoperative

rehabilitation. The arthroscopic procedure may be better suited for individuals returning to an active lifestyle. Also, imaging studies may underestimate the severity of articular loss, which may become evident only during arthroscopy.

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