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Factors associated with failure of surgical treatment for femoroacetabular impingement: Review of the literature

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Abstract

Context—With the recent increased recognition of femoroacetabular impingement (FAI) as a cause of hip pain and early osteoarthritis, surgical treatment has proliferated. A growing body of literature reports on outcomes of surgical intervention for FAI, but factors associated with inferior surgical outcomes have not been reviewed systematically.

Objective—To review available literature and identify factors associated with failure of open or arthroscopic surgery for FAI.

Data Sources—Using the PubMed database, we searched for relevant English-language articles published from January 1966 through August 2012.

Study Selection—Inclusion criteria were primary focus on surgical treatment of FAI, measurement of functional or pain outcomes, identification of treatment failures and statistical analysis of factors leading to failure. Exclusion criteria were review articles, technique-only articles and studies of nonoperative management.

Data Extraction—Two definitions of failure were considered: 1) lack of statistically significant improvement in validated measures of pain, function or satisfaction postoperatively, and 2) revision surgery or conversion to hip arthroplasty because of persistent symptoms. The consistency of association between preoperative variables and clinical outcomes was reported across all studies.

Results—Thirteen studies were included. Three were retrospective. There were no randomized controlled trials. Many studies had important methodological limitations. Preoperative cartilage

damage or osteoarthritis had the strongest and most consistent relationship with conversion to hip arthroplasty and with lack of improvement in pain or function. Greater age at index operation, worse preoperative modified Harris Hip Score and longer duration of symptoms preoperatively (> 1.5 years) were associated with conversion to hip arthroplasty.

Conclusions—Older age, the presence of arthritic changes, longer duration of symptoms and worse preoperative pain and functional scores are associated with poor outcomes of surgery for FAI. Incorporation of these data into discussions with patients may facilitate informed shared decision-making about surgical treatment of FAI.

Keywords

hip; femoroacetabular; impingement; treatment; predictors; outcomes

Introduction

Femoroacetabular impingement (FAI) syndrome, the abutment of a prominent femoral head-neck junction against the acetabular rim or labrum, has been recognized as a cause of hip pain in younger patients who have radiographic hip abnormalities.^{5, 20} It is theorized that the abnormal contact between femoral neck and acetabulum during terminal motion of the hip results in lesions of the labrum and adjacent acetabular cartilage, leading to early degenerative joint disease.^{2, 7, 11, 12, 24}

With increased recognition of FAI as a cause of hip pain leading to early osteoarthritis, surgical techniques have been utilized to correct abnormal hip morphology, relieve pain, improve activity and function, and preserve the hip joint.

Studies of surgical outcomes have provided much information regarding the success of these interventions in reducing hip pain and improving functional status. While most studies report good short-term outcomes of both arthroscopic and open approaches for FAI surgery, these studies invariably contain a subset of patients who do not benefit from these operations and go on to require additional operations or joint replacement for pain relief.^{1, 4, 6, 13, 14, 16, 17, 19, 22, 25, 26, 28, 29} To date, no study has been conducted to specifically review pertinent literature in order to identify patient-related factors that determine post-surgical outcomes.

The purpose of this review is to identify those preoperative factors that have a statistically significant association with failure of open or arthroscopic treatment of femoroacetabular impingement across multiple studies. These findings may be helpful in refining indications and contraindications for FAI surgery, designing new studies of FAI treatment outcomes, and providing clinicians and patients with data to enhance discussions about the advantages and drawbacks of FAI surgery.

Methods

Search strategy for identification of studies

Using the PubMed database, a search was conducted for all relevant English-language articles published between the origin of Medline in 1966 and August 2012. The keywords employed were “femoroacetabular,” “impingement,” and “treatment.” Two authors (ES and SB) screened every title and abstract to identify appropriate articles for this study. To be included, a study had to focus primarily on the treatment of femoroacetabular impingement syndrome; report on measures of pain, function or postoperative satisfaction, indicate whether any patients did not improve symptomatically, required additional operations or were converted to total hip arthroplasty (THA). The paper also examined the association of one or more preoperative factors and failure outcomes. Studies examining both arthroscopic and open techniques were included. Minimum follow up needed to be greater than 6 months. Review articles, articles focusing purely on technique and studies of non-operative management were excluded. Studies that dealt with surgical management of FAI but did not provide quantitative analysis of associations between preoperative factors and outcomes were also excluded (Figure 1).

Data extraction and analysis

Extracted data included study design, cohort composition, study duration and length of follow up, number of cases meeting each definition of failure and patient factors that influenced success or failure. All factors considered in the analysis were measured preoperatively with the exception of intraoperative cartilage assessment, which we included in the analysis because cartilage can also be assessed preoperatively using MRI.

We defined cases of failure as: 1) lack of statistical improvement in validated measures of pain, function or satisfaction postoperatively, or 2) revision surgery or conversion to hip arthroplasty because of persistent symptoms. We use the term “hip arthroplasty” to include both total hip replacement and hip resurfacing.

The first author (ES) extracted all data from the eligible studies. An independent reviewer (SB) also abstracted data from all of the eligible studies. The two reviewers discussed their findings and agreed on 100% of items.

The variability in the specific methodology of the studies included in this review did not allow for the performance of a formal meta-analysis. Specifically, studies differed in the methods used to measure key outcome variables such as functional status, and in the type of analysis done to relate preoperative variables to outcomes. Thus, in assessing the associations of potential predictors with each outcome, we considered the number of studies that found a statistically significant association ($P < 0.05$) between that predictor and one of the failure outcomes. We documented the strength of the association as well, wherever possible. This strategy yields a semiquantitative assessment of the prognostic effect of each preoperative variable.

Results

Three hundred and fifty-four titles were obtained from the PubMed search. Of these, 35 were non-English language studies and were excluded, leaving 319 titles and abstracts that were reviewed. Of these, 275 did not meet the inclusion criteria at the title/abstract review stage and were eliminated, predominantly because the papers did not deal with surgical treatment of FAI or did not report/quantitate failures of treatment. Complete manuscripts of the remaining 45 articles were obtained; of these, 12 did not report any failures and 20 did not carry out a statistical analysis of predisposing factors for failure, and were thus eliminated, leaving 13 articles eligible for inclusion in the present study. The first author (ES) reviewed each article in detail in order to produce the final list of articles to be included in the study. An independent reviewer (SB) screened all of the 319 titles and abstracts to produce an independent list of studies for inclusion. Both reviewers (ES and SB) compared and discussed their results and agreed on 100% of articles.

A total of 13 studies were included in this review (Figure 2, Table 1). Three were retrospective, nine were prospective, and, in one study, prospective or retrospective collection of data was not explicitly noted. There were no randomized controlled trials. All but one of the studies were performed in single centers. Seven were carried out in the United States, two in Switzerland, two in France, one in Spain, and one in Canada. The number of hips included in the studies ranged from 20 to 233. The average age of the patients ranged from 29 to 57 years. One study exclusively examined an athletic population, while another included only patients older than 50 years. Of all included studies, only three^{13, 17, 28} used multivariate analysis to identify independent predictors of failure (Table 2). Average duration of follow-up for the included studies ranged from 22 to 61 months.

Outcome measures

We defined two outcomes that indicated failure of surgical treatment for FAI: 1) lack of statistically significant improvement in validated measures of pain, function or satisfaction postoperatively, and 2) revision surgery or conversion to hip arthroplasty because of persistent symptoms. Included studies described failure in at least one of these ways, and many studies used more than one of these measures as a definition of failure. Ten studies used revision surgery or conversion to hip arthroplasty as a definition of failure, seven measured pain and functional outcomes and two assessed patient satisfaction levels. Pain and functional outcomes were measured using various standardized scoring methods. Of the seven studies measuring pain and functional scores, four used the Harris Hip Score²¹ (HHS) two used the Western Ontario and McMaster Universities (WOMAC) arthritis index³ and one used the Merle d'Aubigné-Postel⁸ and the DEXA combined score²⁹. All included studies noted whether a repeat arthroscopy or hip arthroplasty was offered or performed for any patient.

Factors associated with failure

A detailed summary of potential predictors investigated by each study, along with the measures of effect observed for each predictor, is presented in Table 2. For ease of interpretation, the factors associated with hip arthroplasty are presented separate from those

associated with revision surgery, subjective dissatisfaction, and/or lower pain and functional scores.

Predictors of hip arthroplasty

Demographic factors—Higher age at the index operation was found to be associated with conversion to hip arthroplasty in 4 of the 7 studies in which it was examined. Of these studies, two^{26, 28} included older patients (mean age 59 years in patients receiving hip arthroplasty vs. 56 years in those not undergoing subsequent hip arthroplasty in one study; in another, mean age of 58 years in those receiving subsequent THA/surfacing vs. 39 years in those not undergoing hip arthroplasty). Two studies included younger patients^{19, 25} and, similarly, one study found a mean age of 38 years in patients undergoing subsequent hip arthroplasty vs. 28 years in those not undergoing surgery while another study found the mean age of those undergoing subsequent hip surgery was 40 vs. 32 years in those not undergoing subsequent hip arthroplasty.

Female sex was associated significantly with a poor outcome in 1 of the 3 studies in which it was documented.^{22, 25, 26} The effect of Body Mass Index (BMI) was mixed: One study did not find an effect of BMI on conversion to THA²⁶, while in another the patients who were converted to THA had BMI of 21.3 kg/m² vs. 24.3 kg/m² in those who did not have subsequent surgery, $p = 0.03$).²²

Preoperative cartilage degeneration or osteoarthritis (OA)—At least one measure of cartilage damage, such as preoperative radiographic assessment of cartilage thickness or joint space narrowing, preoperative MRI-based or intraoperative Outerbridge grading²³ of cartilage damage, or preoperative radiographic Tonnis grades³⁰ for osteoarthritis were used in every study. All three studies that assessed preoperative joint space found cartilage thickness of less than 2mm to be statistically significantly associated with conversion to hip arthroplasty^{17, 26, 28}. One of the two studies that evaluated OA (method of evaluation for OA not explicitly stated) found a significant association between these factors and conversion to THA. A higher preoperative Tonnis grade was a significant poor prognostic factor in one of the four studies in which it was examined. Beck grade 5 cartilage (full thickness cartilage defect) was a predictor of failure in the 1 study in which it was examined. Nonspecific cartilage lesions were predictors of failure in 2 of the 4 studies in which this was examined (Tables 2 and 3).

Other prognostic factors for conversion to hip arthroplasty—Of the preoperative pain and functional scores that were studied, a worse modified Harris Hip Score was found to be statically significantly associated with hip arthroplasty in both of the studies in which the association was examined.^{26, 28} One study found a greater duration of symptoms to be associated with need for conversion to THA¹⁷; in another, patients who were converted to THA had undergone microfracture of both femoral head and acetabulum at the index operation²⁶ (Table 2).

Predictors of worse patient-reported outcomes and revision surgery

Demographic factors—Higher age at the index operation was found to be statistically significantly associated with dissatisfaction in 1 of the 4 studies in which it was examined.^{4, 13, 22, 25} Female gender was a significant predictor of major revision in 1 of the 3 studies in which it was examined.^{4, 22, 25}

Preoperative cartilage degeneration or osteoarthritis (OA)—Of the 4 studies that evaluated Tonnis grades, 1 found that 42% of patients with Tonnis grade 2 had no improvement or worsening of their WOMAC or Merle d'Aubigné-Postel scores. The same study noted that patients with Tonnis grade 0 and 1 had significant improvement in clinical outcome scores ($P < 0.001$) at 1 year and remained unchanged at subsequent yearly follow-ups.²⁹

Each of the following factors was found to be associated with lower patient-reported outcomes in at least one study: joint space narrowing¹⁷, higher MRI chondral grade¹⁷, bipolar lesions⁴ and higher Outerbridge cartilage grade.^{4, 22} One study specifically noted that patients without preoperative OA maintained their improved Harris Hip Score at last follow up ($P < 0.001$, range of follow-up: 12-60 months), but there was no improvement in the HHS in patients with pre-existing radiographic OA beyond 1 year.¹⁷

Discussion

We reviewed 13 articles that quantitatively analyzed the association between factors present before or during surgery for femoroacetabular impingement and failure of operative intervention. These studies examined age, sex, BMI, preoperative or intraoperative cartilage damage, preoperative pain and functional status, as well as radiographic measures and intraoperative treatments beyond osteoplasty of the acetabulum or femoral head-neck junction. We found that cartilage damage and higher age at index operation had the most consistent relationship with failure of operative intervention for treatment of FAI. These findings were observed with both definitions of failure: conversion to hip arthroplasty or failure to improve functionally or symptomatically. A lower preoperative modified Harris Hip Score was associated with conversion to THA in two studies^{26, 27}, and one study found the duration of symptoms preoperatively to be significantly associated with subsequent hip arthroplasty¹⁷. Type of impingement and other radiographic measurements such as alpha angle were not associated with poor outcomes in any of the included studies. While several studies in the literature^{10, 15, 16} have documented superior outcome with labral refixation compared to debridement in FAI surgery, neither debridement nor refixation of the labrum was found to be associated with poor outcomes in studies included in this review. These summary results are presented in Table 3.

Preoperative cartilage damage was shown by multiple investigators to be associated with failure of FAI treatment (Table 2). Cartilage damage was assessed with a variety of modalities (plain radiographs, MRI, intraoperative assessment) with similar results. Many authors have implicated the cycle of labral and articular cartilage damage with repetitive loading of an abnormally shaped joint as the mechanism by which FAI leads to hip osteoarthritis.^{2, 7, 11, 12, 24} No long-term study of the natural progression of arthritis in FAI

exists. Further, in a middle-aged patient with FAI and early OA who complains of pain, it is difficult to ascribe the pain to either the impingement or the existing arthritis alone. While many studies demonstrated poor outcomes for FAI surgery in an already arthritic hip^{4, 13, 14, 17, 19, 26, 28, 29}, several of the included studies found that many patients with good outcomes had severe cartilage damage as well.^{1, 14, 22} Investigators in several of the studies included in this review excluded patients without mechanical symptoms, older patients and those with “aching” pain only¹⁷, and offered them a total hip arthroplasty instead.

Older age, longer duration of symptoms prior to the index operation, and worse modified Harris Hip Scores preoperatively were also shown to be poor prognostic factors in several studies (Tables 2 and 3). Age, duration of symptoms and cartilage damage may be interrelated. Two studies^{13, 28} found radiographic OA, but not age, to be associated with failure in multivariate regression. While further study is necessary to untangle these relationships, the studies that used multivariate analyses suggest that age may not be an independent predictor of failure once cartilage status is taken into account^{13, 28}. A similar question arises with respect to the effects of duration of symptoms and cartilage status. The only study¹⁷ that adjusted for joint space narrowing, cartilage damage and duration of symptoms (but not age), found greater duration of symptoms and joint space narrowing to be independent predictors of conversion to THA.

Readers should be aware that many limitations and gaps exist in the available literature on FAI: three of the included studies in this review were retrospective, follow-up times are short, and three studies looked at fewer than 50 hips. Several studies did not provide multivariate analyses, opening the possibility of confounding. The included studies also represent a mixture of open and arthroscopic surgical techniques. Further, most studies of the surgical treatment of FAI were conducted by highly experienced hip surgeons and hip arthroscopists; the generalizability of the data to less-experienced centers is also in question.

Several potential causes of failure of FAI surgery were not addressed in the studies included in this review. While many authors have suggested the cycle of labral and cartilage damage with repetitive loading of an abnormally shaped joint as the mechanism by which FAI leads to labral pathology and hip osteoarthritis,^{2, 7, 11, 12, 24} several other causes of labral and hip pathology have recently been identified. For example, Domb et al report on compression or traction on the anterior capsulo-labral complex by the iliopsoas tendon as a cause for labral pathology.⁹ Of the 13 included studies, only two commented on the iliopsoas tendon: Larson et al¹⁶ performed an iliopsoas release in three cases, but no further information was provided, and Laude et al¹⁹ mention that the iliopsoas was not released from the capsule in their series, without further comment. Additionally, labral tears can be caused by hyperlaxity/hip hypermobility. Whether this factor contributed to the higher failure rate among women in one study²² is unclear, and no studies in this review specifically examined or addressed hip hypermobility. While most studies commented on acetabular retroversion as a cause of hip impingement, none of the studies included in this review assessed or addressed femoral version. Additional factors such as management of the capsule in open and arthroscopic cases and debridement vs excision of ligamentum teres were not discussed in the majority of studies included in this review. Furthermore, while most work on impingement has focused on the femoral head-neck junction and acetabular rim, extra-

articular sources of impingement are increasingly recognized. Larson and colleagues recently reported on three rare cases of external hip impingement, with the anterior-inferior iliac spine impinging against the femoral neck causing pain.¹⁸ Of all the studies included in this review, only one²² expressly addressed this issue. Further research is necessary to address these potential causes for failure in the future.

Despite these shortcomings of the current literature, multiple studies point to the association of cartilage damage and older age with failure of surgical treatment of FAI, and, further imply that patients with a low preoperative modified Harris Hip Score and greater duration of symptoms may have worse outcomes. Adequately powered, multi-center studies examining the long-term effect of surgical treatment of FAI on pain and function adjusted for age, severity of arthritic changes and other anatomic, physiologic and functional factors are still needed.

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What is known about this subject

FAI has been recognized increasingly as a source of hip pain leading to early osteoarthritis. A variety of surgical techniques have been developed to relieve pain, improve function and preserve the joint until older age. Numerous studies report positive short-term outcomes for pain relief and increased function; however, little is known about the patient-related factors that impact the outcome of surgical interventions, particularly the small but significant number of negative outcomes.

What this study adds to existing knowledge

This review identifies preoperative factors that have a statistically significant association with failure of open or arthroscopic treatment of femoroacetabular impingement across multiple studies. These findings may be helpful in refining indications and contraindications for FAI surgery, designing new studies of FAI treatment outcomes, and providing clinicians and patients with data to enhance personalized discussions about the advantages and drawbacks of FAI surgery.

Inclusion criteria:

- Primary focus on treatment of femoroacetabular impingement
- Measure functional or pain outcomes
- Indicate whether any patients did not improve symptomatically or functionally, required revision or conversion to resurfacing or replacement
- Examine factors prior to the intervention that were likely to influence negative outcomes
- Arthroscopic, open or combination of techniques
- Minimum follow up 6 months

Exclusion criteria:

- Non-English language studies
- Cadaveric studies
- Case studies
- Review articles
- Pure technique articles
- Studies of non-operative management
- Treatment of FAI secondary to pre-existing hip disorders
- No cases of failure reported
- No quantitation and statistical analysis of predictive factors for failure

Figure 1. Inclusion and exclusion criteria

Figure 2. Paper selection process

Table 1

Summary of Included Studies

Author, year	Study Design	Type of Surgery	N (hips-total)	Mean Age of Participants	% Female
Naal, 2012	Retrospective	Open	233	30	40%
Cohen, 2012	Prospective	Mini-open	47	32	35%
Philippon, 2012	Prospective	Arthroscopic	153	57	52%
Larson, 2012	Prospective	Arthroscopic	94	29	Not reported
Byrd, 2011	Prospective	Arthroscopic	100	34	33%
Larson, 2011	Prospective	Arthroscopic	227	35	41%
Gedouin, 2010	Prospective multicenter	Arthroscopic	111	31	29%
Horisberger, 2010	Prospective	Arthroscopic	20	47.3	20%
Peters, 2010	Retrospective	Open	96	38	41%
Ribas, 2010	Prospective	Mini-open	117	37	36%
Laude, 2009	Retrospective	Arthroscopically-assisted mini-open	100	33.4	48%
Philippon, 2009	Prospective	Arthroscopic	112	40.6	44%
Beaule, 2007	Not specified	Open	37	40.5	47%

Table 2

Findings of Included Studies

Author, year	Mean Follow Up	N (hips total)	Definition of Failure	N (hips, failure)	% Failure	Predictors Examined	Significant Predictors of Failure	Adjustment for Covariates	Comments
Naal, 2012	61 mo	233	THA or major revision, subjective dissatisfaction	7 (THA); 7 (major revision); 9 (dissatis-fied); 11 (very dissatisfied)	3% (THA); 3% (major revision); 3.9% (dissatisfied); 4.9% (very dissatisfied)	Age, Sex, BMI, Cartilage lesions, Tonnis grade, Previous hip surgery	Predictors of THA: Female sex (OR 13.3, 95% CI 1.3-92.6); BMI: significantly lower in patients converted to THA (21.3 vs 24.3 kg/m2; P = 0.03). Predictor of major revision: Female sex (OR 19.2, 95% CI 2.4-152.9). Predictor of subjective dissatisfaction: Need for microfracture because of residual full-thickness cartilage defects after rim trimming (P = 0.04); Higher Tonnis grades (P = 0.067).	Analysis not adjusted.	No differences in terms of THA conversion, revision, satisfaction or score values between patients who underwent previous hip surgery and those who did not, and between patients with cartilage lesions and those without. No direct association between age or Tonnis grade and THA conversion or revision.
Cohen, 2012	22 mo	47	Incomplete return to preoperative activity level	20	24.00%	Anterosuperior joint space, Tonnis grade, neck-shaft angle, lateral center edge angle, extrusion index, presence of a crossover sign, presence of coxa profunda	None	Analysis not adjusted.	
Philippou, 2012	35 mo	153	THA	31	20.26%	Age, preop cartilage thickness, preop mHHS, HOS for ADL's, HOS for sports, SF-12, ?microfracture at index operation, ?labral refixation at index operation, type of impingement.	Predictors of THA: <2mm of joint space (9.9 times more likely to undergo THA (OR 14.6, 95% CI 5.1-41.83, P = 0.001); Lower preoperative mHHS (OR 3.2, CI 1.1-9.4, P = 0.037).	Adjusted for age and days from injury to surgery.	Older age (59 vs 56 yrs) was a significant, but not independent, predictor for failure (P = 0.015). Patients with < 2mm joint space had significantly less survivorship at 3 years follow up (57% vs 90%, P = 0.001).
Larson, 2012	3.5 yrs	94	THA; conversion to open; mHHS<70	1 (THA); 1 (conversion to open); 6 (HHS<70)	1.06% (THA); 1.06% (conversion to open); 6.38% (HHS<70)	Labral debridement vs labral refixation at index operation	None	Analysis not adjusted.	mHHS significantly better for labral refixation group vs labral debridement group (94.3 vs 84.9; P = 0.001); SF-12

Author, year	Mean Follow Up	N (hips total)	Definition of Failure	N (hips, failure)	% Failure	Predictors Examined	Significant Predictors of Failure	Adjustment for Covariates	Comments
Horis-berger, 2010	3 yrs	20	THA	10	50.00%	Age, preop Tonnis grade, alpha angle, ROM, NAHS	Predictor of THA: Higher preoperative Tonnis grade (P = 0.03).	Analysis not adjusted.	Cases that underwent THA did not have significantly more chondral damage than those who had the native hip in place.
Peters, 2010	26 mo	96	THA or decreased HHS	6	6.25%	Age, sex, preoperative Tonnis grade, preoperative cartilage damage, cartilage treatment, labral treatment	Predictor of THA or decreased HHS: Higher age (38 vs 28 yrs; P = 0.017).	Analysis not adjusted.	Outerbridge grade 4 cartilage had a trend for failure: 66% in failures vs 38% in successes, P = 0.06.
Ribas, 2010	3.7 yrs	117	No improvement or worsening of clinical outcome scores; THA	15 (No improvement in clinical scores); 8 (THA scores); 6.83% (THA)	12.82% (No improvement in clinical scores); 6.83% (THA)	Preoperative Tonnis grade	Predictor of lack of improvement in clinical outcome scores: Tonnis grade 2 (Only 58% of patients with Tonnis grade 2 had improvement in clinical outcome scores, P > 0.05).	Analysis not adjusted.	Patients with Tonnis grade 0 and 1 had significant improvement in clinical outcome scores (P < 0.001) at 1 year and remained unchanged at subsequent yearly follow-ups.
Laude, 2009	28.6 mo	100	THA/Resurfacing; repeat arthroscopy	11 (THA/resurfacing); 13 (repeat arthroscopy)	11% (THA/resurfacing); 13% (repeat arthroscopy for persistent pain)	Age, cartilage lesions, Tonnis grade, NAHS	Predictors of THA/resurfacing: Older age (40.3 vs 32 years; P = 0.04); Deeper acetabular lesion (10.9 mm vs 6 mm, P < 0.000001); Higher percentage of Beck grade 5 acetabular lesions (54% vs 7%, P < 0.000001).	Analysis not adjusted.	No statistical analysis for predictors of repeat arthroscopy; however, authors note that a failure of labrum refixation was noted in 8/13 cases.
Philippon, 2009	2.3 yrs	112	THA	10	8.93%	Age, sex, BMI, preoperative alpha angle, joint space narrowing, preoperative mHHS, 'microfracture on both femoral head and acetabulum	Predictors of THA: Older age at time of arthroscopy (58 vs 39 years, P = 0.001); Less joint space on all three weight bearing surfaces (P = 0.001); Lower preoperative mHHS (47 vs 60, P = 0.026); Microfracture on both the femoral head and acetabulum (P = 0.001).	Analysis for failure not adjusted for covariates.	Those with <2mm of joint space were 39 times more likely to progress to THA (95% CI 5.5 to 263). Taken overall, cartilage changes were associated with THA (P = 0.001). The time from onset of symptoms to surgery correlated with the post-operative modified HHS (r = 0.255, p = 0.022). Patients with poor overall

Author, year	Mean Follow Up	N (hips total)	Definition of Failure	N (hips, failure)	% Failure	Predictors Examined	Significant Predictors of Failure	Adjustment for Covariates	Comments
Beaule, 2007	3.1 yrs	37	No clinical improvement or worsening of WOMAC score	7	18.92%	Cartilage damage	None	Analysis not adjusted.	cartilage had a significantly lower post-operative
									cartilage had a significantly lower post-operative
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									6 of the 7 hips had Beck grade 4 cartilage damage, but there was no statistically-significant correlation between cartilage damage and clinical outcome since 20 hips with a good clinical outcome also had Beck grade 4 or 5 cartilage damage.

Table 3
Summary findings

Factor	<i>Outcome: Conversion to THA/ Resurfacing</i>		<i>Outcome: Patient dissatisfaction/Lower pain-functional scores/Revision hip arthroscopy other than THA or resurfacing</i>	
	Number of studies that examined factor	Number of studies that found significant correlation between factor and failure outcome	Number of studies that examined factor	Number of studies that found significant correlation between factor and failure outcome
Demographic factors				
Greater age	7	4	4	1
Female gender	3	1	3	1
Lower BMI	1	1	1	0
Higher BMI	1	0	0	0
Clinical history/exam findings				
Previous hip surgery	1	0	1	0
Greater duration of symptoms	1	1	1	1
Aching symptoms	1	0	1	0
Preoperative hip range of motion	1	0	0	0
Preoperative pain/functional scores				
mHHS	2	2	0	0
NAHS	2	0	0	0
HOS for ADLs	1	0	0	0
HOS for sports	1	0	0	0
SF-12	1	0	0	0
TOTAL	7	2	0	0
Assessment of cartilage degeneration				
Preoperative osteoarthritis -- unspecified	2	1	1	1
Preoperative cartilage lesions -- unspecified	4	2	3	0
Preoperative joint space narrowing	3	3	2	1
Preoperative Tonnis grade	4	1	4	1
Preoperative MRI chondral grade	1	0	1	1
Bipolar cartilage lesions	0	0	1	1
Intraoperative Outerbridge score	1	0	2	1
Intraoperative Beck score	1	1	0	0
Preoperative labral tear	0	0	1	0
Residual cartilage lesions after index operation	0	0	1	1
TOTAL	16	8	16	7

Factor	<i>Outcome: Conversion to THA/ Resurfacing</i>		<i>Outcome: Patient dissatisfaction/Lower pain-functional scores/Revision hip arthroscopy other than THA or resurfacing</i>	
	Number of studies that examined factor	Number of studies that found significant correlation between factor and failure outcome	Number of studies that examined factor	Number of studies that found significant correlation between factor and failure outcome
Radiographic measurements				
Type of impingement	2	0	2	0
Neck-shaft angle	0	0	1	0
Alpha angle	2	0	0	0
Lateral center edge angle	0	0	1	0
Extrusion index	0	0	1	0
Presence of a crossover sign	0	0	1	0
Presence of coxaprofunda	0	0	1	0
TOTAL	4	0	7	0
Intraoperative treatments				
Labral debridement	3	0	3	0
Labral re-insertion	3	0	2	0
Microfracture	2	0	1	0
Microfracture of both femoral head and acetabulum	1	1	0	0
TOTAL	9	1	6	0