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Surgical Treatment of Femoroacetabular Impingement

Minimum 10-Year Outcome and Risk Factors for Failure

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Investigation performed at the Rothman Orthopaedic Institute at Thomas Jefferson University, Philadelphia, Pennsylvania

Background: Femoroacetabular impingement (FAI) is a well-known cause of hip pain and dysfunction in young adults. Surgical treatment has been widely popularized during the past decade. However, most reported results have been limited to short-term and intermediate-term follow-up. The long-term success rate and risk factors for failure are largely unknown. This study aimed to report the long-term (minimum, 10 years) clinical outcomes of surgical treatment of FAI and to describe the clinical and radiographic parameters associated with the failure of treatment involving femoroacetabular osteoplasty (FAO) and labral repair.

Methods: Using our prospective hip preservation database, 164 patients (178 hips) who had undergone FAO between January 2005 and April 2009 were identified. Patient demographic characteristics, clinical history, duration of preoperative symptoms, radiographic parameters (preoperative and postoperative alpha angles, hip dysplasia and retroversion, Tönnis grade for osteoarthritis), and intraoperative findings were reviewed and compared between the success and failure groups. At a minimum 10-year follow-up, clinical functional outcomes (modified Harris hip score [mHHS] and Short Form-36 [SF-36] at 6 weeks, 6 months, 1 year, and 10 years) and failure rates (conversion to total hip arthroplasty [THA]) were collected.

Results: The mean patient age (and standard deviation) was 34.3 ± 8.4 years, and 65 patients (40%) were female. After the surgical procedure, there was significant improvement in the mean mHHS (59.3 ± 7.3 points preoperatively to 88.4 ± 7.3 points postoperatively) and the mean SF-36 (61.3 ± 8.4 points preoperatively to 89.1 ± 7.2 points postoperatively). At a mean follow-up of 12.5 years, 12% (22 hips) required conversion to THA, with a mean time to THA of 5.3 ± 2.0 years. Older age, longer preoperative symptomatic period, higher preoperative and postoperative alpha angles, presence of hip dysplasia, a higher Tönnis grade, joint space narrowing, and a full-thickness acetabular chondral lesion at the time of the FAO were identified as risk factors for failure and conversion to THA.

Conclusions: Patients with symptomatic FAI who undergo a surgical procedure experience pain relief and functional improvement that appear to endure over a decade in the majority of patients. This study on a relatively large cohort with a long-term follow-up has also identified patients who are at a higher risk for treatment failure.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Femoroacetabular impingement (FAI) and its well-described underlying structural hip abnormality are an established source of hip pain and dysfunction in active young adults that can eventually lead to hip joint arthritis[1-3]. Although the exact etiology of FAI has yet to be elucidated, multiple risk factors, both genetic and environmental, have been reported and likely play a role[3,4]. Previous studies have shown that early-stage surgical intervention in patients with symptomatic FAI with no or minimal evidence of degenerative hip disease may help to increase the longevity of the articular cartilage[2,5-7]. For these reasons, coupled with the improvement in diagnosis and understanding of the disease pathology, the surgical treatment of FAI has gained increasing popularity over the past decade.

The first described technique used for femoroacetabular osteoplasty (FAO) and labral repair was surgical hip dislocation[8]. However, because of its relatively high complication rate, lengthy learning curve, and complexity, multiple other surgical approaches have since been described[9,10]. Still, the goal of surgical intervention remains the same: to address the femoral head-neck junction and acetabular abnormality based on the source and etiology of the impingement. Eliminating the source of impingement may prevent or delay further degenerative

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A346).

changes and increase the symptom-free, prearthritic period in these patients[1,2,6-8,11-16].

The short-term and intermediate-term clinical studies of arthroscopic FAO and risk factors for treatment failure have been reported previously, with favorable outcomes[13,16-20]. The senior author of this study (J.P.) has similarly reported excellent short-term to intermediate-term outcomes with his preferred technique in the past[21,22]. Some of the identified risk factors for treatment failure described thus far include preexisting arthritis, older age at the time of the surgical procedure, longer duration of preoperative symptoms, higher body mass index (BMI), and joint space narrowing[12,13,17,18,21-27].

The primary aim of this study was to report the long-term (minimum 10-year) clinical outcomes of the surgical treatment of FAI. The secondary purpose was to describe the clinical and radiographic parameters associated with failure of treatment involving FAO and labral repair.

Materials and Methods

Following institutional review board approval, our prospective hip preservation database was utilized to identify patients who had undergone FAO between January 2005 and April 2009 and had a minimum 10-year follow-up. Patients in the initial cohort of 197 hips who had a definitive diagnosis of hip dysplasia (8 hips), history of slipped capital femoral epiphysis (5 hips), osteonecrosis of the femoral head (3 hips), or previous femoral head or neck or acetabular fracture (3 hips) were excluded. The final cohort consisted of 164 patients (178 hips). None of the patients underwent labral debridement as part of the procedure. The mean patient age (and standard deviation) was 34.3 ± 8.4 years, and 65 patients (40%) were female. Patient demographic characteristics, duration of preoperative symptoms, radiographic parameters (preoperative and postoperative alpha angles, hip dysplasia and retroversion parameters, joint space, Tönnis grade for osteoarthritis), and intraoperative findings were collected and reviewed. Borderline hip dysplasia was described as a lateral central-edge angle (LCEA) or an anterior center-edge angle (ACEA) between 15° and 20° and Tönnis angle between 10° and 15°. A false-profile view of the involved hip was used for the measurement of the ACEA. Acetabular retroversion was deemed to be present when the crossover sign, posterior wall sign, and prominent ischial spine sign were present in the anteroposterior pelvic radiographic view.

Definite failure of FAO was defined as the need for a conversion to a total hip arthroplasty (THA) at any time. Preoperative and postoperative clinical and radiographic findings were compared between the success and failure groups. Also, at a minimum 10-year follow-up, functional outcome scores (modified Harris hip score [mHHS] and Short Form-36 [SF-36]) were collected before the FAO, before the THA, and at 6 weeks, 6 months, 1 year, and 10 years after the index procedure. A single surgeon performed all of the index FAOs (using a mini-open technique) and all conversions to THAs in symptomatic hips in the failure group.

Surgical Technique

All patients were positioned supine on a regular operating table. A 3-cm-long incision was made distal to the anterior superior iliac spine over the tensor fasciae latae muscle. After retracting the tensor muscle laterally, the rectus muscle was reflected laterally to expose the hip capsule. To expose the medial capsule, the sartorius muscle needed to be retracted medially. Then the cam deformity was visualized through an I-shaped capsulotomy. The labrum was checked for evidence of the tear. To visualize the weight-bearing surface of the joint for any evidence of chondral lesions, minimal traction was applied. Most of the articular surface can be evaluated through this maneuver. A blunt-tipped hook was utilized to feel the posteroinferior surface of the acetabulum. Microfracture was performed for full-thickness chondral lesions, and partial-thickness lesions were excised. In patients with excessive coverage, acetabuloplasty was employed. However, in patients with evidence of acetabular dysplasia and undercoverage, very minimal removal of the acetabular rim was done to refresh the bed for labral repair. Then femoral neck osteoplasty was performed using a burr and small osteotome until achieving an impingement-free hip range of motion. After femoral neck osteoplasty, labral tear repair was done by the placement of anchor sutures in the acetabular rim. After a final check of the impingement-free range of motion, the joint capsule was closed using a running suture. Postoperatively, patients were allowed partial weight-bearing for 6 weeks, followed by full weight-bearing. Return to full activity and sports took 4 to 6 months for most cases[28].

Statistical Analysis

A bivariate analysis of the data was completed to assess the relationship of survival and failure with variables of interest. All continuous parametric data are presented as the mean and the standard deviation, and all categorical data are presented as the frequency and percentage. The p values for continuous data were calculated using the t test, and those for categorical data were calculated using the chi-square test. Following the bivariate analysis, a Cox regression was computed to analyze the relationship between key variables and time to failure. This regression helped us to identify key variables that relate to treatment failure. All statistical analyses were performed using RStudio, version 3.5.1 (The R Foundation for Statistical Computing).

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None.

Results

At the latest follow-up at a mean of 12.5 years (range, 10 to 14 years), 22 hips (12%) required conversion to THA, with a mean time to THA of 5.3 ± 2.0 years. The remaining hips demonstrated favorable outcomes and did not require a THA (Fig. 1). Patients who underwent failed treatment were significantly older at 41.0 ± 7.11 years of age at the time of the FAO compared with 30.8 ± 8.39 years of age for patients who underwent successful treatment ($p < 0.001$). No significant difference was detected in terms of sex and BMI between the groups. The failure cohort had a longer symptomatic period before the FAO procedure (28.2 ± 11.4 compared with 18.8 ± 7.41 months; $p = 0.001$). Borderline dysplasia was present in 7 hips (32%) in the failure group and 10 hips (6%) in the success group ($p = 0.001$). A total of 8 patients had evidence of acetabular retroversion, of whom 3 underwent conversion to THA ($p = 0.061$). A higher rate of full-thickness acetabular chondral lesions (32% compared with 3%) was identified in the failure cohort ($p < 0.001$). Of the other radiographic parameters measured, joint space narrowing, higher Tönnis angle, lower ACEA, higher Tönnis grade of arthritis, and higher preoperative and postoperative alpha angles were found to be associated with failure. The details of the demographic characteristics and perioperative patient-related data and outcome scores are listed in Table I.

After adjusting for covariates (Table II), by using the Cox proportional hazard model, the following variables were independently associated with a higher incidence of conversion to THA after the index FAO: older age at the time of the index surgical procedure, prolonged preoperative symptomatic period, borderline dysplasia of the hip, joint space narrowing before the FAO, presence of a full-thickness chondral lesion, and higher preoperative and postoperative alpha angles.

Significant improvements in clinical functional outcomes were observed in the cohort at the 6-month, 1-year, and 10-year follow-ups after the FAO. At the latest follow-up (minimum, 10 years), the mean mHHS was 88.4 ± 7.34 points in the survival group. The mean mHHS after the THA was 92.3 ± 5.72 points at the latest follow-up. None of the hips underwent revision in the first 2 years after the FAO. At the 2-year follow-up, the mean mHHS was 90.3 ± 6.9 points and the mean SF-36 was 89.6 ± 7.4 points.

Discussion

The current study shows the long-term clinical results, survivorship, and risk factors for the failure of surgical treatment of FAI. The surgical outcome of FAI was deemed to be acceptable, as a relatively low number of patients (12%) eventually required a THA, with the other patients appearing to have excellent clinical functional outcomes at the latest follow-up. As expected, older age at the time of the index surgical procedure, prolonged preoperative symptomatic period, presence of borderline dysplasia of the hip, joint space narrowing, presence of full-thickness chondral lesions, and higher preoperative and postoperative alpha angles were identified as independent variables associated with higher rates of failure, as defined by the need for conversion to THA.

Hip preservation surgery has gained popularity in the past decade, mostly because of its effectiveness in alleviating symptoms and delaying the need for a THA in symptomatic young patients. Favorable intermediate-term results of FAO and labral repair using various open or arthroscopic techniques have been reported in previous studies[13,16-19]. However, there has been a lack of evidence available with regard to long-term functional outcomes and failure rates of FAO in the literature. Menge et al.[28] reported survivorship and outcomes at 10 years after arthroscopic FAO in a retrospective study of 145 patients. The study found a much higher conversion rate at 34% (50 of 145 hips). Although it is difficult to determine the exact reason for the lower treatment failure rate in our cohort, the presence of a higher rate of preoperative joint space narrowing in the cohort reported by Menge et al. may have contributed to the higher rate of treatment failure. The risk factors for failure were also identified by Menge et al. and were found to be older age, joint space of <2 mm, and the need for microfracture during osteoplasty. Our study corroborates the findings of the study by Menge et al. and identifies a few more risk factors for failure.

Clinical outcomes and predictive factors for failure of hip arthroscopy in patients with FAI have been investigated in other studies as well, but mostly at short-term and intermediate-term follow-up[12,13,18,19,22-27,29,30]. Furthermore, the definition of failure (functional outcome, conversion to THA, revision FAO), the sample size, and the type of procedure (open, arthroscopic) differed vastly among these studies, leading to a wide range of results[31].

The goals of any type of hip preservation surgery are to prevent or delay the need for THA and to provide patients with symptom-free function with the native hip. For this reason,

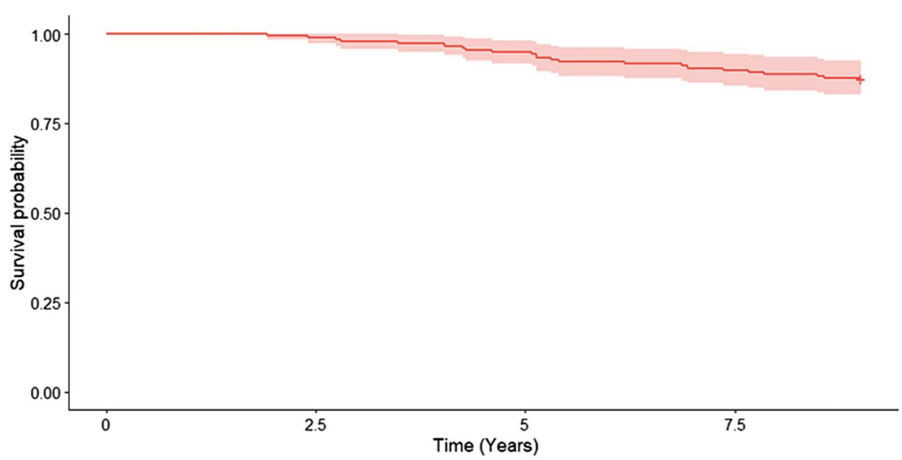

Fig. 1

Kaplan-Meier survivorship of patients treated with FAO. The shaded areas indicate the 95% confidence interval. Conversion to THA was used as the definition of treatment failure.

TABLE I Patient Demographic Characteristics, Perioperative Radiographic Measurements, and Functional Outcome Scores*

	Survival (N = 156)	Failure (N = 22)	P Value
Demographic characteristics			
Age† *(yr)*	30.8 ± 8.39	41.0 ± 7.11	<0.001‡
Sex§			0.488
Male	101 (65%)	12 (55%)	
Female	55 (35%)	10 (45%)	
BMI† *(kg/m²)*	25.9 ± 2.62	25.8 ± 2.47	0.763
Preoperative symptomatic period† *(mo)*	18.8 ± 7.41	28.2 ± 11.4	0.001‡
Time to THA† *(yr)*	NA	5.30 ± 1.99	
Radiographic measurements			
Borderline dysplasia§	10 (6%)	7 (32%)	0.001‡
Retroversion§	5 (3%)	3 (14%)	0.061
Full-thickness chondral lesion§	5 (3%)	7 (32%)	<0.001‡
Preoperative alpha angle† *(deg)*	68.9 ± 8.44	84.7 ± 10.3	<0.001‡
Postoperative alpha angle† *(deg)*	56.6 ± 5.43	59.5 ± 6.52	0.056
Tönnis grade§			<0.001‡
0	110 (71%)	3 (14%)	
1	41 (26%)	12 (55%)	
2	5 (3%)	7 (32%)	
LCEA† *(deg)*	27.8 ± 5.29	25.5 ± 7.51	0.183
ACEA† *(deg)*	27.4 ± 4.08	24.5 ± 5.62	0.028‡
Tönnis angle† *(deg)*	2.35 ± 2.71	4.64 ± 3.81	0.012‡
Medial joint space† *(mm)*	4.87 ± 0.80	4.36 ± 1.26	0.081‡
Superior joint space† *(mm)*	4.83 ± 0.68	3.59 ± 0.67	<0.001‡
Functional outcome score† *(points)*			
mHHS			
Before FAO	59.3 ± 7.29	53.1 ± 8.50	0.003‡
Before THA	NA	42.3 ± 12.3	
Latest follow-up	88.4 ± 7.34	92.3 ± 5.72	0.007‡
SF-36			
Before FAO	61.3 ± 8.39	52.4 ± 9.55	<0.001‡
Before THA	NA	47.6 ± 11.2	
Latest follow-up	89.1 ± 7.15	87.7 ± 8.21	0.470

*NA = not applicable. †The values are given as the mean and the standard deviation. ‡Significant. §The values are given as the number of hips, with the percentage in parentheses.

similar to many other previous hip preservation studies, we decided to use conversion to THA as the definition of treatment failure[12,14,23-26,32-35]. With regard to risk factors for failure, previous short-term to intermediate-term follow-up studies have identified older age, female sex, higher BMI, longer duration of preoperative symptoms, presence of chondral problems, joint space narrowing, and higher Tönnis grade to be associated with poor outcomes[12-14,23-26,32-36]. In a recently published study by Nho et al.[36], Tönnis grade of ≥1, Workers' Compensation, and higher BMI were identified as risk factors for a less optimal outcome in a large multicenter cohort of 935 patients who underwent hip arthroscopy and had a minimum 2-year follow-up. The rate of conversion to THA was 1.2% (11 cases), and 2.5% (23 cases) underwent revision arthroscopy. Also, 27.4% (256 cases) of their cohort reported inferior clinical outcomes and did not reach a minimal clinically important difference in outcome scores postoperatively. Their cohort consisted of a larger number of patients but a shorter follow-up after the surgical procedure compared with our patient population. Also, they excluded patients with borderline dysplasia, those with a Tönnis grade of >1, and patients with a history of contralateral hip surgery.

Similarly, as reported in other studies, older age at the time of the FAO was associated with a higher rate of conversion to THA in our study[12,14,16-20,26,30,31,34,37]. This might be due to less optimal quality of the cartilage in older patients and a longer period of abnormal hip biomechanics before the onset of symptoms. Peters et al.[37] concluded that the incidence of failure of hip preservation procedures increases with a rate of 4% per year.

TABLE II Cox Proportional Hazard Model for Outcome of Failure

Covariate	Hazard Ratio*	P Value
Age in yr	0.85 (0.73 to 1.00)	0.048†
Female sex	5.69 (0.08 to 41.04)	0.426
Preoperative symptomatic period in yr	1.22 (1.07 to 1.40)	0.004†
Borderline dysplasia	2.698×10^5 (2.50 to 2.9×10^{10})	0.034†
Retroversion	94.02 (0.11 to 7,717)	0.184
Chondral lesion	1,761 (8.73 to 36×10^7)	0.011†
Preoperative alpha angle in degrees	1.37 (1.07 to 1.74)	0.011†
Postoperative alpha angle in degrees	1.28 (1.01 to 1.62)	0.045†
Tönnis grade	0.59 (0.04 to 9.08)	0.708
ACEA in degrees	1.67 (0.95 to 2.93)	0.073
Tönnis angle in degrees	0.37 (0.09 to 1.47)	0.158
Medial joint space in mm	0.13 (0.03 to 0.45)	0.002†
Superior joint space in mm	377.7 (12.99 to 1.1×10^6)	0.004†

*The values are given as the hazard ratio, with the 95% confidence interval in parentheses. †Significant.

Measures of the quality of the hip-joint bearing surface, including the status of articular cartilage, the amount of initial cartilage loss, the presence of degenerative changes, and joint space narrowing, were other important risk factors for long-term treatment failure in our patients. The presence of full-thickness delamination of articular cartilage has been shown to adversely affect the outcome of FAO[10,11,30]. In a systematic review by Kemp et al.[20], a strong association was reported between the presence of severe articular cartilage damage and conversion to THA following FAI procedures. Also, preexisting degenerative joint changes categorized by Tönnis grade were another strong predictor of failure[5,12,24-26,32,35]. Based on current evidence, it is not clear that performing FAO on hips with evidence of arthritis should be attempted before proceeding to a discussion of THA with patients. Based on the current body of evidence, we do not believe that FAO and labral repair are indicated in patients with advanced hip arthritis.

Poor outcomes after hip preservation surgery in patients with high BMI have been reported in some studies. Gupta et al.[16] demonstrated that obese patients in their cohort (680 patients) started with lower absolute scores preoperatively and ended with lower absolute postoperative scores at the 2-year follow-up. Our findings differed in that the failure and survival groups had similar mean BMIs, possibly due to the fact that our patient population had a low mean BMI overall.

Another important identified risk factor for treatment failure was a longer preoperative symptomatic period. Some previous studies also mentioned a less optimal outcome in patients with a longer symptomatic period before undergoing an FAO[25,26]. In a study by Kunze et al.[38], superior postoperative outcomes were observed in patients with early surgical intervention, specifically within 6 months from the onset of symptoms. In multivariate regression analysis, symptom duration was predictive of the visual analog scales for pain and satisfaction. We agree with this notion and belief that early surgical intervention after failed nonoperative treatment (physical therapy, nonsteroidal anti-inflammatory drugs [NSAIDs], activity modification) can improve the outcome. Theoretically, a shorter duration of abnormal hip biomechanics may cause less permanent damage to the joint surfaces and may slow down the progression of irreversible changes.

Among the various radiographic parameters measured in our patients, borderline dysplasia, lower ACEA, joint space narrowing, higher Tönnis angle, and higher preoperative and postoperative alpha angles were detected more commonly in our failure group. We recently published our results of FAO in patients with hip dysplasia[39]. At the latest follow-up, 28.8% of 73 dysplastic hips eventually underwent a THA compared with 2.5% in the control group with no evidence of hip dysplasia (n = 550). More extensive preoperative discussion should be conducted with patients who have evidence of hip dysplasia with regard to the expected outcome (symptom and survival) of the native hip postoperatively. In this scenario, one may consider periacetabular osteotomy in isolation (as a definitive treatment) or in combination with FAO in patients with evidence of hip dysplasia.

Although a higher incidence of risk factors for treatment failure was detected in patients who underwent THA, a relatively high number of patients at moderate to high risk, with preexisting chondral damage, mild to moderate arthritis with some degree of joint space narrowing, or evidence of borderline hip dysplasia, are still enjoying excellent function after a minimum of 10 years after the FAO.

Our study had some limitations. Regardless of the fact that we collect data prospectively on patients undergoing hip preservation at our institution, some limitations related to this study's retrospective nature remained. In addition, we did not investigate some other variables that may have been related to poor outcomes, such as socioeconomic status, smoking, race, activity level, and Workers' Compensation. Also, we did not use poor functional and patient-reported outcomes as one of our failure criteria. To our knowledge, there is no gold standard for the definition of a poor or less-optimal clinical outcome score. Therefore, we decided to use conversion to THA as an absolute definition of treatment failure. Also, the low number of hips in the failure group may decrease the external validity of reported risk factors for treatment failure.

However, it appears that the majority of patients with symptomatic FAI who undergo a surgical procedure experience pain relief and functional improvement that lasts over a decade. This study also identified patients who are at higher risk for treatment failure. A majority of patients experienced favorable outcomes and did not undergo THA at the latest follow-up. We believe that the findings will be of value to hip preservation surgeons in careful patient selection and more informative preoperative discussions with patients and their families with regard to the prognosis and outcome of surgical intervention. ■

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