Outcomes 2 to 5 Years Following Hip Arthroscopy for Femoroacetabular Impingement in the Patient Aged 11 to 16 Years

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Purpose: The purpose of this study was to evaluate clinical outcomes after treatment for femoroacetabular impingement in the pediatric and adolescent population with a minimum of 2 years' follow-up. **Methods:** Prospectively collected data on 60 consecutive pediatric and adolescent patients (65 hips), aged 16 years or younger, who underwent hip arthroscopy were retrospectively analyzed. Patients were excluded if they had previous surgery on the hip and if they presented a center-edge angle below 25°. **Results:** The mean age at the time of surgery was 15 years (range, 11 to 16 years), and 31% of patients were boys and 69% were girls. The femoral physis was open in 10% of patients, partially closed in 19%, and closed in 71%. Cam impingement was found in 10% of cases, pincer impingement in 15%, and mixed type in 75%. The mean center-edge angle was 36° (95% confidence interval [CI], 34° to 38°), and the mean alpha angle was 64° (95% CI, 60° to 69°). There was a significant association between age and alpha angle ($r = 0.324$, $P = .02$). After the index procedure, 8 patients (all girls) needed second-look diagnostic arthroscopies because of intra-articular adhesions. At a mean follow-up of 3 years (range, 2 to 5 years) with 91% follow-up, the modified Harris Hip Score increased from a mean of 57 (95% CI, 51 to 62) to a mean of 91 (95% CI, 88 to 94) ($P < .001$). The median rating for patient satisfaction with outcome was 10 (range, 5 to 10). **Conclusions:** Hip arthroscopy in the pediatric and adolescent population is a safe procedure, with excellent clinical outcomes at 2 to 5 years. In this study there was an association between alpha angle and age. Clinical scores showed a significant improvement after surgery; however, 13% of patients did require a second procedure for capsulolabral adhesions. **Level of Evidence:** Level IV, therapeutic case series.

Femoroacetabular impingement (FAI) in the pediatric population can lead to injury of the labrum, chondral damage, and degenerative arthritis, as has been shown in the adult.[1-4] The etiology of FAI in the adult population may be multifactorial; however, it is most commonly caused by an idiopathic anatomic variant.[5,6] In the pediatric and adolescent population, hip pathology can be caused by other conditions including slipped capital femoral epiphysis (SCFE),[7] pistol-grip deformity,[7,8] Legg-Calve-Perthes disease,[9,10] developmental dysplasia of the hip,[11] and other congenital hip disorders.[6,11] In the absence of these hip pathologies in the young patient, FAI may be attributed to a developmental process resulting in prominence of the anterior and superior aspects of the femoral epiphysis.[12]

FAI with labral and chondral pathology has been successfully treated by hip arthroscopy in the adult population.[5,11,13-15] Adolescent hip impingement, especially with open physes, adds complexity to the

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treatment. Previous authors have described open hip dislocations with or without pelvic or femoral osteotomies to address hip impingement in this age group.[16-18] Open hip dislocation is a low-risk procedure[19]; however, some complications have been described in the pediatric population, including iatrogenic SCFE, avascular necrosis of the femoral head, and premature physeal closure.[6] Hip arthroscopy offers the potential advantages of a less invasive procedure, quicker recovery, and quicker return to activity.[20]

Hip arthroscopy in the pediatric and adolescent age group has been well described as a safe procedure for synovial biopsy,[21] septic arthritis,[22] inflammatory arthritis,[11,23] SCFE,[24,25] and Perthes disease.[10,26] Although some authors have described the use of hip arthroscopy to treat labral disorders in the adolescent population,[11] few authors have linked the treatment of adolescent FAI to labral and chondral pathology.[6,18,27] Previous reports of hip arthroscopy for FAI showed that at 1 year after arthroscopy,[27] adolescents returned to high function and activity. It is unclear whether this improvement can be maintained in the active adolescent.

The purpose of this study was to evaluate the outcomes at 2 to 5 years after hip arthroscopy for FAI in pediatric and adolescent patients. We hypothesized that improvement over preoperative modified Harris hip score (mHHS) would be maintained up to 2 to 5 years after hip arthroscopy for FAI in the active pediatric and adolescent population.

METHODS

After we obtained institutional review board approval in 2005, data were collected on patients who were aged 16 years or younger at the time of surgery for the treatment of FAI and/or chondrolabral dysfunction. Patients were required to have a minimum of 2 years' follow-up. Patients were excluded if they had undergone previous hip surgery or if they had a center-edge angle of less than 25°, which we considered to indicate a dysplastic hip. A total of 60 patients (65 hips) who underwent hip arthroscopy between March 2005 and May 2008 met the inclusion and exclusion criteria. All data were prospectively collected and retrospectively reviewed. Patient demographics included in data analysis included age, gender, body mass index, length of symptoms before surgery, and type of sport. All patients were competitive in their individual age group. There were no Olympic athletes in this group.

Patients underwent a detailed physical examination, with specific attention to the anterior impingement test and flexion–abduction–external rotation (FABER) test.[28] The FABER test was considered positive when the difference between sides was greater than 4 cm. Radiographic evaluation was performed with anteroposterior (AP) pelvis and cross-table lateral radiographs.[29] The center-edge angle was measured on the AP view, and the alpha angle was measured on the lateral view.[30,31] Radiographs were also evaluated to determine which type of FAI was present in each patient. Pincer type was documented in cases of coxa profunda or protrusio acetabuli and crossover sign. Cam type was documented in cases where the alpha angle was greater than 50° on the lateral view. The AP pelvic view was retrospectively reviewed by 2 orthopaedic surgeons, and the femoral head physis was graded as open, partially closed, or fully closed. Five preoperative radiographs were not available for femoral physis grading.

Magnetic resonance imaging (MRI) without contrast was obtained in all patients with the goal of evaluating the acetabular labrum, ligamentum teres, chondral surfaces, and other soft-tissue structures.

Subjects were determined to be surgical candidates after failure of nonoperative treatment (minimum of 6 months) with clinical and radiographic evidence of FAI. Before surgery, every patient underwent a nonoperative program. Because all patients were referral patients, not all patients underwent the same program. All patients underwent a hip arthroscopic procedure by the senior author using the modified supine position on a traction table and 2 working portals (anterolateral and midanterior).[5] The technique used was similar to that used for adult arthroscopy. A small capsulotomy was established connecting both portals to facilitate visualization and joint maneuverability. A general evaluation of the joint was performed after the capsulotomy. Labral tears, ligamentum teres tears, and chondral damage were recorded. In cases of cam-type FAI (Fig 1), an osteoplasty of the femoral head-neck junction was performed, and rim trimming was performed in pincer-type cases. Unhealthy tissue was initially debrided from labral tears, and suture anchors were used for labral repair. All patients underwent an intraoperative dynamic examination, in which the hip was taken through a full range of motion in flexion and abduction. The hip joint was directed visualized arthroscopically to guarantee that the labrum maintained contact (seal) with the femoral head through normal range of motion with no impingement of the labrum between the femur and the acetabular rim. At the end of surgery, the hip was flexed to 45° and

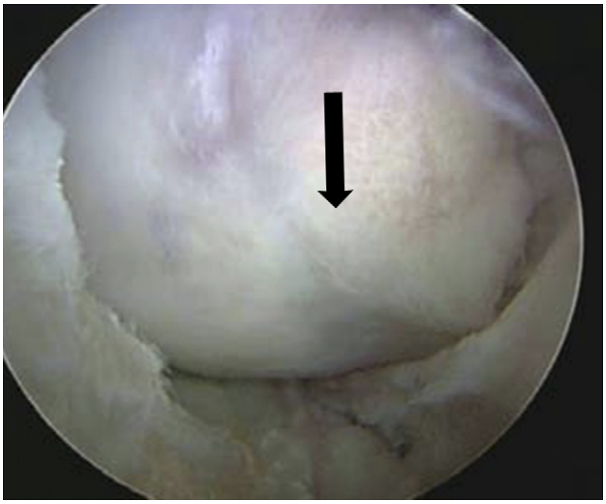

Figure 1. Intraoperative view of cam lesion. The arrow indicates where the deformity has formed on the head-neck junction.

internally rotated, a capsular closure was performed with a suture passer as a knot shuttle, and an absorbable suture was used to complete the closure. In cases of joint laxity as determined by capsular redundancy when the capsule was probed, a capsular plication was performed. The technique for capsular plication is similar to the closure technique, with the hip in 60° of flexion and a greater amount of capsular tissue incorporated into the repair on both sides.

In patients who had open growth plates and in whom the cam lesion did not communicate with the physis, a focal osteoplasty was performed on the femoral head-neck junction. If a significant cam lesion was identified with communication with the physis, then a staged procedure was recommended, addressing the cam lesion after closure of the physis. In this group no cam lesion communicated with the physis, and therefore all lesions could be safely resected.

Patients were kept partially weight bearing for 2 to 3 weeks after surgery. Patients used a stationary bike with no resistance the same day of surgery and continued to bike throughout the rehabilitation program. Motion is encouraged to avoid intra-articular adhesions. Protection of the capsular closure was achieved with limitation of hip extension and use of anti-rotational boots for 3 weeks.

Subjective data were collected from each patient preoperatively, during subsequent office visits, and yearly after surgery. Subjective scores included the mHHS,[32] Hip Outcome Score (HOS)[33] sports subscale, and patient satisfaction with outcome (1, very unsatisfied; 10, very satisfied).

The mHHS was not normally distributed ($P < .05$, Kolmogorov-Smirnov test). Preoperative scores were compared with follow-up scores by use of the Wilcoxon signed rank test. Comparison of mHHS between binary categorical variables was performed with the Kruskal-Wallis test, and for multiple (>2) categorical variables, it was performed with 1-way analysis of variance. We performed comparison of Lysholm improvement for continuous variables by determining the Spearman ρ correlation coefficient. Statistical analyses were performed with PASW Statistics (version 18.0; IBM SPSS, Somers, NY).

RESULTS

Patient's demographics are described in Table 1. On radiographic evaluation, 10% of hips (6) were classified as cam type, 15% (10) as pincer type, and 75% (49) as mixed-type impingement. The mean center-edge angle was 36° (95% confidence interval [CI], 34° to 38°), and the mean alpha angle was 64° (95% CI, 60° to 69°). There was a significant association between age and alpha angle ($r = 0.324$, $P = .02$) (Fig 2). The femoral physis was open in 10% of cases (6), partially closed in 18% (11), and closed in 72% (43). On clinical examination, the impingement sign was positive in 92% of hips (60 of 65), and the FABER test was positive in 52% of hips (31). All hips had a

Table 1. *Patient Demographics for 60 Patients Included in Study*

Variable	Data
Age [mean (95% CI)] (yr)	15 (15.3 to 15.8)
Male/female (No. of patients)	17:43
Right/left (No. of hips)	36:29
Body mass index [mean (95% CI)]	21.1 (20.5 to 21.7)
Onset of symptoms	
Traumatic injury	13 hips
Spontaneous onset	52 hips
Mean time from injury to surgery [mean (95% CI)] (mo)	11 (8.7 to 14.7)
Sports [% of patients (No. of patients)]	
Dance/gymnastics	22% (13)
Soccer	22% (12)
Ice hockey/skating	17% (11)
Volleyball	9% (6)
Basketball	6% (3)
Skiing	6% (4)
Swimming	5% (3)
Baseball/softball	5% (2)
Football/rodeo/running/tennis/wrestling	9% (6)

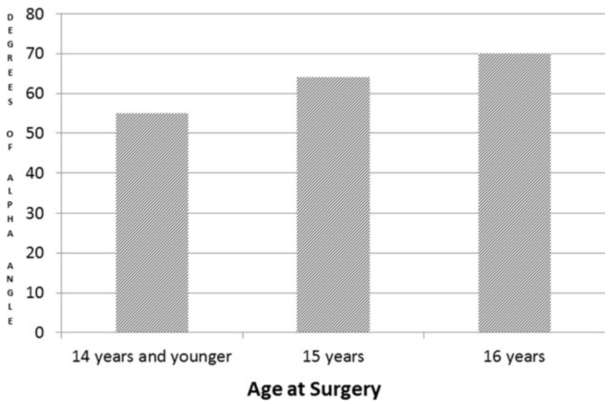

FIGURE 2. Mean alpha angles for patients aged 14 years or less, 15 years, and 16 years. In this patient population, the alpha angle increases with age.

positive impingement sign, a positive FABER test, or an alpha angle greater than 60°. All patients had symptoms for at least 6 months.

During surgery, labral tears were seen in all hips. Of these labral tears, 83% (54) were repaired with suture anchors and 17% (11) were debrided. In debridement cases the amount of tissue removed was small, still leaving a functional labrum. Femoral osteoplasty was performed in 15 hips, and rim trimming was performed in 15 hips. Thirty-five hips underwent both procedures. A partial ligamentum teres tear was observed at arthroscopy in 28 hips, whereas a complete tear was observed in 8 hips. Ligamentum teres pathology was treated by mechanical and thermal debridement. Grade IV chondral damage was found in 2 cases on the femoral side and in no hips on the acetabular side. Both femoral chondral defects were treated by femoral osteoplasty and chondroplasty. A plication of the anterior capsule was performed in 32 cases.

Eight hips needed a second-look diagnostic hip arthroscopy because of persistent pain after surgery. Second-look diagnostic hip arthroscopy was performed at a mean of 26 months (range, 10 to 46 months) after the index procedure. All cases that needed a repeat procedure occurred in female patients. During the second surgery, all hips were diagnosed as having capsulolabral adhesions, and lysis of adhesions was performed. All labral repairs showed excellent healing, with good healing of the chondrolabral junction. Follow-up was obtained on all patients who required a revision. At a mean of 24 months (range, 12 to 38 months), the mean mHHS was 82 (range, 66 to 100). Most patients who needed a revision hip arthroscopy were satisfied after the second procedure, with a median satisfaction rating of 10 (mean, 8.8; range, 4 to 10).

Follow-up was obtained at a mean of 3.5 years after the procedure (range, 2 to 5 years) for 91% of the patients who did not require revision. The mean mHHS was 57 (95% CI, 51 to 62) preoperatively and improved to 91 (95% CI, 88 to 94) ($P < .001$) at follow-up. The mean HOS sports score was 38 (range, 0 to 89) preoperatively and improved to 82 (range, 28 to 100) ($P < .001$) postoperatively. One patient had an HOS sports score under 75. This patient had an mHHS of 85 and patient satisfaction rating of 9. The median rating for patient satisfaction with outcome was 10 (95% CI, 8 to 10). On univariate analysis, gender was the only factor that was associated with mHHS at follow-up (Table 2). Male patients had a higher mean mHHS than female patients (96 *v* 88, $P = .018$).

DISCUSSION

In this study we describe intraoperative findings and clinical outcomes after hip arthroscopy for the treatment of FAI in the pediatric and adolescent

TABLE 2. *Univariate Analysis of Factors Compared With mHHS at Final Follow-up*

Variable and Group	Data	*P* Value
Age	$R = 0.036$	$P = .8$
Gender		$P = .02$
Male	96 (95% CI, 94 to 98)	
Female	88 (95% CI, 83 to 93)	
Body mass index	$r = -0.023$	$P = .9$
Time from injury to surgery		$P = .3$
≤1 yr	92 (95% CI, 87 to 96)	
>1 yr	88 (95% CI, 80 to 97)	
Alpha angle	$\rho = 0.039$	$P = .8$
Center-edge angle	$\rho = 0.147$	$P = .4$
Physis		$P = .2$
Open	96 (95% CI, 91 to 100)	
Partially closed	96 (95% CI, 90 to 100)	
Closed	89 (95% CI, 84 to 94)	
Labral treatment		$P = .2$
Debridement	95 (95% CI, 89 to 100)	
Repair	90 (95% CI, 86 to 95)	
Type of FAI		$P = .6$
Cam	95 (95% CI, 89 to 100)	
Pincer	90 (95% CI, 82 to 98)	
Combined	91 (95% CI, 85 to 96)	
Laxity of capsule		$P = .36$
None	95 (95% CI, 92 to 98)	
Treated with plication/thermal	89 (95% CI, 84 to 94)	

population. Our results showed an increase in alpha angle related to age, mixed-type FAI as the most common FAI pattern, and documentation of labral tears in all surgeries. Moreover, we report a higher rate of second-look diagnostic arthroscopies in female patients, as well as excellent outcomes at 2 to 5 years after surgery.

Previous studies have reported on early outcomes after hip arthroscopy in pediatric patients. Kocher et al.[11] reported results of hip arthroscopy for various hip pathologies in 42 adolescent patients. An improvement in the mHHS from 57.6 to 89.2 was reported in 30 patients with isolated labral tears. Philippon et al.[27] reported an improvement in the mHHS from 55 to 90 in 16 patients. Both of these studies had a minimum follow-up of 1 year. Results of our study are consistent with the literature, because we report an improvement in the mHHS from 60 to 91 in 60 patients. Continued improvement of clinical scores until 2 years after surgery is an important issue to be addressed when counseling patients and parents. FAI patients tend to have muscle weakness and imbalance.[34] Recovery of muscle strength and balance can take a substantial length of time. Patients and parents should be aware of this, and patients should continue to work on their muscle strength, balance, and posture for a long time after surgery.

All patients in this series had labral tears. The decision to perform debridement or repair with suture anchors was made intraoperatively and based on repairability and type of labral tear. Although our study did not show a difference in the mHHS between patients who had labral debridement and those with labral repair, previous studies indicated better clinical outcomes with labral repair compared with debridement in the adult population.[14,35] An interesting finding on MRI was the visualization of the immature stellate crease, which was also visualized at arthroscopy. This should not be confused with chondral damage (Fig 3).

Interestingly, female patients had worse clinical outcomes than male patients (mHHS of 89 *v* 99, $P = .002$), and only female patients underwent second-look surgeries. This higher incidence of capsulolabral adhesions in the female population is not fully understood; however, it may be associated with the underlying bony pathology, hormones, or postoperative compliance with therapy. Previous studies have shown that female patients have an increased incidence of pincer-based conflict,[2,14] which may be associated with adhesion formation because of the proximity of the bony rim trimming with the capsule.

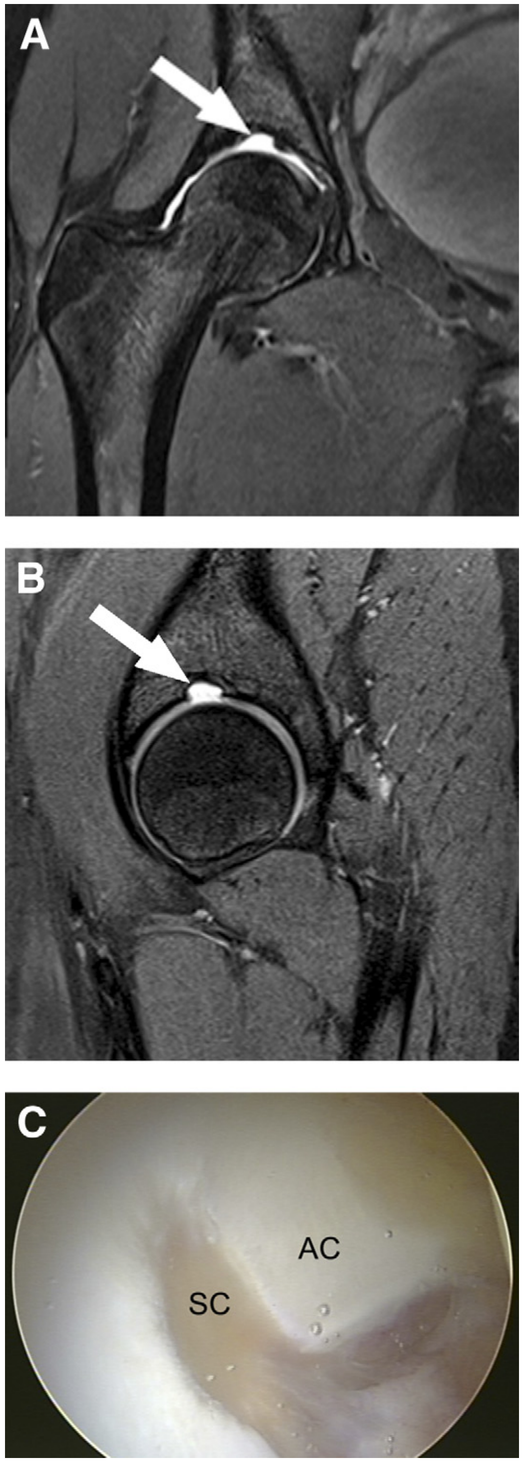

Figure 3. (A, B) T2 MRI scans with fat suppression of the right hip of a 15-year-old female patient. The images show an immature stellate crease (arrow) on the coronal view (A) and axial oblique view (B). (C) Intraoperative view of stellate crease in same patient. The immature stellate crease seen in adolescent patients should not be confused with chondral damage. (AC, acetabulum; SC, stellate crease.)

There also might be a role for hormones in the development of adhesions, as previously shown in abdominal surgery.[36] Compliance with postoperative rehabilitation is of paramount importance to avoid intra-articular adhesions. In 2008 we added circumduction exercises to our program as another way of preventing stiffness and adhesion formation, with the ultimate goal of decreasing the prevalence of second-look surgeries for adhesions.

Cam impingement is characterized by a nonspherical head with an abnormal head-neck offset of the proximal femur. The causes of this bony abnormality remain unclear. Siebenrock et al.[12] used MRI to measure epiphyseal extension of the proximal femur, comparing FAI patients and control subjects. Their findings showed that an abnormal epiphyseal extension correlates with a nonspherical femoral head and a decreased femoral head-neck offset, suggesting growth abnormality as a cause for cam deformity. Several developmental disorders can also be the cause of cam-type deformity, such as SCFE,[7] pistol-grip deformity,[7,8] Legg-Calve-Perthes disease,[9,10] developmental dysplasia of the hip,[11] and other congenital hip disorders.[6,11] Our study showed an association between age and alpha angle. All patients in our series had a primary diagnosis of FAI, and none were considered to have FAI due to other pathologies. The increase in alpha angle with age in this active population corroborates the theory of a developmental characteristic to cam-type FAI. Ilizaliturri et al.[18] described findings in adult patients who had pediatric hip disease. All of the patients had cam deformity with a mean alpha angle of 75°. When the open femoral physis is submitted to high stresses in competitive sports as the adolescent grows, it may be prone to development of a cam deformity.

Although theoretic concerns exist regarding growth disturbance at the proximal femur and possible iatrogenic SCFE,[27] neither was observed in our study. Other studies have described the rate of complications in hip arthroscopy in children to be as low as 1.8%.[37] Longer follow-up studies are needed to evaluate the outcome of femoral osteoplasty and acetabular rim trimming in the long-term.

Limitations of this study include the absence of data from re-examination or follow-up radiographs. Another limitation is that, although all patients had a diagnosis of FAI, not all patients had the same treatment. There was also no control group with which to compare.

CONCLUSIONS

Hip arthroscopy in the pediatric and adolescent population is a safe procedure, with excellent clinical outcomes at 2 to 5 years. In this study there was an association between alpha angle and age. Clinical scores showed a significant improvement after surgery; however, 13% of patients did require a second procedure for capsulolabral adhesions.

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