Original Article With Video Illustration

Concomitant Hip Arthroscopy and Periacetabular Osteotomy

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Purpose: To detail our early experience using concomitant hip arthroscopy and periacetabular osteotomy (PAO) for the treatment of acetabular dysplasia. **Methods:** We prospectively collected and retrospectively reviewed the surgical and outcome data of 17 patients who underwent concomitant hip arthroscopy and PAO between October 2010 and July 2013. Preoperative and postoperative range of motion, outcome and pain scores, and radiographic data were collected. Intraoperative arthroscopic findings and postoperative complications were recorded. **Results:** The group consisted of 3 male and 14 female patients with a mean follow-up period of 2.4 years. Three patients had undergone previous surgery on the affected hip. Chondrolabral pathology was identified in all 17 patients. Twelve patients underwent labral repair, and five patients underwent partial labral debridement. No patient was converted to total hip arthroplasty or required revision surgery at short-term follow-up. All 4 patient-reported outcome scores showed statistically significant changes from baseline to latest follow-up ($P < .001$). An excellent outcome was obtained in 82% of patients (13 of 16). The lateral center-edge angle averaged 11° preoperatively and 29° postoperatively. The acetabular inclination averaged 18° preoperatively and 3° postoperatively. The anterior center-edge angle averaged 7° preoperatively and 27° postoperatively. At most recent radiographic follow-up, 1 patient had progression of arthritic changes but remained asymptomatic. No other patient showed any radiographic evidence of progression of arthritis. Complications included 3 superficial wound infections, 1 pulmonary embolism, and 1 temporary sciatic neurapraxia. **Conclusions:** Our initial experience with concomitant hip arthroscopy and PAO has been favorable. We noted that all our patients have evidence of chondrolabral damage at the time of PAO when the joint is distracted and evaluated. All patients in this series had intra-articular pathology treated arthroscopically and showed satisfactory mean clinical improvement. Hip arthroscopy with PAO did not appear to introduce complications beyond the PAO alone. **Level of Evidence:** Level IV, therapeutic case series.

Acetabular dysplasia is a common cause of premature arthrosis in adults and can lead to total hip arthroplasty (THA) at a relatively young age.[1] The Bernese periacetabular osteotomy (PAO) has been shown to be an effective treatment option for acetabular dysplasia.[1-10] Long-term results have shown this osteotomy to be durable, with 20-year results showing a 60% survivorship rate.[2] As surgeons gain experience, patient selection and technical refinements may improve these results.[11,12]

In addition to extra-articular correction, recent evolutions in PAO surgical technique include addressing femoral head-neck offset and treating intra-articular pathology.[12,13] Several authors have noted symptoms after PAO that may be attributable to postoperative femoroacetabular impingement or acetabular labral tears.[13-19] The prevalence of intra-articular pathology at the time of PAO is substantial.[13,19,20] It stands to reason that many of these symptoms may be a cause of failure or revision surgery after osteotomy. To address femoral head-neck offset and labral lesions, many authors have recommended intra-articular inspection at the time of PAO.[18,21]

Several reports that have identified and treated intra-articular pathology at the time of PAO have been published.[17,19,20] Intra-articular inspection can be

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performed through an arthrotomy or arthroscopically. Although it has not yet been established whether the addition of concomitant arthroscopy will affect outcomes, our early experience has shown a very high prevalence of intra-articular pathology at the time of PAO.[13,19] At our institution, this evidence has led us to include concomitant hip arthroscopy as a part of all PAO procedures. During arthroscopy, intra-articular pathology is treated, and femoral osteoplasty is frequently performed to improve head-neck offset.

Currently, there are very few clinical follow-up data available on patients undergoing combined hip arthroscopy and PAO.[20,22] The purpose of this study was to detail our early experience using concomitant hip arthroscopy and PAO for the treatment of acetabular dysplasia. Our hypothesis was that concomitant hip arthroscopy and PAO for the treatment of acetabular dysplasia would result in clinical improvement.

Methods

We performed a retrospective chart review of patients who underwent concomitant hip arthroscopy and PAO. Previous surgical intervention involving the same hip was recorded. The duration of symptoms before surgery was recorded. Demographic data including age, body mass index, gender, and laterality were gathered. All 17 patient charts were screened for perioperative complications and recorded. The time to latest follow-up was calculated. Institutional review board approval and patient informed consent were obtained.

Clinical Examination

Preoperative and postoperative range-of-motion data including flexion, abduction, internal rotation, and external rotation were recorded by the surgeon. Postoperative range of motion was recorded at the point of latest follow-up. Patients followed up with both surgeons involved in their care (B.G.D., J.M.L.), and an average of the range-of-motion measurements was recorded.

Imaging

Radiographs were obtained preoperatively and postoperatively at 2 weeks, at 6 weeks, at 3 months, and yearly and included a supine anteroposterior pelvis view and false-profile lateral view. They were evaluated by measuring the lateral center-edge angle (LCEA), acetabular inclination (AI), and anterior center-edge angle (ACEA). The presence of osteoarthritis was graded on preoperative and postoperative radiographs according to the Tönnis classification.[23] Two of the authors (J.M.R. and J.E.H.) reviewed all radiographs, and the average measurement was recorded. Intraclass correlation coefficients (ICCs) were then determined for all radiographic variables. All patients underwent preoperative magnetic resonance imaging to evaluate chondrolabral pathology.

Patient-Reported Outcome Scores

All patients were assessed prospectively preoperatively and postoperatively with 4 patient-reported outcome (PRO) measures: modified Harris Hip Score (mHHS), Non-Arthritic Hip Score, Hip Outcome Score—Activities of Daily Living Subscale, and Hip Outcome Score—Sport-Specific Subscale.[24] Pain was estimated on a visual analog scale (VAS) ranging from 0 to 10 (with 10 being the worst), and satisfaction was measured by asking patients the following question (1, not at all; 10, the best it could be): "How satisfied are you with your surgery results?" An excellent outcome was defined as a patient satisfaction score of 8 or more. Scores were collected preoperatively and postoperatively at 3 months, 1 year, 2 years, and 3 years. Scores were collected in the clinic, over the phone, and electronically. Scores reported in this study were the most current scores available at the time of chart review.

Surgical Technique

Patients underwent epidural placement for postoperative pain control and then general anesthesia (Video 1, available at www.arthroscopyjournal.org).[25] Skeletal muscle relaxation was necessary during the arthroscopic procedure, but its use was stopped during the osteotomy for clinical monitoring. A traction table with the patient in the supine position was used initially to perform hip arthroscopy. A fluoroscope was positioned opposite the operative hip and remained in place for the PAO. Arthroscopy was carried out using a standard anterolateral portal, a modified anterior portal, and a distal-lateral accessory portal. Care was taken to avoid labral penetration, which may be difficult given the hypertrophied labrum in dysplastic patients. Venting the joint during distraction and careful needle placement can avoid labral penetration in most patients; the technique has previously been described.[26] Diagnostic arthroscopy was then carried out and intra-articular pathology documented. All intra-articular pathology was treated arthroscopically, and a detailed intraoperative data sheet including all arthroscopic procedures was filled out. Traction was then released and attention turned to the peripheral compartment. The hip was flexed on the traction table and a femoral osteoplasty performed using a 5.5-mm round burr.

After hip arthroscopy, the patient was transferred to a radiolucent table. The technique for PAO has been described by Ganz et al.[4] and modified by Murphy and Millis.[27] A modified iliofemoral or bikini-style incision was used. After superficial dissection, the anterior superior iliac spine (ASIS) underwent osteotomy to allow

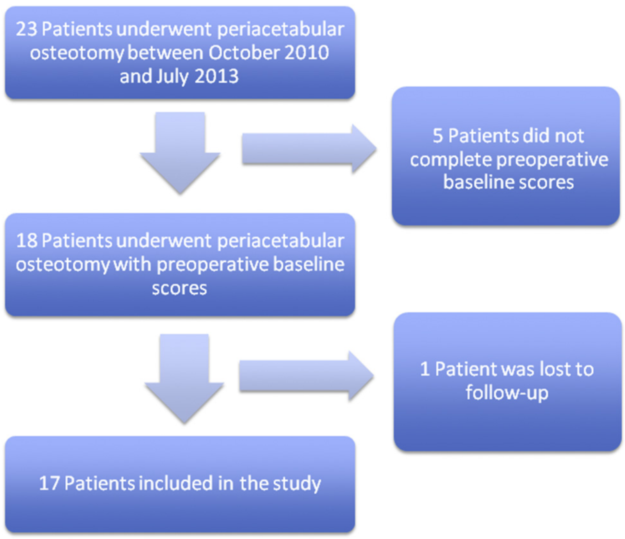

Fig 1. Flow diagram depicting study inclusion and exclusion criteria for the total number of patients who underwent periacetabular osteotomy between October 2010 and July 2013.

reflection of the sartorius. Dissection was then continued to the anterior inferior iliac spine. The direct and reflected heads of the rectus femoris were identified, released, and tagged for later repair.

The interval between the medial joint capsule and iliopsoas was developed, and a Ganz osteotome was used to perform the ischial osteotomy. After satisfactory ischial osteotomy, the hip was flexed and the pubis exposed. A Gigli saw or small Ganz osteotome was used to perform osteotomy of the pubis medial to the iliopectineal eminence.

The ilium was then exposed. The abductors were left attached to the lateral iliac wing. A sagittal saw was used to create an osteotomy from just inferior to the ASIS to the pelvic brim. The posterior column was then exposed by placing a deep retractor along the quadrilateral surface. A long spinal osteotome was used to create the posterior column osteotomy. This connected to the ischial osteotomy, which allowed fragment mobilization. The articular fragment was then corrected and held in place with 4.5- or 3.5-mm fully threaded screws.

The hip capsule was closed. The anterior inferior iliac spine was decompressed and the rectus tendon repaired through drill holes. The ASIS was repaired to the ilium through drill holes with heavy nonabsorbable suture. Estimated blood loss was recorded for all cases. The operative time was available for 16 patients and was divided between the arthroscopy and PAO.

Postoperative Course

An epidural catheter was used for the first 24 to 48 hours after surgery. A continuous passive motion

Table 1. Cohort Demographic Data for Study Patients With Concomitant Hip Arthroscopy and Periacetabular Osteotomy

	Data
Age at surgery, yr	
Mean	24.2
SD	7.1
Gender, n	
Male	3
Female	14
Side, n	
Left	7
Right	10
Duration of symptoms, mo	
Mean	28.3
SD	39.3
BMI, kg/m^2	
Mean	24.3
SD	4.8

BMI, body mass index.

machine was used on postoperative day 1 and continued for 4 weeks. Weight bearing was restricted to one-sixth of the patient's body weight for the first 6 to 8 weeks. Subsequent physical therapy focused first on achieving range of motion, second on strengthening the hip stabilizers and core muscles, and third on functional rehabilitation. All patients received thrombosis prophylaxis with low-molecular-weight heparin.

Results

We identified 23 patients who underwent combined hip arthroscopy and PAO from October 2010 to July 2013. To be included in this study, patients had to have undergone hip arthroscopy and PAO for the diagnosis of acetabular dysplasia. Patients were excluded if they lacked preoperative PRO scores and pain scores. Five patients were excluded during this time frame because of a lack of PRO scores and pain scores. One patient was lost to follow-up. This left 17 patients for retrospective review (Fig 1).

Demographic data for the study cohort are shown in Table 1. There were 3 male and 14 female patients. The mean age was 24.2 years, with a range from 12.3 to 35.3 years. The mean duration of symptoms before surgery was 28.3 months. The mean length of follow-up was 2.4 years, with a maximum of 3.3 years and a minimum of 0.6 years. Three patients had undergone previous arthroscopy of the hip at an average of 1.67 years before the current surgical procedure. Of the 17 hips that underwent concomitant hip arthroscopy and PAO, none have undergone conversion to THA or revision surgery at an average follow-up of 2.4 years.

Arthroscopic Procedures

Arthroscopic procedures performed before PAO are shown in Table 2. Labral repair was performed in 12 patients and partial labral debridement in 5 patients.

Table 2. Arthroscopic and Procedures Performed During Concomitant Hip Arthroscopy and Periacetabular Osteotomy

	n
Arthroscopic	
Labral repair	12
Labral debridement	5
Iliopsoas fractional lengthening	4
Acetabular chondroplasty	3
Loose body removal	1

Four patients underwent iliopsoas fractional lengthening. One patient underwent loose body removal. Eight patients underwent an arthroscopic femoral osteoplasty, and two underwent an open femoral osteoplasty. Three patients underwent microfracture.

Range of Motion

Hip range of motion preoperatively for internal rotation, external rotation, flexion, and abduction averaged 32°, 43°, 109°, and 51°, respectively. Postoperative range of motion for internal rotation, external rotation, flexion, and abduction averaged 22°, 38°, 100°, and 39°, respectively. Average range of motion decreased in all planes postoperatively.

Radiographs

Preoperative and postoperative radiographic data were available for all patients and are shown in Table 3. The LCEA averaged 11° (range, −9° to 20°) preoperatively and 29° (range, 20° to 39°) postoperatively. The AI averaged 18° (range, 11° to 32°) preoperatively and 3° (range, −8° to 13°) postoperatively. The ACEA averaged 7° (range, −17° to 23°) preoperatively and 27° (range, −6° to 37°) postoperatively. The Tönnis grade was 0 for 15 patients and 1 for 2 patients preoperatively. At latest radiographic follow-up, 1 patient changed from Tönnis grade 1 to Tönnis grade 2 at 8 months postoperatively. No other patients had radiographic Tönnis grade changes compared with preoperative radiographs. The mean time from surgery to final radiographic follow-up was 1.7 years. Excellent reliability was observed for almost all measurements (ICC >0.80), with the exception of the postoperative measurement of ACEA, which had substantial reliability (ICC = 0.78).

Table 3. Radiographic Measurements for LCEA, AI, ACEA, and Tönnis Grade Preoperatively and Postoperatively

	Preoperative	Postoperative
LCEA, °		
Mean	11.15	29.06
SD	6.96	4.23
AI, °		
Mean	18.03	2.65
SD	5.44	4.67
ACEA, °		
Mean	6.94	25.85
SD	5.95	9.80
Tönnis grade, n		
0	15	15
1	2	2
2	0	0

ACEA, anterior center-edge angle; AI, acetabular inclination; LCEA, lateral center-edge angle.

Table 4. Cohort Mean Preoperative and Postoperative Patient-Reported Outcome and VAS Scores

	Preoperative	Postoperative	*P* Value
mHHS	63.9	84.1	< .001
HOS-ADLS	65.4	80.1	.005
HOS-SSS	37.7	74.4	< .001
NAHS	57.7	79.5	.001
VAS score	5.6	2.6	.001

HOS-ADLS, Hip Outcome Score−Activities of Daily Living Subscale; HOS-SSS, Hip Outcome Score−Sport-Specific Subscale; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

Table 4 shows detailed information regarding functional outcome scores and VAS data. The score improvement from preoperatively to latest follow-up was 63.9 to 84.1 for the mHHS ($P < .001$), 57.7 to 79.5 for the Non-Arthritic Hip Score ($P < .001$), 65.4 to 80.1 for the Hip Outcome Score−Activities of Daily Living Subscale ($P = .005$), and 37.7 to 74.4 for the Hip Outcome Score−Sport-Specific Subscale ($P < .001$) (Fig 2). The VAS score decreased from 5.6 to 2.6 ($P < .001$). Patient satisfaction at final follow-up averaged 8.2 on a 10-point scale. An excellent outcome was obtained in 82% of patients (13 of 16). It should noted that 1 patient continued to come to the clinic for follow-up but refused to fill out the PRO score and pain score questionnaires; therefore the outcome measurement data are based on 16 patients.

Complications and Estimated Blood Loss

Complications including wound infection, thrombosis, iatrogenic fracture, and neurapraxia were recorded. All patients in this series underwent screw removal postoperatively for potential further imaging or surgery. Charts were reviewed for conversion to THA or revision surgery.

There were 2 wound complications. In 1 patient a superficial wound infection developed and was treated successfully with oral antibiotics. In the second patient proximal wound dehiscence and possible infection developed. This patient required a return to the operating room for irrigation and debridement. A pulmonary embolism developed in 1 patient, after noncompliance with the discontinuation of oral contraceptive medication. A partial sciatic nerve palsy developed in 1 patient and resolved on postoperative

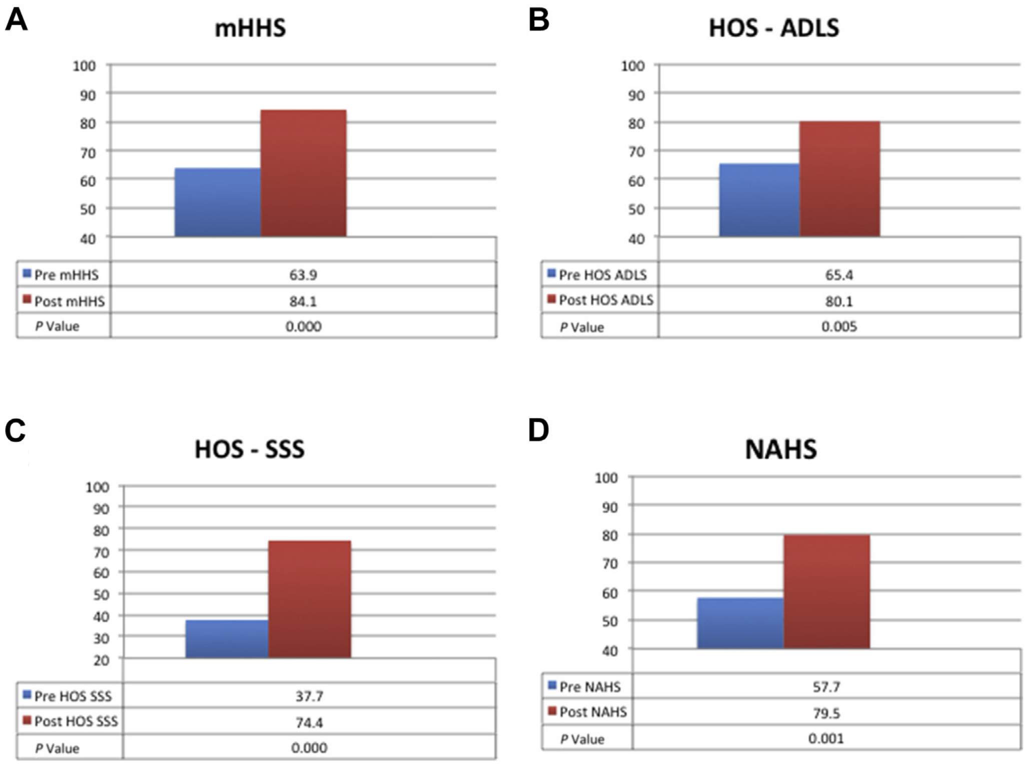

Fig 2. Preoperative (Pre) and postoperative (Post) patient-reported outcome scores: (A) modified Harris Hip Score (mHHS), (B) Hip Outcome Score—Activities of Daily Living Subscale (HOS-ADLS), (C) Hip Outcome Score—Sport-Specific Subscale (HOS-SSS), and (D) Non-Arthritic Hip Score (NAHS).

day 3; this same patient had a known intraoperative posterior column fracture. Mean estimated blood loss was 1,064 mL (range, 300 to 2,000 mL). The mean operative time for hip arthroscopy was 59 minutes (range, 39 to 110 minutes), and the mean operative time for PAO was 300 minutes (range, 236 to 435 minutes).

Discussion

On the basis of our early experience with the described technique, concomitant hip arthroscopy and PAO appear to be safe and effective at short-term follow-up. We do not believe that arthroscopy using a traction table before PAO led to further complications beyond the PAO alone. Improvements in functional outcome scores and pain scores appear satisfactory. The results of this study are of interest because this is one of the first series to report early clinical results of concomitant hip arthroscopy and PAO. Although previous reports have identified intra-articular lesions using the arthroscope before PAO, few clinical data have been reported.[17,19,20]

Kim et al.[22] reported on 43 patients who underwent combined hip arthroscopy and periacetabular rotational osteotomy with a mean follow-up period of 74 months and noted that 38 patients (88%) had labral lesions. In this series all labral tears were treated with debridement. These patients showed improvements in the Harris Hip Score (HHS) from 72.4 to 94.0 ($P <$ .001). This previous study differs technically from our study. The patients in the study by Kim et al. underwent arthroscopy of the joint through an open arthrotomy under manual traction; we believe that our ability to evaluate and repair chondrolabral pathology is better on a traction table using standard arthroscopic technique. Given that the patients in the study by Kim et al. were not placed on a traction table, one would not expect any cases of traction-related neurapraxia. In our study, we placed patients under traction for the evaluation and treatment of chondrolabral pathology, as well as femoroplasty, without observing any complications related to arthroscopy under traction. Moreover, we did not believe the fluid extravasation from the arthroscopy hindered the ability to perform PAO. Our series also included patients who underwent labral repair rather than debridement, which has been shown to improve outcomes in non-dysplastic patients.[28]

Ross et al.[20] described intra-articular findings of patients undergoing hip arthroscopy before re-directional osteotomy for dysplasia in 73 hips. They found labral tears and acetabular chondral lesions in 65.8% and 68.5% of hips, respectively. They reported that an LCEA less than 15° and AI angle greater than 20° were associated with more severe intra-articular pathology. In their series 63% of patients underwent arthroscopic treatment before osteotomy. The patients in our series were found to have intra-articular pathology in all instances. All of our patients underwent a partial labral debridement or labral repair. On the basis of our early observations, the chondrolabral junction in these patients is frequently destabilized and torn. Domb et al.[19] have previously published the intra-articular findings of patients undergoing hip arthroscopy before PAO and noted that 100% of patients had intra-articular pathology. The current study also details early clinical results.

Fujii et al.[17] detailed their experience with arthroscopy during acetabular osteotomy in 121 patients. Even among patients with mild degenerative changes, they observed labral tears in 96% of patients and chondral damage in 88% of patients. Patients with Kellgren-Lawrence grade 2 or 3 changes had labral tears 100% of the time. This group also showed that advanced articular lesions and labral tears were correlated with a progression to end-stage degenerative joint disease after acetabular osteotomy.

Several concerns have arisen when considering hip arthroscopy before PAO. First, fluid extravasation may lead to more difficult surgical dissection for the PAO. This can be minimized by limiting arthroscopic pump pressure, as well as being efficient with central and peripheral compartment work. Second, the traction table used for hip arthroscopy can put the patient at risk of sciatic neurapraxia during arthroscopy, and combined with the osteotomy, there could be a potential double-hit phenomenon. On the basis of our early experience, only 1 patient had a temporary partial sciatic neurapraxia and this resolved on postoperative day 3. Sciatic neurapraxia in this case was likely a result of known intraoperative iatrogenic fracture of the posterior column. This result is likely attributable to technical error as opposed to prolonged traction time. We have not observed an increased risk of sciatic nerve injury in this series, although the number of patients is small. Third, performing concomitant hip arthroscopy and PAO requires a surgeon skilled in hip arthroscopy and a surgeon skilled in osteotomy to avoid complications related to prolonged surgical time. At our institution, the procedures are always performed by 2 surgeons, one who specializes in arthroscopy and one who specializes in osteotomy, although 1 surgeon skilled in both procedures could be used. This series represents the learning curve of the osteotomy surgeon (J.M.L.) after a dedicated 6-month hip-preservation fellowship.

Crockarell et al.[1] reported the Mayo Clinic's early experience with PAO for acetabular dysplasia. The average HHS improved from 62 to 86 at short-term follow-up. Peters et al.[9] reported their early experience with PAO and noted an improvement in the average HHS from 55 to 87. Our early results showed similar improvement at short-term follow-up, with the average mHHS increasing from 64 to 84.

Kain et al.[29] published their experience performing PAO in the setting of failed hip arthroscopy for dysplastic labral tears. They matched a group of 17 patients who had previously undergone hip arthroscopy to a control group of 34 patients who had not undergone previous surgery at the time of PAO. They found no difference between the groups for conversion to THA or clinical outcome scores. In our cohort 4 patients had undergone previous hip arthroscopy. All 4 patients had a postoperative satisfaction score of 8 or more. Three of the four patients had a postoperative mHHS of 80 or more. Although our numbers are limited, PAO does appear to be an option for patients in whom hip arthroscopy has failed in the setting of dysplasia.

Several advantages of concomitant hip arthroscopy and PAO have been proposed. First, hip arthroscopy allows a detailed examination of the entire joint before osteotomy. This allows the surgeon to abort the osteotomy should the intra-articular damage found be deemed excessive. Second, hip arthroscopy allows treatment of central compartment pathology and femoral head-neck osteoplasty. Third, it has been suggested that central compartment lesions are more accurately diagnosed when the hip is placed in traction and the acetabulum visualized, and arthroscopy allows for complete visualization.[26] Whether this will improve clinical results or reduce revisions will be the subject of future research; however, previous reports have commented on the need to return to the operating room for subsequent labral tears. Fourth, the peripheral compartment can be addressed arthroscopically using fluoroscopy to perform a thorough head-neck osteoplasty. We have found that the correction of head-neck offset and cam lesions is best performed arthroscopically. This allows for better visualization and fluoroscopic correction. It does not require additional traction time, and fluid extravasation has not compromised the PAO.

Our initial experience with concomitant hip arthroscopy and PAO has been favorable. We have noted that all patients have evidence of chondrolabral damage at the time of PAO when the joint is distracted and evaluated. All patients in this series had intra-articular pathology treated arthroscopically. Postoperatively, slightly decreased hip range of motion develops in all planes. Patients shows routine improvement in radiographic parameters for dysplasia. They also show improvement in functional outcome scores and pain at short-term follow-up. Additional, long-term follow-up will be necessary to determine if the procedure remains effective; however, the early results of concomitant hip arthroscopy and PAO show this to be a safe and effective procedure. The strengths of this study include our assessment of a group of patients undergoing a relatively new combined procedure that addresses the majority of pathology present at the time of PAO. The data for pain and functional outcome scores were prospectively collected for all patients.

Limitations

This study has several weaknesses. First, there is no control group. It is difficult to determine whether patients treated with concomitant hip arthroscopy benefit compared with patients undergoing open surgery alone, and this study does not answer that question. It does, however, establish safety and early efficacy data on this procedure. Second, the number of patients in this series is small, and larger numbers of patients will be necessary to determine if our results are generally applicable. Third, the follow-up period in this report is relatively short, and the lack of conversion to THA or revision surgery is difficult to interpret at this point. Fourth, the study includes limited outcome data in this patient group. Finally, not all patients underwent identical treatment at the time of arthroscopy.

Conclusions

Our initial experience with concomitant hip arthroscopy and PAO has been favorable. We noted that all our patients have evidence of chondrolabral damage at the time of PAO when the joint is distracted and evaluated. All patients in this series had intra-articular pathology treated arthroscopically and showed satisfactory mean clinical improvement. Hip arthroscopy with PAO did not appear to introduce complications beyond the PAO alone.

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