Arthroscopic Femoral Neck Osteoplasty in Slipped Capital Femoral Epiphysis

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Purpose: To investigate the outcomes of arthroscopic femoral neck osteoplasty in patients with slipped capital femoral epiphysis (SCFE)—related impingement. Methods: We retrospectively reviewed 37 consecutive patients (40 hips; 19 male and 18 female patients; age range, 10 to 19 years) with SCFE who underwent hip arthroscopy for femoral neck osteoplasty over a 4-year period. Six hips were excluded because of the severity of the slip or conversion to an open procedure. The preoperative and postoperative slip angle, alpha angle, and internal rotation in flexion were compared. Patients were evaluated for pain, functional limitations, and obligatory external rotation deformity (OERD) at each follow-up visit. The mean follow-up period was 22 months (range, 12 to 56 months). Results: We analyzed the results of 34 hips. Adequate distraction could not be obtained initially in 7 hips. The labral and acetabular cartilage damage appeared to be from crushing and abrasion from the bony prominence of the neck. The goals of complete pain relief and correction of OERD were achieved in 88% of the hips. OERD and pain persisted in 2 hips, and 2 patients had residual pain despite good motion. There was a statistically significant improvement in alpha angle (from 88.22° to 56.91°, P < .0001) and internal rotation in flexion (from −21.5° to 10.28°, P < .0001) with intervention. Conclusions: Arthroscopic femoral neck osteoplasty is effective in decreasing pain, the alpha angle, and OERD in mild to moderate SCFE. Morbid obesity, scarring from previous surgery, and the presence of screws in the anterior neck presented challenges to the arthroscopic technique. Level of Evidence: Level IV, therapeutic case series.

Slipped capital femoral epiphysis (SCFE) is the most common adolescent hip disorder. Typically, the deformity is caused by posteromedial displacement of the epiphysis with subsequent loss of anterior femoral neck concavity. Early stabilization of SCFEs with in situ screw fixation has become the standard to prevent slip progression and encourage physeal closure. Stabilizing the slip, however, does not address the residual deformity.

The natural history of SCFE deformity is controversial. One long-term study suggested that most hips did well, with an increasing risk of arthritis with more severe deformities. Other studies and our personal experience have shown that early joint damage occurs even with milder slips. This damage is believed to be from cam-type femoroacetabular impingement (FAI). The prominent anterior femoral neck impinges on the acetabular labrum and damages the articular cartilage, causing pain and limiting range of motion. The prominence of the anterior aspect of the femoral neck is known to remodel after stabilization of the epiphysis; however, the retroverted position of the femoral head does not correct after physeal closure with in situ fixation. Thus the remodeling of the anterior neck prominence occurs at the cost of joint integrity as this prominence impinges against the labrum and articular cartilage, potentially damaging these structures.

Although accurate correction of the deformity requires an osteotomy of the proximal femur to realign the head on the shaft, simple contouring of the neck (osteoplasty) to re-create the anterior head-neck concavity hypothetically could relieve impingement in mild to moderate slips. Femoral neck osteoplasty was performed through an anterior approach by Herndon et al. in 1963. Osteoplasty also can be performed through an open surgical dislocation approach. Arthroscopic osteoplasty for SCFE-related impingement was reported in a small case series with good results.
The upper limit of the deformity that can be addressed with ostheoplasty alone depends on the amount of neck that would remain after the ostheoplasty. Ganz and colleagues11 suggested that hips with a slip angle of 30° or less are amenable to ostheoplasty alone. A cadaveric study suggested that removal of more than 30% of the femoral neck could compromise the mechanical strength of the neck.12 However, this observation may not be valid in the SCFE because the femoral neck shows extensive callus formation in the posterior and inferior aspects and the neck is further reinforced with the in situ screw placement.

The purpose of our study was to investigate the outcomes of arthroscopic femoral neck ostheoplasty in patients with SCFE-related impingement. We hypothesized that arthroscopic treatment of SCFE-related impingement would be safe and reliable in decreasing pain and improving motion.

**Methods**

We found 37 consecutive patients (40 hips) who underwent hip arthroscopy for FAI due to SCFE between 2008 and 2011. The mean age of our patients was 13.1 years (range, 10 to 19 years). There were 19 male and 18 female patients. Twenty-two slips involved the left hip, and 18 involved the right hip. On the basis of the classification of Southwick,13 there were 21 mild, 16 moderate, and 3 severe slips. The mean follow-up period was 22 months (range, 12 to 56 months).

Seventeen slips presented with open physes that were not previously stabilized. All these hips were treated with in situ screw fixation before hip arthroscopy. Twenty-three hips presented after physeal closure and were treated with arthroscopy alone. Of these 23 hips, 18 underwent previous procedures, including 1 open osteoplasty and 2 modified Dunn osteotomies.

The indications for osteoplasty were mild to moderate SCFE hips with obligatory external rotation deformity (OERD) at 90° of hip flexion of less than 30°, bony morphology amenable to at least 30° of alpha angle correction, and neck pain especially in hips with closed physes. Hips with more severe deformity, arthritis, or conversion to open osteoplasty were excluded.

Six patients were excluded from the final analysis. Three were excluded because they were converted to an open osteoplasty, and the other 3 had severe slips and arthritis. Two of the 3 hips were converted to a limited anterior approach after initial arthroscopy under the same anesthetic. One conversion was because of technical difficulty in completing the procedure during the initial learning curve. The second conversion was because of obesity compounded by soft-tissue swelling preventing the arthroscope and the burr from reaching the femoral neck. The final conversion was because of pulmonary edema that developed within 30 minutes into the case during the diagnostic portion.14

Internal rotation of the hip in 90° of hip flexion (IRIF) is usually decreased from anterior FAI and was used as the functional expression of femoral and acetabular morphology.15,16 The slip angle was used to measure the severity of the slip. The alpha angle, originally used to measure asphericity of the femoral head on magnetic resonance imaging, was measured on lateral radiographs.17

Preoperative and postoperative data were obtained during physical examination and from radiographic imaging. IRIF of all hips was documented by the primary investigator using a goniometer. The degree of OERD was expressed as negative IRIF on clinical examination. Frog-leg lateral radiographs were used to measure the slip and alpha angles. The difference between the preoperative and postoperative values of slip angle, alpha angle, and IRIF was analyzed using a paired t test for statistical significance.

**Surgical Technique**

The percutaneous in situ screw fixation was modified by placing the screw more posteriorly in the femoral neck to allow for adequate anterior femoral neck osteoplasty. We described this technique in detail elsewhere.18 The screw placement is started as close to the lateral midline of the proximal femur as possible while still maintaining the screw anterior to the posterior cortex of the femoral neck and aiming it at the center of the femoral epiphysis, ignoring the oblique angle subtended to the physeal plane (Fig 1).

All hip arthroscopies were performed with patients in the supine position on the fracture table. Both feet were padded and rigidly fixed to the footplates, allowing a substantial amount of traction to be applied against a large perineal post to distract the affected hip joint. An anterolateral portal was established under fluoroscopic guidance, an anterior portal was established under arthroscopic visualization, and the joint was inspected. Labrum and articular cartilage flaps were stabilized or debrided routinely (Fig 2). Acetabular rim trimming was performed in one hip for increased acetabular coverage.

In hips that could not be distracted adequately in the beginning, traction was released and the hip was flexed to allow establishment of the anterolateral portal into the peripheral compartment first.19 This was followed by an anterior portal placement under direct visualization, capsulotomy, and joint distraction to inspect the central compartment.

The peripheral compartment was then inspected without traction using the same anterior portal. The anterolateral portal was redirected using the same skin incision. In our experience, the anterolateral portal in the capsule under distraction usually needs redirection through the muscles to the anterior neck as traction is released and the hip is flexed for peripheral-compartment access. A large T-shaped capsulotomy was performed,
and the anterior neck prominence was visualized (Fig 3). The retinaculum on the neck was usually soft and loosely attached to the bone and could be elevated or removed. The articular cartilage margin was easily identified as the loose retinaculum transitioned into white, firm cartilage that could not be elevated from the underlying bone. The bony prominence caused by the displaced femoral neck was removed, and the normal concavity was re-created at the head-neck junction using a burr. Flexion and extension of the hip allowed access to the femoral neck from the medial synovial fold to the lateral synovial fold. When the physis was open, the physeal cartilage could be visualized as a thin white line under the articular cartilage margin (Fig 4A). Because the epiphysis moves posteriorly at the growth plate in SCFE, the articular cartilage margin and the edge of the physeal cartilage converge to mark the medial extent of the neck contouring. Hence the osteoplasty involved shaving of the metaphyseal bone only, whereas the epiphyseal cartilage and bone were left intact. This is in contrast to idiopathic cam FAI, in which the osteoplasty extends into the articular cartilage medial to the physis (Fig 4B).

The hip joint could be flexed maximally to directly visualize any residual impingement and evaluate the adequacy of bone removal. Fluoroscopy was also used to confirm adequate reshaping of the head-neck junction (Fig 1B). The capsulotomy was left open, and the portal sites were closed and injected with a local anesthetic.

Most patients were sent home on the same day and were advised to use crutches and bear weight as tolerated. Home exercises using a stationary bicycle were encouraged to prevent stiffness. Patients were seen at 10 days’ follow-up for suture removal, at 4 weeks to assess range of motion, and every 3 months for a year.

**Results**

None of the 34 hips with mild to moderate SCFE treated successfully with the arthroscopic technique...
were lost to follow-up. Seven hips could not be distracted adequately initially, precluding safe central-compartment visualization. Two patients sustained minor iatrogenic injury: 1 labral injury and 1 acetabular lesion during initial portal placement. Neither patient was symptomatic or had stiffness. There were no other complications.

Arthroscopy showed synovitis, labral fraying, and adjacent articular cartilage damage in the anterosuperior quadrant of the acetabulum in most hips. Labral damage was seen in all 34 hips, and the labral lesions were descriptive only. The labral lesions were characterized by multiple intrasubstance splits, fraying, and erythema as if the labrum was crushed between the acetabular rim and the femoral neck prominence. None of the hips showed unstable labral tears that could benefit from repair. The labrum was minimally debrided routinely (Fig 2). Acetabular cartilage damage adjacent to the damaged labrum was seen in 26 hips. The damage appeared to be abrasive with roughening of the surface, without the softening or full-thickness flaps that are typically seen in idiopathic cam impingement. Full-thickness cartilage loss noted in 2 hips was left untreated.

There was no significant change between the mean preoperative slip angle of 25.44° (range, 12° to 56°) and mean postoperative slip angle of 25.05° (range, 13° to 55°) (P = .2). There was, however, a statistically significant decrease in the alpha angle with intervention; the mean preoperative and postoperative alpha angles were 88.22° (range, 70° to 118°) and 54.92° (range, 33° to 67°), respectively (P < .0001). The mean IRIF was −21.53° (range, −45° to 10°) preoperatively compared with 10° (range, −20° to 20°) postoperatively. This difference was also statistically significant (P < .0001). The mean results of all 34 hips are shown in Fig 5.

OERD was eliminated in 32 of 34 hips after arthroscopic osteoplasty alone. IRIF of 10° or more was obtained in 26 hips, 0° to 9° was obtained in 6 hips, and 2 hips had residual OERD (10° and 20°). Most children recovered their range of motion in a few weeks. Only 1 child required physical therapy because of stiffness at 4 weeks.

Overall, 88% of patients (30 of 34) met the goals of surgical intervention of neutral or greater IRIF and complete pain relief. Mild residual pain was seen in 2 patients. A quantitative pain scale was not used. Pain was relieved and the narrowed joint space improved in 1 patient with repeat osteoplasty. The other patient’s hip did not show any abnormal findings during the second arthroscopy, and it continued to be painful. Both children with residual OERD underwent correction with subsequent open osteotomies.

**Discussion**

We found that the pain and deformity from mild SCFE can be decreased with femoral neck osteoplasty. FAI is common in hips with residual SCFE deformity. However, the initial slip angle does not correlate directly with FAI, and even milder slips may require intervention.1-3,5-7,20 Femoral neck osteoplasty to decrease the bony prominence in SCFE has been advocated even for

**Fig 4.** (A) Arthroscopic view of right hip with mild slip as viewed through anterior portal without hip distraction. The osteoplasty extended to the articular margin and physsis of the femoral head (H). Exposure of the physsis (arrow) was performed for demonstration purposes only. (B) Arthroscopic view of right hip with idiopathic cam deformity as viewed through anterior portal without joint distraction. To restore femoral head (H) sphericity, the femoral neck osteoplasty extended well medial to the physsis (arrow). (L, labrum.)
mild slips. It was also performed in severe slips along with a proximal femoral osteotomy.

Hip range of motion seems to be predicted by residual deformity, femoral version, and acetabular morphology and is a reasonable measurement of impingement severity. Both the slip and alpha angles only measure the femoral deformity. Hence we used IRIF as a better measure of anterior impingement and the effect of the osteoplasty.

Femoral neck osteoplasty can be performed well through surgical dislocation, anterior arthrotomy, or arthroscopy. Arthroscopy is minimally invasive but does carry a low risk of unique complications such as traction injury, pudendal nerve compression, fluid distention, and iatrogenic damage. Although surgical dislocation is very safe for the articular cartilage and provides excellent visualization of the joint and the osteoplasty, it requires a large incision, muscle dissection, and trochanteric osteotomy and yields increased blood loss. A limited anterior approach does not show the joint well without distraction.

Arthroscopy in acute SCFE was initially described before in situ pinning. Roy recommended the use of arthroscopic osteoplasty in previously stabilized, milder slips with persistent signs of impingement. Leunig et al. reported on 3 cases of mild slips treated with in situ screw fixation and arthroscopic osteoplasty. Compared with open procedures, arthroscopic femoral neck osteoplasty in idiopathic cam-type deformity has not shown any statistically significant difference in terms of location and size of the resection. We believe that early arthroscopic management of the metaphyseal prominence eliminates further impingement; improves hip range of motion and function, as shown in Fig 5; and potentially decreases the incidence of post-slip osteoarthritis.

The impingement associated with SCFE appears to be anatomically and pathologically distinct from idiopathic cam impingement. In the former, the epiphysis moved posteriorly at the growth plate, leaving the anterior aspect of the femoral neck in a prominent position, leading to impingement. Hence the osteoplasty involved shaving of the metaphyseal bone only, whereas the epiphysial cartilage and bone were left intact. In idiopathic cam deformity, the physis and the epiphysial cartilage typically extended onto the neck without any retroversion of the head on the neck. This requires removal of the epiphysial bone and cartilage medial to the physeal cartilage to restore a spherical femoral head-neck contour. Our experience suggests that idiopathic cam deformity is not related to a mild undiagnosed slip. We also observed more labral damage and acetabular cartilage damage from abrasion in milder slips compared with idiopathic cam impingement, in which labral damage was minimal, with chondrolabral separation and articular cartilage debonding from the subchondral bone being diagnostic.

We also observed that hip arthroscopy in SCFE was more difficult because of severe obesity in some patients, scarring of the anterior capsule to the neck from previous surgery, and the need to remove screws that prevented an adequate osteoplasty when they were placed in the anterior neck. Dynamic evaluation of the adequacy of the resection was also difficult because of obesity.

We estimated the likely improvement of the alpha angle and internal rotation with the osteoplasty while leaving enough bone in the femoral neck on the frog-leg lateral view. Although the alpha angle was shown to correlate with remodeling, it was not an established predictor of success after osteoplasty. The effect of the retroverted head on the articular contact area of the hip may be significant, and this was not considered in our review.

Limitations

Our study has several limitations inherent to a retrospective case series performed without using standardized outcome measures or pain scales. Although an
experienced orthopaedic surgeon recorded physical examination measurements, measurement of IRIF is prone to observer error.

Despite these limitations, our study is the largest series of slips treated with arthroscopic osteoplasty to date. With proper patient selection and technique, elimination of pain and deformity can be expected in almost every patient at intermediate follow-up. This preliminary information should encourage further studies to define the indications and measure the outcomes to validate arthroscopic femoral neck osteoplasty in slips.

Conclusions

Arthroscopic femoral neck osteoplasty is effective in decreasing pain, the alpha angle, and OERD in mild to moderate SCFE. Morbid obesity, scarring from previous surgery, and the presence of screws in the anterior neck presented challenges to the arthroscopic technique.

References


