Predictors of Outcomes After Hip Arthroscopic Surgery for Femoroacetabular Impingement

A Systematic Review

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Background: The benefits of hip arthroscopic surgery in the setting of femoroacetabular impingement (FAI) have been well established; however, some patients may experience a greater degree of improvement than others. Identifying positive and negative predictors of outcomes would assist the orthopaedic surgeon's management algorithm for patients with FAI.

Purpose/Hypothesis: The objective of this systematic review was to identify demographic, radiographic, and other operative predictors of positive and negative outcomes after hip arthroscopic surgery for patients with FAI. It was hypothesized that factors including FAI morphology, age, body mass index (BMI), sex, dysplasia, articular cartilage damage, radiographic joint space, and labral treatment would predict outcomes after hip arthroscopic surgery.

Study Design: Systematic review; Level of evidence, 4.

Methods: This systematic review was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Three databases (Embase, PubMed, and Ovid [MEDLINE]) were searched on May 19, 2018, using terms including "hip," "arthroscopy," and "FAI." Studies were screened and data extracted in duplicate.

Results: A total of 39 studies were included in this systematic review, comprising 9272 hips with a mean age of 36.5 years (47.2% female). Younger age, male sex, lower BMI (<24.5 kg/m^2), Tönnis grade 0, and preoperative pain relief from diagnostic intra-articular hip injections predicted positive outcomes. Female sex, older age (>45 years), longer duration of preoperative symptoms (>8 months), elevated BMI, increased Tönnis grade (≥1), chondral defects, decreased joint space (≤2 mm), increased Kellgren-Lawrence grade (>3), increased lateral center-edge angle (LCEA), and undergoing labral debridement alone were predictors of negative outcomes.

Conclusion: In patients with FAI, younger age, male sex, lower BMI (<24.5 kg/m^2), Tönnis grade 0, and pain relief from preoperative intra-articular hip injections are significantly more likely to achieve positive outcomes after hip arthroscopic surgery. On the other hand, older age (>45 years), female sex, elevated BMI, osteoarthritic changes, decreased joint space (≤2 mm), chondral defects, increased LCEA, and undergoing labral debridement compared with labral repair are associated with negative outcomes.

Keywords: femoroacetabular impingement; hip arthroplasty; predictors; cam; pincer

Femoroacetabular impingement (FAI) is increasingly recognized as a cause for hip and groin pain in the young, active patient.[19] The bony morphologies of FAI, classified as pincer-, cam-, or combined-type deformities, are often accompanied by chondrolabral abnormalities. Hip arthroscopic surgery is indicated to treat FAI and related defects including labral lesions, ligamentum teres injuries, and articular cartilage delamination.[37] Compared with open approaches, hip arthroscopic surgery may result in faster recovery, lower complication rates, less pain, and less morbidity.[4] Over the past decade, hip arthroscopic surgery rates have risen exponentially.[30] Hip arthroscopic surgery has reduced pain and improved function in patients in most age groups, body mass indices (BMIs), sexes, income levels, and activity levels.[44,61]

Negative outcomes after hip arthroscopic surgery for FAI may be defined as persistent pain, looseness, and stiffness with reduced range of motion, refractory to nonsurgical

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treatment or reoperation.[13] Furthermore, dissatisfaction can result from an inability to return to desired activities. Failure rates for hip arthroscopic surgery range from 2.9% to 13.2%.[11,12,26] Residual or unaddressed FAI is the most common cause of negative outcomes in hip arthroscopic surgery.[3] Other potential causes of negative outcomes include unrecognized acetabular dysplasia, soft tissue laxity, and osteoarthritis. Positive outcomes after hip arthroscopic surgery usually involve achieving the minimal clinically important difference (MCID) or substantial clinical benefit (SCB) on patient-reported outcome measures (PROMs).[47,48] Negative outcomes after hip arthroscopic surgery for FAI are typically managed with revision arthroscopic surgery or open surgical hip dislocation but sometimes require total hip arthroplasty (THA).[3]

Now that the benefits of hip arthroscopic surgery have been well established in the literature, the next logical step is to identify predictors of positive and negative outcomes in the setting of FAI. The previous identification of these factors in arthroscopic surgery has been important; for example, labral debridement versus labral repair as a predictor for negative outcomes has changed surgical strategies and techniques over the past decade.[34,54] Identifying such predictors would undoubtedly alter the orthopaedic surgeon's management algorithm for patients with FAI. The objective of this systematic review was to identify clinical, radiographic, and demographic predictors of positive and negative outcomes after hip arthroscopic surgery for patients with FAI. It was hypothesized that factors including FAI type, age, BMI, sex, dysplasia cartilage damage, radiographic joint space, and labral treatment would predict outcomes after hip arthroscopic surgery.

METHODS

Search Strategy

The methodology of the following systematic review was adopted from a previous study.[29] This systematic review was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Three online databases (Embase, PubMed, and Ovid [MEDLINE]) were searched from database inception until May 19, 2018, for studies investigating the predictors of clinical outcomes after hip arthroscopic surgery for FAI. The broad and inclusive search included the terms "hip," "arthroscopy," and "FAI" (Appendix Table A1).

Study Screening

The titles, abstracts, and full-text articles were screened by 2 reviewers (J.K., M.M.) independently and in duplicate. Disagreements during title and abstract screening moved onto the next stage for a more in-depth review. Any disagreements were discussed between the reviewers, and a senior author (O.R.A.) was consulted for any remaining discrepancies. The references of the included studies were subsequently manually screened for additional articles that may have eluded the initial search strategy.

Assessment of Study Eligibility

The research question and study eligibility criteria were established a priori. The inclusion criteria were English-language studies, studies investigating humans, studies with level of evidence 1 to 4, studies with a minimum follow-up of 6 months, those published after January 1, 2010, and those reporting the predictors of outcomes after the arthroscopic management of FAI. Exclusion criteria were animal studies, commentaries, book chapters, review articles, and technical studies.

Data Abstraction

Data were collected by 2 reviewers (O.A.S., A.S.) and recorded in an Excel spreadsheet (version 2007; Microsoft). Abstracted data included the author names, year of publication, study design, sample size, sex ratio, mean age, types of procedures performed, definitions of positive and negative outcomes, and clinical, radiographic, or intraoperative predictors assessed.

Quality Assessment

The methodological quality of the included studies was assessed using the Methodological Index for Non-Randomized Studies (MINORS) instrument. This tool was designed to assess the methodological quality of comparative and noncomparative, nonrandomized surgical studies.[59] Using the MINORS checklist, noncomparative studies are assigned a maximum score of 16, and comparative studies can achieve a maximum score of 24. The methodological quality of noncomparative studies was categorized a priori as follows: 0-4 indicated very low quality evidence, 5-7 indicated low quality, 8-12 indicated fair quality, and ≥13 indicated high quality. Furthermore, for comparative studies, the methodological quality was

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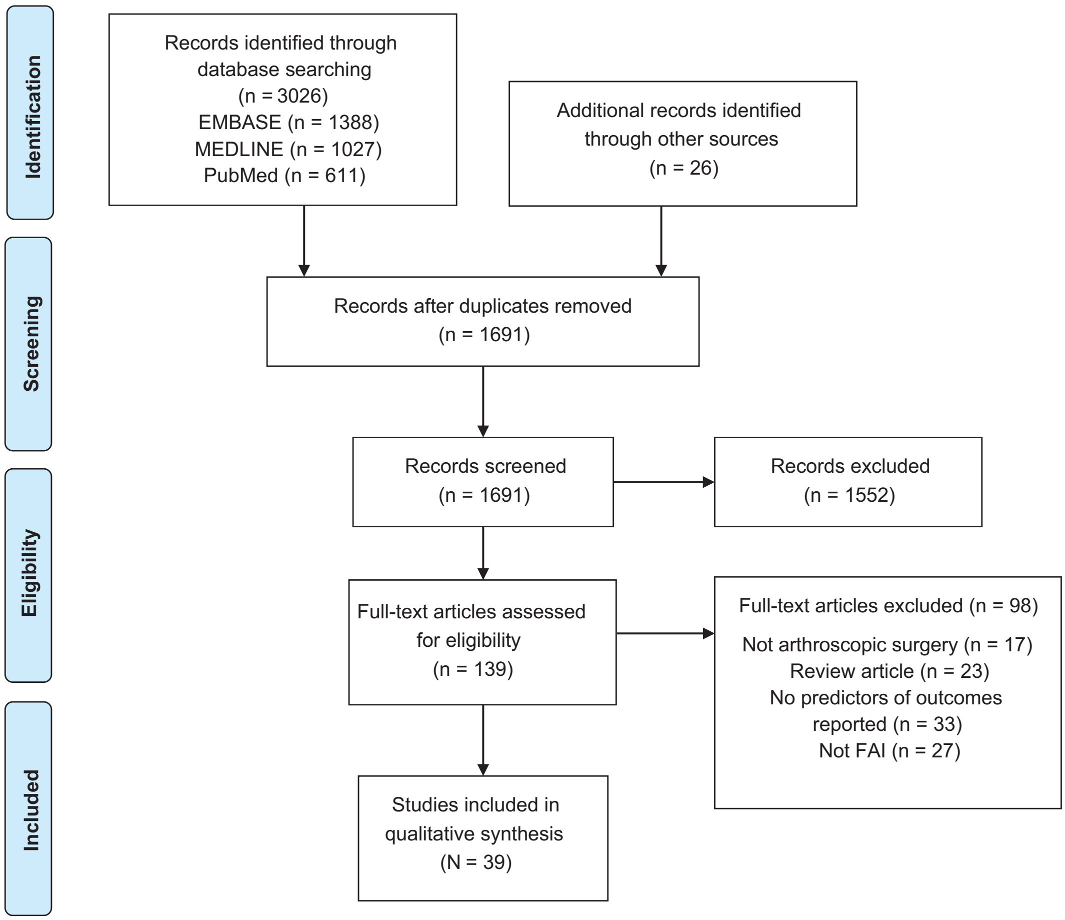

Figure 1. PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) flow diagram demonstrating a systematic review of the literature for clinical, radiographic, and other operative predictors of positive and negative outcomes of hip arthroscopic surgery in the management of femoroacetabular impingement (FAI).

categorized as follows: 0-6 indicated very low quality, 7-10 indicated low quality, 11-15 indicated fair quality, 16-20 indicated good quality, and ≥21 indicated high quality.

Statistical Analysis and Assessment of Agreement

To assess interreviewer agreement, the kappa (κ) statistic was calculated for the title, abstract, and full-text screening stages. Agreement was categorized a priori as follows: κ/intraclass correlation coefficient (ICC) of ≥0.60, substantial agreement; κ/ICC of 0.21-0.59, moderate agreement; and κ/ICC of ≤0.20, slight agreement.[33] Given the nonuniform nature of the studies included in this systematic review in terms of techniques and outcome reporting, the results are presented in narrative summary fashion. Definitions of positive and negative outcomes were derived from the identified studies in this review. Descriptive statistics including means, proportions, standard deviations and 95% confidence intervals were calculated using Minitab statistical software (version 17; Minitab).

RESULTS

Search Strategy

The initial search of the online databases resulted in 3026 total studies. A systematic screening and assessment of eligibility identified 39 full-text articles that satisfied the inclusion and exclusion criteria (Figure 1). The reviewers reached substantial agreement at the title (κ = 0.829 [95% CI, 0.798-0.860]), abstract (κ = 0.853 [95% CI, 0.821-0.885]), and full-text (κ = 1.00) screening stages.

Study Quality

The 39 included studies (Table 1) comprised 19 case series (level of evidence 4), 9 case-control studies (level 4), 3 prognostic studies (level 2), and 8 prospective cohort studies (level 2). The 28 noncomparative studies had a mean MINORS score of 13 of 16 (range, 9-15), which corresponds to high quality of evidence. Also, 52% of studies did not report a blinded assessment of outcomes, and 3 studies had a loss to follow-up of >5%. All noncomparative studies included a

TABLE 1
Study Characteristics and Demographics[a]

Author (Year)	Study Design (LOE)	MINORS Score	No. of Patients (Hips)	Female Sex, %	Follow-up Time, Mean (Range), mo	Age, Mean (Range), y	Country of Publication
Ayeni et al[1] (2014)	Prospective cohort (2)	13/16	52	58	6	37 (16-62)	Canada
Byrd et al[5] (2018)	Case-control (4)	16/24	100	34	24	34.7 (13-76)	USA
Byrd and Jones[6] (2011)	Case series (4)	12/16	200	26	19 (12-60)	28.6 (11-60)	USA
Chandrasekaran et al[7] (2017)	Case-control (4)	17/24	72	50	24	Experimental group: 31.2 (15.9-49.6); matched group: 31.6 (15.5-52.7)	USA
Claßen et al[9] (2016)	Prospective cohort (2)	11/16	177	54	6	48.2	Germany
Comba et al[10] (2016)	Case series (4)	12/16	42	36	7 y	38 (23-56)	Argentina
Cvetanovich et al[11] (2018)	Case-control (4)	12/16	386 (414)	60.6 (251/414)	24	33.3 ± 12.1	USA
Fabricant et al[17] (2015)	Prognostic (2)	17/24	243	51 (n = 123/243)	21 (12-42)	29.2	USA
Frank et al[18] (2016)	Prognostic (2)	15/24	150	50 (n = 75/150)	33.64 ± 5.7	37.9 ± 12.83	USA
Gédouin et al[20] (2010)	Case series (4)	12/24	110 (111)	29 (n = 32/111)	10 (6-18)	31 (16-49)	France
Gicquel et al[21] (2014)	Case series (4)	14/24	58	60	Short term: 10 (6-18); midterm: 55 (50-66)	31 (NR)	France
Gigi et al[22] (2016)	Case-control (4)	16/24	106	35	12 (NR)	Sports group: 32.54; AC group: 32.03; NAS group: 45.74	Israel
Gupta et al[24] (2016)	Case series (4)	9/16	595	61.7	28.98 (24-66.1)	38 (13.2-76.4)	USA
Haefeli et al[25] (2017)	Case series (4)	11/16	50 (52)	89	7 y (5-11 y)	35 (16-63)	Switzerland
Herrmann et al[27] (2016)	Case series (4)	15/24	99	NR	32	48.6 ± 6.1	Germany
Horisberger et al[28] (2010)	Case series (4)	12/16	20	20	36	47.3 (22-65)	Switzerland
Krych et al[31] (2016)	Case series (4)	16/24	319 hips	74	14.8 (11-30)	37.6 ± 14	USA
Larson et al[35] (2011)	Case series (4)	17/24	296 (319)	FAI group: 35.7 (n = 81); FAI-OA group: 5.7 (n = 13)	12	FAI group: 31.8 (14-61); FAI-OA group: 44.7 (24-64)	USA
Maempel et al[39] (2018)	Case series (4)	10/16	88 (89)	55	Minimum, 12; median, 24.3	31.73 (15-57)	Scotland
Malviya et al[40] (2012)	Case series (4)	11/16	612 hips	42	3.2 y (1-7 y)	36.7 (14-75)	UK
Martínez et al[41] (2015)	Case series (4)	12/16	179	64.8	23.8 ± 9.89	43.7 ± 10.4	Colombia
Menge et al[42] (2017)	Prospective cohort (2)	14/16	154 (169)	48.1	≥10 y	40.7	USA
Menge et al[43] (2017)	Case series (4)	14/16	51 (60)	0	36	27 (20-38)	USA
Mygind-Klavsen et al[45] (2018)	Case-control (4)	14/16	1835 (2054)	53	24	37.9 (9-79)	Denmark
Nabavi et al[46] (2015)	Prospective cohort (2)	12/16	253 (280)	49	24	39	Australia
Nwachukwu et al[47] (2017)	Prospective cohort (2)	13/16	364	57.1	12	32.5 ± 10.3	USA
Öhlin et al[49] (2017)	Prospective cohort (2)	13/16	198	38.4	24	41.0 ± 12.1	Sweden
Palmer et al[50] (2012)	Case series (4)	15/16	185 (201)	50.7	46	40.2 (14-87)	USA
Philippon et al[51] (2013)	Prognostic (2)	15/16	96	49.0	54 (49.9-58.9)	57 (50-78)	USA
Philippon et al[53] (2012)	Case series (4)	14/16	60 (65)	71.7	42 (24-60)	15 (15.3-15.8)	USA
Philippon et al[52] (2009)	Prospective cohort (2)	13/16	112	55.4	27.6 (24.0-34.8)	40.6 (37.7-43.5)	USA
Saltzman et al[56] (2017)	Case-control (4)	15/16	381 (409)	61	31.2 ± 6	33.1 ± 12.1	USA
Sansone et al[57] (2017)	Prospective cohort (2)	14/16	289 (359)	34.2	25.4 ± 2	37 ± 13	Sweden
Schilders et al[58] (2011)	Case-control (4)	20/24	151 (156)	24.75	29.28 (24-48)	37 (15-71)	UK
Sochacki et al[60] (2018)	Case-control (4)	13/16	77	72.7	12	35.2 ± 12.5	USA
Stähelin et al[62] (2008)	Case series (4)	15/16	22	31.8	6	42 (18-67)	Switzerland
Thomas et al[64] (2017)	Case series (4)	10/16	469	34.1	30	29 (18-55)	USA
Tjong et al[65] (2017)	Case series (4)	13/16	86 (106)	58	37.2 (27.9-79.2)	38.1 (17-59)	USA
Weber et al[66] (2017)	Case-control (4)	14/16	66	60.6	30.2 ± 4.8	Recreational: 29.7 ± 6.8; athletes: 18.4 ± 2.3	USA

[a]AC, active claims; FAI, femoroacetabular impingement; LOE, level of evidence; MINORS, Methodological Index for Non-Randomized Studies; NAS, non–sports-related injuries; NR, not reported; OA, osteoarthritis.

clearly stated aim, included all patients fit for inclusion, prospectively collected data according to a protocol, and selected endpoints appropriate to the study. The 11 comparative studies had a mean MINORS score of 16 of 24 (range, 12-20), indicating good quality of evidence. In 2 studies, the control group did not have baseline equivalence.

Study Characteristics

Study investigators performed arthroscopic procedures in patients with FAI, including labral repair (82.9% of studies), labral debridement (75.6%), femoroplasty (75.0%), acetabuloplasty (51.0%), capsular plication (9.7%), microfracture (51.2%), removal of loose bodies (7.3%), and ligamentum teres debridement (14.6%). Twenty-seven studies provided a definition for negative outcomes. Outcomes after hip arthroscopic surgery were deemed negative if subsequent revision arthroscopic surgery, THA, or another operative procedure was required (50% of studies); hip pain and functional scores failed to meet the MCID or SCB (31%); patients could not return to work or sport (10%); there was a failure in the reduction of the alpha angle (3%); there was no postoperative functional improvement (3%); or if a patient's death was reported (3%).

Sixteen studies provided a definition for positive outcomes. Of these 16 studies, 7 reported an improvement in postoperative scores meeting the MCID or SCB (Table 2). In the remaining studies, hip arthroscopic surgery outcomes were deemed positive if hip pain and functional scores improved and there was no conversion to THA or hip resurfacing procedure during the study period. Overall, hip arthroscopic surgery had positive outcomes in 1245 of 1723 hips (72.2%) in the population of studies that specified an MCID or SCB in their definitions of positive outcomes. Hip arthroscopic surgery had negative outcomes in 873 of 3968 hips (22.0%) in the population of studies that provided a definition of negative outcomes and reported these rates. The mean follow-up time for the 11 identified comparative studies was 22.4 months (range, 10-34 months). The remaining 28 noncomparative studies had a mean follow-up time of 40.8 months (range, 6-120 months). The key findings for each study reviewed are reported in Appendix Table A2.

Clinical and Demographic Predictors of Positive Outcomes

Eleven studies examined clinical and demographic predictors of positive outcomes after hip arthroscopic surgery (Table 2). The most frequently reported demographic variables for positive outcomes were age, sex, and preoperative patient-reported outcomes. Three studies reported significant associations between undergoing surgery at a younger age and positive outcomes. Cvetanovich et al[11] found that younger age was associated with increased positive outcomes after arthroscopic surgery compared with older age (28.8 ± 11.1 vs 36.7 ± 11.7 years, respectively; $P < .001$). Two other studies used age in a regression model as continuous variables and found significant associations between younger age and positive outcomes; however, no binary cutoff was identified (Table 3).[24,47]

Studies reported a significant association between sex and positive outcomes after hip arthroscopic surgery (Table 3). Frank et al[18] found that male patients older than 45 years scored significantly higher than female patients older than 45 years on the Hip Outcome Score (HOS)–Sports-Specific Subscale (SSS) ($P = .024$) and modified Harris Hip Score (mHHS) ($P = .042$). Malviya et al[40] reported that male sex was a significant predictor for improvement after hip arthroscopic surgery ($P < .001$). Increases in preoperative patient-reported outcomes (>60 on the HOS–Activities of Daily Living [ADL]) were associated with patients having positive outcomes. Gupta et al[24] also identified increases in the preoperative Non-Arthritic Hip Score (NAHS) (rate ratio [RR], 0.980 [95% CI, 0.965-0.995]; $P = .009$) as associated with decreases in negative outcomes (Table 3), although a cutoff was not provided.

Cvetanovich et al[11] also investigated BMI and workers' compensation status as predictors for patients after hip arthroscopic surgery. They found that a lower BMI (<24.5 kg/m^2) was associated with successfully achieving the MCID on the HOS-SSS (odds ratio [OR], 0.92 [95% CI, 0.87-0.98]; $P = .006$). Patients who did not have workers' compensation status were associated with achieving the MCID on the HOS-SSS (OR, 0.16 [95% CI, 0.03-0.75]; $P = .02$). Saltzman et al[56] also reported that patients with a normal BMI (18.5-24.9 kg/m^2) had positive outcomes. Gigi et al[22] investigated and compared outcomes after arthroscopic surgery in patients with work-related active claims, sports injuries with no active claims, and non–sports-related injuries with no active claims pending. The sports injury group demonstrated a greater improvement on the mHHS, from a mean score of 67.01 (95% CI, 61.40-72.62) to 83.26 (95% CI, 78.22-88.29) ($P < .001$), than the active claims group, from a mean score of 59.62 (95% CI, 52.75-66.49) to 64.92 (95% CI, 52.65-72.19) ($P < .042$). This had a significant intergroup comparison of change in the mHHS (active claims vs sports injury; $P = .019$). Gupta et al[24] found that increased preoperative flexion was a significant predictor for decreased postoperative conversion to THA or a hip resurfacing procedure. They reported a mean preoperative flexion of 118.36° (range, 12°-160°) in their study population, with 9.1% of patients having negative outcomes (Table 3).

Clinical and Demographic Predictors of Negative Outcomes

Twenty-six studies examined clinical and demographic predictors for negative outcomes in hip arthroscopic surgery (Table 2). The most frequently reported demographic variables for negative outcomes in the included studies were age and sex. Older age was identified as a significant predictor for negative outcomes after hip arthroscopic surgery (Table 4).[9,10,18,24,42,45,52] Frank et al[18] similarly identified age and sex as predictors for negative outcomes. Female and male patients >45 years old scored significantly worse

TABLE 2
Study Definitions and Details of Positive/Negative Outcomes, Operative Details, and Radiographic Details[a]

Author (Year)	Procedures Performed During Arthroscopic Surgery	Definition of Negative Outcomes	Negative Outcomes, %	Definition of Positive Outcomes	Alpha Angle, Mean ± SD, deg	Center-Edge Angle, Mean ± SD, deg
Ayeni et al[1] (2014)	Labral repair (n = 8), femoral osteochondroplasty (n = 49), capsular plication (n = 3), labral debridement (n = 45), acetabular rim trimming (n = 32), microfracture (n = 6), removal of loose bodies (n = 1)	NR	NR	Postoperative mHHS >70	NR	NR
Byrd et al[5] (2018)	Labral debridement (n = 92), acetabular chondroplasty (n = 68), femoral chondroplasty (n = 23), femoroplasty (n = 81), acetabuloplasty (n = 38)	Conversion to arthroplasty, repeat arthroscopic surgery	Tönnis grade 0-1: 6.1; Tönnis grade 2: 6.7	>8-point improvement on mHHS	NR	NR
Byrd and Jones[6] (2011)	Femoroplasty (n = 150), acetabuloplasty (n = 10), correction of combined lesions (n = 31)	NR	NR	mHHS improvement postoperatively	NR	NR
Chandrasekaran et al[7] (2017)	Study group: labral repair (n = 26), labral debridement (n = 8), labral reconstruction (n = 2), capsular repair (n = 20), capsular release (n = 16), acetabuloplasty (n = 72), microfracture (n = 2), acetabular chondroplasty (n = 21), femoroplasty (n = 1), femoral head microfracture (n = 1), femoral head chondroplasty (n = 10), ligamentum teres treatment (n = 24), iliopsoas release (n = 10), trochanteric bursectomy (n = 1), removal of loose bodies (n = 7); control group: labral repair (n = 26), labral debridement (n = 8), labral reconstruction (n = 2), capsular repair (n = 20), capsular release (n = 16), microfracture (n = 3), acetabular chondroplasty (n = 22), subchondral cyst removal (n = 1), femoroplasty (n = 1), femoral head microfracture (n = 1), femoral head chondroplasty (n = 12), ligamentum teres treatment (n = 17), iliopsoas release (n = 9), removal of loose bodies (n = 6)	NR	NR	Postoperative difference of >10 on mHHS, improvement on HOS-ADL postoperatively, improvement on HOS-SSS postoperatively, improvement on VAS postoperatively, satisfaction on NRS postoperatively	NR	Study group: 45.0 ± 4.69; control group: 31.3 ± 3.72
Claßen et al[9] (2016)	Labral debridement (n = 138), labral repair (n = 5), ligamentum teres resection (NR), transcapsular psoas release (NR), femoral head and neck resection (n = 177)	NAHS <55, WOMAC <77, presence of chondral lesions	81.9	NR	NR	NR
Comba et al[10] (2016)	Microfracture (NR), labral debridement (NR), femoral osteochrondoplasty (NR)	Requiring THA indicated failure of joint preservation	17	NR	NR	NR
Cvetanovich et al[11] (2018)	Labral repair (n = 391), microfracture (n = 66), femoral osteochondroplasty (n = 410), T-capsulotomy closed (n = 414)	NR	NR	PASS of 87 for HOS-ADL, 75 for HOS-SSS, and 74 for mHHS; MCID of 5 for HOS-ADL, 6 for HOS-SSS, and 8 for mHHS	61.6 ± 10.7	32.9 ± 6.3
Fabricant et al[17] (2015)	Labral repair (n = 194), labral debridement (n = 47), microfracture (n = 5)	NR	NR	MCID of 8 for mHHS, 5 for HOS-ADL, 6 for HOS-SSS, and 10 for iHOT-33	Decreased version: 65 ± 13; normal version: 64 ± 12; increased version: 63 ± 12	NR

(continued)

TABLE 2 (continued)

Author (Year)	Procedures Performed During Arthroscopic Surgery	Definition of Negative Outcomes	Negative Outcomes, %	Definition of Positive Outcomes	Alpha Angle, Mean ± SD, deg	Center-Edge Angle, Mean ± SD, deg
Frank et al[18] (2016)	Labral repair (n = 130), labral debridement (n = 20), femoral osteochondroplasty (NR), capsular closure (NR)	Statistically significant decreased scores on PROMs postoperatively	NR	Statistically significant increased scores on PROMs postoperatively (HOS-ADL, HOS-SSS, mHHS, satisfaction)	58.43 ± 10.87	31.52 ± 5.38
Gédouin et al[20] (2010)	Femoral osteochrondoplasty (NR), labral repair (n = 14), labral debridement (n = 89), acetabular rim trimming (NR)	NR	NR	Improvement on WOMAC postoperatively, improved satisfaction	64.6 ± 12	NR
Gicquel et al[21] (2014)	Microfracture (n = 17), labral debridement (n = 40), labral repair (n = 13), femoral osteochondroplasty (n = 43), acetabular rim trimming (n = 20)	NR	NR	Improvement on WOMAC at short term and midterm, improvement in satisfaction at short term and midterm	Not specifically measured	Not specifically measured
Gigi et al[22] (2016)	Labral repair (n = 73), acetabuloplasty (n = 89), femoral osteochondroplasty (n = 80), AIIS decompression (n = 3), microfracture (n = 5), iliopsoas release (n = 4)	NR	NR	Improvement on mHHS and HOS-ADL postoperatively	AC group: 75.14 ± 2.12; sports group: 73.03 ± 2.16; NAS group: 77.8 ± 3.13	AC group: 37.57 ± 1.83; sports group: 36.20 ± 1.42; NAS group: 38.82 ± 2.63
Gupta et al[24] (2016)	Acetabuloplasty (n = 416), femoral osteochondroplasty (n = 392), labral repair (n = 352), capsular release (n = 360), ligamentum teres debridement (n = 297), capsular repair (n = 233), labral debridement (n = 213), iliopsoas release (n = 193), chondroplasty (n = 179), synovectomy (n = 103), microfracture (n = 72), trochanteric bursectomy (n = 66), removal of loose bodies (n = 65), gluteus medius repair (n = 19), excision of bone cyst–femur (n = 18), labral resection (n = 17), acetabular notchplasty (n = 16), os acetabulum removal (n = 13), labral reconstruction (n = 9), iliotibial band release (n = 5), excision of bone cyst (n = 3), piriformis release (n = 3), sciatic neurolysis (n = 3), arthroscopic removal of screws (n = 2), pubic symphysis resection (n = 2)	Conversion to THA, revision hip arthroscopic surgery during study period, NAHS <10	9.1 (n = 44) for patients who underwent conversion to THA; 7.7 (n = 47) for patients who underwent revision	No conversion to THA or hip resurfacing procedure during study period, change in NAHS >10	59.37 (range, 32-105)	29.18 (range, 11-49)
Haefeli et al[25] (2017)	Offset correction (n = 39), acetabular rim trimming (n = 4), offset and rim addressed (n = 9), labral refixation (n = 4), labral excision (n = 16), adhesiolysis (n = 2)	Need for revision surgery	17 (9 hips)	NR	59 ± 11	31 ± 6
Herrmann et al[27] (2016)	Femoral osteochondroplasty (NR), synovial debridement (NR), labral repair (NR), labral resection (NR), acetabular rim trimming (NR)	Conversion to THA	22.8 (n = 18)	NR	67 ± 13	32 ± 7.5
Horisberger et al[28] (2010)	Microfracture (n = 15), labral resection (n = 20), acetabular rim trimming (n = 9)	Death, implantation of THA	40 (n = 8) THA (planned in 2 cases)	NR	79.6 (range, 57-110)	All <40
Krych et al[31] (2016)	Labral repair (n = 77), labral debridement (n = 19), femoral osteoplasty (n = 16), acetabular osteoplasty (n = 2), combined osteoplasty (n = 73), microfracture (n = 2), iliopsoas lengthening (n = 34)	NR	NR	mHHS >70, significant improvement on HOS	Not specifically measured	Not specifically measured

(continued)

TABLE 2 (continued)

Author (Year)	Procedures Performed During Arthroscopic Surgery	Definition of Negative Outcomes	Negative Outcomes, %	Definition of Positive Outcomes	Alpha Angle, Mean ± SD, deg	Center-Edge Angle, Mean ± SD, deg
Larson et al[35] (2011)	Labral debridement (n = 132), labral repair (n = 95), microfracture (n = 43)	Postoperative mHHS <70, conversion to hip arthroplasty	FAI group: 12 (n = 18); FAI-OA group: 52 (n = 29)	NR	NR	NR
Maempel et al[39] (2018)	Labral repair (n = 71), labral resection (n = 18), femoral cam removal (n = 78)	NR	NR	Improvement on iHOT-12, EQ-5D index, and EQ-5D VAS postoperatively	NR	NR
Malviya et al[40] (2012)	Femoral osteochondroplasty (n = 537), femoral osteochondroplasty with acetabular recession (n = 61), labral repair (NR)	NR	NR	Improvement on mHHS translated using Rosser Index Matrix to create quality-of-life score	NR	NR
Martínez et al[41] (2015)	Microfracture (NR), chondroplasty (NR), labral resection or reinsertion (NR), osteoplasty (NR), acetabuloplasty (NR), psoas tenotomy (NR)	Need for revision arthroscopic surgery or open surgery	3.91 (n = 7/179)	No need for revision arthroscopic surgery or open surgery	59.9 ± 6.39	36.6 ± 8.02
Menge et al[42] (2017)	Labral repair (n = 79), labral debridement (n = 75), bony resection (NR), microfracture (NR)	NR/subsequent hip arthroscopic surgery or arthroplasty	Arthroscopic surgery: 4.5 (n = 7/154); THA: 34 (n = 50/145)	NR	Debridement group: 70 ± 12; repair group: 71 ± 8	Debridement group: 36 ± 6; repair group: 35 ± 9
Menge et al[43] (2017)	Femoroacetabular osteoplasty (n = 47), femoral osteoplasty (n = 7), acetabular osteoplasty (n = 2), labral repair (n = 45), labral debridement (n = 11), labral reconstruction (n = 4), chondroplasty (n = 24), microfracture (n = 22)	NR/unsuccessful return to sport	13 (n = 8/60)	NR	NR	NR
Mygind-Klavsen et al[45] (2018)	Labral repair (n = 1737), cartilage surgery (n = 1470), femoral osteoplasty (n = 1807)	Score <2/3 of maximum on individual subscales or below top 33% on HAGOS	NR	NR	68	32
Nabavi et al[46] (2015)	Hip arthroscopic surgery (NR)	<20-point improvement or <80 on mHHS or NAHS at 1 year postoperatively	23 (n = 64/280)	NR	NR	NR
Nwachukwu et al[47] (2017)	Labral repair (n = 288), labral debridement (n = 72), cam decompression (n = 325), pincer decompression (n = 107)	Failure to achieve SCB (based on net change for PROMs)	NR	NR	62.5 ± 11.4	34.0 ± 8.9
Öhlin et al[49] (2017)	Cam decompression (n = 60), combined cam and pincer decompression (n = 138)	NR	NR	Significant improvement on PROMs postoperatively	NR	NR
Palmer et al[50] (2012)	Cam decompression (n = 152), combined decompression (n = 49), labral debridement/repair/refixation (NR), chondroplasty (NR), microfracture (n = 31)	Conversion to THA, decreased NAHS	14 (THA: n = 13; NAHS: n = 15)	NR	Anteroposterior: 72.3; lateral: 58.5	NR
Philippon et al[51] (2013)	Labral repair (n = 75), labral debridement (n = 21), pincer decompression (n = 4), cam decompression (n = 16), combined decompression (n = 76), acetabular microfracture (n = 41), femoral microfracture (n = 27)	Subsequent THA	43 (n = 41/96)	NR	NR	NR
Philippon et al[53] (2012)	Labral repair (n = 54), labral debridement (n = 11), femoroplasty (n = 15), acetabular rim trimming (n = 15), combined decompression (n = 35), ligamentum teres debridement (n = 36), femoral chondroplasty (n = 2), capsular plication (n = 32)	Revision arthroscopic surgery	12 (n = 8/65)	NR	64 (range, 60-69)	36 (range, 34-38)

(continued)

TABLE 2 (continued)

Author (Year)	Procedures Performed During Arthroscopic Surgery	Definition of Negative Outcomes	Negative Outcomes, %	Definition of Positive Outcomes	Alpha Angle, Mean ± SD, deg	Center-Edge Angle, Mean ± SD, deg
Philippon et al[52] (2009)	Cam decompression (n = 23), pincer decompression (n = 3), combined decompression (n = 86), microfracture (n = 47), labral repair (n = 58), labral debridement (n = 54), ligamentum teres debridement (n = 94)	Conversion to THA, decreased mHHS postoperatively	THA: 9 (n = 10/112)	NR	72 (range, 70.5-73.5)	NR
Saltzman et al[56] (2017)	Labral repair (n = 358), acetabular rim trimming (n = 320), femoral osteochondroplasty (n = 377), capsular plication (n = 381), microfracture (n = 5), trochanteric bursectomy (n = 10)	Reoperation, conversion to THA, decreased PROMs	2 (n = 8/409)	NR	61.7 ± 10.4	33.0 ± 6.4
Sansone et al[57] (2017)	Cam decompression (n = 149), combined decompression (n = 201), pincer decompression (n = 9), labral repair (n = 26), microfracture (n = 19), labral debridement (n = 22), ligamentum teres debridement (n = 2)	Reoperation, conversion to THA, dissatisfaction, decreased PROMs	Reoperation: n = 17; THA: n = 14	NR	NR	NR
Schilders et al[58] (2011)	Labral repair (n = 69), labral debridement (n = 32), acetabular rim trimming (n = 82), femoroplasty (n = 74), microfracture (n = 11)	Decreased mHHS	NR	NR	NR	Repair group: 38.1 (range, 36.7-39.4); debridement group: 38.3 (range, 36.6-39.9)
Sochacki et al[60] (2018)	NR	Failure to achieve MCID	33.8 (n = 26/77)	NR	NR	NR
Stähelin et al[62] (2008)	Labral debridement (n = 13), labral repair (n = 2), osteochondroplasty (n = 14), microfracture (n = 7)	<20° reduction of alpha angle	18 (n = 4/22)	NR	75.1 ± 12.7	NR
Thomas et al[64] (2017)	Labral repair/debridement (NR), osteochondroplasty (NR), microfracture (NR), capsular repair (NR), psoas tenotomy (NR)	Failure to return to active duty	n = 195/469	NR	NR	NR
Tjong et al[65] (2017)	NR	Decreased PROMs postoperatively	NR	NR	69.0 (range, 55-80)	NR
Weber et al[66] (2017)	Labral repair (n = 63), femoral osteochondroplasty (n = 66), acetabular rim trimming (n = 56), capsular closure (n = 66)	Failure to return to sport	8 (n = 5/66)	NR	59.2 ± 9.8	34.1 ± 5.7

[a]AC, active claims; AIIS, anterior inferior iliac spine; EQ-5D, EuroQol–5 Dimensions; FAI, femoroacetabular impingement; HAGOS, Copenhagen Hip and Groin Outcome Score; HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SSS, Hip Outcome Score–Sports-Specific Subscale; iHOT, International Hip Outcome Tool; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; NAS, non–sports-related injuries; NR, not reported; NRS, numeric rating scale; OA, osteoarthritis; PASS, patient acceptable symptom state; PROM, patient-reported outcome measure; SCB, substantial clinical benefit; THA, total hip arthroplasty; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

than younger female and male patients on postoperative PROMs (Table 4).

Menge et al[42] observed that men were more likely to undergo subsequent THA than women (44% vs 20%, respectively; $P = .002$). Mygind-Klavsen et al[45] reported that female patients scored worse on the postoperative Copenhagen Hip and Groin Outcome Score (HAGOS) and Hip Sports Activity Scale (HSAS) at 1-year follow-up and worse on the HSAS at 2-year follow-up (RR, 1.20 [95% CI, 1.12-1.29]; $P = .01$). Philippon et al[53] evaluated revision arthroscopic surgery as a negative outcome. All patients who required revision in their study were female. Overall, they observed that male patients had higher mHHS scores postoperatively than female patients (96 vs 88, respectively; $P = .018$). Thomas et al[64] assessed hip arthroscopic surgery for FAI in a military population. They observed that female patients (OR, 0.44 [95% CI, 0.38-0.52]; $P < .0001$) and patients with Axis I psychiatric disorders (OR, 0.46 [95% CI, 0.3-0.7]) were less likely to return to active duty. Finally, Gupta et al[24] reported that female sex

TABLE 3

Predictors of Positive Outcomes After Arthroscopic Surgery for FAI, Organized by Descending Level of Evidence[a]

Operative Predictors	
Intra-articular bupivacaine injections	Among patients with Tönnis grade 1, those reporting >50% pain relief had a significantly higher HOS-SSS score than those reporting <50% pain relief (71.7 vs 52.7, respectively; $P = .03$).[31] The likelihood ratio was 1.15 (95% CI, 0.85-1.56). Patients having pain relief from intra-articular injections were 1.15 times more likely to experience improved function and decreased pain at 6 months (as measured by mHHS >70).[1]
Sports fellowship training versus arthroplasty fellowship training	There was a higher rate of return for surgeons with sports fellowship training versus arthroplasty fellowship training (47% vs 32%, respectively; $P < .0001$).[64]
Clinical and Demographic Predictors	
Younger age	Younger age was associated with achieving the MCID for the HOS-ADL (OR, 0.97 [95% CI, 0.95-0.99]; $P = .008$) and the PASS for the HOS-ADL (OR, 0.97 [95% CI, 0.94-0.98]; $P < .001$).[11] Younger age was associated with achieving the MCID for the HOS-SSS (OR, 0.94 [95% CI, 0.92-0.97]; $P < .002$) and the PASS for the HOS-SSS (OR, 0.97 [95% CI, 0.94-0.99]; $P = .001$).[11] Patients who achieved the MCID and PASS for the HOS-SSS and HOS-ADL were younger than those who did not (28.8 ± 11.1 vs 36.7 ± 11.7 years, respectively; $P < .001$).[11] Age at surgery (RR, 0.95 [95% CI, 0.93-0.98]; $P < .001$) was associated with a decrease in revision failure rates.[24] Younger age (OR, 0.89 [95% CI, 0.87-0.92]) was predictive of the SCB for the HOS-ADL.[47]
Male sex	Male patients >45 years of age scored significantly better than female patients >45 years of age on the HOS-SSS ($P = .024$) and mHHS ($P = .042$).[18] The mean quality-of-life score for men was significantly better than for women at 1 year (0.982 [95% CI, 0.7-1] vs 0.964 [95% CI, 0.7-1], respectively; $P < .001$, *t* test) after surgery.[40] Male patients had higher mHHS scores than female patients (96 vs 88, respectively; $P = .018$).[53]
Higher preoperative patient-reported outcomes	A preoperative HOS-ADL score >60 was associated with achieving the PASS for the HOS-ADL (OR, 1.05 [95% CI, 1.03-1.06]; $P < .001$).[11] An increased preoperative HOS-SSS score was associated with achieving the PASS for the HOS-SSS (OR, 1.02 [95% CI, 1.01-1.03]; $P < .001$).[11] An increase in the preoperative NAHS score (RR, 0.980 [95% CI, 0.965-0.995]; $P = .009$) was associated with a decrease in failure rates.[24]
Normal BMI	A lower BMI was associated with achieving the MCID for the HOS-SSS (OR, 0.92 [95% CI, 0.87-0.98]; $P = .006$).[11] Patients who achieved the MCID and PASS for the HOS-SSS and HOS-ADL had a lower BMI (24.5 ± 4.7 vs 25.8 ± 4.7 kg/m^2, respectively; $P = .011$).[11] Patients with a normal BMI (18.5-24.9 kg/m^2) had higher HOS-ADL, HOS-SSS, and mHHS scores and greater improvement on the VAS than overweight and obese patients.[56]
Preoperative flexion	Preoperative flexion (RR, 0.973 [95% CI, 0.956-0.990]; $P = .001$) was associated with a decrease in failure rates.[24]
Non–workers' compensation status	Patients who had non–workers' compensation status were associated with achieving the MCID for the HOS-SSS (OR, 0.16 [95% CI, 0.03-0.75]; $P = .02$).[11] Patients who achieved the MCID and PASS for the HOS-SSS and HOS-ADL were less likely to have workers' compensation status (10% vs 50.8%, respectively; $P = .02$).[11]
Radiographic Predictors	
Tönnis grade 0	Tönnis grade 0 was associated with achieving the MCID for the HOS-ADL (OR, 2.49 [95% CI, 1.13-5.44]; $P = .022$).[11] Tönnis grade 0 was associated with achieving the PASS for the HOS-SSS (OR, 2.72 [95% CI, 1.22-6.33]; $P = .014$).[11] Patients who achieved the MCID and PASS for the HOS-SSS and HOS-ADL were more likely to have Tönnis grade 0 than grade 1 (52.3% vs 25.7%, respectively; $P = .004$).[11] The postoperative WOMAC score for Tönnis grade 0 was 87.5 ± 26 and for Tönnis grade 1 was 73.7 ± 18 ($P < .001$).[20] Postoperative satisfaction for Tönnis grade 0 was 81% and for Tönnis grade 1 was 61% ($P = .041$).[20]

(continued)

TABLE 3 (continued)

	The Tönnis grade 1 group had lower midterm WOMAC scores (77 ± 18 [range, 47-100]) compared with the Tönnis grade 0 group (88 ± 14 [range, 39-100]) ($P = .03$).[21]
	The procedure survival rate after a mean of 55 months was 97.1% (95% CI, 91.6%-100.0%) in the Tönnis grade 0 group versus 66.7% (95% CI, 44.9%-88.4%) in the Tönnis grade 1 group ($P = .002$).[21]
	Tönnis grade 0/1 had higher mHHS (83.5 vs 71.5, respectively; $P = .01$), HOS-SSS (81.3 vs 59.9, respectively; $P = .02$), and iHOT-12 (71.1 vs 58.8, respectively; $P = .04$) scores than Tönnis grade 2.[65]
Larger joint space width	A larger medial joint space width was associated with achieving the PASS for the HOS-ADL (OR, 1.40 [95% CI, 1.04-1.90]; $P = .028$).[11]
	The central joint space (RR, 0.003 [95% CI, 0.0001-0.07]; $P < .001$) was associated with a decrease in failure rates.[24]
LCEA	An increase in the LCEA (RR, 0.898 [95% CI, 0.862-0.935]; $P < .001$) was associated with a decrease in failure rates.[24]
Lower acetabular version	Lower acetabular version at 2 o'clock predicted the SCB for the iHOT-33 (OR, –0.95 [95% CI, 0.92-0.98]).[47]
Decreased chondral defects	A lower Outerbridge grade (OR, 0.44 [95% CI, 0.15-0.94]) was predictive of the SCB for the HOS-ADL.[47]

[a]BMI, body mass index; FAI, femoroacetabular impingement; HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SSS, Hip Outcome Score–Sports-Specific Subscale; iHOT, International Hip Outcome Tool; LCEA, lateral center-edge angle; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; OR, odds ratio; PASS, patient acceptable symptom state; RR, rate ratio; SCB, substantial clinical benefit; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

TABLE 4
Predictors of Negative Outcomes After Arthroscopic Surgery for FAI, Organized by Descending Level of Evidence[a]

Operative Predictors	
Microfracture	Microfracture (RR, 2.15 [95% CI, 0.87-5.3]; $P = .09$) was associated with an increased need for revision in female patients with acute injuries.[24]
	Acetabular microfracture increased the HR for THA (HR, 2.86 [95% CI, 1.07-7.62]; $P = .036$).[42]
	Microfracture was associated with THA ($P = .001$).[52]
Labral debridement	Labral debridement versus repair was not significantly different; however, in patients undergoing acetabular microfracture, debridement affected THA outcomes (HR, 1.88 [95% CI, 1.03-3.41]; $P = .039$).[42]
	The repair group performed better than the debridement group by 6.99 points on the mHHS (95% CI, 0.27-13.73; $P = .042$).[58]
Anterior rim resection	Patients who received anterior rim resection for pincer FAI showed less improvement on the NAHS compared with those who did not receive rim resection (16.1 vs 23.9, respectively; $P = .01$).[50]
Clinical and Demographic Predictors	
Increased age	Patients >55.5 years old had a poor postoperative NAHS score of <55 ($P < .001$).[9]
	Age of ≥45 years at the time of arthroscopic surgery was a significant risk factor to evolve to THA ($P = .005$).[10]
	Female patients >45 years old scored significantly worse compared with female patients <30 years old on the HOS-ADL ($P < .0001$), HOS-SSS ($P < .0001$), and mHHS ($P < .0001$) and female patients 30 to 45 years of age on the HOS-ADL ($P < .0001$), HOS-SSS ($P < .0001$), and mHHS ($P = .003$).[18]
	Male patients >45 years of age scored significantly worse compared with male patients <30 years of age on the HOS-ADL ($P = .007$), HOS-SSS ($P < .0001$), and mHHS ($P = .011$) and male patients 30 to 45 years of age on the HOS-ADL ($P = .021$), HOS-SSS ($P = .005$), and mHHS ($P = .018$).[18]
	Patients >45 years of age scored significantly worse on the HOS-ADL, HOS-SSS, and mHHS compared with patients <30 years of age ($P < .0001$ for all) and patients 30 to 45 years of age ($P = .001$ for HOS-ADL and $P < .0001$ for both HOS-SSS and mHHS).[18]
	An increase in age at surgery (RR, 1.09 [95% CI, 1.063-1.116]; $P < .001$) was associated with an increased failure rate.[24]
	The mean age was higher in patients undergoing THA than those not undergoing THA (53 vs 35 years, respectively; $P < .001$) (HR, 3.06 [95% CI, 1.69-5.56]; $P < .001$).[42]
	Older age (25-39 and ≥40 years) groups had poorer outcomes than the youngest group (<25 years) (RR, >1.0; $P < .01$ for most PROMs).[45]
	Older patients were more likely to undergo THA than younger patients (58 vs 39 years, respectively; $P = .001$).[52]

(continued)

TABLE 4 (continued)

Female sex	The factor that significantly predicted dissatisfaction in the midterm was female sex (P = .002).[21]
	Female sex (RR, 2.86 [95% CI, 1.43-5.73]; P < .002) was associated with an increased need for revision.[24]
	Female patients scored worse on the HAGOS and HSAS at 1-year follow-up and worse on the HSAS at 2-year follow-up (RR, 1.20 [95% CI, 1.12-1.29]; P = .01).[45]
	All patients requiring revision were female.[53]
	Female patients were less likely to return to active duty (OR, 0.44 [95% CI, 0.38-0.52]; P < .0001).[64]
Symptom duration before surgery	The optimal cutoff value of "pain duration before surgery" as a predictor of failure was 9.5 months.[9]
	A greater duration of symptoms preoperatively predicted a lower HHS score (effect, 11.0 [95% CI, 2.3-19.76]; P = .014) and an increased failure rate (OR, 0.153 [95% CI, 0.034-0.693]; P = .015).[35]
	Symptom duration correlated negatively with iHOT-12 (r = –0.189, P = .012) and HAGOS–quality of life (r = –0.209, P = .004) scores.[57]
	There was a positive association between the duration of sport withdrawal and return to sport (r = 0.45, P = .001). A >8-month withdrawal had lower HOS-ADL and HOS-SSS scores.[66]
Abnormal BMI	An elevated BMI increased the risk of failure (OR, 1.06 [95% CI, 0.87-0.99]; P = .03).[46]
	Underweight (BMI <18.5 kg/m^2) patients had decreased improvement on the HOS-ADL (–15.3, P = .29) and HOS-SSS (–28.2, P = .032) compared with patients with normal weight after multivariate regression.[56]
	An elevated BMI negatively correlated with HOS-SSS (r = 0.26, P = .04) and mHHS (r = 0.39, P < .01) scores.[66]
Sport type	Football linemen were less likely to return to sport than other positions (OR, 5.6 [95% CI, 1.1-35.0]; P = .04).[43]
	Contact athletes had lower postoperative HOS-ADL scores than noncontact athletes (83.0 ± 22.8 vs 92.4 ± 8.7, respectively; P = .038).[66]
Psychiatric disorders	Axis I psychiatric disorders (OR, 0.46 [95% CI, 0.3-0.7]) negatively predicted return to duty.[64]
Workers' compensation status	Workers' compensation status increased the likelihood of failure (OR, 3.84 [95% CI, 0.13-0.51]; P < .0001).[46]
Male sex	Men were more likely to undergo subsequent THA than women (44% vs 20%, respectively; P = .002).[42]
Radiographic Predictors	
Chondral defects	An increasing MRI chondral grade preoperatively predicted a lower HHS score (effect, 12.5 [95% CI, 2.1-22.7]; P = .019).[35]
	Acetabular cartilage damage had a significant RR for 1 subscale of the HAGOS and NRS (RR [HAGOS–physical activity, NRS-walk], >1.0; P = .04).[45]
	Beck grades 2 to 4 had poorer HAGOS, NRS, and EQ-5D scores than Beck grades 0 to 1.[45]
	ICRS grades 2 to 4 had poorer HAGOS scores than ICRS grades 0 to 1.[45]
	There was a higher proportion of grade 4 chondral defects in the conversion to THA group versus the no THA group (54% vs 20%, respectively; P = .03).[50]
	Cartilage changes were associated with THA (P = .001). Patients with poor cartilage had lower mHHS scores than those with mild and moderate degeneration (62 vs 79 and 87, respectively; P = .011).[52]
Decreased joint space	Patients with a joint space of ≤2 mm as compared with >2 mm were more likely to require THA after index arthroscopic surgery (75% vs 15.9%, respectively; P = .001).[27]
	There was a 33% failure rate with mild-moderate preoperative joint space narrowing (<50% joint space narrowing or >2-mm joint space) and an 82% failure rate with advanced preoperative joint space narrowing (>50% joint space narrowing or ≤2-mm joint space) at last follow-up (P < .001).[35]
	Increased radiographic joint space narrowing preoperatively predicted a lower HHS score (effect, 17.1 [95% CI, 7.536-26.744]; P = 0.001) and an increased failure rate (OR, 0.126 [95% CI, 0.024-0.657]; P = .014).[35]
	A joint space of ≤2 mm versus >2 mm predicted eventual THA (89% vs 15%, respectively) (HR, 4.26 [95% CI, 1.98-9.2]; P < .001).[42]
	THA was associated with a ≤2-mm joint space (OR, 12 [95% CI, 5-34]). A joint space of ≤2 mm predicted THA on binary regression (r^2 = 0.45, P = .001).[51]
	A joint space of <2 mm predicted THA (OR, 39 [95% CI, 5.5-263]).[52]
	A joint space of <2 mm independently predicted postoperative mHHS scores.[52]
Increased Tönnis grade	In patients with radiographic preoperative Tönnis grades 0 and 1, the risk was 0% (95% CI 0%-12.77%). In patients with preoperative Tönnis grades 2 and 3, the risk was 46.67% (95% CI, 21.27%-73.41%). A statistical significance was found between both groups (P = .003).[10]
	The factor that significantly predicted dissatisfaction in the midterm was preoperative Tönnis grade 1 (P < .001).[21]
	The procedure survival rate after a mean of 55 months was 97.1% (95% CI, 91.6%-100.0%) in the Tönnis grade 0 group versus 66.7% (95% CI, 44.9%-88.4%) in the Tönnis grade 1 group (P = .002).[21]
	The Tönnis grade 1 group had a lower midterm WOMAC score (77 ± 18 [range, 47-100]) compared with the Tönnis grade 0 group (88 ± 14 [range, 39-100]) (P = .03).[21]
	A higher preoperative Tönnis grade increased the risk for subsequent THA significantly (P = .03).[28]

(continued)

TABLE 4 (continued)

	THA was associated with Tönnis grades 2 to 3 (OR, 4.8 [95% CI, 1.8-12.6]; $P = .002$).[51]
	Tönnis grade 0/1 had higher mHHS (83.5 vs 71.5, respectively; $P = .01$), HOS-SSS (81.3 vs 59.9, respectively; $P = .02$), and iHOT-12 (71.1 vs 58.8, respectively; $P = .04$) scores than Tönnis grade 2.[65]
Femoral retroversion	Patients with relative retroversion (<5°) demonstrated a clinically important and significantly decreased magnitude of improvement on all PROMs compared with patients with normal version (mHHS: 14 vs 22, respectively [$P = .004$]; HOS-ADL: 11 vs 16, respectively [$P = .008$]; HOS-SSS: 12 vs 27, respectively [$P = .008$]; iHOT-33: 19 vs 35, respectively [$P < 0.001$]), with lower odds of achieving the MCID on the mHHS (adjusted OR, 0.32 [95% CI, 0.14-0.72]; $P = .006$) and iHOT-33 (adjusted OR, 0.33 [95% CI, 0.13-0.84]; $P = .02$).[17]
Increased K-L grade	Patients with K-L grade 3 were significantly more likely to require THA after an arthroscopic intervention as compared with those with K-L grade ≤2 (66.7% vs 16.2%, respectively; $P = .003$).[27]
	THA was associated with K-L grades 3 to 4 (OR, 4.8 [95% CI, 2.0-11.3]; $P = .003$).[51]
Increased LCEA	Patients with an LCEA >40° and coxa profunda did not report as much improvement as the control group for all PROMs, with significance achieved for the mHHS.[7]
	A preoperative factor for revision surgery was an LCEA >33° (HR, 4.63 [95% CI, 1.07-19.94]; $P = .040$).[25]
Acetabular index (<3°)	A preoperative acetabular index of <3° (HR, 95.58 [95% CI, 8.02-1162.64]; $P < .001$) predicted revision.[25]
Pistol grip deformity	An increased offset in the superior portion of the femoral neck (pistol grip deformity) predicted revision (HR, 1.55 [95% CI, 1.34-1.78]; $P < .001$).[25]

[a]BMI, body mass index; EQ-5D, EuroQol–5 Dimensions; FAI, femoroacetabular impingement; HAGOS, Copenhagen Hip and Groin Outcome Score; HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SSS, Hip Outcome Score–Sports-Specific Subscale; HR, hazard ratio; HSAS, Hip Sports Activity Scale; ICRS, International Cartilage Repair Society; iHOT, International Hip Outcome Tool; K-L, Kellgren-Lawrence; LCEA, lateral center-edge angle; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; MRI, magnetic resonance imaging; NAHS, Non-Arthritic Hip Score; NRS, numeric rating scale; OR, odds ratio; PROM, patient-reported outcome measure; RR, rate ratio; THA, total hip arthroplasty; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

was associated with an increased need for revision after hip arthroscopic surgery (RR, 2.86 [95% CI, 1.43-5.73]; $P < .002$). Overall, studies consistently identified the older female patient (>45 years) as the demographic at an increased risk for negative outcomes after hip arthroscopic surgery for FAI.

Four identified studies concurred that a longer duration of symptoms preoperatively (ranging from 8 months to 4 years) was a predictor for negative outcomes after hip arthroscopic surgery.[9,35,57,66] Menge et al[43] found that football linemen were less likely to return to sport compared with other position players (OR, 5.6 [95% CI, 1.1-35.0]; $P = .04$). Two studies reported that an elevated BMI increased the risk of negative outcomes.[46,66] More specifically, Nabavi et al[46] reported a mean BMI of 29 kg/m^2 in their identified poor outcomes group. In addition, Weber et al[66] reported that contact athletes had a lower postoperative HOS-ADL score than noncontact athletes (83.0 ± 22.8 vs 92.4 ± 8.7, respectively; $P = .038$). Saltzman et al[56] found that underweight patients (BMI <18.5 kg/m^2) had decreased improvement compared with patients with a normal BMI. Nabavi et al[46] also assessed workers' compensation status and reported that it increased the likelihood of negative outcomes (OR, 3.84 [95% CI, 0.13-0.51]; $P < .0001$). Finally, Thomas et al[64] reported that patients with Axis I psychiatric disorders were associated with negative outcomes. These findings are summarized in Table 4.

Radiographic Predictors of Positive Outcomes

Eight studies examined radiographic predictors of positive outcomes after hip arthroscopic surgery (see Table 2). Four studies reported Tönnis grade 0 as a significant predictor for positive outcomes.[11,20,21,65] Cvetanovich et al[11] found that patients who were preoperatively determined to be Tönnis grade 0 achieved the MCID for the HOS-ADL (OR, 2.49 [95% CI, 1.13-5.44]; $P = .022$) and the patient acceptable symptom state (PASS) for the HOS-SSS (OR, 2.72 [95% CI, 1.22-6.33]; $P = .014$) relative to patients with Tönnis grade 1. In patients not requiring revision arthroplasty in the study by Gicquel et al,[21] the only factors associated significantly with the midterm Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score were preoperative Tönnis grade ($P = .047$) and midterm Tönnis grade ($P = .03$).

Gupta et al[24] investigated the center-edge angle as a predictor for positive outcomes and found that increases in the sagittal center-edge angle (SCEA) and lateral center-edge angle (LCEA) were associated with decreased negative outcomes. These authors reported a mean SCEA and LCEA of 58.0° ± 9.7° and 29.18° (range, 11°-49°), respectively. Cutoff angles were not reported. Nwachukwu et al[47] reported that lower Outerbridge grade (96.7% grade 0) (OR, 0.44 [95% CI, 0.15-0.94]) and lower acetabular version (OR, –0.95 [95% CI, 0.92-0.98]) were predictive of reaching positive outcomes after arthroscopic surgery.

An increased joint space was identified as a significant predictor for positive outcomes in 2 studies (Table 3).[11,24] Gupta et al[24] reported a mean central joint space of 3.46 mm (range, 1.3-6.7 mm), and Cvetanovich et al[11] reported a mean medial joint space of 4.1 ± 0.8 mm. No specific cutoffs for positive outcomes were reported. Overall, preoperatively determined Tönnis grade 0 with decreased chondral defects and an increased center-edge angle were associated with improved outcomes after arthroscopic surgery for FAI.

Radiographic Predictors of Negative Outcomes

Eighteen studies examined radiographic predictors of negative outcomes after hip arthroscopic surgery (see Table 2). The preoperatively determined Tönnis grade was reported in 8 studies. Numerous studies reported that a higher preoperatively determined Tönnis grade (≥1) led to more negative outcomes after hip arthroscopic surgery (Table 4).[10,21,28,51,65] The LCEA was also predictive of negative outcomes after hip arthroscopic surgery in 2 studies (Table 4).[7,25] More specifically, Chandrasekaran et al[7] reported a mean LCEA of 45.0° in their study and noted that although arthroscopic interventions significantly improved patient outcomes, patients with an LCEA >40° and coxa profunda did not report as much improvement in comparison with their matched control group with a mean LCEA of 31.3°. Additionally, Haefeli et al[25] reported an LCEA >33° (hazard ratio [HR], 4.63 [95% CI, 1.07-19.94]; $P = .040$) as a preoperative factor for revision surgery. They also found that a decreased acetabular index <3° (HR, 95.58 [95% CI, 8.02-1162.64]; $P < .001$) and increased offset in the superior portion of the femoral neck (pistol grip deformity) (HR, 1.55 [95% CI, 1.34-1.78]; $P < .001$) predicted negative outcomes.

Two studies investigated the Kellgren-Lawrence (K-L) grade and reported that a higher K-L grade (≥3) was significantly associated with negative outcomes after hip arthroscopic surgery (Table 4).[27,51] Furthermore, a lower preoperatively determined joint space (≤2 mm) was associated with negative outcomes after arthroscopic surgery (Table 4).[27,35,42,51,52] Fabricant et al[17] found that femoral retroversion (<5°) predicted negative outcomes. Finally, increased chondral defects were associated with negative outcomes (Table 4).[35,45,50,52] The constellation of degenerative changes and decreased joint space (≤2 mm) strongly predicted negative outcomes after arthroscopic surgery for FAI.

Other Operative Predictors of Positive Outcomes

Preoperative bupivacaine intra-articular hip injections tended to predict patients' having positive outcomes after arthroscopic surgery for FAI (see Table 3).[1,31] Thomas et al[64] found that hip arthroscopic surgery performed by surgeons with sports fellowship training had a higher rate of return to active duty than patients treated by arthroplasty fellows (47% vs 32%, respectively; $P < .0001$).

Other Operative Predictors of Negative Outcomes

Acetabular microfracture was predictive of the progression to revision or THA in 3 studies.[24,42,52] Labral debridement was associated with poorer postoperative patient-reported outcomes. Schilders et al[58] investigated labral debridement versus labral repair and found that the repair group performed better by 6.99 points on the mHHS (range, 0.27-13.73; $P = .042$). Menge et al[42] found no difference between debridement and repair; however, in patients undergoing acetabular microfracture, debridement affected the THA outcome (HR, 1.88 [95% CI, 1.03-3.41]; $P = .039$). Six studies investigated labral repair as an operative predictor of negative outcomes.[42,47,50,52,53,58] None of them reported significant results. Palmer et al[50] performed arthroscopic surgery on a cohort of patients with cam FAI. Combined decompression was performed on 49 of 201 hips in their study. They reported that anterior rim resection for pincer FAI showed less improvement on the NAHS compared with patients who did not receive rim resection (16.1 vs 23.9, respectively; $P = .01$). Five of 13 conversions to THA originated from this subgroup.

DISCUSSION

Clinical and demographic predictors of positive outcomes after hip arthroscopic surgery for FAI included younger age, male sex, and lower BMI (<24.5 kg/m^2), and clinical and demographic predictors of negative outcomes included older age (>45 years), female sex, longer duration of preoperative pain symptoms (>8 months), and elevated BMI. Radiographic predictors of positive outcomes included Tönnis grade 0 and increased joint space. Higher Tönnis grade (≥1), LCEA >33°, chondral defects, higher K-L grade (≥3), and decreased joint space (≤2 mm) were common radiographic predictors of negative outcomes. Other identified operative predictors of positive outcomes were pain relief from preoperative intra-articular hip injections. Other operative predictors of negative outcomes were labral debridement compared with labral repair. Finally, the studies that reported an MCID or SCB in their definitions for positive outcomes found that relief from preoperative intra-articular hip injections, lower BMI (<24.5 kg/m^2), younger age, Tönnis grade 0, and increased joint space predicted positive outcomes.

The predictors of positive and negative outcomes identified in our review are supported by existing literature on outcomes after hip arthroscopic surgery. Both male and female sex has been associated with positive outcomes after hip arthroscopic surgery.[12,44,55] However, female sex as an identifiable factor appears to be clearer as a negative predictor. Although there is no clear consensus, the role of soft tissue laxity in female patients, possibly leading to negative outcomes, could be postulated. This is a potential area for further investigation in future studies. Surgeons performing arthroscopic surgery in patients with FAI who are older than 45 years should proceed with caution, as this demographic was more likely to have negative outcomes regardless of sex.[15,43] Furthermore, in the setting of FAI, female and overweight patients (BMI >24.5 kg/m^2) with a prolonged duration of preoperative pain may be prone to negative outcomes after arthroscopic surgery. Specifically, athletes with a longer preoperative withdrawal time (>8 months) from sports, and also football linemen in general, could be more prone to negative outcomes.[46,66]

Osteoarthritic changes and pre-existing cartilage damage have been thought to be factors associated with negative outcomes after hip arthroscopic surgery.[8,12,28,44] The current study similarly identified osteoarthritic changes, as seen on preoperative imaging, as significant predictors of negative outcomes. Specifically, a decreased joint space

($\leq$2 mm); the presence of cysts, osteophytes, and sclerosis as evidenced by an increased Tönnis grade ($\geq$1); and K-L grade ($\geq$3) predicted negative outcomes. As such, surgeons should counsel their patients on the potential negative impact that pre-existing degenerative changes can have on outcomes after arthroscopic surgery for FAI. Although no specific cutoff was identified, the overall mean follow-up time for the studies that identified degenerative changes was 48 months. Therefore, caution is warranted, as it is likely that the survivorship of the hip decreases in this cohort of patients.

Typically, acetabuli with an LCEA >39° to 40° and concomitant protrusion are classified as pincer-type FAI.[14,36,63] A higher preoperative LCEA was identified as a protective factor against eventual THA in 1 study. However, overall, it appears that practitioners can expect a decreased postoperative improvement in patients with an increased preoperative LCEA and decreased acetabular index (extrusion), both indicators of pincer-type FAI. Combined acetabular overcoverage with protrusion will not exhibit the same degree of improvement compared with hips without protrusion.[7] These findings may be related to procedural technical difficulties or differing patterns of labral damage.[8] Acetabular microfracture for chondral defects in the setting of FAI has generally led to positive outcomes.[38] We identified 3 studies that reported it as a risk factor for eventual conversion to THA, a finding that has been previously documented.[23] Similar to reports on the knee, it has been theorized that this technique exposes the subchondral bone, and if formation fails, fragility and subchondral bone cysts can develop, accelerating degenerative changes.[2] In the microfracture studies that we identified, patients were older (mean age, 58 years) and had a decreased joint space ($\leq$2 mm) with chondral defects (Outerbridge grade 4). These cofactors must be considered when interpreting these results of microfracture after hip arthroscopic surgery, as previous literature has reported their association with negative outcomes.[16] Therefore, it is possible that microfracture should be avoided in the setting of the older patient with degenerative changes. Finally, studies have documented superior outcomes with labral repair compared with labral debridement, which supports our findings.[32,34]

This review was primarily limited by the quality of reporting, varying levels of evidence, heterogeneity of variables assessed, and use of multiple PROMs across the included studies. Specifically, there was significant heterogeneity in the definition of “negative outcomes” after hip arthroscopic surgery. Definitions included conversion to THA/revision arthroscopic surgery, failure to achieve the SCB/MCID, failure to return to sport, and failure to achieve improvement on PROMs/radiographic findings. This heterogeneity in the definition of “negative outcomes” limits the generalizability of the findings of this systematic review and precluded the ability to perform a meta-analysis. Additionally, there were few reported MCIDs or SCBs for the PROMs used in the various definitions of “positive outcomes.” This can limit the external validity of the positive predictors that did not include these measures. However, the studies in this review had high and good quality of evidence, indicating that the predictors identified in this review likely contribute to outcomes in some form. A secondary limitation is that not all studies reported a mean LCEA or alpha angle in their patient populations. As established in the literature, these radiographic parameters can confound postoperative results. Finally, we were unable to identify a clear cutoff for younger age as a predictor for negative outcomes. Future investigations should be undertaken to provide clarity for this predictor.

This systematic review successfully identified clinical, radiographic, and other operative predictors of positive and negative outcomes after hip arthroscopic surgery in the setting of FAI. Hip arthroscopic surgery for FAI necessitates a comprehensive selection of suitable patients to maximize favorable postoperative outcomes. Future studies, including a prospective evaluation of a large sample size of patients with an accepted and uniform definition of positive and negative outcomes, are warranted. The information from these studies could provide clinical guidelines for orthopaedic surgeons to use when assessing patients with FAI for hip arthroscopic surgery.

CONCLUSION

In patients with FAI, younger age, male sex, lower BMI (<24.5 kg/m^2), Tönnis grade 0, increased joint space and pain relief from preoperative intra-articular hip injections were significantly more likely to achieve positive outcomes after hip arthroscopic surgery. More specifically, pain relief from preoperative intra-articular hip injections, lower BMI (<24.5 kg/m^2), younger age, Tönnis grade 0, and increased joint space were positive predictors defined by an MCID or SCB. On the other hand, older age (>45 years), female sex, longer duration of preoperative pain symptoms (>8 months) elevated BMI, osteoarthritic changes, decreased joint space ($\leq$2 mm), chondral defects, increased LCEA, and undergoing of labral debridement versus labral repair were associated with negative outcomes.

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APPENDIX

TABLE A1
Search Strategy

Embase: 1388 Studies		MEDLINE: 1027 Studies		PubMed: 611 Studies	
Strategy	No. of Studies	Strategy	No. of Studies	Strategy	No. of Studies
1. hip arthroscopy.mp. or arthroscopy/ or hip arthroscopy/ or arthroscopic surgery/	26,332	1. Arthroscopy/ or hip arthroscopy.mp.	21,318	1. hip	
2. femoroacetabular impingement.mp. or femoroacetabular impingement/	2950	2. arthroscopic.mp.	18,503	2. arthroscop*	
3. FAI.mp.	2743	3. femoroacetabular impingement.mp. or Femoracetabular Impingement/	2114	3. 1 and 2	
4. CAM	29,552	4. FAI.mp.	1953	4. (FAI or (femoroacetabular impingement) or (CAM) or (Pincer))	
5. Pincer.mp	1611	5. CAM.mp.	24,047	5. 3 and 4	611
6. 2 or 3 or 4 or 5	34,146	6. Pincer.mp.	1964		
7. 1 and 6	1388	7. 1 or 2	27,543		
		8. 3 or 4 or 5 or 6	28,136		
		9. 7 and 8	1027		

TABLE A2
Study Key Findings[a]

Author (Year)	Primary Outcomes After Arthroscopic Surgery	Key Finding
Ayeni et al[1] (2014)	mHHS	A negative response from an intra-articular hip injection may predict a higher likelihood of having a negative result from surgery.
Byrd et al[5] (2018)	mHHS	There was an improvement on the mHHS after arthroscopic surgery regardless of the Tönnis grade.
Byrd and Jones[6] (2011)	mHHS	No predictors were investigated.
Chandrasekaran et al[7] (2017)	mHHS	Patients with overcoverage had improvement but did not do as well after arthroscopic surgery compared with matched controls.
Claßen et al[9] (2016)	NAHS, WOMAC	The date of surgery is an important predictor in avoiding the occurrence of chondral defects in patients with symptomatic cam-type FAI.
Comba et al[10] (2016)	WOMAC, mHHS	Patients with advanced osteoarthrosis and patients >45 years old had a higher risk of requiring THA.
Cvetanovich et al[11] (2018)	HOS-ADL, HOS-SSS	Younger age, a lower BMI, no workers' compensation status, and a normal joint space correlated with higher postoperative PROM scores.
Fabricant et al[17] (2015)	HOS-ADL, HOS-SSS, iHOT-33, mHHS	Patients with relative retroversion (<5° of anteversion) had smaller, but clinically important, improvements on all PROMs compared with those with normal or increased version when controlling for relevant covariates in multiple regression analysis. Relative femoral retroversion should not be considered an absolute contraindication to surgical correction of FAI.
Frank et al[18] (2016)	HOS-ADL, HOS-SSS, mHHS	Age and sex were found to be significant independent predictors of PROM scores, with older age being the most influential predictor of worse scores.
Gédouin et al[20] (2010)	WOMAC, satisfaction	The presence of established osteoarthritis emerged as an important negative prognostic factor for functional results.
Gicquel et al[21] (2014)	WOMAC, satisfaction	Tönnis grade 1 hips should be managed with caution. In this population, arthroscopic treatment should be reserved for those patients at the severe end of the symptom spectrum, who should be informed of the increased risk of negative outcomes, particularly in the presence of incipient joint space narrowing.
Gigi et al[22] (2016)	mHHS, HOS	There was decreased improvement in postoperative outcomes in the active claims group compared with other groups.
Gupta et al[24] (2016)	NAHS, mHHS	Increased preoperative PROM scores, preoperative flexion, and central joint space were associated with decreased revision rates. Female sex, increased age, and microfracture were associated with an increased need for revision.
Haefeli et al[25] (2017)	Revision rate as a negative outcome	An LCEA >33° and pistol grip deformity were significant preoperative factors for revision surgery.
Herrmann et al[27] (2016)	Prognostic factors for early conversion to THA	An increased K-L grade and decreased joint space were significantly more likely to require THA.
Horisberger et al[28] (2010)	Conversion to THA, NAHS, VAS	A higher Tönnis grade significantly increased the risk for subsequent THA.
Krych et al[31] (2016)	HOS	Intra-articular anesthetic injections were weak predictors of outcomes after hip arthroscopic surgery. Patients with >50% relief had similar outcomes to those who showed no relief.
Larson et al[35] (2011)	Conversion to THA, <70 on mHHS	Identified negative predictors were a greater duration of symptoms preoperatively and increasing MRI chondral grade.
Maempel et al[39] (2018)	No definition; assessment of age, sex, and socioeconomic status on PROMs	There were no significant predictor findings.
Malviya et al[40] (2012)	NR	Preoperative quality of life and male sex predicted positive outcomes.
Martínez et al[41] (2015)	Revision arthroscopic surgery, open hip surgery	There was an association between higher preoperative WOMAC scores and negative outcomes after arthroscopic surgery.

(continued)

TABLE A2 (continued)

Author (Year)	Primary Outcomes After Arthroscopic Surgery	Key Finding
		Osteochondroplasty was the only surgical procedure associated with positive outcomes.
Menge et al[42] (2017)	HOS-ADL, HOS-SSS, mHHS, SF-12 PCS	There was a high rate of conversion to THA in patients with a preoperative joint space of ≤2 mm.
Menge et al[43] (2017)	Return to sport	Linemen were less likely to return to sport. Microfracture was not associated.
Mygind-Klavsen et al[45] (2018)	HAGOS, HSAS, NRS, EQ-5D	Age >25 years and higher grade cartilage injuries (femoral head and acetabulum) negatively affected outcomes.
Nabavi et al[46] (2015)	mHHS, NAHS	An elevated BMI and workers' compensation status predicted poor outcomes.
Nwachukwu et al[47] (2017)	HOS-ADL, HOS-SSS, iHOT-33, mHHS	Advanced age and Outerbridge grade negatively prognosticated the SCB. Preoperative HOS thresholds predicted the SCB.
Öhlin et al[49] (2017)	iHOT-12	Preoperative iHOT-12 scores correlated with postoperative iHOT-12 scores (1 point higher = 0.65 points higher at 2-year follow-up).
Palmer et al[50] (2012)	NAHS, VAS, satisfaction	There was no difference in age. Cam hips had poorer outcomes compared with the rest of the study group.
Philippon et al[51] (2013)	K-L grade, Tönnis grade	A joint space of ≤2 mm best predicted negative outcomes in patients ≥50 years old.
Philippon et al[53] (2012)	HOS-SSS, mHHS	There was no difference between patients undergoing labral debridement and those undergoing labral repair. Female patients had worse outcomes.
Philippon et al[52] (2009)	mHHS, HOS-ADL, HOS-SSS, NAHS	A preoperative joint space of ≥2 mm and labral repair were associated with good outcomes.
Saltzman et al[56] (2017)	HOS-ADL, HOS-SSS, VAS, mHHS	No associations were observed between BMI and clinical outcomes after multivariate analysis.
Sansone et al[57] (2017)	iHOT-12, HAGOS, HSAS, VAS, EQ-5D	A long symptom duration was correlated with inferior outcomes. There was no correlation between age, cartilage status, and outcomes.
Schilders et al[58] (2011)	mHHS	Labral repair was favored over resection.
Sochacki et al[60] (2018)	BDI-II, HOS, iHOT-33	Preoperative moderate and severe depression predicted poorer outcomes compared with mild/moderate depression.
Stähelin et al[62] (2008)	Range of motion, VAS, NAHS	Offset correction was not correlated with clinical outcomes.
Thomas et al[64] (2017)	VAS, SANE, return to duty	Return to duty was negatively affected by female sex, Axis I psychiatric disorders, a low rank, and pelvic pain. Special forces and infantry experienced better outcomes.
Tjong et al[65] (2017)	mHHS, iHOT-12, HOS-SSS	Patients with degenerative changes (Tönnis grade 2) demonstrated lower scores. There was no correlation between the alpha angle and PROM scores.
Weber et al[66] (2017)	mHHS, HOS-SSS, HOS-ADL	A longer preoperative withdrawal from sport predicted a longer time for return to sport. A higher BMI predicted poorer outcomes.

[a]BDI-II, Beck Depression Inventory–II; BMI, body mass index; EQ-5D, EuroQol–5 Dimensions; FAI, femoroacetabular impingement; HAGOS, Copenhagen Hip and Groin Outcome Score; HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SSS, Hip Outcome Score–Sports-Specific Subscale; HSAS, Hip Sports Activity Scale; iHOT, International Hip Outcome Tool; K-L, Kellgren-Lawrence; LCEA, lateral center-edge angle; mHHS, modified Harris Hip Score; MRI, magnetic resonance imaging; NAHS, Non-Arthritic Hip Score; NR, not reported; NRS, numeric rating scale; PROM, patient-reported outcome measure; SANE, Single Assessment Numeric Evaluation; SCB, substantial clinical benefit; SF-12 PCS, 12-Item Short Form Health Survey physical component summary; THA, total hip arthroplasty; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.