Radiographic and Clinical Outcomes of Adolescents With Acetabular Retroversion Treated Arthroscopically

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Background: Retroversion of the acetabulum is a cause of pincer impingement. Symptomatic retroversion has traditionally been treated with anteverting periacetabular osteotomy (PAO). However, arthroscopic rim trimming can also treat pincer impingement associated with acetabular retroversion. The purpose of this study was to report the outcomes and radiographic findings in a series of adolescent patients with symptomatic acetabular retroversion treated arthroscopically.

Methods: Data were prospectively gathered at a single institution using an established hip preservation registry. Patients below 18 years with a retroverted acetabulum that underwent primary hip arthroscopy with 2-year follow-up were included. Acetabular retroversion was defined by 3 radiographic criteria: the presence of crossover, ischial spine sign, and posterior wall sign. Radiographic measurements of the lateral center-edge angle, anterior center-edge angle, alpha angle, and crossover percentage were reported preoperatively and postoperatively. Patient-reported outcome (PROs) measures included the modified Harris Hip Score, the non-Arthritic Hip Score, Hip Outcome Score Sports Subscale, visual analog scale, and patient satisfaction, recorded at 3 months, 1 year, and 2 years, postoperatively. In addition, International Hip Outcome Tool scores were gathered at 2 years.

Results: Between April 2008 and July 2014, there were 43 patients (48 hips) treated with hip arthroscopy who met the inclusion criteria. The average age was 16.1 years (range, 13.9 to 17.9 y) and there were 38 females and 10 males. The average follow-up was 50.4 months, with a minimum of 2 years. Statistically significant improvements in all PROs were found at 2 years postoperatively. There were 9 hips with lateral center-edge angle $\leq$25 degrees; the PROs of this group was not different than patients with normal coverage. Three patients underwent arthroscopic revision. No patient subsequently underwent anteverting PAO during the study period. There were no reported complications.

Conclusions: Femoroacetabular impingement caused by acetabular retroversion treated with hip arthroscopy demonstrates good outcomes at 2 years with a low complication rate. Symptomatic adolescents may be safely and successfully treated arthroscopically, potentially avoiding anteverting PAO.

Study Design: Level of evidence 4—case series.

Key Words: hip arthroscopy, acetabular retroversion, adolescents, pincer impingement

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Femoroacetabular impingement (FAI) is a condition receiving increasing attention as a cause of hip pain. The impingement is caused by a cam lesion of the proximal femur or pincer-type morphology of the acetabulum that causes impingement of the femoral neck on the acetabulum during flexion. Both acetabular overcoverage and retroversion can cause pincer-type impingement, which leads to tearing of the labrum and hip pain. Eventually, osteoarthritis will result if left untreated.[1] The classic treatment for FAI caused by acetabular retroversion is a reverse periacetabular osteotomy (PAO) that corrects the acetabular version. Good long-term results have been reported treating acetabular retroversion with this open procedure.[2,3]

Hip arthroscopy is now being used to treat a greater range of pathology. For example, FAI caused by cam morphology was also initially addressed with a surgical hip dislocation to reshape the femoral neck. However, femoroplasty via a minimally invasive arthroscopic approach also demonstrates clinical improvement and equivalent or better outcomes than with an open procedure.[4–6]

A potential concern in patients with acetabular retroversion is the creation of iatrogenic hip dysplasia by decreasing the contact area and increasing the shear forces. However, this theoretical risk is countered by several benefits of hip arthroscopy as compared with an anteverting PAO. Arthroscopy is a much less invasive procedure, with smaller incisions, less blood loss, and shorter recovery time. Furthermore, arthroscopy allows excellent visualization for careful intra-articular evaluation and treatment of labral pathology.

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There are some recent reports of acetabular retroversion being treated arthroscopically with good results.[7–9] However, these studies were all performed in adults. Adolescents represent a unique population because of their level of activity, high demands on the hip joint, and the need for particularly durable results. The purpose of this study was to report the 2-year outcomes of adolescent patients with symptomatic acetabular retroversion treated arthroscopically.

METHODS

Data Collection

Data were prospectively gathered at a single institution and retrospectively reviewed. This study received institutional review board approval (IRB ID: 5276) and was completed at the American Hip Institute. Patients were included in the study if they underwent primary hip arthroscopy at below 18 years of age, had follow-up after a minimum of 2 years, and had all 3 signs of radiographic retroversion on a preoperative anteroposterior (AP) pelvis radiograph: positive crossover sign (COS), ischial spine sign (ISS), and a medialized posterior wall sign (PWS). Patients were excluded if they had a preoperative Tönnis grade >1 or a previous ipsilateral hip surgery or condition such as Legg-Calvé-Perthes disease or Ehlers-Danlos syndrome.

Patient-reported Outcomes (PROs)

Three PRO measures were used preoperatively and postoperatively: the modified Harris Hip Score (mHHS), non-Arthritic Hip Score (NAHS), and Hip Outcome Score Sports Subscale (HOS-SSS). Chahal et al[10] recently reported on the patient acceptable symptomatic state in which patients were noted to be satisfied with their hip preservation surgery. This was found to be 74 for the mHHS and 74 for HOS-SSS. Therefore, we selected these values as goals for this study. We began collecting the International Hip Outcome Tool 33 (iHOT) at 2014 and therefore only have scores at final follow-up. However, we included this measure because it has been it is a self-administered evaluation tool specifically directed at young, active patients, which has demonstrated reliability and sensitivity to clinical changes.[11]

Pain was measured on the visual analog scale (VAS), and patient satisfaction was similarly quantified on a 0 to 10 scale. Complications and revision surgeries were also noted. These data were collected through patient questionnaires in clinic, by encrypted email, or by telephone at 3 months and annually postoperatively.

Radiographic Assessment

Preoperative and postoperative radiographs were obtained for all patients and included standard AP pelvic views, false profile, and 45 degrees Dunn view. AP pelvis radiographs were considered acceptable if the obturator foramen were symmetric, the coccyx was centered over the pubic symphysis and located 3 to 4 cm cephalad (Fig. 1). We defined acetabular retroversion based on

FIGURE 1. The sacrococcygeal junction should lie about 3 to 4 cm directly superior to the pubic symphysis (thick gray line) and the obturator foramen should be symmetric (outlined in black). The ischial spine sign is outlined (thin gray line) and the crossover is outlined in white (solid line = anterior wall, dotted line = posterior wall). The center of the femoral head is denoted by a star, which falls lateral to the posterior wall (dotted line) and demonstrates a posterior wall sign.[7]

3 radiographic criteria: COS, ISS, and PWS. The crossover was also quantified by dividing its distance from the superolateral acetabulum by the total length of the posterior wall. Other radiographic measurements included lateral center-edge angle (LCEA), anterior center-edge angle (ACEA), and alpha angle, as well as Tönnis classification of osteoarthritis.

Clinical Assessment

Range of motion data for internal rotation, external rotation, flexion, and abduction were collected preoperatively and at postoperative clinical visits. The results of anterior, lateral, and posterior impingement test were also collected.

Surgery

Surgery was indicated for all patients that had symptoms for a minimum of 3 months despite nonoperative treatment. Arthroscopy was contraindicated for patients with an LCEA < 18 or with clinical evidence of posterior instability, and anteverting PAO was recommended in these cases. All hip arthroscopies were performed by the senior surgeon (B.G.D). Patients were positioned supine on a traction table. During arthroscopy, 3 portals (anterolateral, midanterior, and distal lateral accessory) were used. A diagnostic arthroscopy was performed. Comprehensive intraoperative data were recorded describing the labral tear by Seldes classification,[12] cartilage status according to Outerbridge grade, the status of the ligamentum, and any other intra-articular findings.

Acetabuloplasty was performed on most patients to decrease the area of overcoverage. The amount of the anterior wall overhanging the posterior wall from the

12 to 3 o'clock position was measured in millimeters on a preoperative AP pelvis x-ray. Because an AP hip overestimates acetabular version, it is important that the depth of resection necessary to correct the contour of the anterior wall be determined according to the preoperative AP pelvis x-ray.[13] In patients with an LCEA of >35, resection was performed to decrease the LCEA to 30 to 35. Intraoperative visualization and fluoroscopy guided this resection according to a previously published strategy[14] (Fig. 2).

Other intra-articular pathology including labral tears, cartilage damage, and cam morphology were addressed. Labral tears were preferentially treated with repair and debrided in a minority of cases. Labral tears were repaired with a simple looped suture technique or by labral base refixation per the surgeon's preference. Cartilage damage was treated with debridement or microfracture depending on Outerbridge grade. Femoroplasty was performed to correct head-neck offset in patients with alpha angle >55 or evidence of impingement visualized intraoperatively. The capsule was treated by capsular closure or release. All patients treated before 2009 underwent release, as the senior author was not yet performing closure. Subsequently, closure was performed for patients who demonstrated ligamentous laxity based on the Beighton score or LCEA < 30.

Postoperatively, patients were restricted to flat foot weight-bearing for a minimum of 2 weeks and 8 weeks if microfracture was performed. A DonJoy hip brace (DJO Global, Vista, CA) was worn for 2 weeks after surgery to restrict hip range of motion. All patients worked with a physical therapist over a minimum of 3 months to regain strength and return to activity.

Statistical Analysis

We assessed for statistically significant improvements in PROs and VAS scores preoperatively and at minimum 2-year follow-up. Shapiro-Wilk tests were performed to identify if the data were normally distributed. Two-tailed *t* tests were used for normally distributed data

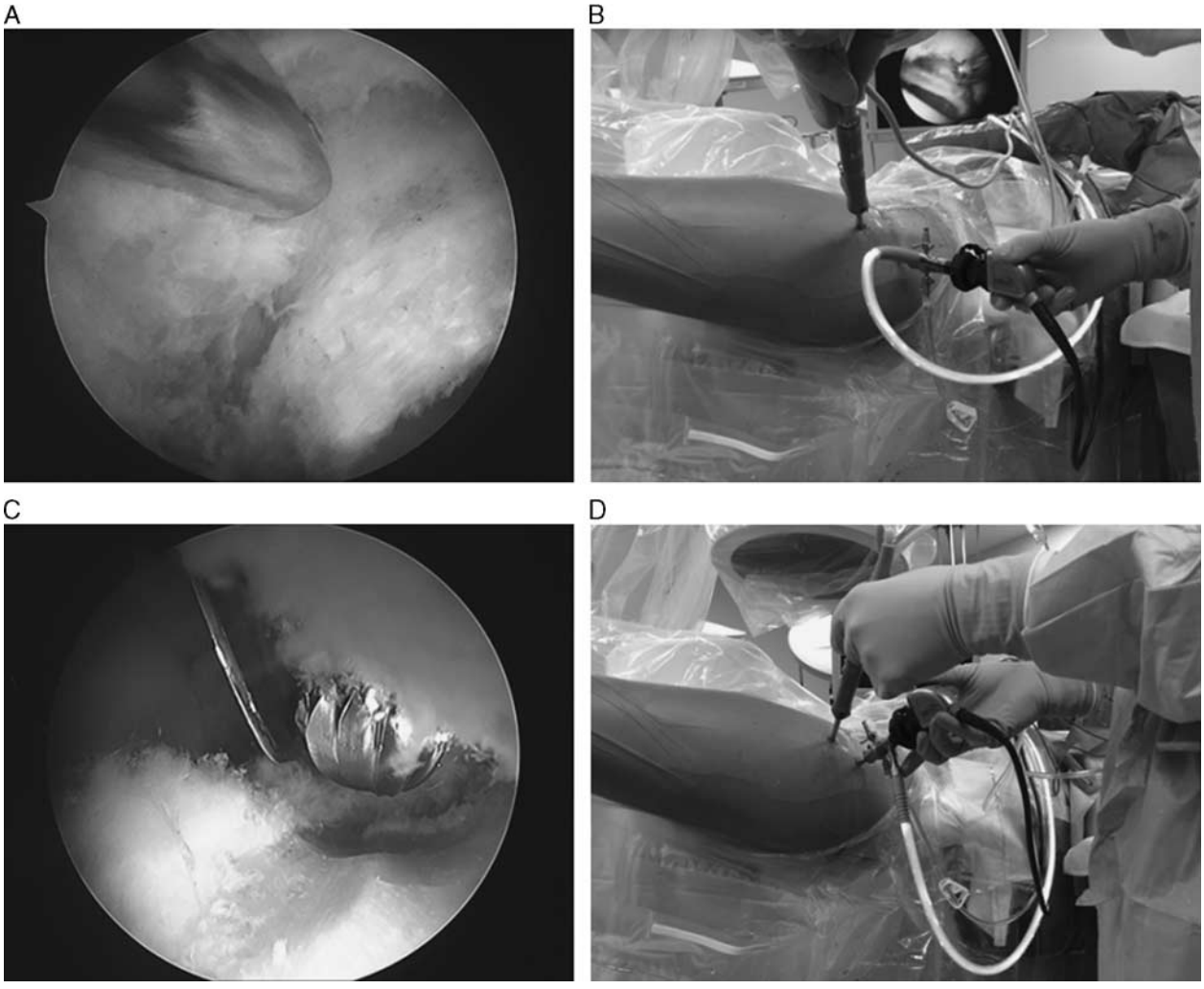

FIGURE 2. Intraoperative photographs demonstrating the arthroscopic view and surgeon's positioning while performing acetabular rim trimming. Bird's eye view (A and B), upper deck view (C and D).

TABLE 1. Patient Demographic Data

Patients	43
Hips [n (%)]	48
Left	25 (52.1)
Right	23 (47.9)
Sex	
Female	38 (79.2)
Male	10 (20.8)
Age at surgery (y)	16.1 ± 1.0 (13.9-18.0)
BMI	20.9 ± 2.5 (17.0-29.0)
Follow-up (mo)	50.4 ± 21.6 (24.0-89.9)
Follow-up percentage	80.0
Future revisions [n (%)]	3 (6.3)
Time to revision (wk)	44.1 ± 33.6 (7.9-74.2)

BMI indicates body mass index.

and Mann-Whitney *U* test was used for non-normally distributed data.

RESULTS

There were 240 hip arthroscopies performed in adolescents by the senior author during the study period. There were 60 cases that met the inclusion criteria, and 48 cases (80.0%) in 43 patients had complete follow-up. The average age was 16.1 years (range, 13.9 to 17.9 y), and there were 38 females and 10 males. The average follow-up was 50.4 months, with a minimum of 2 years. Additional demographic data are shown in Table 1.

All PROs demonstrated improvement from their preoperative baseline at 3 months, 1 year, and 2 years postoperatively. These improvements were present at the 3-month follow-up visit and appeared stable until 2-year follow-up (Table 2 and Fig. 3). Preoperative mHHS, NAHS, and HOS-SS, were 65.1, 69.3, 48.5. At 2-year follow-up, scores improved to 91.9, 93.5, and 87.8, which surpassed the patient acceptable symptomatic state.[10] Similarly, the VAS improved from 5.3 to 1.4, and patient satisfaction was 8.8. These were all statistically significant changes. At final follow-up, of ≥ 2 years, these statistically significant improvements were all maintained. The iHOT, collected only at final follow-up, was 82.2.

In addition to acetabuloplasty, the other most commonly performed procedures were labral repair (85%), and iliopsoas fractional lengthening (75%) (Table 3). The capsule was closed or plicated in 88% of hips. Cartilage damage (Outerbridge grade 2 or higher) on the acetabular or femoral side was encountered in 21% and 11% of hips, respectively. No patient had exposed subchondral bone that was treated with microfracture.

Radiographs were assessed preoperatively and postoperatively for LCEA, ACEA, and alpha angle. All patients included in this study were positive for COS, ISS, and PWS. The mean preoperative crossover was 35.1%, which decreased to 23.2%, postoperatively. In addition, there were statistically significant decreases in the LCEA, ACEA, and alpha angle. There were 45 patients had a preoperative Tönnis grade of 0, 3 were grade 1, and no patients had progression of arthritis after their surgery (Table 4).

Given the distinctive concern associated with rim trimming in the dysplastic hip, the outcomes of patients with borderline dysplasia were compared with the remainder of the cohort. The mean preoperative LCEA was 29.3, with 9 (18.8%) patients that were borderline dysplastic (LCEA, 18 to 25). Preoperatively and at 2-year follow-up, the PROs for these patients were not significantly different from those with normal coverage.

The mean range of motion values measured preoperatively and at latest clinical follow-up were as follows: internal rotation 26.8 to 29.7 degrees ($P = 0.219$), external rotation 52.8 to 54.1 degrees ($P = 0.691$), flexion 119.6 to 122.2 degrees ($P = 0.243$), and abduction 44.3 to 44.7 degrees ($P = 0.790$), respectively. Thus, there were no significant changes in range of motion after arthroscopy. All patients had a positive anterior impingement test before surgery. In addition, 20 (41.7%) had positive lateral impingement and 16 (33.3%) had positive posterior impingement.

There were 3 patients that underwent arthroscopic revision. The reasons for revision were removal of heterotopic ossification, reinjury due to fall, and recurrence of pain after treatment of contralateral foot injury. No patient subsequently underwent anteverting PAO during or after the study period. There were no reported complications.

DISCUSSION

Hip arthroscopy is a field with increasing popularity and growing applications. The results of this series demonstrate statistically significant improvements in the PROs, and pain scores, as well high patient satisfaction. Previous studies have demonstrated the safety and effectiveness of hip arthroscopy in adult patients with acetabular retroversion.[7] This is the first study to document

TABLE 2. Patient-reported Outcome Scores

	Preoperative	3 mo	1 y	2 y	≥ 2 y
mHHS	65.1 ± 16.7	88.7 ± 14.4	91.5 ± 11.8	91.9 ± 8.0*	90.3 ± 10.9*
NAHS	69.3 ± 19.1	86.7 ± 15.1	91.2 ± 10.8	93.5 ± 7.3*	91.9 ± 8.7*
HOS-SSS	48.5 ± 25.0	76.1 ± 24.6	87.0 ± 14.5	87.8 ± 14.6*	85.3 ± 16.3*
VAS	5.3 ± 2.6	1.9 ± 1.9	1.4 ± 1.4	1.4 ± 1.6*	1.2 ± 1.5*
Satisfaction	—	8.6 ± 1.9	8.7 ± 1.3	8.8 ± 1.7*	8.9 ± 1.3*

*Compared with preoperative scores ($P < 0.001$).
HOS-SSS indicates Hip Outcome Score Sports Subscale; mHHS, modified Harris Hip Score; NAHS, the non-Arthritic Hip Score; VAS, visual analog scale.

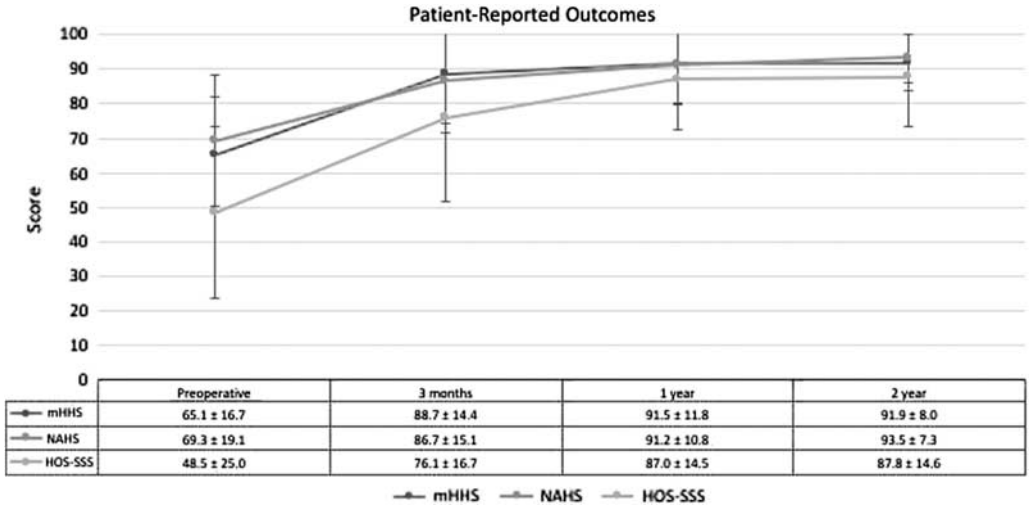

FIGURE 3. Recovery curves using patient-reported outcomes from preoperative through 2-year follow-up. HOS-SSS indicates Hip Outcome Score Sports Subscale; mHHS, modified Harris Hip Score; NAHS, the non-Arthritic Hip Score.

good clinical results in adolescents treated arthroscopically for pincer impingement caused by acetabular retroversion.

The standard treatment for acetabular retroversion has traditionally been an anteverting PAO. Some benefits of the PAO are that it does an adequate job resecting the acetabular rim and had successful outcomes. Its disadvantages are that it is complex and has a steep learning curve. It is associated with high blood loss, with reports of up to 30% of the total blood volume.[15] Recovery times are longer while the osteotomy heals. Hip arthroscopy, although it possesses its own learning curve, is less invasive and therefore offers an attractive alternative.

Studies of anteverting PAO have demonstrated good results with long-term follow-up,[3,16] even as much as 10 years.[2] The outcome measures used in these studies included the Harris Hip Score, the Merle d'Aubigne, radiographic progression of arthritis by Tönnis grade, and conversion to total hip arthroplasty. Although these studies reported improvement in these outcomes scores, and low rates of arthritis progression or conversion to total hip arthroplasty, these may not be the most sensitive measures of clinical improvement. For example, both the Harris Hip and Merle d'Aubigne scores have reported ceiling effects.[17,18] Another important consideration when using radiographic progression of arthritis is that in a young population, even longer time periods may need to be studied to truly discover this difference.

A concern about treating acetabular retroversion arthroscopically is the creation of dysplasia with rim trimming. Because of the concern for creation of dysplasia with acetabuloplasty, patients with borderline dysplasia present an interesting challenge. In our series, there were 9 patients with LCEA $\leq$25. At final follow-up, there were no differences between this group and the remainder of the cohort. This is consistent with other series that did not find any differences comparing patients treating arthroscopically for FAI with and without borderline dysplasia. However, it is logical to reserve arthroscopic treatment of acetabular retroversion for patients without frank dysplasia. It is our practice to treat borderline dysplastic patients (LCEA, 18 to 24) with arthroscopy and perform a capsular plication, and to correct acetabular retroversion in the setting of significant dysplasia with an anteverting PAO.

TABLE 3. Concomitant Arthroscopic Procedures

Procedures	n (%)
Labral treatment	
Debridement	6 (12.5)
Repair	41 (85.4)
Capsular release	6 (12.5)
Ligamentum teres debridement	9 (18.8)
Femoroplasty	24 (50.0)
Acetabuloplasty	39 (81.3)
Subspine decompression	1 (2.1)
Trochanteric bursectomy	0 (0.0)
Capsular repair/plication	42 (87.5)
Synovectomy	0 (0.0)
Loose body removal	0 (0.0)
Gluteus medius/minimus repair	0 (0.0)
Iliopsoas fractional lengthening	36 (75.0)
Notchplasty	0 (0.0)
Femoral head microfracture	0 (0.0)
Acetabular microfracture	0 (0.0)

TABLE 4. Radiographic Data

	Preoperative	Postoperative	*P*
LCEA (deg.)	29.3 ± 4.9	27.6 ± 3.6	< 0.001
ACEA (deg.)	33.7 ± 5.9	30.4 ± 7.4	0.010
Alpha angle (deg.)	58.7 ± 9.5	46.8 ± 7.2	< 0.001
Crossover (%)	35.1 ± 12.3	23.2 ± 12.7	< 0.001
Tönnis grade			> 0.999
0	45	45	—
1	3	3	—

ACEA indicates anterior center-edge angle; LCEA, lateral center-edge angle.

Our results indicate that hip arthroscopy for acetabular retroversion is an effective treatment for patients younger than 18 years old. Because of the benefit of arthroscopy to visualize and address joint pathology, we were able to identify and treat labral tears, which are inherent to impingement and contribute to pain. In our series, 85% of adolescent underwent labral repair. Other joint pathology was addressed as well with concomitant procedures.

The main limitation of this study are that it is a retrospective case series that does not directly compare results to anteverting PAO, and that complete follow-up is limited to 2 years. Presently, there are no studies directly comparing arthroscopic versus anteverting PAO to specifically answer this important question. Our study suggests arthroscopy is an effective treatment at 2 years that provides a potential advantage over an open procedure because of its minimally invasive nature. However, anteverting PAO is considered the gold standard treatment for symptomatic acetabular retroversion, and prospective data comparing the 2 techniques are truly needed. In addition, we plan to continue to follow the patients in our series long-term, to better delineate the rate of cartilage degeneration following arthroscopy. Although our data show excellent results according to the PROs used, longer follow-up is needed to understand if radiographic progression of arthritis is truly affected. A final consideration is that crossover percentage was not totally eliminated on postoperative radiographs. Future investigation may be valuable to identify thresholds for correction.

CONCLUSIONS

FAI caused by acetabular retroversion treated with hip arthroscopy demonstrates good outcomes at 2 years with a low complication rate. Symptomatic adolescents may be safely and successfully treated arthroscopically, potentially avoiding anteverting PAO.

REFERENCES

1. Giori NJ, Trousdale RT. Acetabular retroversion is associated with osteoarthritis of the hip. *Clin Orthop*. 2003;417:263–269.
2. Siebenrock KA, Schaller C, Tannast M, et al. Anteverting periacetabular osteotomy for symptomatic acetabular retroversion: results at ten years. *J Bone Joint Surg Am*. 2014;96:1785–1792.
3. Parry JA, Swann RP, Erickson JA, et al. Midterm outcomes of reverse (anteverting) periacetabular osteotomy in patients with hip impingement secondary to acetabular retroversion. *Am J Sports Med*. 2016;44:672–676.
4. Ilizaliturri VM, Orozco-Rodriguez L, Acosta-Rodríguez E, et al. Arthroscopic treatment of cam-type femoroacetabular impingement: preliminary report at 2 years minimum follow-up. *J Arthroplasty*. 2008;23:226–234.
5. Domb BG, Stake CE, Botser IB, et al. Surgical dislocation of the hip versus arthroscopic treatment of femoroacetabular impingement: a prospective matched-pair study with average 2-year follow-up. *Arthroscopy*. 2013;29:1506–1513.
6. Zingg PO, Ulbrich EJ, Buehler TC, et al. Surgical hip dislocation versus hip arthroscopy for femoroacetabular impingement: clinical and morphological short-term results. *Arch Orthop Trauma Surg*. 2013;133:69–79.
7. Hartigan DE, Perets I, Walsh JP, et al. Clinical outcomes of hip arthroscopy in radiographically diagnosed retroverted acetabula. *Am J Sports Med*. 2016;44:2531–2536.
8. Ilizaliturri VM, Joachin P, Acuna M. Description and mid-term results of the "over the top" technique for the treatment of the pincer deformity in femoroacetabular impingement. *J Hip Preserv Surg*. 2015;2:369–373.
9. Krych AJ, Thompson M, Knutson Z, et al. Arthroscopic labral repair versus selective labral debridement in female patients with femoroacetabular impingement: a prospective randomized study. *Arthroscopy*. 2013;29:46–53.
10. Chahal J, Van Thiel GS, Mather RC, et al. The patient acceptable symptomatic state for the modified harris hip score and hip outcome score among patients undergoing surgical treatment for femoroacetabular impingement. *Am J Sports Med*. 2015;43:1844–1849.
11. Mohtadi NGH, Griffin DR, Pedersen ME, et al. The development and validation of a self-administered quality-of-life outcome measure for young, active patients with symptomatic hip disease: the International Hip Outcome Tool (iHOT-33). *Arthroscopy*. 2012;28:595–605; quiz 606.e1–610.e1.
12. Seldes RM, Tan V, Hunt J, et al. Anatomy, histologic features, and vascularity of the adult acetabular labrum. *Clin Orthop*. 2001;382:232–240.
13. Tannast M, Siebenrock KA, Anderson SE. Femoroacetabular impingement: radiographic diagnosis—what the radiologist should know. *AJR Am J Roentgenol*. 2007;188:1540–1552.
14. Colvin AC, Koehler SM, Bird J. Can the change in center-edge angle during pincer trimming be reliably predicted? *Clin Orthop*. 2011;469:1071–1074.
15. Novais EN, Carry PM, Kestel LA, et al. Factors that predict blood loss after bernese periacetabular osteotomy. *Orthopedics*. 2016;39:1147–1153.
16. Peters CL, Anderson LA, Erickson JA, et al. An algorithmic approach to surgical decision making in acetabular retroversion. *Orthopedics*. 2011;34:10. Doi:10.3928/01477447-20101123-07.
17. Moed BR, Yu PH, Gruson KI. Functional outcomes of acetabular fractures. *J Bone Joint Surg Am*. 2003;85-A:1879–1883.
18. Wamper KE, Sierevelt IN, Poolman RW, et al. The Harris hip score: do ceiling effects limit its usefulness in orthopedics? *Acta Orthop*. 2010;81:703–707.