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Does Primary Hip Arthroscopy Result in Improved Clinical Outcomes?

2-Year Clinical Follow-up on a Mixed Group of 738 Consecutive Primary Hip Arthroscopies Performed at a High-Volume Referral Center

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Background: Hip arthroscopy has gained increasing popularity over the past decade. The need to develop metrics to evaluate success and complications in primary hip arthroscopy is an important goal.

Purpose: To evaluate 2-year patient-related outcome (PRO) scores and patient satisfaction scores for a single surgeon at a high-volume referral center for all primary hip arthroscopy procedures performed.

Study Design: Case series; Level of evidence, 4.

Methods: During the study period between April 2008 and October 2011, data were collected on all patients who underwent primary hip arthroscopy. All patients were assessed pre- and postoperatively with 4 PRO measures: the modified Harris Hip Score (mHHS), Non-Arthritic Hip Score (NAHS), Hip Outcome Score–Activities of Daily Living (HOS-ADL), and Hip Outcome Score–Sport-Specific Subscale (HOS-SSS). Pain was estimated on the visual analog scale (VAS), and satisfaction was measured on a scale from 0 to 10. The number of patients who underwent revision arthroscopy, total hip arthroplasty (THA), or a resurfacing procedure during the study period was also reported.

Results: A total of 595 patients were included in the study. The score improvement from preoperative to 2-year follow-up was 61.29 to 82.02 for mHHS, 62.79 to 83.05 for HOS-ADL, 40.96 to 70.07 for HOS-SSS, 57.97 to 80.41 for NAHS, and 5.86 to 2.97 for VAS. All scores were statistically significantly different ($P < .0001$). Overall patient satisfaction was 7.86 $\pm$ 2.3 (range, 1-10). Forty-seven (7.7%) patients underwent revision hip arthroscopy, and 54 (9.2%) patients underwent either THA or the hip resurfacing procedure during the study period. The multivariate regression analysis showed that increased age at time of surgery was a significant risk factor for conversion to THA, revision arthroscopy, and change in NAHS <10 points. Acute injury, acetabuloplasty, iliopsoas release, and patient sex were significant for 2 of the 3 types of failure. In addition, the success rate, defined as change in NAHS >10 with no revision arthroscopy or conversion to THA during the study period, was 59.8%.

Conclusion: Primary hip arthroscopy for all procedures performed in aggregate had excellent clinical outcomes and patient satisfaction scores at short-term follow-up in this study. While the chance for a successful outcome was 59.8%, more studies must be conducted to determine the definition of a successful outcome. There was a 6.1% minor complication rate, which was consistent with previous studies. Patients should be counseled regarding the potential progression of degenerative change leading to arthroplasty as well as the potential for revision surgery.

Keywords: hip arthroscopy; outcomes; high-volume referral center; labral tears; FAI

Hip arthroscopy was first described in 1931 by Burman,[3] with the first arthroscopic description of a labral tear described in 1986 by Suzuki et al.[43] Hip arthroscopy initially was used more as a diagnostic tool and to facilitate the removal of loose bodies. As intra-articular sources for pain were further investigated, labral lesions were identified and various treatments were developed for these lesions.[25,30,41]

The concept of femoroacetabular impingement (FAI) was first introduced by Ganz et al[22] as a cause for early osteoarthritis in the nondysplastic hip. Since that landmark study, there has been a dramatic rise in the popularity and prevalence of hip arthroscopy performed.[9,35] As newer techniques and indications are developed, the need for developing metrics to evaluate the efficacy and complications rates of these procedures is important. Philippon

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et al[39] performed a prospective analysis of outcomes after hip arthroscopy with a minimum 2-year follow-up. They found improvement of mean modified Harris Hip Score (mHHS) and a median patient satisfaction of 9 (1-10 scale). Similarly, Byrd and Jones[6] prospectively evaluated 200 patients who underwent arthroscopic correction of cam impingement with a minimum follow-up of 12 months. They reported an increase in the Harris Hip Score of 20 points with a 0.5% conversion to total hip arthroplasty (THA) and a 1.5% complication rate. Harris et al[24] recently conducted a systematic review of more than 6000 patients to examine the aggregate complications and reoperation rates. They reported a minor complication rate of 0.58% and a major complication rate of 7.5%. The overall reoperation rate was 6.3%, with THA the most common procedure (conversion rate, 2.9%). The largest reported study to date was by Palmer et al,[38] who evaluated 185 consecutive patients with a minimum follow-up of 36 months undergoing hip arthroscopy with cam FAI.

The purpose of our study was to report on the largest series to date of all primary hip arthroscopies performed at a high-volume tertiary referral center for hip preservation with a minimum 2-year follow-up. Our hypothesis was that primary hip arthroscopy will show significant improvement in all patient-reported outcome (PRO), pain, and satisfaction scores at a minimum of 2 years postoperatively, with similar complication rates as reported in the literature.

MATERIALS AND METHODS

Patient Inclusion and Data Collection

During the study period, February 2008 to October 2011, data were collected prospectively on all patients undergoing primary hip arthroscopy by the senior surgeon (B.G.D.). The study included primary hip arthroscopy surgeries in patients who agreed to participate in the study with a minimum 2-year follow-up. All patients with Tönnis grade ≥2 as well as any previous hip condition, such as acetabular fracture, avascular necrosis, Legg-Calvé-Perthes disease, Ehlers-Danlos syndrome, and pigmented villonodular synovitis, were excluded. The number of patients who underwent revision arthroscopy, total hip arthroplasty, or a resurfacing procedure during the study period was also reported.

Physical Examination

A detailed physical examination was conducted on all hips before surgery, including assessment of passive range of motion (ROM), measurements of flexion, abduction, and internal and external rotation. Internal and external rotation was measured while the patient was in the supine position with both the hip and knee flexed at 90°. Anterior impingement test was considered positive if pain was elicited in forced flexion combined with internal rotation of the hip as previously described by Byrd.[4] Lateral impingement test was considered positive if symptoms were produced in forced abduction with external rotation. Evaluation of internal snapping of the iliopsoas tendon was performed as the hip was brought from a flexed, abducted, and externally rotated position into extension with internal rotation.[4] All physical examinations were performed and documented in degrees by the senior surgeon in a clinical setting.

Imaging

Plain radiographs included an anteroposterior (AP) pelvic view, Dunn view, cross-table lateral view, and a false-profile view.[18,34,45] Measurements were made from these views, including the Tönnis angle (acetabular inclination angle) using the method described in Jessel et al,[27] the lateral center-edge angle of Wiberg,[47] joint space at its lowest point,[45] ischial prominence size (in mm),[46] crossover sign,[26,42,46] alpha angle (Dunn view),[1] and offset (in mm).[19] The alpha angle was measured on the Dunn view[18] using the method described by Notzli et al[36] for magnetic resonance imaging (MRI) and modified by Meyer et al.[34] Cam impingement was defined as an alpha angle greater than 60°. Hips classified as having pincer impingement had a crossover sign, coxa profunda, or protrusion acetabula. The crossover sign size was quantified according to its percentage from the superior edge of the acetabulum; for instance, crossover at the middle of the acetabulum was quantified at 50%. The same orthopaedic surgeon (B.G.D.) made all measurements using a picture archiving and computer system (PACS). All radiographs were evaluated for arthritis and graded with the Tönnis classification of osteoarthritis.[45] Magnetic resonance imaging was obtained in all patients to evaluate for labral and articular cartilage injuries. Acetabular cartilage damage and labral tears were classified intraoperatively. Cartilage damage was classified according to the Outerbridge, Seldes, and Acetabular Labrum Articular Disruption (ALAD) classification systems.[37]

Surgical Procedure

All hip arthroscopies were performed at a tertiary referral center dedicated to hip arthroscopy and preservation. All

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were performed in the modified supine position using a minimum of 2 portals (anterolateral and midanterior).[5,28] The indications for surgery were predominantly labral tears with mechanical symptoms and failure of nonoperative treatment.

Intraoperative data were documented, including ligamentum teres, capsule, gluteus medius, femoral neck, acetabular rim, the presence and size of labral tears, and the presence and location of articular cartilage lesions. The Outerbridge, Seldes, and ALAD classifications were used to classify articular cartilage damage.[37]

Bony lesions were corrected under fluoroscopic guidance. An acetabuloplasty was performed for pincer impingement, and a femoral neck osteoplasty was performed for cam impingement. Each case with a crossover sign of 50% or greater was evaluated in the context of global over- or undercoverage and cam-type deformity. Performance of an acetabuloplasty was conducted on a case-by-case basis by the senior surgeon, taking into account acetabular and femoral structure, intra-articular damage, and ligamentous laxity. Labral tears were repaired when possible[21]; otherwise, they were selectively debrided until a stable labrum was achieved while preserving as much labrum as possible. If the labrum was unrepairable, labral reconstruction was performed using either an autograft or an allograft gracilis hamstring tendon.[13,32] Full-thickness cartilage damage was treated with debridement to create stable borders. Microfracture was performed according to the technique developed by Steadman in cases where bone was present after the bony decompression at the surgeon's discretion.[10,20] Iliopsoas fractional lengthening was performed when patients had painful internal snapping and corresponding iliopsoas impingement lesion on the labrum.[16] For trochanteric bursitis, lateral compartment endoscopy was performed with bursectomy and repair of gluteus medius tears if necessary.[11,12,14] Iliotibial band release was performed for those patients with painful external snapping documented on history and physical examination. Capsule closure or plication was performed unless contraindicated in cases such as preoperative decreased ROM.[15,17]

Postoperative Rehabilitation

Postoperatively, patients were given a fitted hip brace to limit their adduction and flexion. They were also placed on a 20-lb weightbearing restriction on the operative extremity for a minimum of 2 weeks and a maximum of 8 weeks, depending on the procedure performed. In addition, patients were placed on 4 weeks of 325 mg aspirin twice daily. On postoperative day 1, patients were assigned to either a continuous passive motion machine or recumbent bike daily for a total of 8 weeks. Physical therapy was also initiated on postoperative day 1. Specific protocols were determined based on the underlying surgical procedure performed.

Surgical Outcome Measurement

All patients undergoing hip arthroscopy were assessed using 4 PRO measures: the mHHS, Non-Arthritic Hip Score (NAHS),[8] Hip Outcome Score–Activities of Daily Living (HOS-ADL), and Hip Outcome Score–Sport-Specific Subscale (HOS-SSS). Patients were assessed preoperatively and at the 3-month, 1-year, 2-year, and 3-year follow-ups. All 4 questionnaires were used, since it has been reported that there is no conclusive evidence for the use of a single PRO questionnaire for patients undergoing hip arthroscopy.[31,44] Pain was estimated on a visual analog scale (VAS) from 0 to 10 (10 being the worst), and satisfaction with surgery was rated on a scale of 0 to 10 (10 being the best). Failure was defined as conversion to total hip arthroplasty, need for revision hip arthroscopy during the study period, or change in NAHS <10 points.

Statistical Analysis

A paired Student *t* test was used to calculate significance between preoperative and postoperative groups. $P < .05$ was considered statistically significant. The overall failure risk (cumulative probability of failure) as a function of time, also called the *cumulative failure incidence curve*, was computed using the competing risk methods of Gray.[23] This is a generalization of the Kaplan-Meier method for the situation where there is more than one type of failure. The *P* values for comparing medians for continuous variables were computed using the nonparametric Kruskal-Wallis method, since some continuous variables did not follow a normal (bell curve) distribution. The *P* values for comparing means for continuous variables that follow the normal distribution, such as age or body mass index (BMI), were computed using 1-way analysis of variance (ANOVA). The *P* values for comparing proportions were computed using Fisher's exact test or the exact permutational chi-square test. To simultaneously assess all 33 potential predictors (see the Appendix, available online at http://ajsm.sagepub.com/supplemental), backward stepwise competing multivariate risk regression analyses were carried out, in which all 33 variables were simultaneously evaluated as candidate predictors of (log) failure rate. The backward variable retention criterion was a *P* value of <.10, a liberal criterion. The subset of the 33 variables that were simultaneously significant is reported along with their corresponding failure rate ratios, 95% confidence bounds, and *P* values. A separate regression analysis was carried out for THA failure, revision hip arthroscopy failure, and change in NAHS <10 failure, controlling for the other 2 types of failure. Thus, there were 3 regression models. Computations were carried out using SAS software (version 9.4; SAS, Inc) and R software (version 3.02; R Project for Statistical Computing, http://www.r-project.org/).

RESULTS

Patient Demographics

Patient demographics are given in Table 1. The average age of the group was 38 years (range, 13.2-76.4 years); there were 228 male (38.3%) and 367 female (61.7%)

TABLE 1
Patient Demographics

Age, y, mean (range)	38.04 (13.2-76.4)
Male sex, No. (%)	228 (38.3)
Right side affected, No. (%)	318 (53.45)
Duration of symptoms, mo, mean (range)	26.8 (1-300)
Workers' compensation, No. (%)	54 (9.08)
Acute injury, No. (%)	396 (66.55)
High-energy trauma, No. (%)	34 (5.71)
Weight, lb, mean (range)	166.86 (100-350)
Height total, in., mean (range)	67.53 (57-78)
Body mass index, mean (range)	25.53 (16.27-48.71)

patients at the start of the study. Average patient height was 67.5 inches (range, 57-78 inches), and average weight was 166.86 pounds (range, 100-350 pounds). Average BMI was 25.53 (range, 16.3-48.7). The mean follow-up was 28.98 months (range, 24-66.1 months). There were 318 (53.45%) right-hip surgeries and 277 (46.55%) left-hip surgeries. Fifty-four (9.08%) procedures involved a workers' compensation claim. There were 396 (66.55%) procedures involving an acute injury and 34 (5.71%) involving high-energy trauma.

Physical Examination Findings

Provocative physical examination tests—including anterior, posterior, or lateral impingement; internal or external hip click; flexion, abduction, and external rotation (FABER) test; and straight-leg test—are presented in Table 2. Average preoperative ROM for the operative hip is also presented in Table 2.

Imaging Findings

Preoperative radiographic findings are presented in Table 3. The mean joint space was 3.46 mm (range, 1.3-6.7 mm) preoperatively and 3.47 mm (range, 1.4-6.7 mm) postoperatively (P = .37). The mean lateral center-edge angle changed from 29.18° (range, 11°-49°) to 27.7° (range, 10°-46°) postoperatively (P < .001). The mean anterior center-edge angle changed from 30.22° (range, 3°-56°) to 29.04° (range, 5°-55°) postoperatively (P < .001). The mean preoperative alpha angle was 59.37° (range, 32°-105°) with postoperative correction to 46.65° (range, 29°-106°) (P < .001). Femoral offset was 5.41 mm (range, –2.7 to 12.2 mm) preoperatively and 7.63 mm (range, 0 to 14.3 mm) postoperatively (P < .001). Crossover percentage was 14.86% (range, 0%-65%) preoperatively and changed to 9.68% (range, 0%-65%) postoperatively (P < .001). Tönnis grades for those patients who did not have a secondary procedure during the study period and those who underwent a THA or hip resurfacing procedure during the study are presented in Table 4.

Operative Findings

The main surgical procedures performed on the groups are summarized in Table 5. Most patients underwent

TABLE 2
Preoperative Physical Examination Findings[a]

Finding	Value
Anterior impingement	546 (93.49)
Lateral impingement	338 (58.18)
Posterior impingement	215 (37.01)
Internal hip click	122 (20.96)
External hip click	18 (3.10)
FABER	334 (57.49)
Straight-leg raise (positive)	10 (1.74)
Range of motion, deg, average (range)	
Internal rotation	23.81 (0-90)
External rotation	50.82 (5-90)
Abduction	45.46 (0-85)
Flexion	118.36 (12-160)

[a]Values are presented as No. (%) unless otherwise indicated. FABER, flexion, abduction, and external rotation.

acetabuloplasty (69.9%), femoroplasty (65.9%), capsular release (60.6%), and labral repair (59.2%). Intraoperative findings are presented in Table 6. The most common diagnoses were labral tear (99.3%), FAI (pincer, 70%; cam, 66%), and ligamentum teres partial tear (50%) (Table 6).

Clinical Results

Clinical results are summarized in Table 7. With a minimum 2-year follow-up, 738 patients underwent primary hip arthroscopy during the study period. In total, 595 (80.6%) patients were available for follow-up and were included in our study. The score improvement from preoperative to 2-year follow-up was 61.29 (range, 0-100) to 82.02 (range, 24-100) for mHHS, 62.79 (range, 7-100) to 83.05 (range, 19-100) for HOS-ADL, 40.96 (range, 0-100) to 70.07 (range, 0-100) for HOS-SSS, and 57.97 (range, 0-99) to 80.41 (range, 2-100) for NAHS. Visual analog scale decreased from 5.86 (range, 0-10) preoperatively to 2.94 (range, 0-10) postoperatively. All scores demonstrated statistically significant improvement (P < .0001). Overall patient satisfaction was 7.86 (range, 0-10) at latest follow-up.

Complications

With regard to postoperative complications, 3 (0.5%) patients had lateral femoral cutaneous nerve neuropraxia, 4 (0.67%) patients had pudendal nerve neuropraxia, and 6 (0.10%) patients had sciatic nerve neuropraxia. In all cases, neuropraxia resolved within 3 months. Fourteen (2.35%) patients had heterotopic ossification. Three (0.5%) patients had lower extremity deep vein thrombosis (DVT). Five (0.84%) patients had superficial wound infections that resolved with a course oral antibiotics. One patient (0.17%) had a deep infection that was treated with an irrigation and debridement, with resolution of infection. Our overall minor complication rate was 6.1%.

TABLE 3
Preoperative Radiographic Findings[a]

	Preoperative	Postoperative	*P* Value
Joint space, mm	3.46 (1.3 to 6.7)	3.47 (1.4 to 6.7)	.37
Crossover %	14.86 (0 to 65)	9.68 (0 to 65)	<.001
Acetabular Inclination	4.35 (–11 to 20)	5.00 (–7 to 22)	<.001
Lateral center-edge angle, deg	29.18 (11 to 49)	27.7 (10 to 46)	<.001
Anterior center-edge angle, deg	30.22 (3 to 56)	29.04 (5 to 55)	<.001
Alpha angle (Dunn view), deg	59.37 (32 to 105)	46.65 (29 to 106)	<.001
Femoral head-neck offset, mm	5.41 (–2.7 to 12.2)	7.63 (0 to 14.3)	<.001

[a]Values are reported as mean (range).

TABLE 4
Tönnis Grade for Patients With Primary Hip Arthroscopy Only and Patients With THA or Hip Resurfacing[a]

Tönnis Grade	Patients Who Did Not Have a Secondary Procedure (n = 438)	Patients Who Underwent THA or Hip Resurfacing (n = 50)
0	334 (76.26)	27 (54)
1	104 (23.74)	23 (46)
2	0	0
3	0	0

[a]Values are reported as No. (%). THA, total hip arthroplasty.

TABLE 5
Surgical Procedures Performed (n = 595)[a]

Procedure	No. (%)
Acetabuloplasty	416 (69.91)
Femoral osteoplasty	392 (65.88)
Capsular release	360 (60.61)
Labral repair	352 (59.16)
Ligamentum teres debridement	297 (49.91)
Capsular repair	233 (39.23)
Labral debridement	213 (35.80)
Iliopsoas release	193 (32.44)
Chondroplasty	179 (30.08)
Synovectomy	103 (17.31)
Microfracture	72 (12.10)
Trochanteric bursectomy	66 (11.09)
Loose body removal	65 (10.92)
Gluteus medius repair (arthroscopic)	19 (3.19)
Excision of bone cyst (femur)	18 (3.03)
Labral resection	17 (2.86)
Acetabular notchplasty	16 (2.69)
Os acetabulum removal	13 (2.18)
Labral reconstruction	9 (1.51)
Iliotibial band release	5 (0.84)
Excision bone cyst (acetabulum)	3 (0.50)
Piriformis release (arthroscopic)	3 (0.50)
Sciatic neurolysis (arthroscopic)	3 (0.50)
Arthroscopic removal of screw	2 (0.34)
Pubic symphysis resection	2 (0.34)

[a]All procedures are arthroscopic unless otherwise specified.

TABLE 6
Final Diagnosis (n = 595 Procedures)

Diagnosis	No. (%)
Labral tear	591 (99.3)
Pincer defect	416 (70.0)
Cam defect	392 (66.0)
Ligamentum teres tear	296 (50.0)
Articular cartilage damage	251 (42.1)
Painful internal snapping	193 (32.4)
Synovitis	103 (17.3)
Trochanteric bursitis	66 (11.1)
Loose body	65 (10.9)
Gluteus medius tear	19 (3.19)
Acetabular notch osteophyte	16 (2.69)
Os acetabuli	13 (2.18)
Painful external snapping	5 (0.84)
Piriformis syndrome	3 (0.5)
Painful internal hardware	2 (0.34)
Osteitis pubis	2 (0.34)

Endpoints

The clinical endpoint was set as whether the patient did or did not undergo a THA or a hip resurfacing procedure. Fifty-four (9.1%) patients underwent either THA (46 patients) or hip resurfacing procedure (8 patients) during the study period. For the patients undergoing conversion to THA/resurfacing procedure, 54% had preoperative Tönnis grade 0, and 46% had Tönnis grade 1. For those patients who did not undergo an arthroplasty procedure, 76.2% had preoperative Tönnis grade 0, and 23.7% had Tönnis grade 1. This difference between groups was statistically significant ($P < .001$). There were no patients with Tönnis grade 2 or higher. In addition, 47 (7.7%) patients underwent revision hip arthroscopy during the study period. For the patients undergoing revision hip arthroscopy, the preoperative diagnoses are presented in Table 8. The most common reasons for revision arthroscopy include labral retear (85.1%), residual cam deformity (53.2%), loose body removal (51.1%), adhesions (10.6%), and heterotopic ossification (8.5%). After revision arthroscopy, the score improvement from preoperative to last follow-up (average, 15.7 months) was 56.94 to 69.25 for mHHS, 59.25 to 70.43 for HOS-ADL, 36.54 to 53.43 for HOS-SSS, and 53.76 to 68.11 for NAHS. Scores on the

TABLE 7
Mean Preoperative and Postoperative Patient-Reported Outcome Scores for Patients Undergoing Primary Hip Arthroscopy[a]

Measure	Preoperative	Postoperative	P Value
mHHS	61.29 ± 15.7	82.02 ± 16.82	<.0001
HOS-ADL	62.79 ± 20.1	83.05 ± 18.8	<.0001
HOS-SSS	40.96 ± 25.04	70.07 ± 28.04	<.0001
NAHS	57.97 ± 18.52	80.41 ± 18.64	<.0001
VAS	5.86 ± 2.2	2.94 ± 2.42	<.0001

[a]Values are reported as mean ± SD. HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SSS, Hip Outcome Score–Sport-Specific Subscale; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

visual analog scale improved from 6.24 to 4.23. All scores showed significant improvement after revision surgery (Table 9). Overall patient satisfaction was 6.95 at last follow-up.

Multivariate Regression Analysis

The online Appendix lists all 33 factors that were analyzed in our multivariate regression analysis. We defined clinical success as no conversion to THA or hip resurfacing procedure during the study period and change in NAHS >10. Of the 33 factors considered, 10 were simultaneously significant at $P < .10$. According to our model, increases in age at surgery and acetabuloplasty were associated with increased THA failure rates, whereas increases in preoperative NAHS, acute injury, central joint space, crossover percentage, lateral center-edge angle, preoperative flexion, and trochanteric bursectomy were simultaneously associated with decreases in THA failure rates (Table 10).

For those patients who underwent revision arthroscopy during the study period (Table 11), acute injury, microfracture, and female sex were simultaneously associated with increases in the need for revisions, whereas preoperative mHHS, age at surgery, and iliopsoas fractional lengthening were simultaneously associated with decreases in revision failure rates. Thus, 6 of 33 factors were simultaneously significant.

For those patients who had a change in NAHS <10 (Table 12), preoperative NAHS, age at surgery, BMI, preoperative abduction, and iliopsoas fractional lengthening were simultaneously associated with increases in the change in NAHS failure rate, whereas preoperative VAS, lower Tönnis grade, acetabuloplasty, capsular release, and female sex were associated with decreases in the change in NAHS failure rate—a total of 10 simultaneously significant factors out of 33. Only age at surgery was a significant factor for all 3 types of failure; however, acute injury, acetabuloplasty, iliopsoas release, and sex were significant for 2 of the 3 types of failure. Eleven factors were not significant for any of the failure types after controlling for those factors that were significant. Figure 1 shows the competing failure (risk) cumulative incidence versus follow-up time. At the 30-month follow-up, the cumulative risk of THA failure was 8.6%, the cumulative risk of revision failure was 6.8%, and the cumulative risk of a change in NAHS <10 was 24.8%. Our overall survivorship at 2 years postoperatively was 91.4%.

TABLE 8
Preoperative Diagnosis for Revision Arthroscopy (n = 47)

Diagnosis	No. (%)
Labral tear	40 (85.1)
Cam-type deformity	25 (53.19)
Joint stiffness/limited range of motion	25 (53.19)
Loose body (intra-articular)	24 (51.06)
Synovitis	16 (34.04)
Chondral defect	15 (31.91)
Instability	14 (29.79)
Ligamentum teres tear	13 (27.66)
Pincer deformity	13 (19.15)
Hip flexor tendinitis	7 (14.89)
Internal snapping	7 (14.89)
Iliopsoas bursitis	6 (12.77)
Adhesive capsulitis	5 (10.64)
Heterotopic ossification	4 (8.51)
Gluteus medius tear	2 (4.26)
Iliotibial band friction syndrome	1 (2.13)
Subspine impingement	1 (2.13)

TABLE 9
Mean Preoperative and Postoperative Patient-Reported Outcome Scores for Patients Undergoing Revision Hip Arthroscopy[a]

Measure	Preoperative	Postoperative	P Value
mHHS	56.94 ± 14.22	69.25 ± 17.03	<.0001
HOS-ADL	59.25 ± 19.45	70.43 ± 20.13	.006
HOS-SSS	36.54 ± 23.5	53.43 ± 28.26	.009
NAHS	53.76 ± 18.19	68.1 ± 18.67	.001
VAS	6.24 ± 1.7	4.23 ± 2.28	<.0001

[a]Values are reported as mean ± SD. HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SSS, Hip Outcome Score–Sport-Specific Subscale; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

DISCUSSION

We present minimum 2-year follow-up of all primary hip arthroscopies performed at a high-volume tertiary referral center for hip preservation. Our results show that in aggregate for all patients, hip arthroscopy shows a statistically significant improvement for all PRO measures, radiographic measures, and visual pain scores. Our overall complication rate was 6.1% for minor complications. We did not have any major complications, including hip dislocation or femoral neck fracture. Revision arthroscopy was performed on 7.7% of the group, and a THA or hip resurfacing procedure was performed on 9.2% of the group. Our multivariate regression analysis showed that increases in age at time of

TABLE 10
Multivariate Regression Analysis Using THA as an Endpoint

Predictor	Rate Ratio	Lower	Upper	*P* Value
Preoperative NAHS	0.980	0.965	0.995	.009
Age at surgery	1.09	1.063	1.116	<.001
Acute injury	0.401	0.214	0.752	.004
Central joint space	.003	.0001	.07	<.001
Crossover percentage	0.982	0.963	1.001	.066
Lateral center-edge angle	0.898	0.862	0.935	<.001
Preoperative flexion	0.973	0.956	0.990	.0018
Acetabuloplasty	1.9	1.1	3.28	.022
Trochanteric bursectomy	0.451	0.191	1.061	.068

NAHS, Non-Arthritic Hip Score; THA, total hip arthroplasty.

TABLE 11
Multivariate Regression Analysis Using Revision Hip Arthroscopy as an Endpoint

Predictor	Rate Ratio	Lower	Upper	*P* Value
Preoperative modified Harris Hip Score	0.98	0.97	1.00	.0497
Age at surgery	0.95	0.93	0.98	<.001
Acute injury	2.69	1.4	5.17	.0025
Iliopsoas fractional lengthening	0.51	0.26	1.03	.054
Microfracture	2.15	.87	5.3	.09
Female sex	2.86	1.43	5.73	.002

TABLE 12
Multivariate Regression Analysis Using the Change in NAHS <10 as an Endpoint[a]

Predictor	Rate Ratio	Lower	Upper	*P* Value
Preoperative VAS	0.78	0.72	0.846	<.001
Age at surgery	1.01	0.997	1.025	.12
Tönnis grade	0.596	0.393	0.905	.015
Acetabuloplasty	0.713	0.502	1.013	.059
Capsular release	0.567	0.369	0.872	<.01
Iliopsoas fractional lengthening	1.69	1.126	2.52	.011
Female sex	0.461	0.315	0.673	<.001

[a]NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

surgery is a significant risk factor for conversion to THA, revision arthroscopy, and change in NAHS <10 points. In addition, we defined a successful outcome as a change in NAHS >10 with no revision arthroscopy or conversion to THA during the study period. Our success rate was 59.8% at 2 years postoperatively based on our criteria. Our overall survivorship was 91.4% at 2 years postoperatively.

With regard to conversion to THA, our multivariate regression analysis found that an acetabuloplasty and increase in age at the time of surgery were risk factors for conversion to THA. We theorize that patients requiring acetabuloplasty may have pincer-type impingement and possible underlying cartilage damage, which was difficult to detect preoperatively. Similarly, patients with increased age at the time of surgery may have more intra-articular cartilage damage and early arthritis that

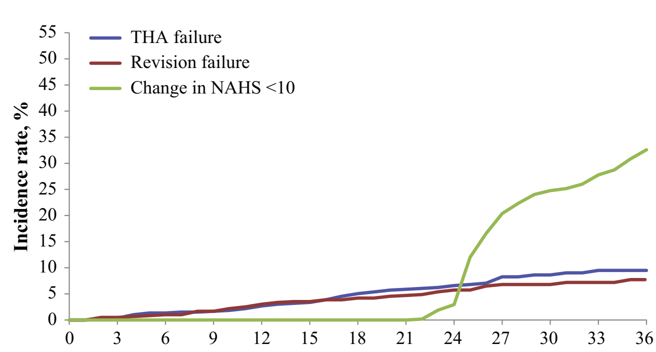

Figure 1. Competing failure (risk) cumulative incidence versus follow-up time. The median follow-up time was 25 months. NAHS, Non-Arthritic Hip Score; THA, total hip arthroplasty.

was not detectable preoperatively. This was confirmed by those patients undergoing THA or a resurfacing procedure having statistically significant more Tönnis grade 1 changes compared with those patients who did not receive these procedures.

Philippon et al[39] evaluated the outcomes after hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction with a minimum 2-year follow-up. They studied 112 patients and found an improvement in mHHS from 58 to 84 with a median satisfaction of 9 (scale of 1-10). Ten patients underwent total hip replacement at a mean of 16 months after arthroscopy. Similarly, we found an increase in mHHS at 2 years postoperatively from 61.29 to 82.02. Our THA failure rate during the study period was 8.6%, which is again similar to 8.9% reported by Philippon et al during their study period.

Matsuda et al[33] published a systematic review comparing open, mini-open, and arthroscopic surgical intervention for femoroacetabular impingement. The subgroup analysis for hip arthroscopy (8 studies) had a clinical success rate of 67% to 90% at a mean follow-up of 1.8 years. Their THA conversion rate was 0% to 9%. They found a major complication rate of 0% to 5% with no reports of femoral neck fracture. In our study, we reported a THA failure rate of 8.6% and an overall minor complication rate of 6.1%. We did not report any major complications.

Harris et al[24] performed a systematic review to determine the prevalence and complications and reoperations during and after hip arthroscopy. Ninety-two studies (6134 participants) were included, and they found a 0.58% major complication rate and a 7.5% minor complication rate. The overall reoperation rate was 6.3%, occurring at a mean of 16 months, with THA the most common reoperation. The conversion rate to THA was 2.9%. This study did not have a minimum of 2-year follow-up, and clinical outcomes scores were not reported. These numbers are comparable with our own study, which showed a similar overall minor complication rate. We theorize that with longer follow-up, the incidence of reoperation should increase over time.

Kowalczuk et al[29] performed a similar systematic review to determine the complication rate associated with hip arthroscopy in the literature. Sixty-six studies were identified (6962 hips) with a 4.0% overall complication rate and 0.3% major complication rate. Similarly, in our current study, we found a minor complication rate of 6.1% and no major complications.

Byrd and Jones[7] published 10-year follow-up data on the outcomes of hip arthroscopy performed on 50 patients and analyzed a subset of 15 patients who developed symptoms in the course of athletic activity. Median improvement in mHHS was 45 points (range, 51-96) postoperatively, with 13 patients returning to their sports. All 5 athletes with preoperative arthritis eventually underwent total hip arthroplasty.

With regard to heterotopic ossification (HO), we found a 2.3% rate postoperatively. In our practice, patients are given 325 mg aspirin taken twice daily for 4 weeks. Bedi et al[2] performed a cohort study of 616 primary hip arthroscopies with the addition of indomethacin to a standard 4-week postoperative protocol of naproxen. They found that HO occurred at a rate of 8.3% without indomethacin and 1.8% with the addition of indomethacin, for an overall HO rate of 4.7%. Rath et al[40] reviewed 83 patients who underwent various hip arthroscopy procedures and found a 44% rate of radiographic evidence of postoperative HO. Logistic regression analysis was unable to find a significant contributing factor.

One of the strengths of this study was that, to our knowledge, this is the largest series of primary hip arthroscopy patients studied from a single surgeon with a minimum 2-year follow-up. In addition, we were able to analyze 4 PRO measures and radiographic measurements both preoperatively and at 2-year follow-up. Limitations of our study include the mixed patient population, which is inherent in a study of this design. Our aims of this study were to present the aggregate data of all hip arthroscopies performed; we did not perform a logistic regression analysis to substratify the success rate of individual procedures within our data. In addition, we did not have a control group in our large case series.

CONCLUSION

Primary hip arthroscopy for all procedures performed in aggregate showed excellent clinical outcomes and patient satisfaction scores, with an overall survivorship of 90.8% at 2-year follow-up. Clinical scores showed significant improvement for all patient-reported outcome scores. There was a 6.1% minor complication rate and a 9.2% conversion rate to THA, consistent with previous studies. These results show that primary hip arthroscopy provides significant benefits with regard to PRO, VAS, and patient satisfaction scores at 2-year follow-up. Patients should be counseled regarding the potential progression of degenerative change leading to arthroplasty and the potential for revision surgery.

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