Surgical Treatment of Femoroacetabular Impingement: What Are the Limits of Hip Arthroscopy?

Ira Zaltz, M.D., Bryan T. Kelly, M.D., Christopher M. Larson, M.D., Michael Leunig, M.D., and Asheesh Bedi, M.D.

Abstract: The variety of hip pathology that can be addressed in a minimally invasive fashion in the young, pre-arthritic patient has rapidly grown in parallel with technical advances in hip arthroscopy. However, the indications and limits of arthroscopy must be carefully defined and indications must evolve correspondingly to avoid an increase in failure rates and unsatisfactory clinical outcomes. Some diagnoses may be better and more comprehensively addressed with open procedures or combined surgical approaches. The purpose of this article is to provide an unbiased and evidence-based review of conditions of the pre-arthritic hip to define our current understanding of the advantages, disadvantages, and limitations of an arthroscopic approach.

The concept of femoroacetabular impingement (FAI) has evolved considerably since its incorporation into an accepted mechanistic explanation for the pathogenesis of osteoarthritis. Two surgical techniques that are used to treat FAI, open surgical dislocation and hip arthroscopy, have emerged as the most commonly used surgical treatment approaches. Although both techniques are powerful, each has unique strengths and limitations that must be considered in selecting the ideal surgical approach for the specific deformity of symptomatic patients.

Open surgical dislocation has provided invaluable insight into acetabular and femoral dysmorphism, associated labral and chondral injury patterns, technical methods for skeletal recontouring and cartilage restoration, dynamic assessment of both pretreatment and post-treatment skeletal morphology, extra-articular movement-limiting skeletal impingement, and practical applications of the vascular anatomy of the upper femur. It is upheld by its proponents as the gold standard in the treatment of FAI because it provides nearly 360° access to the hip joint, the capability to precisely contour the femoral head, and the ability to treat all types of hip abnormalities, both intra-articular abnormalities and extra-articular deformities, such as rotational deformities and pelvic-trochanteric impingement. It is often criticized, however, because it is a "big" operation that requires a trochanteric osteotomy with potential for increased blood loss, sacrifice of the ligamentum teres, more extensive muscle dissection, and thus, a potentially prolonged rehabilitation (Table 1).

Hip arthroscopy has evolved rapidly and has become the most prevalent technique for the treatment of FAI. To be fair, arthroscopy has also helped to elucidate many of the effects of FAI and instability. The ability to see and to evaluate intra-articular abnormalities of the ligamentum teres, articular cartilage, labrum, capsule, and synovium is unique. Many arthroscopic techniques and instruments that were developed for the treatment of ligament, meniscus, and cartilage restoration in the knee and shoulder have evolved and been modified to be very effective in the hip. The attractiveness, for surgeons and patients, of an arthroscopic approach is obvious. For patients, it offers a potentially "less" invasive approach for treatment, less muscle dissection, and faster rehabilitation. It must be recognized, however, especially in difficult cases performed early in a surgeon’s experience, that repeated introduction of instruments into the hip
joint and manipulation of tissue have the potential to result in significant muscle, tendon, and capsular damage. In addition, the attractiveness of arthroscopy must be accepted with some caution because the procedure is technically demanding and the risks of iatrogenic chondral injury and incomplete correction of the deformity and, consequently, the potential need for revision surgery can be considerable. It is also criticized because it is difficult to accurately measure the femoral contour, dynamic assessment is more challenging, and the associated traction-related neurologic complications and complications of fluid extravasation are unique to arthroscopy and can be devastating (Tables 1 and 2).

As the field of hip-preserving surgery expands, what are the roles for arthroscopy and surgical dislocation? Does the arthroscopic approach to the hip joint have limitations, and are there cases in which surgical dislocation is better? Should the 2 procedures/approaches be used interchangeably depending on a surgeon’s training, or should they be used when appropriate depending on the anatomy of the hip disorder requiring treatment?

Three publications have compared surgical dislocation, the “mini”-open anterior approach, and the arthroscopic approach for the treatment of FAI. The studies are systematic literature reviews that attempted to compare technique-associated reported complications and outcomes. Matsuda et al. concluded that all techniques were associated with clinical improvement and the surgical dislocation procedure was associated with the highest complication rate, mostly related to the trochanteric osteotomy. The conclusion of Botser et al. largely drawn from the same references used by Matsuda et al., suggests that surgical arthroscopy is associated with a more rapid rehabilitation, fewer complications, and fewer reoperations. The conclusions of both reviews, however, were highly influenced by the selection of patients who participated in the analyzed studies. Most of the patients who were treated by open dislocation represented cohorts treated from the mid 1990s until approximately 2003. In contrast, most of the arthroscopy patients were treated in the mid to late 2000s. Furthermore, the selection of patients who underwent surgical dislocation included patients with more advanced degeneration and diagnoses other than traditional cam- or pincer-type FAI. In contrast, most of the arthroscopy patients did not have arthritis and had traditional forms of FAI. Papalia et al. also examined similar literature and concluded that the results after all 3 procedures are equivalent and that there are insufficient data to support 1 technique over another. A recent prospective matched series published by Domb et al. suggests that the outcome scores in arthroscopically treated patients are higher at 2 years’ follow-up. Consequently, the answers to the aforementioned questions remain unclear, and the available information is not sufficient to support 1 treatment modality over another.

There are reports that support excellent clinical function after both open and arthroscopic treatment of FAI. These reports primarily come from centers that have expertise and experience using either arthroscopy or surgical dislocation. Nevertheless, the efficacy of both techniques is not presently debatable. The arthroscopic approaches are being used for traditional cam- and pincer-type FAI, whereas surgical dislocation is increasingly reserved for more complex deformities with treatment performed surgeons or institutions that use both approaches (Tables 1 and 2).

The limitations of arthroscopic hip surgery depend on surgeon skill level and the pathologic entity that requires treatment. Arthroscopic skill level and surgical judgment are difficult to assess, as is the hip arthroscopy learning curve. The learning curve is very difficult to define and depends on the depth of knowledge of hip anatomy and mechanics, understanding of hip pathoanatomy, and previous general arthroscopic skills. Consequently, as a surgeon progresses through the learning curve, the limits of the procedure expand to include increasingly complex and challenging deformities.

### Table 1. Advantages of Techniques for Hip Preservation Surgery

<table>
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<tr>
<th>Technique</th>
<th>Advantages</th>
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<tr>
<td>Open surgical dislocation</td>
<td>360° access to femoral head and acetabulum</td>
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<td>Optimal visualization for correction of deformity</td>
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<td>Ability to confirm sphericity with open templates</td>
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<td>Treatment of extra-articular and intra-articular deformation</td>
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<td>Optimal visualization with open dynamic assessment</td>
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<td>Ability to perform relative neck lengthening</td>
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**Hip arthroscopy**

- Minimally invasive
- Potentially reduced pain and outpatient procedure
- Potentially faster rehabilitation
- Potential for reduced soft-tissue injury

### Table 2. Limitations of Techniques for Hip Preservation Surgery

<table>
<thead>
<tr>
<th>Technique</th>
<th>Limitations</th>
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<tr>
<td>Open surgical dislocation</td>
<td>Trochanteric osteotomy and potential for symptomatic hardware/nonunion</td>
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<tr>
<td></td>
<td>Increased blood loss</td>
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<td></td>
<td>Ligamentum teres disruption</td>
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<td>Potential for prolonged rehabilitation</td>
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<td>Risk of avascular necrosis</td>
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<tr>
<td>Hip arthroscopy</td>
<td>Traction-related complications and nerve injury</td>
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<td>Steep learning curve</td>
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<td>Incomplete access and correction of deformity</td>
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<td></td>
<td>Inability to directly confirm restoration of sphericity and offset</td>
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<td></td>
<td>Iatrogenic chondral injury</td>
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<td>Fluid extravasation and thigh or abdominal compartment syndrome</td>
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<td>Portal complications (lateral femoral cutaneous nerve injury)</td>
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**Trochanteric osteotomy**

- Potential for reduced soft-tissue injury
- Prolonged rehabilitation
- Risk of avascular necrosis
- Inability to directly confirm restoration of sphericity and offset
With the assumption of arthroscopic proficiency and a detailed understanding of hip pathoanatomy, the limitations of arthroscopy, where surgical dislocation may provide superior exposure and more reconstructive options and may be associated with fewer complications, should be decided based on the pathomorphology and the desired mechanical result. To determine the suitability of arthroscopic treatment for these more challenging pathomorphologies, each anatomic entity that may generate hip pain should be considered individually. These include slipped capital femoral epiphysis (SCFE), Legg-Calvé-Perthes (LCP) disease, acetabular dysplasia and other causes of hip instability, femoral causes of FAI, and acetabular causes of FAI (Table 3).

**Slipped Capital Femoral Epiphysis**

The association between SCFE and damage to the acetabular labrum and peripheral cartilage is well-established. After or in combination with epiphyseal stabilization, specific cases of SCFE may be suitable for arthroscopic treatment. Most cases of acute displaced or painful chronic SCFE with an increased slip angle are more appropriately treated with open surgical techniques that enable osteochondroplasty, epiphyseal reduction, or redirection osteotomy (Fig 1). It is important to emphasize that adjuvant arthroscopic treatment of SCFE is an emerging technique with little long-term follow-up. A recent report by Akkari et al suggests that arthroscopic technique may be used to effect epiphyseal reduction even in patients with severe deformity. The anatomic analysis and mechanical implications of various femoral and acetabular morphologies are of renewed interest and will certainly influence the ability to eliminate impingement that may be associated with SCFE.

Presently, the selection of patients who may benefit from arthroscopy depends largely on femoral morphology. The precise indication for arthroscopy has not been established; however, a concomitant osteochondroplasty may be suitable in cases of untreated “mild” SCFE with minimal angulation, no chronic neck deformity, and translation of the epiphysis less than roughly 5 mm (or one-fifth the width of the epiphysis). Certainly, more extensive neck resection is technically possible and may not pose a significant risk of femoral fracture; however, the mechanical implications of a persistent displaced epiphysis are not known. Previously treated SCFE that has healed and partially remodeled may resemble a cam-type morphology radiographically. If impinging portions of the deformity are accessible with an arthroscopic approach, then the surgeon may consider arthroscopic decompression rather than an open approach (Fig 2); however, the mechanical effect of varying degrees of femoral neck retroversion, acetabular depth and orientation, and epiphyseal displacement must be considered. Recent data underscore the complexity of impingement mechanics associated with SCFE including acetabular depth and orientation. Thus, at present, treatment recommendations cannot be based on femoral morphology alone.

**LCP Disease**

The deformity and mechanical consequences that are associated with healed LCP disease are complex. The
primary deformity is at the femoral head; the secondary deformity of the acetabulum, developmental chondrolabral abnormalities, and upper femoral deformity that are found in combination or in isolation may contribute to mechanical dysfunction, chondral and labral damage, and hip pain. FAI in healed LCP disease often comprises a complicated combination of extra-articular femoropelvic impingement and intra-articular impingement that can lead to both mechanical dysfunction and cartilage damage.

Given the complexity of LCP disease, most symptomatic patients are most efficiently accessed and treated by open approaches because the combination of anatomic sites and required techniques is generally beyond the capacity of arthroscopy. The coxa breva and vara deformity cannot be corrected arthroscopically and may be addressed more thoroughly by open approaches that restore both neck length and offset. Furthermore, many patients with LCP disease have significant acetabular deformity that can contribute to impingement or instability (Fig 3). Large osteochondral defects may necessitate open surgical treatment as well (Fig 4). Unique patients with isolated symptomatic labral or intra-articular osteochondral abnormalities may benefit from arthroscopy and should be considered on a case-by-case basis. Arthroscopic access in patients with retroverted LCP disease may be difficult to achieve and should be considered preoperatively. There is a paucity of available follow-up data concerning the efficacy of arthroscopic treatment in Legg-Calvé-Perthes disease. Certain patients, especially those with identifiable discreet chondral, ligamentum teres, or labral damage may improve symptomatically with arthroscopic treatment.

Acetabular Dysplasia and Instability

The role of standalone arthroscopy in the management of symptomatic acetabular dysplasia is a matter of continued controversy and concern. It is understood that acetabular dysplasia leads to failure of the peripheral chondrolabral complex, an event that typically coincides with increased pain and dysfunction. The rationale for arthroscopic repair of the rim defect is to restore the labrum to its pre-failure state, but such treatment ignores the underlying structural abnormality that precipitated the tear. The following factors are incompletely characterized and contribute variably to hip stability: the complexity of dysplastic acetabular anatomy; the variability and effect of femoral head size, shape, and orientation; the contribution from varying degrees of femoral torsion; and the supportive role of soft tissues, including the ligamentum teres, labrum, and capsule. Representative of the complexity of hip instability are recent reports of hip dislocation after arthroscopic capsular release or resection and failure of psoas tenotomy in patients with femoral anteverversion.

The available published information is conflicting, and meaningful conclusions are difficult to deduce. Byrd and Jones reported the results of hip arthroscopy in dysplastic and borderline dysplastic hips classified using...
the lateral center-edge angle. They showed improvement in each dysplastic type of at least 10 points on the modified Harris Hip Score (mHHS) scale, representing a modest clinical improvement. Subsequent publications have documented failure after arthroscopic treatment. Consequently, the decision to treat dysplastic or unstable hips arthroscopically should be made cautiously because surgical destabilization caused by capsulotomy, ligamentum teres resection, and labral debridement is a significant concern, and the patients should be followed up carefully after surgery for signs of increased instability. The complexity of hip instability, the mechanical role of femoral version, and the coexistence of morphologic features consistent with impingement and instability are increasingly recognized. Consequently, it is increasingly difficult to diagnose dysplasia based on only traditional radiographic measures. As such, the role of arthroscopy in patients with focal acetabular hypoplasia and increasing femoral version should be approached cautiously.

Fig 2. (A) Anteroposterior pelvis and (B) Dunn lateral radiographs of an 18-year-old woman with symptomatic right hip pain and restricted flexion and internal rotation after in situ pinning of an SCFE. (C) Three-dimensional computed tomography imaging shows loss of offset and the prominent, symptomatic hardware potentially impinging in the terminal range of motion. The slip angle is less than 30°, and there is minimal epiphyseal translation. Intraoperative arthroscopic photographs show (D) prominent screw and (E) osteochondroplasty after screw removal to restore sphericity and offset. The camera is in the modified midanterior portal.
There is general agreement that patients with classic anterolateral acetabular insufficiency, lower-range center-edge angles, and/or increased femoral anteversion should not undergo arthroscopy as a standalone procedure. Arthroscopy may be used in conjunction with acetabular reorientation to treat intra-articular pathology and as a means of staging the degree of cartilage damage.42

**Femoroacetabular Impingement**

The evolution of hip arthroscopy has substantially altered the approach and understanding of FAI. Whereas mechanical principles have been established based on the surgical dislocation approach,1,2 multiple publications have substantiated the efficacy of arthroscopic treatment of FAI. There is an acknowledged debate on the relative efficacy and appropriate use of each approach in the treatment of FAI. Advantages of the open approach include complete access to the intracapsular femur and the acetabulum, the ability to access and correct extra-articular portions of the upper femur, and the ability to dynamically assess the hip morphology, as well as the improvement in kinematics after surgical correction (Fig 5). The procedures that can be performed using a surgical hip dislocation include labral and cartilage debridement, femoral neck osteoplasty, acetabular rim osteoplasty, labral repair or reconstruction, cartilage restoration (microfracture, autologous matrix induced chondrogenesis, osteoarticular transfer system, allograft), capsular repair or plication, femoral neck osteotomy, femoral neck lengthening, trochanteric transfer, and intertrochanteric or subtrochanteric osteotomy. The main disadvantage of the procedure involves the more extensive muscular dissection, need for a trochanteric osteotomy, and associated postoperative rehabilitation. The complications of the procedure have been retrospectively reported.5,43,44 Outcomes after surgical hip dislocation are
favorable provided that chondral loss is absent, even in high-level athletes. Hip arthroscopy has evolved considerably over the past decade. Improvements in instruments designed specifically for the hip joint, alterations in capsular management techniques, and intraoperative radiographic and dynamic assessments have improved the versatility of the procedure (Fig 5). Currently, arthroscopy enables visualization of nearly the entire acetabulum and femoral head; the anterior two-thirds of the peripheral compartment; and the periarticular extra-acetabular structures, including the anterior inferior iliac spine (AIIS), acetabular rim, and peritrochanteric space. Access highly depends on technical expertise and is typically limited to approximately two-thirds of the acetabulum, the anterolateral half of the femoral head and neck, and the AIIS. Very experienced arthroscopists, however, have shown the ability to access the posterosuperior/lateral and inferior/medial head-neck junction as well as the posterior acetabular rim for more complex deformities. As in the open approach, dynamic assessment requiring specific capsular management techniques remains a critical portion of the procedure and is more technically challenging to perform during arthroscopy because varying positions of flexion, extension, adduction, and abduction, with both internal and external rotation, are necessary to understand the mechanical consequences of surgical interventions.

Multiple reports provide short-term outcomes after hip arthroscopy for the treatment of FAI. Singh and O’Donnell reported that 23 of 24 Australian Football League players were able to return to sport. The mean mHHS values preoperatively and at 4 years postoperatively were 87 points and 96 points, respectively. Similarly, the Nonarthritic Hip Scores were 81 points and 96 points, respectively. Nho et al. reported outcomes in high-level athletes participating in multiple sports. Of 47 patients, 33 (70%) were followed up for a mean of 27 months. Seventy-three percent returned to play at 2 years. The mHHS improved from 68 ± 12 points preoperatively to 88 ± 17 points postoperatively. Byrd and Jones reported on 100 consecutive patients with 2-year outcomes after arthroscopic treatment of cam-, pincer-, and mixed-type FAI. The mean preoperative mHHS was 65 points, and the mean improvement was 21 points. Preoperative and postoperative scores were worse in patients with more severe chondral damage. Philippon et al. reported the results of 63 of 153 patients, aged 50 years or older, 3 years after arthroscopy for FAI. Conversion to total hip replacement soon after arthroscopy occurred in 20% of patients (31 of 153). The mHHS improved from 58 points to 84 points in surviving hips. Philippon et al. also reported their results in 60 children and adolescents who were treated arthroscopically for FAI. They noted improvement in the mHHS from 57 points to 91 points at 3 years’ follow-up in 54 patients. Eight female patients required second-look arthroscopy for capsulolabral adhesions. Boykin et al. reported the results of arthroscopy in high school and collegiate rowers. Only 56% had a documented return to sport. McCormick et al. followed up 125 of 176 patients who had arthroscopy for labral tears due to FAI. Seventy-one percent reported good or excellent results, and the presence of osteoarthritis was identified as an independent predictor of a worse outcome.

Recent information comparing improvements in outcome scores and patients’ interpretation of success after treatment for FAI indicates that improvement in scores does not correlate linearly with “feeling good.” When applied to information after both open and arthroscopic treatment of FAI, the data suggest significant room for improvement in both open and arthroscopic treatment.
Fig 5. Intraoperative photographs of a left hip undergoing surgical dislocation (A) before and (B) after open osteochondroplasty for symptomatic FAI in a 20-year-old male soccer player. A sphericity tool can be used intraoperatively to confirm the quality of correction. The circumferential nature of the cam lesion extending superior and posterior to the lateral retinacular vessels may make an open approach more reliable with such an extensive deformity. (C) Intraoperative arthroscopic photograph of right hip arthroscopy for symptomatic FAI. The camera is in the modified midanterior portal of the right hip. The cam-type deformity may be well visualized with effective capsular management, including definition of the plane between the gluteus minimus and iliacusus musculature, followed by (D) T-capsulotomy and (E) retraction to perform a complete osteochondroplasty, followed by (F) capsular closure. (G) Preoperative and (H) postoperative Dunn lateral fluoroscopic images show excellent restoration of sphericity and offset.
Surgical indications for arthroscopic hip surgery vary because the technique has been reported in children, adolescents, and adults with varying anatomy. There is general agreement that patients who have greater than Tönnis grade 1 changes are unsuitable candidates for treatment of FAI regardless of surgical modality.\(^{45,54}\) Bardakos and Villar\(^{56}\) suggested that patients with cam-type morphology, a higher neck-shaft angle, and a hypoplastic acetabulum are at greater risk of rapid progression of arthrosis. Consequently, it is accepted that patients with higher neck-shaft angles and hypoplastic acetabuli should be approached individually and with caution, especially in the presence of anterior acetabular chondromalacia that is associated with anterior translation of the femoral head and a non-concentric joint center.

**Limits of Hip Arthroscopy**

Despite tremendous advancements in the understanding of FAI and in arthroscopic techniques to access and instrument the central and peripheral compartments, there remain certain limitations. Technical limitations, especially while one is ascending the arthroscopic “learning curve,” and cognitive limitations in interpreting the mechanical consequences of hip anatomy are the primary concerns, acknowledging that these issues also exist for open surgeons. It is helpful to categorize certain pathomorphologies that may not be appropriate for an arthroscopic approach. Femoral-sided deformities may include large cam deformity with significant posterior and posterolateral extension, associated femoral chondral defects, and confirmed or suspected extra-articular ischiofemoral or trochanteric-pelvic impingement, as well as hips with morphology that can also be associated with hip instability such as coxa valga, a high fovea, an everted femoral head, and a retroverted femoral head with insufficient or minimal offset. Acetabular-sided morphologies that may be better treated by an open approach include borderline dysplastic acetabuli (anteverted or superiorly or posteriorly deficient), moderate to severe acetabular retroversion that may also be associated with posterosuperior deficiency, and coxa profunda. Protrusio is a particularly complex deformity that can even be associated with a large lunate fossa and deficient articular cartilage and should be approached arthroscopically with greater caution.

Cam-type femoral morphology is highly variable and includes localized anterior deformity to global asphericity. The mechanical significance of any particular deformity may depend on sport-specific movements. For example, a hockey goaltender, a soccer player, and a baseball catcher may be affected differently by the same femoral morphology. Bedi et al.\(^{57}\) evaluated the efficacy of arthroscopic and open surgery on alpha angle measurement and concluded that posterolateral cam morphology may be more effectively treated by an open approach. Posterior femoral neck cam morphology or osteophytes may not be symptomatic; however, when posterior impingement is thought to be symptomatic, an open approach is clearly superior to arthroscopy for both assessment and treatment.

Extra-articular impingement may be an underdiagnosed entity. Anatomically, impingement between the ischium and lesser trochanter, AIIS and medial femur,\(^{58,59}\) and greater trochanter and trochanteric base with the lateral ilium and rim of acetabulum has been described. Both diagnosis and treatment are challenging with current radiologic techniques. Often, confirmation of a suspected diagnosis is made at the time of surgery. Although arthroscopic AIIS/subspine osteoplasty is technically possible, the diagnosis and treatment of ischiofemoral and trochanteric-pelvic impingement are not possible through an arthroscopic approach. As such, an open approach in these situations may be more effective.

Cam morphology associated with increased femoral anteversion may be treated effectively with an open or arthroscopic approach, but the open approach affords an evaluation of extra-articular pathomechanics that may be missed or not correctable arthroscopically.\(^{59,60}\) These patients may have impingement on the posterior acetabulum in extension or external rotation, which can cause primary posterior chondrolabral lesions, as well as anterior shearing injuries. Although femoral osteoplasty is certainly possible in these patients, it is difficult to assess the mechanical effectiveness of the arthroscopic intervention. In addition, failure by inexperienced arthroscopists to securely repair the anterior capsule may risk suboptimal clinical results or potentiate instability. FAI that occurs in the setting of deficient acetabular coverage or significant coxa valga may be better treated by either a surgical dislocation approach or peri-acetabular osteotomy and simultaneous osteoplasty. The definition of a “deficient acetabulum” is controversial and dependent on femoral neck version. A volumetrically insufficient acetabulum that is present in the setting of FAI is often identified as having a posterior wall sign, crossover sign, and borderline measurement of acetabular coverage.\(^{61,62}\) The long-term effect of an unrepaired capsulotomy in patients with borderline acetabuli is not predictable but can provoke or potentiate instability. Consequently, the surgeon should consider an open approach in such patients.

Certain acetabulum-sided deformities associated with symptomatic FAI that may be easier, safer, and more completely treated by an open approach include protrusio, coxa profunda, and secondary acetabular overcoverage due to circumferential labral ossification. Although arthroscopy has been reported in the treatment of these cases,\(^{63}\) the optimal treatment is not yet established and rim resection alone may not address or
correct the increased medial contact pressures, in particular for protrusion. Although arthroscopic subtotal rim resection is technically possible, it is a technical challenge. Protrusio with a negatively tilted sourcil and enlarged acetabular fossa may be more effectively managed by acetabular reorientation. Lastly, in cases of focal acetabular overcoverage that can be treated by rim osteoplasty and labral advancement, it is not known whether a compensatory femoral osteoplasty without treatment of the rim coverage is physiologically superior.

References
dislocation and relative femoral neck lengthening. 


