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Survivorship Rate and Clinical Outcomes 10 Years After Arthroscopic Correction of Symptomatic Femoroacetabular Impingement

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Background: Femoroacetabular impingement (FAI) is a common mechanical hip condition, prevalent in both the athletic and the general population. Surgical intervention is an effective treatment option that improves both symptoms and function in short- to medium-term follow-up. Few studies within the literature have reported the longer-term success of arthroscopic surgery.

Purpose: The aim of this study was to quantify the 10-year survivorship and clinical outcome for patients treated arthroscopically for symptomatic FAI.

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

Methods: Patients from our hip registry (n = 119) completed patient-reported outcome measures (PROMs) including the modified Harris Hip Score (mHHS), University of California Los Angeles (UCLA) activity scale, 36-Item Short Form Health Survey (SF-36), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) at a minimum of 10 years after arthroscopy (range, 10-12 years). Results were compared with baseline scores using the Wilcoxon signed rank test. The associations among several prognostic factors, which included age, sex, Tönnis grade, and labral treatment, and subsequent conversion to total hip replacement (THR) or repeat hip arthroscopy (RHA) were analyzed using the chi-square analysis. Relationships between range of motion and radiological findings with clinical outcome were also examined using Pearson correlation analysis. Minimal clinically important difference (MCID) was calculated using a distribution method (0.5 standard deviation of the change score), and substantial clinical benefit (SCB) was determined using an anchor method. Finally, receiver operating characteristic curves with subsequent Youden index were used to determine cutoffs for PROMs, which equated to a Patient Acceptable Symptom State (PASS).

Results: A total of 8.4% of cases required conversion to THR, and 5.9% required RHA. Statistically significant improvements in mHHS, SF-36, and WOMAC scores, with high satisfaction (90%), were observed 10 years after surgery. No significant change was seen in activity level (UCLA score) despite patients being 10 years older. A high percentage of patients achieved MCID for mHHS (88%), SF-36 (84%), and WOMAC (60%). The majority of patients also achieved PASS (62% for mHHS, 85% for UCLA, 78% for SF-36, and 84% for WOMAC) and SCB (74% for mHHS, 58% for UCLA, 52% for SF-36, and 56% for WOMAC).

Conclusion: Arthroscopic intervention is a safe and viable treatment option for patients with symptomatic FAI, and patients can expect long-term improvements and high satisfaction. Results indicated a high satisfaction (90%) and survivorship rate (91.6%), with excellent clinical outcome, 10 years after the initial procedure.

Keywords: hip impingement; cam deformity; pincer deformity; labral repair; PROM; clinical outcome

Femoroacetabular impingement (FAI), described by Ganz et al,[12] is a bony deformity of the hip joint either on the head-neck junction (cam impingement) or the acetabulum (pincer impingement) or, in cases of dual pathology, both. These deformities obstruct fluid movement of the femoral head within the acetabulum during motion. Repetitive abnormal contact may result in subsequent damage to the acetabular labrum and articular cartilage. The onset of symptoms is often insidious in nature and primarily includes anterior groin pain and joint stiffness, often made substantially worse by bouts of intense physical activity. Progressive symptoms with a reduced range of motion (ROM) result in gradual loss of hip function.[6,42] Chronic injury to the joint increases the risk of osteoarthritis (OA) and eventual conversion to total hip replacement (THR).[1,11,12] Interventions entail either a nonsurgical or a surgical approach. Nonsurgical management focuses on education, activity modification, strengthening exercises, or intra-articular injections, including corticosteroids and

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hyaluronic acid.[26] Alternatively, the aim of surgical intervention is to remove the obstructing bone and repair the underlying tissue where possible. Research comparing both strategies has found improved symptoms and outcome in the short term, although to a greater extent with a surgical approach.[14,28,41]

Studies reporting the longer term benefits of surgical intervention are beginning to emerge. Steppacher et al[47] quantified outcomes of patients treated for FAI using a dislocation approach 10 years after the initial treatment. The authors reported on failure rates, patient-reported outcomes, and radiological imaging; failure was defined as a change in Tönnis grade, conversion to THR, or a Merle d'Aubigne-Postel score <15. Cumulatively, 80% of hips had survived at 10 years, and patient-reported outcome measures (PROMs) had improved when compared with the 5-year analysis. Menge et al[32] described a 66% survival rate at the 10-year follow-up after arthroscopy for FAI, although no differences were noted in outcomes between those with a labral repair versus debridement. In contrast, Lee et al[23] compared long-term outcomes with both preoperative and short-term outcomes in a small cohort of Korean patients treated for labral tears and FAI, in which 12.2% had further hip surgery and 2.4% converted to THR; significant improvements in PROMs were also noted.

For most long-term studies examining the outcome after arthroscopic hip surgery, definitions of FAI and surgical treatment techniques have varied.[23,47] The differences in survival rates reported across the literature may be attributed to the inclusion of patients with dysplasia or osteoarthritic changes (Tönnis grade >1) and surgeries in which abnormal bony morphology was not corrected.[4,29] Therefore, the extent to which corrective surgical intervention improves long-term outcomes and the factors likely to influence these results in a population without arthritis and dysplastic FAI remain unclear.

Predicting the likelihood of eventual failure and conversion to THR is necessary for clinical decision making. Some predictors of failure have been described previously and include age,[24] sex,[54] prolonged symptom duration and pain,[35] and more significant degenerative changes in the joint at the time of intervention.[7,44] The primary aim of this study was to report on the survivorship and clinical outcome of hip arthroscopy for symptomatic FAI at 10 years after intervention and to determine both patient characteristics and pathological parameters likely to predict failure. A secondary aim was to quantify clinically meaningful improvement using minimal clinically important difference (MCID), Patient Acceptable Symptom State (PASS), and substantial clinical benefit (SCB).

METHODS

Assessments

Institutional approval was provided for the analysis of prospectively collected data as part of a hip registry. After written consent was obtained, we considered consecutive patients between September 2008 and September 2010 diagnosed and treated arthroscopically for symptomatic FAI by the senior author (P.C.) for inclusion in the study (182 hips). The senior author was blinded to individual patient outcomes, which were collected by the second and third authors (D.F. and K.M.).

Patients were diagnosed with FAI via clinical examination, patient clinical history, and specialized hip imaging.[13] Standardized plain radiographs (anteroposterior pelvis) were used to detect the presence of an anterolateral rim deformity by quantifying the lateral center-edge angle (LCEA). Cam deformities were detected by measuring the alpha angle; an alpha angle >55° was considered abnormal. Pincer deformities were diagnosed via the presence of crossover, ischial spine, posterior wall signs, and LCEA angle >35°. Patients were excluded from the study if they were diagnosed with Tönnis grade >1, dysplasia (ie, LCEA <25°), or Perthes/slipped capital femoral epiphysis or had previous ipsilateral hip surgery. Magnetic resonance imaging scans were used to support the diagnosis of FAI and exclude those with early OA or evidence of dysplasia.

Hip function and general health were assessed both initially and 10 years later using the modified Harris Hip Score (mHHS),[5,18,43] University of California Los Angeles (UCLA)[48,52] activity scale, 36-Item Short Form Health Survey (SF-36),[15,22] and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).[30] The mHHS is a measure of functional capacity, whereas the UCLA score quantifies physical activity engagement using an incremental scale that ranges from complete inactivity to regular engagement in impact sports. The SF-36 is a measure of general health and well-being that includes an assessment of the emotional as well as physical well-being of the patient. Finally, the WOMAC is a measure of daily pain and stiffness. At the 10-year follow-up, patients were contacted initially via telephone and received a hard copy of the questionnaires via mail or email.

Surgical Intervention

Patients were positioned supine, and the hip was distracted under image intensifier guidance; an anterolateral portal and a modified anterior portal were used to gain access to

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the hip joint. An interportal capsulotomy was undertaken to permit good visualization and surgical access to the acetabular rim and femoral head-neck region. Where a pincer deformity was present, the acetabular labrum was surgically detached from the rim using a surgical blade, and a pincer resection was completed using a 4.5-mm mechanical bur under radiographic guidance. The labrum was refixed to the rim via 2 suture anchors using a simple looped repair technique. A calcified or poor-quality labrum not suitable for repair underwent segmental excision. Specific treatment techniques for damaged cartilage such as microfracture were not used in any cases, irrespective of chondral damage; unstable or fibrillated chondrolabral tearing was lightly debrided, preserving as much of the chondral substance as possible. A cam deformity was removed using a 5.5-mm mechanical bur, restoring head-neck offset under image intensifier guidance. Capsule repair was not undertaken for any cases during the study period.

Postoperative Rehabilitation

Patients were permitted to fully bear weight as comfortable using 2 crutches for assistance for 4 to 5 days. Static cycling was encouraged from day 1, and hydrotherapy was encouraged after incisions had healed, usually at 10 days from operation. All hip movements were permitted as comfortable other than extension and external rotation, which were protected for 4 weeks, at which point full ROM was encouraged. Patients with minimal articular cartilage damage were permitted to begin running at week 8, to begin sprinting at week 10, and to return to sports training at week 12. Those with more advanced articular cartilage injury were advised to avoid running for at least 12 weeks.

Statistical Analysis

Statistical Package for Social Sciences (SPSS) Version 26 software (IBM SPSS Statistics) was used for all statistical analysis. A Shapiro-Wilk test was first conducted to assess all data for normality. Differences in patient-reported outcomes from preoperative assessment to follow-up for the entire group were assessed using Wilcoxon signed rank testing. Differences in outcomes between subcategories based on sex, Tönnis grade, labral treatment (excision, debridement, repair), and age at the time of surgery (<25 years, 25-40 years, >40 years) were assessed using a 1-way analysis of variance. PROMs are presented as median and 25th to 75th interquartile range (IQR) in each case. THR and repeat hip arthroscopy (RHA) rates relative to these categories were assessed using chi-square analysis. A Kaplan-Meier curve was included to determine survivorship of the entire group with respect to THR. Regression analysis was carried out to identify subsequent predictors of THR. Pearson correlations were used to assess relationships between pre- and postoperative ROM and radiological findings with follow-up outcomes. A subgroup of the entire cohort who had PROM outcomes at 2, 5, and 10 years was analyzed using repeated-measures analysis of variance with pairwise comparisons. In each instance, the α level was set at .05. For each statistical test where a statistically significant value was recorded, the relevant effect size with appropriate interpretation was calculated.[19]

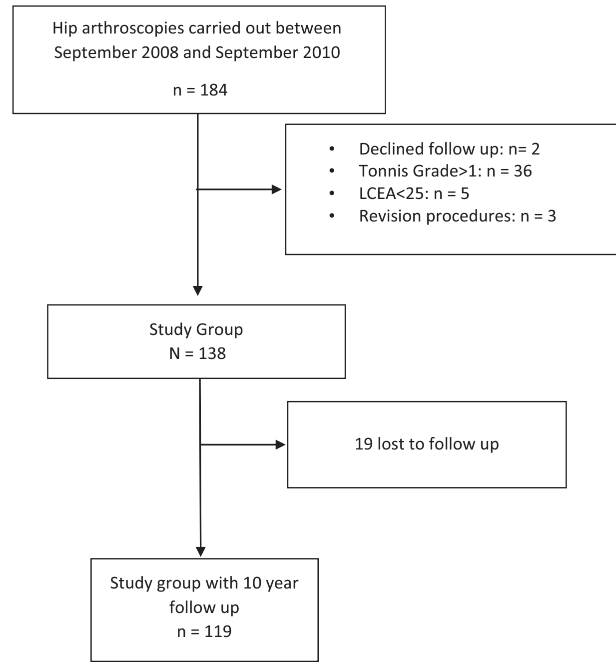

Figure 1. Patient recruitment. LCEA, lateral center-edge angle.

Clinical significance was determined using the MCID,[21] SCB,[38] and PASS.[50] MCID was quantified using a distribution method[36] (0.5 SD of the change score) to determine values that equated to the minimum change needed to observe clinical relevance. The percentage of patients meeting or exceeding this value was then reported for each PROM. SCB values were determined using an anchor-based method. Patients were asked, "How well did the surgery on your joint meet your expectations?"[27] Five possible responses were provided: excellent, very good, good, fair, and poor. We considered a rating of "good" and above to equate an SCB. Patients who reported satisfaction rates of good and above were assessed independently. The SCB value for each PROM for this group was quantified, and the percentage of athletes from the total group meeting or exceeding this figure was determined.

To evaluate the PASS, patients were asked, "Taking into account all the activities you have during your daily life, your level of pain and also your functional impairment, do you consider that your current state is satisfactory?"[50] Receiver operating characteristic curves and the subsequent Youden index[10] were used to determine scores for each PROM that would equate to PASS and SCB. An area under the curve of 0.7 was considered acceptably predictive of PASS.[16]

RESULTS

A total of 138 cases met the inclusion criteria (Figure 1) within the study period (10 patients with bilateral

TABLE 1
Case Characteristics[a]

Variable	n (%) or Mean ± SD (Range)
Sex	
Male	110 (80)
Female	28 (20)
Age at surgery, y	31.6 ± 9.7 (15.3-54.7)
Tönnis grade	
0	101 (73.2)
1	37 (26.8)
Type of impingement	
Cam type	28 (20.3)
Pincer type	13 (9.4)
Mixed impingement	97 (70.3)
Outerbridge score	
Acetabulum	
0	79 (57.2)
1	8 (5.8)
2	9 (6.5)
3	10 (7.2)
4	19 (13.8)
NA	13 (9.4)
Femoral	
0	115 (83.3)
1	3 (2.2)
2	2 (1.4)
3	3 (2.2)
4	4 (2.9)
NA	11 (8)
Labral treatment	
Excision	12 (8.7)
Debridement	28 (20.3)
Repair	98 (71.0)
Alpha angle	68 ± 18 (40-101)
Lateral center-edge angle	37.5 ± 8 (25-64)
Preoperative flexion	97.4 ± 8.7 (85-130)
Preoperative abduction	42.9 ± 7.1 (30-70)
Preoperative adduction	8.1 ± 6.4 (0-30)
Preoperative external rotation	41.3 ± 9.3 (10-70)
Preoperative internal rotation	9.5 ± 8 (0-50)
Preoperative total range of motion	199 ± 29 (150-335)

[a]Angle measurements and ranges of motion are expressed as degrees. NA, not applicable.

surgery). In total, 86% of cases were followed up at minimum 10 years after operation (range 10-12 years; n = 119 cases in 113 patients). Table 1 describes the operated case characteristics, whereas Table 2 examines differences between cases who responded to follow-up and those who did not. A total of 10 cases (8.4%) were converted to THR (91.6% survivorship), and 7 cases required RHA (5.9%). The average times of THR and RHA were 6.4 ± 2.7 and 2.3 ± 2.2 years, respectively.

Significant improvements were recorded in all PROMs at 10 years after intervention for the entire group (*P* < .05 for all) with medium to large effect sizes (ESs) except for the UCLA measure (*P* = .265). The UCLA demonstrated an increase in median value from 8 to 9, but this improvement was not statistically significant (Table 3).

A subset of 46 cases who had PROM outcomes at 2, 5, and 10 years were analyzed using a repeated-measures

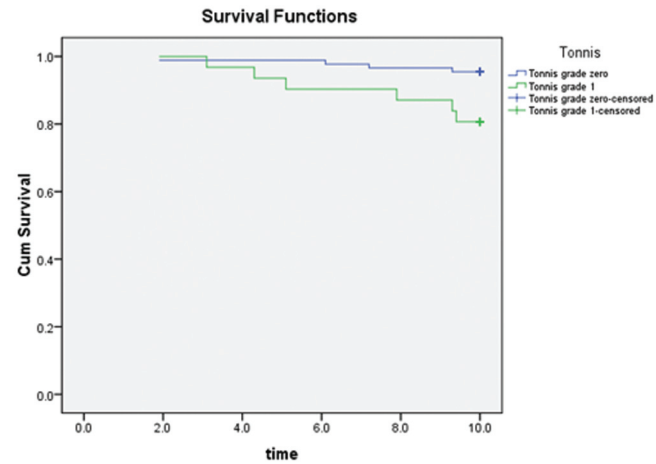

Figure 2. Kaplan-Meier curve indicating cumulative (Cum) survival over time (years) based on Tönnis grade.

approach (Table 4). Large improvements compared with baseline, which were statistically significant at every time point (2, 5, and 10 years), were recorded for each outcome. The initial and midterm improvements in the UCLA measure (2 and 5 years) had decreased to the preoperative value at 10 years after surgery.

Effects of Sex

Sex (Table 5) was not associated with THR (*P* = .687) or RHA (*P* = .659), and there were no differences between sexes and PROMs with the exception of the UCLA score. Males had significantly higher UCLA scores at baseline compared with females (median [IQR], 9 [6-10] vs 6 [4-9], respectively; *P* = .001; ES = 0.363 [medium]), which was maintained at 10 years (median [IQR], 9 [7-10] vs 6 [6-8], respectively; *P* = .001; ES = 0.382 [medium]).

Effect of Age

Age was not associated with increased likelihood of conversion to THR (*P* = .188) or RHA (*P* = .433) (Table 5). Patients aged <25 years at the time of surgery had significantly higher UCLA scores at 10 years compared with those aged >40 years (median [IQR], 10 [9-10] vs 7 [6-8], respectively; *P* = .009; ES = 1.1 [large]). Patients between the ages of 25 and 40 years at the time of surgery had superior WOMAC scores at 10 years compared with those aged >40 years (median [IQR], 2 [0-9] vs 17 [0-24], respectively; *P* = .032; ES = 0.629 [medium]). No differences between age categories were detected for the other PROM measures.

Effect of Bony Morphology, Labral Management, and Outerbridge Score

Tönnis grade was associated with subsequent THR (*P* = .026). The survival rate of cases with Tönnis grade 1 was

TABLE 2
Characteristics of Cases Who Responded and Those Who Were Lost to Follow-up[a]

Variable	Responded to Follow-up (n = 119)	Lost to Follow-up (n = 19)	*P* Value
Sex			
Male	93 (78.2)	17 (89.5)	.254
Female	26 (21.8)	2 (10.5)	
Age at surgery, y	32.3 ± 9.5	27.6 ± 9.8	.066
Tönnis grade			
0	85 (71.4)	16 (84.2)	
1	34 (28.6)	3 (15.8)	.243
Type of impingement			
Cam type	24 (20.2)	4 (21.1)	
Pincer type	11 (9.2)	2 (10.5)	.977
Mixed impingement	84 (70.6)	13 (68.4)	
Outerbridge score			
Acetabulum			
0	67 (56.8)	12 (63.2)	
1	6 (5.1)	2 (10.5)	
2	7 (5.9)	2 (10.5)	.297
3	8 (6.8)	2 (10.5)	
4	18 (15.3)	1 (5.3)	
NA	12 (10.2)	0	
Femoral			
0	97 (82.2)	18 (94.7)	
1	3 (2.5)	0	
2	1 (0.8)	1 (5.3)	.441
3	3 (2.5)	0	
4	4 (3.4)	0	
NA	10 (8.5)	0	
Labral treatment			
Excision	11 (9.2)	1 (5.3)	.392
Debridement	26 (21.8)	2 (10.5)	
Repair	82 (68.9)	16 (84.2)	
Alpha angle, deg	68 ± 19	69 ± 15	.774
Lateral center-edge angle, deg	37 ± 7	41 ± 11	.200
Baseline mHHS [scored 0-100]	81 (69-86)	83 (78-91)	.276
Baseline UCLA [scored 0-10]	8 (6-10)	10 (6-10)	.471
Baseline SF-36 [scored 0-100]	82 (66-93)	90 (64-98)	.157
Baseline WOMAC [scored 0-100]	10 (4-24)	4 (2-17)	.043 (effect size = 0.185; small)
Total hip range of motion, deg	199 ± 31	196 ± 18	.529

[a]Values are presented as n (%), mean ± SD, or median (interquartile range). mHHS, modified Harris Hip Score; NA, not applicable; SF-36, 36-Item Short Form Health Survey; UCLA, University of California Los Angeles activity scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

TABLE 3
Comparison of PROM Scoring at Baseline and 10 Years After Surgery[a]

Variable	Baseline	10 Years Postoperative	*P* Value (ES)
mHHS [scored 0-100]	80 (68-86)	100 (96-100)	<.001 (ES = 0.804; large)
UCLA [scored 0-10]	8 (6-10)	9 (6-10)	.265
SF-36 [scored 0-100]	78 (65-92)	92 (84-96)	.001 (ES = 0.479; medium)
WOMAC [scored 0-100]	13 (4-27)	4 (0-13)	.019 (ES = 0.359; medium)

[a]Values are presented median (interquartile range). ES, effect size; mHHS, modified Harris Hip Score; PROM, patient-reported outcome measure; SF-36, 36-Item Short Form Health Survey; UCLA, University of California Los Angeles activity scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

80% compared with 96% survival in cases with Tönnis grade 0 (Figure 2). Whereas a 73% survival rate was noted in cases who had a labrum not suitable for preservation (excised) and a >90% survival rate was noted in cases whose labrum was preserved (debridement, 92%; repair, 94%), these differences were not statistically significant (*P* = .057). Binary regression showed that an Outerbridge grade 4 on the femoral side was predictive of subsequent THR (*P* = .023; odds ratio, 11.250;

TABLE 4
Comparison of PROM Scoring at Baseline, 2 Years, 5 Years, and 10 Years After Surgery[a]

Variable	Baseline	2 Years	5 Years	10 Years	P Value
mHHS [scored 0-100]	80 (66-86)	100 (96-100)	97 (96-100)	100 (96-100)	<.001
UCLA [scored 0-10]	8 (5-10)	9 (8-10)	9 (7-10)	8 (7-10)	.007
SF-36 [scored 0-100]	79 (65-92)	91 (87-96)	92 (87-97)	90 (86-96)	.001
WOMAC [scored 0-100]	18 (4-30)	5 (0-9)	2 (0-8)	4 (0-17)	<.001

[a]Values are presented as median (interquartile range). mHHS, modified Harris Hip Score; PROM, patient-reported outcome measure; SF-36, 36-Item Short Form Health Survey; UCLA, University of California Los Angeles activity scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

95% confidence interval, 1.393-90.873). At follow-up, no differences in PROMs were noted based on Tönnis grade 0 or 1, Outerbridge grade, labral treatment, impingement type, or bilateral or unilateral surgery.

Effect of Radiological Parameters and Hip ROM

No significant correlations between preoperative alpha angles or LCEA angles and PROMs were observed. Higher preoperative flexion (P = .034; ES = −0.313 [small]) and internal rotation (P = .042; ES = −0.301 [small]) were associated with improved WOMAC scores 10 years after operation. Higher preoperative abduction was associated with higher postoperative mHHS (P = .046; ES = 0.220 [small]). No other associations between preoperative ROM and PROMs were recorded. No statistically significant correlations between postoperative ROM (measured at 2 years after surgery) and PROMs were recorded.

Psychometric Analysis

MCID. The change required for MCID (Table 6) for mHHS was 7 points, and 88% of cases achieved or exceeded this value. The MCID for UCLA was 1.5, and 58% achieved this value. Further, 84% achieved MCID for SF-36 (9 points required), and 60% achieved it for WOMAC (8 points required).

SCB. The mean change required for SCB based on the anchor-based method for the mHHS was 20 points, which 74% of eligible cases achieved. The SCB was 2 for UCLA, and 58% of cases achieved this. A change of 18 points was required for SCB for the SF-36 measure, and 52% of cases achieved or exceeded this value. Finally, an improvement of 16 points on the WOMAC corresponded to SCB, with 56% of cases achieving this value.

PASS. In total, 90% of patients were satisfied with their current hip function (PASS), and 85% would repeat the surgery again if required. The values for mHHS, UCLA, SF-36, and WOMAC that equated to PASS in this cohort were 97, 5.5, 81.5, and 17.5, respectively. We noted that 62% achieved PASS for mHHS; 85%, for UCLA; 78%, for SF-36; and 84%, for WOMAC. The receiver operating characteristic curves for PASS (each with an area under the curve >0.7) can be found in the Appendix (available in the online version of this article).

DISCUSSION

The results of this study demonstrate the long-term success of arthroscopic correction of FAI for symptomatic patients. At 10 years after the procedure, patients can expect a high survivorship (91.6%) as demonstrated by low conversion to THR (8.4%) and RHA rates (5.9%). Furthermore, patients can expect sustained improvements in general health status as well as hip-specific symptoms and function. High satisfaction rates from arthroscopy (90% satisfied with their current 10-year postoperative state) were also observed.

Survivorship, and specifically the avoidance of THR, are key outcomes of interest in the assessment of long-term benefits of hip arthroscopy. To date, a limited number of studies have been published with longer term outcomes from arthroscopic hip surgery.[§] However, in the majority of these studies, the cohorts examined were not representative of FAI exclusively. In a study examining the 10-year outcome from arthroscopic labral debridement (without bony deformity correction) in a general population, Byrd and Jones[4] demonstrated good outcome for patients without arthritis in 83% of cases; the presence of features of arthritis resulted in a conversion rate of 88% to THR at a mean of 63 months (~5 years). Olach et al[40] reported a mean 11.2-year follow-up in a mixed hip pathology cohort of which just 35% represented FAI. Among this cam-type FAI group, 33% underwent an undefined revision procedure. Meftah and colleagues[31] reported results from a mixed pathology group of patients undergoing arthroscopic labral debridement. At 8 years of follow-up, a 4% conversion to THR was reported. In the current study, we aimed to assess a more homogeneous sample representative of a population with true symptomatic FAI. The 91.6% survivorship from THR at 10 years after primary hip arthroscopy supports this intervention as an effective management strategy in the appropriately selected patient. This survivorship rate is comparable with an 86.3% survivorship in patients undergoing arthroscopy for FAI with Tönnis grade <2 reported in a recent study.[54]

The indications for hip arthroscopy as a treatment intervention for FAI have evolved over the years. Certain morphologic and patient predictors of increased risk of conversion to THR or reoperation are now well established.[46,54] A strong association between the extent of

[§]References 1-3, 5, 7, 8, 15, 21, 28, 29, 36, 47, 48.

TABLE 5
Comparisons Between Cases With THR or RHA and Those With No Further Procedure[a]

Variable	THR (n = 10)	No Further Procedure (n = 102)	*P* Value
Sex			.687
Male (n = 88)	9 (10.2)	79 (89.8)	
Female (n = 24)	1 (4.2)	23 (95.8)	
Age			.188
<25 y (n = 25)	0	25 (100)	
25-40 y (n = 63)	8 (12.7)	55 (87.3)	
>40 y (n = 24)	2 (8.3)	22 (91.7)	
Tönnis grade			.026 (effect size = 0.226; small)
0 (n = 81)	4 (4.9)	77 (95.1)	
1 (n = 31)	6 (19.4)	25 (80.6)	
Outerbridge score			
Acetabulum			.211
0	4 (6.2)	60 (93.8)	
1	0	6 (100)	
2	1 (14.3)	6 (85.7)	
3	0	7 (100)	
4	2 (12.5)	14 (87.5)	
NA	3 (27.3)	8 (72.7)	
Femoral			.165
0	7 (7.6)	85 (92.4)	
1	0	3 (100)	
2	0	1 (100)	
3	0	3 (100)	
4	2 (50)	2 (50)	
NA	1	8 (88.9)	
Labral treatment			.057
Excision (n = 10)	3 (30)	7 (70)	
Debridement (n = 23)	2 (8.7)	21 (91.3)	
Repair (n = 79)	5 (6.3)	74 (93.7)	
Variable	**RHA (n = 7)**	**No Further Procedure (n = 102)**	***P* Value**
Sex			.659
Male (n = 84)	5 (6)	79 (94.0)	
Female (n = 25)	2 (8)	23 (92)	
Age			.433
<25 y (n = 28)	3 (10.7)	25 (89.3)	
25-40 y (n = 59)	4 (6.8)	55 (93.2)	
>40 y (n = 22)	0	22 (100)	
Tönnis grade			.370
0 (n = 81)	4 (4.9)	77 (95.1)	
1 (n = 28)	3 (10.7)	25 (89.3)	
Outerbridge score			
Acetabulum			.422
0	3 (4.9)	58 (95.1)	
1	0	11 (100)	
2	0	5 (100)	
3	1 (12.5)	7 (87.5)	
4	2 (14.3)	12 (85.7)	
NA	1 (10)	9 (90)	
Femoral			.457
0	5 (5.6)	84 (94.4)	
1	0	2 (100)	
2	0	2 (100)	
3	0	3 (100)	
4	0	4 (100)	
NA	2 (22.2)	7 (77.8)	
Labral treatment			.249
Excision (n = 8)	1 (12.5)	7 (87.5)	
Debridement (n = 24)	3 (12.5)	21 (87.5)	
Repair (n = 77)	3 (3.9)	74 (96.1)	

[a]Values are presented as n (%). NA, not applicable; RHA, repeat hip arthroscopy; THR, total hip replacement.

TABLE 6
Psychometric Analysis[a]

	MCID	SCB
mHHS		
Change required, points	7	20
Percentage of cases not achieving change	6	49
Percentage of eligible cases achieving change required	88	74
UCLA		
Change required, points	1.5	2
Percentage of cases not achieving change	53	53
Percentage of eligible cases achieving change required	58	58
SF-36		
Change required, points	9	18
Percentage of cases not achieving change	37	47
Percentage of eligible cases achieving change required	84	52
WOMAC		
Change required, points	8	16
Percentage of cases not achieving change	53	63
Percentage of eligible cases achieving change required	60	56

ROC Curve Analysis	PASS
mHHS	
Score required, points	97
Percentage of cases achieving score required	62
UCLA	
Score required, points	5.5
Percentage of cases achieving score required	85
SF-36	
Score required, points	81.5
Percentage of cases achieving score required	78
WOMAC	
Score required, points	17.5
Percentage of cases achieving score required	84

[a]MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; PASS, Patient Acceptable Symptom State; ROC, receiver operating characteristic; SCB, substantial clinical benefit; SF-36, 36-Item Short Form Health Survey; UCLA, University of California Los Angeles activity scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

articular cartilage damage with progression of OA and conversion to THR is largely reported. Skendzel et al[45] demonstrated that a joint space width <2 mm results in poorer outcomes and higher rate of conversion to THR at 5 years (86%) compared with preserved joint space (16%). Menge et al[32] demonstrated 89% conversion to THR in patients with joint space <2 mm. Moreover, a recent study by Malahias et al[25] reported a 2-year conversion rate to total hip arthroplasty of 68.4% in patients with OA. In the current study, no patients with radiological evidence of OA were included (Tönnis grade >1), although a higher Tönnis grade was still associated with subsequent THR.

Increasing patient age and presence of articular cartilage damage may also lead to higher conversion to THR; Kaldau et al[17] reported 6- to 8-year results in a cohort of 84 patients with FAI and no OA. A total of 18% of patients had converted to THR (17.1% at 5 years) with a reoperation rate of 8.2%. The investigators reported that patients >40 years old and those with a high grade of articular cartilage damage were at a greater risk of THR conversion. Conversely, in the absence of advanced age, a recent study involving adolescents at a minimum of 10 years of follow-up reported no conversion to THR.[33] In a population-based review by Degen et al,[8] failure after surgery for FAI at 10 years was reported as 25.1% for any revision surgery or 19.1% for conversion to THR. In their report, labral repair and surgical volume were associated with a lower risk of reoperation, whereas older age (>50 years) and the presence of OA resulted in a higher risk of THR conversion. Similarly, we observed a greater proportional survivorship at 10 years when labral repair was performed (>90% vs 73%), but this observation was not statistically significant. This may have been in part due to the relatively small number of THR conversions, which underpowered the analysis. Although it is generally accepted that older age and the presence of OA may increase the risk of THR conversion,[17,24,29,32] in the current study where patients with Tönnis grades 2 and 3 were excluded, there was no correlation with increasing age and higher THR conversion rates. This would suggest that in the absence of OA, age may be less of a factor than was previously thought. Dwyer et al[9] suggested that the presence of articular cartilage damage was a more potent indicator of THR conversion than was age, with comparable survivorship rates observed in patients with similar cartilage damage, irrespective of age. Similarly, in the current study, an Outerbridge grade 4 on the femoral head was predictive of subsequent THR in regression analysis, whereas age and any other patient factors were not. The results indicate the need for timely intervention in the young active patient to avoid irreversible cartilage damage.

The natural history of untreated FAI remains unclear; it is still unknown whether the presence of cam or pincer deformity results in a higher risk of OA development in the asymptomatic patient. Wyles et al[51] reviewed radiographs of 172 patients who underwent unilateral THR 20 years earlier and graded the pathology as dysplasia, FAI, or normal. There was no difference in the risk of progression to OA between FAI and normal; however, dysplasia demonstrated an increased risk of OA progression. In a separate study, Steppacher et al[47] reported that the strongest risk factors associated with failure after surgical dislocation for FAI included age >40 years, body mass index >30, and LCEA <22° or >32°. The authors indicated that optimal acetabular coverage was important for long-term preservation. However, the higher and earlier failure in those with acetabular LCEA <22° would indicate that undercoverage or dysplasia may be the major factor and these cases may not represent true FAI. The preoperative radiological FAI angles measured in our study were not predictive of outcome or survivorship. To ensure the present cohort was truly representative of patients with FAI, we narrowed our inclusion criteria to exclude cases with early OA (Tönnis >1) and dysplasia (LCEA <25°).

The patient-reported outcomes reported in the current study, 10 years after index hip arthroscopy, are comparable with successful shorter term outcomes reported in the literature.[37,39] Significant improvements in hip-specific outcomes (mHHS, $P < .001$; WOMAC, $P = .019$) and generalized well-being (SF-36, $P = .001$) were observed, with medium to large ESs. In a smaller cohort of cases, a complete outcomes data set was available at 2, 5, and 10 years after surgery (n = 46). A highly significant improvement was seen in all outcome measures at each timepoint when compared with preoperative scores, other than activity level (UCLA score). The UCLA score improved at 2 and 5 years but returned to preoperative values at 10 years after surgery; this was not unexpected, most likely reflecting a natural reduction in activity level given patients were 10 years older. This highlights the advantages of measuring activity levels using a separate outcome tool. More recent FAI-specific outcome measures incorporate activity level as part of the overall score.[34,49] This may lead to inaccuracies over longer follow-up periods with the natural decline in intense physical activity participation, irrespective of any limitations in functional ability. The use of validated outcome measures such as the mHHS and WOMAC may be more suitable to capture any deterioration of function or progression to OA among patients with hip arthroscopy over time.

In addition to the statistically significant improvement in overall PROMs sustained at 10 years after surgery, clinical improvement was evaluated. Achievability of MCID and SCB, respectively, was observed for 88% and 74% of cases for mHHS, 60% and 56% for WOMAC, 84% and 52% for SF-36, and 58% and 58% for UCLA. These rates are consistent with those in a recent study by Nwachukwu et al,[37] who reported a 5-year MCID achievability of 79.3% and SCB achievability of 56.6%. Patients in that study, however, were deemed to have achieved both MCID and SCB if they scored appropriately across any 1 of the 4 PROMs used for evaluation. Quantification and reporting of meaningful improvement perceived by the patient are becoming more important within health care assessment; however, interpretation can become confused among the comparative literature. In the only available comparable study to our knowledge assessing the long-term metrics of clinical improvement, Zimmerer et al[53] calculated the MCID for mHHS to be 19.6 points. This is considerably different from our calculated 7 points for the same metric, despite evaluating the same PROM using the same calculation method (0.5 SD of the change score). Nonetheless, an equivalent proportion of cases in the current study (88%) and the study by Zimmerer et al[53] (89%) achieved the study-specific calculated MCID. Likewise, comparative SCB thresholds are different: 31.5 points in the aforementioned comparative study, resulting in a 59% rate of achievability, versus 20 points reported in the current study, resulting in a 74% achievability. In both cases, an anchor-based calculation was used, although the precise questions posed to patients were different. A recent systematic review highlighted the variability in values reported for MCID and SCB within the hip arthroscopy literature to date even for the same PROMs, of which 19 different outcome measures within the hip arthroscopy were identified.[20] A benefit of the current study is that MCID and SCB metrics of measuring change over time were calculated specific to our study cohort, as opposed to using previously published values that may not be representative of the patient cohort under evaluation.

Surgical techniques have evolved over the 10-year period since the management of the patients in this study, with emphasis on labral preservation and capsular repair to optimize hip function and stability. Interestingly, although no patients underwent capsular repair and almost 30% had excision or debridement of the labrum, the results overall remained excellent at 10 years after surgery.

Limitations

This study had limitations. (1) No long-term radiographic follow-up was included, and despite the high survival rate and overall excellent patient-reported outcomes, the morphologic progression and/or preservation of the hip at 10 years after hip arthroscopy cannot be fully determined. (2) Patients were included in this study between 2008 and 2010, but it was not until 2011 that standardized 90° Dunn and false-profile views were routinely incorporated into our clinical practice, improving the assessment and measurement of true bony deformity and extent of deformity correction after surgery. This may have resulted in less accurate measurements of deformity in this study. However, magnetic resonance imaging scans were used to confirm inclusion of patients with FAI. (3) For each of our measures of clinically perceived improvement (MCID and SCB), a proportion of cases (approximately half the sample in each SCB case; 47%-63%) could not be evaluated in terms of clinical change (calculated threshold of MCID and SCB) due to high baseline scores and ceiling effects of PROMs. This can be considered a limitation of the capabilities of such metrics and was not necessarily specific to this study. All cases, however, were suitably assessed for clinical improvement using the established PASS metric. (4) Although the low incidence of THR conversion and RHA was a very positive outcome after the initial hip arthroscopy, this introduced the possibility of type 2 error when determining factors likely to be associated with or to predict failure, owing to a lack of study power.

CONCLUSION

Arthroscopic intervention is a safe and viable treatment option for patients with symptomatic FAI, and patients can expect long-term improvements and high satisfaction. Results indicated high rates of satisfaction (90%) and survivorship (91.6%) with excellent clinical outcome at 10 years after the initial procedure.

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