Revision Surgery and Progression to Total Hip Arthroplasty After Surgical Correction of Femoroacetabular Impingement

A Systematic Review

Filippo Migliorini,*† MD, Nicola Maffulli,‡§|| MD, MS, PhD, Alice Baroncini,† MD, PhD, Jörg Eschweiler,‡ PhD, Markus Tingart,† MD, and Marcel Betsch,§ MD, MBHA

Investigation performed at RWTH Aachen University, Aachen, Germany

Background: Femoroacetabular impingement (FAI) is a major cause of hip pain in young adults and athletes. Surgical treatment of FAI is recommended in cases of failed nonoperative treatment that have the typical clinical and radiographic findings. At present, the role of risk factors for revision surgery and progression to total hip arthroplasty (THA) in patients with FAI is still unclear.

Purpose: To investigate the possible association between (1) rate of revision and progression to THA and (2) patient characteristics, type of lesion, family history of hip disease, type of intervention, radiographic parameters, physical examination, and pre- and postoperative scores.

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

Methods: The present systematic review was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. In October 2020, the main online databases were accessed. All articles concerning surgical correction for selected patients with FAI were accessed. Patient characteristics, type of intervention, radiographic parameters, physical examination, and pre- and postoperative scores were assessed. The outcomes of interest were the possible association between these variables and the rate of revision and subsequent progression to THA using a multivariate analysis through the Pearson product-moment correlation coefficient.

Results: Data from 99 studies (9357 procedures) were collected. The median follow-up was 30.9 months (interquartile range, 24.0-45.0). The mean ± SD age was 33.4 ± 9.3 years; mean body mass index (BMI), 24.8 ± 4.8; percentage right side, 55.8% ± 8.0%; and percentage female sex, 47.5% ± 20.4%. The overall rate of revision was 5.29% (351 of 6641 patients), while the rate of subsequent progression to THA was 3.78% (263 of 6966 patients). Labral debridement (P < .0001), preoperative acetabular index (P = .01), and BMI (P = .03) all showed evidence of a statistically positive association with increased rates of THA. No other statistically significant associations were found between patient characteristics, type of lesion, family history of hip disease, type of intervention, radiographic parameters, physical examination, or pre- and postoperative scores and the rate of revision and/or progression to THA.

Conclusion: Although surgical procedures to treat FAI led to satisfactory outcomes, there was a revision rate of 5.29% in the 9357 procedures in the present systematic review. The rate of progression to THA after a median follow-up of 30 months was 3.78%. Patients who have a higher BMI and/or have a pathologic acetabular index and/or undergo labral debridement during correction of FAI are more at risk for a subsequent THA. We advocate additional education of this patient population in terms of expected outcomes and suggest surgical labral repair instead of debridement if needed.

Keywords: femoroacetabular impingement; revision surgery; total hip arthroplasty; risk factors

In patients with femoroacetabular impingement (FAI), anatomic abnormalities of the femoral head and/or the acetabulum produce pathologically high contact forces between the femur and the acetabulum. FAI can be a cause of activity limitation, decreased hip function, and significant hip pain, especially in young adults and athletes, because of cartilage and labral damage. These
repetitive insults to the cartilage and labrum result in early hip degeneration and osteoarthritis. Osteoarthritis of the hip displayed subtle developmental changes on radiographs obtained before adulthood. FAI can be classified into 3 types depending on the origin of the pathology, being on the femur (cam), acetabulum (pincer), or both (mixed). In previous cross-sectional studies of 4151 individuals, 19.6% of men and 5.2% of women exhibited a pistol grip deformity of the proximal femur, which was defined by calculating the triangular index. Surgery is indicated in symptomatic patients with clinical and radiographic findings of FAI whose nonoperative treatment has failed for a minimum of 3 months. In these patients, surgical options include femoral osteochondroplasty to improve the femoral head-neck offset; debridement, repair, or reconstruction of the labrum; and/or removal of an excessive acetabular rim. Ganz et al described the technique of surgical hip dislocation for the treatment of FAI in 2003, and several studies have shown good clinical outcomes using this technique. Given the long operating and recovery time of open hip dislocation surgery, a mini-open anterior technique was developed by Clohisy and McClure, who accessed the hip joint through a Hueter approach. Over the past few years, arthroscopic management of FAI has become popular, with a decrease in complications and faster recovery.

All surgical interventions aim to improve patients’ activity levels, relieve hip pain, and restore natural hip function. The various surgical techniques for management of FAI are all successful (surgical hip dislocation, mini-open, arthroscopy), but data on rates of revision and progression to total hip arthroplasty (THA) are limited. So far, prognostic factors for surgical outcome for FAI are still unclear. Thus, the present systematic review investigated the risk factors for revision surgery and progression to THA in patients who underwent surgery for symptomatic FAI. A multivariate analysis was conducted to investigate the association between (1) rate of revision and progression to THA and (2) patient characteristics, type of lesion, type of intervention, radiographic parameters, physical examination, and pre- and postoperative scores.

METHODS

Search Strategy

The present systematic review was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. We followed the PICO protocol for the preliminary search:

P (problem): FAI
I (intervention): surgical correction
C (comparator): generalities, type of intervention, radiographic parameters, tests, scores
O (outcomes): revision rate and progression to THA

Literature Search

Two authors (F.M., A.B.) independently performed the literature search in October 2020, accessing the following databases with no time constraints: PubMed, Embase, Google Scholar, and Scopus. The following keywords were used in combination: hip, FAI, femoroacetabular impingement, arthroscopy, mini-open, open, surgery, dislocation, treatment, therapy, cam, pincer, mixed, labral, acetabulum, femur, pelvis, pain, debridement, repair, reconstruction, THA, complications, pain. The resulting titles and eventually the abstracts were screened by the 2 authors. The full text of the articles of interest was accessed. The references were also screened. Disagreements between the authors were solved by a third senior author (M.B.).

Eligibility Criteria

All the articles concerning surgical correction for patients with FAI were accessed. To be eligible for inclusion, articles had to report the rate of revision and/or progression to THA at last follow-up. Any kind of surgical intervention that did not involve THA was considered revision surgery. According to the authors language capabilities, articles in English, Italian, French, German, and Spanish were considered. Articles of level 1 to 4 according to the Oxford Centre of Evidenced-Based Medicine were considered. Data from national registries were not considered. Reviews, letters, expert opinion, case reports, and editorials were not eligible. Animal, biomechanical, and cadaveric studies were also not considered. Articles regarding revision settings were not eligible. Studies with data based on combined treatments, as well as those focusing on rehabilitation protocols, were excluded. Studies including adjuvants or innovative surgical procedures were excluded. The studies were included regardless of the surgical exposure (arthroscopic, mini-open, open). Studies treating skeletally immature patients were included, as were those describing outcomes in patients who were obese. Studies with data on patients >60 years old or with clear evidence...
of advanced hip degeneration (Tönnis grade III) were not included. Case series of <10 patients were also excluded. Only studies reporting quantitative data under the outcomes of interest were analyzed.

Data Extraction

Data extraction was performed by 2 authors (F.M., A.B.). Data from the following endpoints were collected:

**Generalities**: author and publication year, journal, type of study, follow-up duration, number of patients and procedures, mean age, body mass index (BMI), sex, side of surgery, return to sport

**Type of intervention**: labral debridement, labral repair, labral reconstruction

**Radiographic parameters**: femoral offset (millimeters), acetabular inclination (Tönnis angle), α-angle (anteroposterior, groin-lateral), β-angle, sharp angle, center-edge angle, anterior center-edge angle, lateral center-edge angle, acetabular index, Tönnis grade, caudocranial femoral coverage (percentage), anterior coverage (percentage), posterior coverage (percentage), crossover sign, and joint space (medial, foveal, lateral)

**Physical examination**: range of motion (flexion, extension, abduction, adduction, internal and external); anterior, lateral, and posterior impingement test (percentage positive)

**Pre- and postoperative scores**: Harris Hip Score, modified Harris Hip Score, Non-arthritic Hip Score, 12-Item Short Form Health Survey (SF-12; physical and mental subscales), Hip Outcome Score (activities of daily living and sport-specific subscales), International Hip Outcome Tool–12 and –33, and visual analog scale

The present work investigated whether the aforementioned endpoints were associated with the rate of revision and subsequent progression to THA. Thus, every endpoint was independently analyzed, and its association with revision and progression to THA was assessed.

Methodological Quality Assessment

The methodological quality assessment was made through the Coleman Methodology Score (CMS). The CMS analyzes studies under several items: number of patients, follow-up, type of surgical approach, and study design, as well as descriptions of diagnosis, surgical technique, and postoperative rehabilitation. Furthermore, outcome criteria, the procedure of assessing outcomes, and a description of the sample selection process are evaluated. The quality is scored from 0% (poor) to 100% (excellent), with values >60% considered satisfactory.

Statistical Analysis

The statistical analyses were performed by the main author (F.M.). For the analytical statistics, STATA software (Version 16; StataCorp) was used. The Shapiro-Wilk test was performed to investigate data distribution. For normal data, mean and standard deviation were calculated. For nonparametric data, median and interquartile range were calculated. Multiple pairwise correlations using the Pearson product-moment correlation coefficient (r) were performed to investigate the association between the endpoints were accomplished. According to the Cauchy-Schwarz inequality, the final effect ranks between +1 (positive linear correlation) and –1 (negative linear correlation). Values of 0.1 < |r| < 0.3 and 0.3 < |r| < 0.5 and 0.5 < |r| were considered to have poor, moderate, and strong correlation, respectively. Possible associations with the outcomes of interest were evaluated for each endpoint. Overall significance was evaluated using the χ² test. A linear regression of the statistically significant correlations were made, and added-variable plots were displayed. Values of P > .05 were considered statistically significant.

RESULTS

Search Results

The literature search resulted in 1174 articles. Initially, 509 articles were excluded because of duplication; 529 articles were then excluded because of the following: type of study (n = 187), nonoperative techniques (n = 91), combined treatments (n = 47), adjuvants and/ or innovative surgeries (n = 41), language limitations (n = 22), uncertain data (n = 7), or other (n = 134). A further 37 articles were excluded because they did not match the topic of interest or report quantitative data under the outcomes of interest.
Finally, 99 articles were included for analysis: 3 randomized clinical trials, 36 prospective studies, and 60 retrospective studies. The literature flowchart is shown in Figure 1.

Methodological Quality Assessment

The CMS evidenced the overall limited quality of the studies. Indeed, 60% of studies were retrospective, 36% prospective, and only 3% were randomized trials. Eligibility criteria and rehabilitation protocols were frequently not indicated. General health measures were rarely cited. The procedure of assessing outcomes was often biased or not clearly described. The study size and mean follow-up were well-reported in most studies. The descriptions of diagnoses and surgical techniques were also commonly well-described. The overall CMS was 64.7 points (range, 40-85), attesting to the acceptable quality of the methodological assessment of the present study (Table 1).

Patient Demographics

Data from 9357 procedures (8897 patients) were collected. The median follow-up was 30.9 months (interquartile range, 24.0-45.0). The mean ± SD age was 33.4 ± 9.3 years; mean BMI, 24.8 ± 4.8; percentage right side, 55.8% ± 8.0%; and percentage female sex, 47.5% ± 20.4%. Baseline characteristics are shown in Table 1.

Outcomes of Interest

The overall rate of revision was 5.29% (351 of 6641 patients), while the rate of subsequent progression to THA was 3.78% (263 of 6966 patients). Labral debridement showed evidence of a statistically significant positive and strong association with an increased rate of progression to THA ($r = 0.77; P < .0001$). Equally, a higher preoperative acetabular index showed evidence of a statistically significant positive and strong association with an increased rate of progression to THA ($r = 0.89; P = .01$). The BMI at baseline showed evidence of a statistically significant positive and moderate association with an increased rate of THA ($r = 0.43; P = .03$). No other statistically significant associations were found between patient characteristics, type of lesion, type of intervention, radiographic parameters, physical examination, or pre- and postoperative scores and the rate of revision and/or progression to THA. The added-variable plots of these regressions are shown in Figure 2. The multivariate analysis including all the endpoints is shown in Appendix Table A1 (available in the online version of this article).

DISCUSSION

FAI is a frequent and well-recognized cause for hip pain, joint damage, and early-onset osteoarthritis in young adults and athletes. Over the past few decades, better understanding of the pathophysiology and natural course of FAI has led to earlier identification and improved treatment options for this condition. The present study described the rates of revision and THA progression after surgical treatment of FAI, identifying some variables associated with increased rates of progression to THA. The overall revision rate after surgical treatment of FAI was 5.29%, and 3.78% of 9357 procedures progressed to THA. To date, this is the largest systematic review to analyze revision and progression rates after surgical treatment of FAI, including a total of 99 studies. According to the main results of the present study, BMI at baseline, labral debridement, and acetabular index were significantly associated with an increased rate of progression to THA. No other statistically significant associations were identified between patient characteristics, type of lesion, type of intervention, radiographic parameters, physical examination, or pre- and postoperative scores and the rate of revision and/or progression to THA.

Surgical hip dislocation for the treatment of FAI—including labral repair, labral debridement, femoral osteochondroplasty, and acetabuloplasty—leads to improvements in hip range of motion, radiographic parameters, and clinical outcomes comparable with those of hip arthroscopy.\cite{30,80,91,117} Surgical treatment for FAI, regardless of the technique, improves hip function, with 68% to 96% of patients reporting good to excellent results after a minimum follow-up of 2 years.\cite{21}

One of the main findings of our study was an overall revision rate of 5.29% after surgical treatment of FAI (open hip dislocation, mini-open, and arthroscopic). These findings are similar to those from a registry study from the United Kingdom, which showed a revision hip...
### TABLE 1
Generalities of the Included Studies and Demographic Baseline of the Patients

| First Author | Year | Journal | Study Design | CMS | Treatment | Mean Follow-up, mo | Procedures, No. | Mean Age, y | Female, % |
|--------------|------|---------|--------------|-----|-----------|-------------------|----------------|-------------|-----------|
| Anwander | 2017 | Clin Orthop Rel Res | Retrospective | 68 | Open | Resection, 156; 60 (resection, 25, 25); 144,0 (resection, 29); | Resection, 24; reattachment, 37 | 34.3 | 50.0 |
| Bardakos | 2008 | J Bone Joint Surg Br | Retrospective | 61 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Beck | 2013 | J Bone Joint Surg Am | Retrospective | 53 | Open | 10,0 | 90.0; | 40.0 |
| Beck | 2014 | Clin Orthop Rel Res | Retrospective | 56 | Open | 10,0 | 90.0; | 40.0 |
| Beck | 2011 | J Bone Joint Ortho Med | Retrospective | 53 | Open | 10,0 | 90.0; | 40.0 |
| Bellett | 2016 | Hip Int | Retrospective | 53 | Mini-open | 10,0 | 90.0; | 40.0 |
| Bosch | 2011 | HSJ J | Retrospective | 50 | Open | 10,0 | 90.0; | 40.0 |
| Botas | 2014 | J Am Orthop | Prospective | 72 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Bryan | 2016 | Am J Sports Med | Prospective | 82 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Buhr | 2013 | Arthroscopy | Retrospective | 61 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Byrd | 2009 | Clin Orthop Relat Res | Prospective | 79 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Byrd | 2011 | J Am Orthop | Prospective | 76 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Byrd | 2009 | Arthroscopy | Prospective | 70 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Byrd | 2016 | J Hip Pres Surg | Retrospective | 66 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Camenzind | 2015 | J Hip Pres Surg | Retrospective | 66 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Chaundy | 2015 | Indian J Orthop | Retrospective | 61 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Cho | 2015 | Hip Pelvis | Retrospective | 57 | Open | 10,0 | 90.0; | 40.0 |
| Cohen | 2012 | J Am Orthop | Retrospective | 59 | Mini-open | 10,0 | 90.0; | 40.0 |
| Comba | 2016 | Muscles Ligaments Tendons J | Prospective | 72 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Dagen | 2017 | Arthroscopy | Retrospective | 66 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Domb | 2017 | J Am Orthop | Retrospective | 68 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Domb | 2014 | J Am Orthop | Retrospective | 66 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Domb | 2015 | Arthroscopy | Prospective | 77 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Domb | 2013 | Arthroscopy | Retrospective | 68 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Espinosa | 2006 | J Bone Joint Surg Am | Retrospective | 61 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Eriechiella | 2016 | Technical Health Care | Retrospective | 63 | Mini-open | 10,0 | 90.0; | 40.0 |
| Fabricant | 2015 | J Bone Joint Surg Am | Retrospective | 67 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Flores | 2018 | Orth J Sport Med | Prospective | 72 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Frank | 2014 | Am J Sports Med | Retrospective | 64 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Fukui | 2015 | Arthroscopy | Retrospective | 75 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Fukui | 2015 | Bone Joint J | Retrospective | 64 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Godoun | 2010 | Orthop Traum Surg Res | Retrospective | 58 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Giapint | 2014 | Orthop Traum Surg Res | Retrospective | 64 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Gupta | 2016 | Am J Sports Med | Retrospective | 77 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Gupta | 2014 | Am J Sports Med | Prospective | 71 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Hasself | 2017 | Clin Orthop Relat Surg | Retrospective | 72 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Hartigan | 2017 | J Hip Pres Surg | Retrospective | 64 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Hartman | 2009 | Arch Orthop Trauma Surg | Retrospective | 60 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Hatakeyama | 2018 | Am J Sports Med | Retrospective | 69 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Honda | 2020 | Knee Surg Sports | Retrospective | 66 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Horisberger | 2010 | Arthroscopy | Retrospective | 56 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Horisberg | 2010 | Clin Orthop Relat Res | Retrospective | 69 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Hufeland | 2016 | Arch Orthop Trauma Surg | Retrospective | 64 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Iliakari | 2017 | J Bone Joint Surg Br | Retrospective | 61 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Iliakari | 2008 | J Arthroplasty | Prospective | 50 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Kyri | 2013 | Arthroscopy | Prospective, 76 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| LaFranco | 2015 | J Hip Pres Surg | Prospective | 71 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Larson | 2009 | Arthroscopy | Retrospective | 63 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Larson | 2012 | Am J Sports Med | Prospective | 79 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Levy | 2017 | Am J Sports Med | Retrospective | 49 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Levy | 2018 | Am J Sports Med | Retrospective | 65 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Maldonado | 2017 | Arthroscopy | Retrospective | 57 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Maldonado | 2016 | Muscles Ligaments Tendons J | Retrospective | 53 | Mini-open | 10,0 | 90.0; | 40.0 |
| Mardona | 2015 | J Hip Pres Surg | Retrospective | 64 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| McConkey | 2019 | J Pediatr Orth | Retrospective | 60 | Arthroscopy | 10,0 | 90.0; | 40.0 |
| Mohan | 2017 | Arthroscopy | Retrospective | 69 | Arthroscopy | 10,0 | 90.0; | 40.0 |

(continued)
arthroscopy of 4.5% at a mean 1.7 years. In a systematic review of >6000 patients, the reoperation rate was 6.3% at a mean 1.6 years, and the most common reason for revision surgery was progression to THA. No or mild hip osteoarthritis, labral repair, young age, and limited cartilage damage have been associated with good clinical outcomes, with a progression to THA in 0% to 26% of the cases. A systematic review compared outcomes and rates of progression to THA between surgical hip dislocation and arthroscopy: 7% of the hips were converted to a THA after a maximum follow-up of 12 years in the open group, as compared with 9.5% after 8.1 years in the arthroscopic group, with no statistical difference between them. Byrd and Jones reported THA progression rates between 0% and 29% at 2 years after hip arthroscopy. Schairer et al used population-level data of State Ambulatory Surgery Databases and State Impatient Databases for California and Florida from 2005 to 2012 to examine the progression rate of THA within 2 years after hip arthroscopy. They found an overall progression rate of 12.4% within 2 years after hip arthroscopy, with a significant difference between age groups. In patients <40 years old, the progression rate to THA was 3.0%, which is comparable with our findings of a 3.78% progression rate to THA in patients with a mean age of 33.9 years. The rate of THA progression decreased steadily over time from 14.3% in 2005 to 10.3% in 2010. Age seems to be a risk factor for THA progression: patients aged >50 years exhibited a progression rate of about 20%. This contrasted with the findings of the present systematic review, where age was not significantly associated with a higher rate of THA progression. Differences between our results and the findings of others might be explained by the fact that we included all types of surgical treatment for FAI, instead of focusing on arthroscopic procedures; other potential reasons include the type of data

| First Author | Year | Journal | Study Design | CMS | Treatment | Mean Follow-up, mo | Procedures, No. | Mean Age, y | Female, % |
|--------------|------|---------|--------------|-----|-----------|-------------------|----------------|-------------|-----------|
| Morigi et al. | 2017 | J Orthop Surg Res | Retrospective | 61 | Arthroscopy | 28.0 | 23 | 59.3 | 73.9 |
| Murphy et al. | 2004 | Clin Orthop Relat Res | Prospective | 71 | Open | 62.4 | 23 | 35.4 | 43.5 |
| Nad et al. | 2012 | Am J Sports Med | Retrospective | 68 | Open | 65.7 | 253 | 30.0 | 40.0 |
| Nad et al. | 2011 | Am J Sports Med | Retrospective | 59 | Open | 45.1 | 30 | 19.7 | 0.0 |
| Nawabi et al. | 2016 | Am J Sports Med | Prospective | 62 | Arthroscopy | 31.3 | 60 | 19.5 | 80.0 |
| Nho et al. | 2011 | Arthroscopy | Retrospective | 61 | Arthroscopy | 27.0 | 47 | 22.8 | 28.0 |
| Nielsen et al. | 2014 | BMC Musc Dis | Prospective | 72 | Arthroscopy | 24.6 | 127 | 37.0 | 59.0 |
| Novak et al. | 2014 | J Pediatr Orth Surg | Retrospective | 41 | Open | 21.6 | 29 | 17.0 | 31.0 |
| Palmer et al. | 2013 | Arthroscopy | Retrospective | 72 | Arthroscopy | 46.0 | 185 | 40.2 | 55.7 |
| Peres et al. | 2017 | Arthroscopy | Prospective | 67 | Arthroscopy | 35.7 | 11 | 14.7 | 100.0 |
| Peres et al. | 2015 | Arthroscopy | Retrospective | 62 | Arthroscopy | 49.1 | 60 | 15.5 | 80.0 |
| Peres et al. | 2018 | J Bone Joint Surg Am | Retrospective | 68 | Arthroscopy | Obese, 71.6; control, 71.3 | 148 (obese, 74; control, 74) | 44.2 | Obese, 60.8; control, 60.8 |
| Peters et al. | 2006 | J Bone Joint Surg Am | Prospective | 60 | Open | 32.0 | 30 | 31.0 | 44.8 |
| Peters et al. | 2012 | Clin Orthop Relat Res | Retrospective | 58 | Open | 28.0 | 96 | 28.0 | 41.5 |
| Philippon et al. | 2009 | J Bone Joint Surg Br | Prospective | 71 | Arthroscopy | 27.6 | 112 | 40.6 | 55.4 |
| Philippon et al. | 2012 | Arthroscopy | Retrospective | 64 | Arthroscopy | 36.0 | 60 | 15.0 | 69.0 |
| Philippon et al. | 2007 | Knee Surg Sports Traumatol Arthrosc | Retrospective | 65 | Arthroscopy | 19.2 | 45 | 31.0 | 6.7 |
| Philippon et al. | 2012 | Arthroscopy | Retrospective | 60 | Arthroscopy | 37.5 | 153 | 57.0 | 52.9 |
| Philippon et al. | 2010 | Am J Sports Med | Retrospective | 62 | Arthroscopy | 24.0 | 28 | 27.0 | 0.0 |
| Polsello et al. | 2014 | Hip Int | Retrospective | 62 | Arthroscopy | 73.2 | 26 | 34.6 | 12.5 |
| Polsello et al. | 2009 | Rev Bras Ortop | Retrospective | 48 | Arthroscopy | 27.0 | 28 | 34.0 | 35.0 |
| Rafalski et al. | 2015 | Arthroscopy | Prospective, Randomized | 84 | Arthroscopy | 24.0 | 57 | Group 1, 34.2; group 2, 36.5 | 47.4 |
| Rego et al. | 2018 | Int Orthop | Retrospective | 62 | Arthroscopy | 44.0 | 102 | 34.3 | 47.0 |
| Rhee et al. | 2016 | Arch Orthop Trauma Surg | Prospective, Randomized | 85 | Arthroscopy | Open | 76.0 | 96 | 34.0 | 40.0 |
| Ros et al. | 2017 | Rev Bras Ortop | Retrospective | 60 | Arthroscopy | 29.1 | 41 | 36.1 | 13.0 |
| Sanders et al. | 2017 | Knee Surg Sports Traumatol Arthrosc | Retrospective | 65 | Arthroscopy | 30.0 | 46 | 62.4 | 67.4 |
| Sansone et al. | 2015 | Orthop J Sports Med | Retrospective | 72 | Arthroscopy | 12.3 | 115 | 25.0 | 18.0 |
| Sansone et al. | 2013 | Sc J Med Sci Sports | Prospective | 77 | Arthroscopy | 25.4 | 359 | 37.0 | 34.3 |
| Sansone et al. | 2016 | J Hip Prox Surg | Prospective | 74 | Arthroscopy | 25.5 | 80 | 47.0 | 23.0 |
| Singh et al. | 2010 | Arthroscopy | Prospective | 66 | Arthroscopy | 22.0 | 27 | 22.0 | 0.0 |
| Singh et al. | 2013 | Clin Orthop Relat Res | Retrospective | 61 | Open | 27.0 | 52 | 18.2 | 84.1 |
| Skendzel et al. | 2014 | Am J Sports Med | Retrospective | 63 | Arthroscopy | 73.0 | 383 | 37.0 | 40.0 |
| Skovronok et al. | 2017 | Indian J Orthop | Retrospective | 66 | Open | 45.0 | 39 | 28.3 | 35.9 |
| Stake et al. | 2013 | Am J Sports Med | Prospective | 61 | Arthroscopy | 24.0 | 42 (WC, 21; control, 21) | 39.0 | WC, 15; control, 15 |
| Steppecher et al. | 2014 | Clin Orthop Relat Res | Retrospective | 70 | Open | 72.0 | 97 | 32.0 | 41.9 |
| Tjøtta et al. | 2016 | Orthop J Sports Med | Retrospective | 46 | Arthroscopy | 24.0 | 23 | Return, 44; not return, 43.7 | Return, 47; not return, 53 |
| Tjøtta et al. | 2017 | Arthroscopy | Prospective | 62 | Open | 37.2 | 106 | 38.1 | 58.0 |
| Tran et al. | 2013 | ANZ J Surg | Retrospective | 61 | Arthroscopy | 14.0 | 41 | 15.7 | 14.7 |
| Wang et al. | 2011 | Orthop Surg | Retrospective | 51 | Arthroscopy | 11.6 | 21 | 37.1 | 57.1 |
| Wu et al. | 2015 | J Orthop Surg Res | Retrospective | 55 | Mini-open | 44.0 | 39 | 43.6 | 47.2 |
| Zingg et al. | 2013 | Arch Orthop Trauma Surg | Retrospective | 68 | Arthroscopy | Open | 23 | 27.6 | 21.7 |
| Zingg et al. | 2013 | Arch Orthop Trauma Surg | Prospective | 67 | Arthroscopy | Open | 15 | 28.9 | 26.7 |

BD, borderline dysplastic; CLT, complete labral tear; CMS, Coleman Methodology Score; IFL, iliopsoas fractional lengthening; PRP, platelet-rich plasma; WC, workers' compensation.
BMI at baseline was significantly associated with an increase in the rate of THA progression at a mean follow-up of 38 months. These findings confirm previous results, which found that obesity is an independent risk factor for THA progression after hip arthroscopy at a mean follow-up of 2 years. In addition, Gupta et al. confirmed, in small case series studies, that obesity is associated with higher rates of THA progression after arthroscopic procedures. Our results showed that BMI was a risk factor for THA progression, regardless of the surgical technique.

We were also able to show that the preoperative acetabular index was significantly associated with an increased rate of progression to THA. So far, no studies showed an association between the preoperative acetabular index and the progression rate to THA. However, high lateral center-edge angles and low acetabular indices, which require more complex surgical techniques for adequate treatment, are associated with higher rates of revision surgery.

Furthermore, we found that labral debridement was associated with an increase in the rate of THA revision for the 3 major surgical techniques analyzed in the present investigation. Schilders et al. demonstrated superior outcomes after labral repair as compared with labral debridement in 96 patients with a mean follow-up of 2 years. This was confirmed by Larson et al. in a case-control study, with better Harris Hip Score, SF-12, and visual analog scale outcomes in the labral repair group. Menge et al. compared 79 patients who underwent labral repair and 75 patients who underwent labral debridement at a mean follow-up of 10 years: no difference in clinical outcomes between the techniques was evident. However, when controlling for acetabular microfracture, Menge et al reported that labral debridement was associated with a significantly higher risk of progression to THA, confirming our findings.

This study presents several limitations. Although we have carefully followed recommended guidelines for the preparation of systematic reviews, the overall quality of the studies was low. Most of the studies were retrospective, and eligibility criteria and rehabilitation protocols were not frequently reported. The overall CMS of 64 shows acceptable quality. The mean follow-up of the studies was 30 months, which is longer than most previous studies, but revision and progression rates are likely to increase with long-term follow-up. Given these premises, the risk of biased results is moderate to high; thus, data from the present study must be interpreted with caution. The purpose of the present study was to investigate whether the aforementioned endpoints are associated with the rate of revision and subsequent progression to THA. Thus, every endpoint was investigated independently, and its risk of recurrence in revision and progression to THA was assessed. We did not perform any comparison between endpoints and their overall effect on the surgical outcomes. Future studies should overcome these limitations, and high-quality investigations with longer follow-up should be performed.

CONCLUSION

Surgical treatment for FAI leads to satisfactory outcomes. In this systematic review of 99 studies and 9357 procedures, we found an overall revision rate of 5.29% after surgical treatment. After a median follow-up of 30 months, the progression rate to THA was 3.78%. Patients were at higher risk for a subsequent progression to THA if they had a high BMI, a pathologic acetabular index, or labral debridement during correction of FAI. Therefore, we do advocate additional education of this patient population in terms of its expected outcomes and surgical labral repair instead of simple debridement if needed and technically feasible.

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ORCID iDs

Filippo Migliorini https://orcid.org/0000-0001-7220-1221
Nicola Maffulli https://orcid.org/0000-0002-5327-3702

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REFERENCES

1. Anwander H, Siebenrock KA, Tannast M, Steppacher SD. Labral reattachment in femoroacetabular impingement surgery results in increased 10-year survivorship compared with resection. Clin Orthop Relat Res. 2017;475(4):1178-1188.
2. Bardakos NV, Vasconcelos JC, Villar RN. Early outcome of hip arthroscopy for femoroacetabular impingement: the role of femoral osteoplasty in symptomatic improvement. *J Bone Joint Surg Br.* 2008;90(12):1570-1575.

3. Beaulé PE, Le Duff MJ, Zaragoza E. Quality of life following femoral head-neck osteochondroplasty for femoroacetabular impingement. *J Bone Joint Surg Am.* 2007;89(4):773-779.

4. Beck M, Buchler L. Prevalence and impact of pain at the greater trochanter after open surgery for the treatment of femoro-acetabular impingement. *J Bone Joint Surg Am.* 2011;93(suppl 2):66-69.

5. Beck M, Leunig M, Parvizi J, et al. Anterior femoroacetabular impingement: part II. Midterm results of surgical treatment. *Clin Orthop Relat Res.* 2004;418:67-73.

6. Bedi A, Dolan M, Hetsroni I, et al. Surgical treatment of femoroacetabular impingement improves hip kinematics: a computer-assisted model. *Am J Sports Med.* 2011;39:435-495.

7. Bellotti V, Cardenas C, Astarita E, et al. Mini-open approach for femoroacetabular impingement: 10 years experience and evolved indications. *Hip Int.* 2016;26(suppl 1):38-42.

8. Boone GR, Pagnotto MR, Walker JA, Trousdale RT, Sierra RJ. Caution should be taken in performing surgical hip dislocation for the treatment of femoroacetabular impingement in patients over the age of 40. *HSS J.* 2012;8(3):230-234.

9. Botser IB, Jackson TJ, Smith TW, et al. Open surgical dislocation versus arthroscopic treatment of femoroacetabular impingement. *Am J Orthop (Belle Mead NJ).* 2014;43(5):209-214.

10. Bryan AJ, Krych AJ, Pareek A, et al. Are short-term outcomes of hip arthroscopy in patients 55 years and older inferior to those in younger patients? *Am J Sports Med.* 2016;44(10):2526-2530.

11. Büchler L, Neumann M, Schwab JM, et al. Arthroscopic versus open cam resection in the treatment of femoroacetabular impingement. *Arthroscopy.* 2013;29(4):653-660.

12. Byrd JW, Jones KS. Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. *Clin Orthop Relat Res.* 2009;467(3):739-746.

13. Byrd JW, Jones KS. Arthroscopic management of femoroacetabular impingement in athletes. *Am J Sports Med.* 2011;39:75-135.

14. Byrd JW, Jones KS. Arthroscopic management of femoroacetabular impingement: minimum 2-year follow-up. *Arthroscopy.* 2011;27(10):1379-1388.

15. Byrd JW, Jones KS. Hip arthroscopy for labral pathology: prospective analysis with 10-year follow-up. *Arthroscopy.* 2009;25(4):365-368.

16. Byrd JW, Jones KS, Gwathmey FW. Arthroscopic management of femoroacetabular impingement in adolescents. *Arthroscopy.* 2016;32(9):1800-1806.

17. Camenzind RS, Steurer-Dobner I, Beck M. Clinical and radiographical results of labral reconstruction. *J Hip Preserv Surg.* 2015;2(4):401-409.

18. Chaudhary MM, Chaudhary IM, Vikas KN, et al. Surgical hip dislocation for treatment of cam femoroacetabular impingement. *Indian J Orthop.* 2015;49(5):496-501.

19. Cho SH. Open surgical treatment for femoroacetabular impingement in patients over thirty years: two years follow-up results. *Hip Pelvis.* 2015;27(4):241-249.

20. Clohisy JC, McClure JT. Treatment of anterior femoroacetabular impingement with combined hip arthroscopy and limited anterior decompression. *Iowa Orthop J.* 2005;25:164-171.

21. Clohisy JC, St John LC, Schutz AL. Surgical treatment of femoroacetabular impingement: a systematic review of the literature. *Clin Orthop Relat Res.* 2010;468(2):555-564.

22. Cohen SB, Huang R, Ciccomi MG, Dodson CC, Parvizi J. Treatment of femoroacetabular impingement in athletes using a mini-direct anterior approach. *Am J Sports Med.* 2012;40(7):1620-1627.

23. Coleman BD, Khan KM, Maffulli N, Cook JL, Wark JD; Victorian Institute of Sport Tendon Study Group. Studies of surgical outcome after patellar tendonopathy: clinical significance of methodological deficiencies and guidelines for future studies. *Scand J Med Sci Sports.* 2000;10(1):2-11.
groin pain, and risk of osteoarthritis: a population-based survey. J Bone Joint Surg Am. 2010;92(5):1162-1169.
43. Gupta A, Redmond JM, Hammarstedt JE, et al. Does obesity affect outcomes after hip arthroscopy? A cohort analysis. J Bone Joint Surg Am. 2015;97(1):16-23.
44. Gupta A, Redmond JM, Stake CE, Dunne KF, Domb BG. Does primary hip arthroscopy result in improved clinical outcomes? 2-year clinical follow-up on a mixed group of 738 consecutive primary hip arthroscopies performed at a high-volume referral center. Am J Sports Med. 2016;44(1):74-82.
45. Gupta A, Redmond JM, Stake CE, et al. Does the femoral cam lesion regrow after osteoplasty for femoroacetabular impingement? Two-year follow-up. Am J Sports Med. 2014;42(9):2149-2154.
46. Haefeli PC, Albers CE, Steppacher SD, Tannast M, Buchler L. What are the risk factors for revision surgery after hip arthroscopy for femoroacetabular impingement at 7-year followup? Clin Orthop Relat Res. 2017;475(4):1169-1177.
47. Harris JD, McCormick FM, Abrams GD, et al. Complications and reoperations during and after hip arthroscopy: a systematic review of 92 studies and more than 6,000 patients. Arthroscopy. 2013; 29(3):589-595.
48. Harris WH. Etiology of osteoarthritis of the hip. J Bone Joint Surg Am. 1986;123:20-33.
49. Hartigan DE, Perets I, Yuen LC, Domb BG. Results of hip arthroscopy in patients with MRI diagnosis of subchondral cysts—a case series. J Hip Preserv Surg. 2017;4(4):324-331.
50. Hartmann A, Gunther KP. Arthroscopically assisted anterior decompression for femoroacetabular impingement: technique and early clinical results. Arch Orthop Trauma Surg. 2009;129(8):1001-1009.
51. Hatakeyama A, Utsunomiya H, Nishikino S, et al. Predictors of poor clinical outcome after arthroscopic labral preservation, capsular plication, and cam osteoplasty in the setting of borderline hip dysplasia. Am J Sports Med. 2018;46(1):135-143.
52. Honda E, Utsunomiya H, Hatakeyama A, et al. Patients aged in their 70s do not have a high risk of progressive osteoarthritis following arthroscopic femoroacetabular impingement correction and labral preservation surgery. Knee Surg Sports Traumatol Arthrosc. 2020; 28(6):1648-1655.
53. Hörisberger M, Brunner A, Herzog RF. Arthroscopic treatment of femoral acetabular impingement in patients with preoperative generalized degenerative changes. Arthroscopy. 2010;26(6):623-629.
54. Hörisberger M, Brunner A, Herzog RF. Arthroscopic treatment of femoroacetabular impingement of the hip: a new technique to access the joint. Clin Orthop Relat Res. 2010;468(1):182-190.
55. Howick J, Chalmers I, Glasziou P, et al. The 2011 Oxford levels of evidence. BMJ. 2011;343:d4094. Published 2011. https://www.worldmedindex.org?x=5653.
56. Hufeland M, Kruger D, Haas NP, Perka C, Schroder JH. Arthroscopic treatment of femoroacetabular impingement shows persistent clinical improvement in the mid-term. Arch Orthop Trauma Surg. 2016; 136(5):687-691.
57. Ilizaliturri VM Jr, Nossa-Barrera JM, Acosta-Rodriguez E, Camacho-Galindo J. Arthroscopic treatment of femoroacetabular impingement secondary to paediatric hip disorders. J Bone Joint Surg Br. 2007;89(8):1025-1030.
58. Ilizaliturri VM Jr, Orozco-Rodriguez L, Acosta-Rodriguez E, Camacho-Galindo J. Arthroscopic treatment of cam-type femoroacetabular impingement: preliminary report at 2 years minimum follow-up. J Arthroplasty. 2008;23(2):226-234.
59. Kaplan FS, Dalinka M, Karp JS, et al. Quantitative computed tomography reflects vertebral fracture morbidity in osteopenic patients. Orthopedics. 1989;12(7):949-955.
60. Khadnja V, Villar RN. The arthroscopic management of femoroacetabular impingement. Knee Surg Sports Traumatol Arthrosc. 2007;15(8):1035-1040.
61. Krych AJ, Thompson M, Knutson Z, Scoon J, Coleman SH. Arthroscopic labral repair versus selective labral debridement in female patients with femoroacetabular impingement: a prospective randomized study. Arthroscopy. 2013;29(1):46-53.
62. Kunze KN, Beck EC, Nwachukwu BU, Ahn J, Nho SJ. Early hip arthroscopy for femoroacetabular impingement syndrome provides superior outcomes when compared with delaying surgical treatment beyond 6 months. Am J Sports Med. 2019;47(9):2038-2044.
63. LaFrance R, Kenney R, Giordano B, et al. The effect of platelet enriched plasma on clinical outcomes in patients with femoroacetabular impingement following arthroscopic labral repair and femoral neck osteoplasty. J Hip Preserv Surg. 2015;2(2):158-163.
64. Larson CM, Giveans MR. Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement. Arthroscopy. 2009;25(4):369-376.
65. Larson CM, Giveans MR, Stone RM. Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement: mean 3.5-year follow-up. Am J Sports Med. 2012;40(5):1015-1021.
66. Lavigne M, Parvizi J, Beck M, et al. Anterior femoroacetabular impingement: part I. Techniques of joint preserving surgery. Clin Orthop Relat Res. 2004;418:61-66.
67. Levy DM, Cvetanovich GL, Kuhns BD, et al. Hip arthroscopy for atypical posterior hip pain: a comparative matched-pair analysis. Am J Sports Med. 2017;45(7):1627-1632.
68. Levy DM, Kuhns BD, Frank RM, et al. High rate of return to running for athletes after hip arthroscopy for the treatment of femoroacetabular impingement and capsular plication. Am J Sports Med. 2017;45(1):127-134.
69. Maldonado DR, Krych AJ, Levy BA, et al. Does iliopsoas lengthening adversely affect clinical outcomes after hip arthroscopy? A multicenter comparative study. Am J Sports Med. 2018;46(11):2624-2631.
70. Maldonado DR, Laseter JR, Perets I, et al. The effect of complete tearing of the ligamentum teres in patients undergoing primary hip arthroscopy for femoroacetabular impingement and labral tears: a match-controlled study. Arthroscopy. 2019;35(1):80-88.
71. Malviya A, Raza A, Jameson S, et al. Complications and survival analyses of hip arthroscopies performed in the national health service in England: a review of 6,395 cases. Arthroscopy. 2015;31(5):836-842.
72. Mardones R, Via AG, Tornic A, et al. Arthroscopic release of iliopsoas tendon in patients with femoro-acetabular impingement: clinical results at mid-term follow-up. Muscles Ligaments Tendons J. 2016;6(3):378-383.
73. Matsuda DK, Gupta N, Burchette RJ, Sehgal B. Arthroscopic surgery for global versus focal pincer femoroacetabular impingement: are the outcomes different? J Hip Preserv Surg. 2015;2(1):42-50.
74. McConkey MO, Chadayammuri V, Garabekyan T, et al. Simultaneous bilateral hip arthroscopy in adolescent athletes with symptomatic femoroacetabular impingement. J Pediatr Orthop. 2019;39(4):193-197.
75. Menge TJ, Briggs KK, Dornan GJ, McNamara SC, Philippson MJ. Survivorship and outcomes 10 years following hip arthroscopy for femoroacetabular impingement: labral debridement compared with labral repair. J Bone Joint Surg Am. 2017;99(12):997-1004.
76. Mohan R, Johnson NR, Hevesi M, et al. Return to sport and clinical outcomes after hip arthroscopic labral repair in young amateur athletes: minimum 2-year follow-up. Arthroscopy. 2017;33(9):1679-1684.
77. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. BMJ. 2009;339:b2535.
78. Moriya M, Fukushima K, Uchiyama K, et al. Clinical results of arthroscopic surgery in patients over 50 years of age—what viability does it have as a joint preservative surgery? J Orthop Surg Res. 2017;12(1):2.
79. Murphy S, Tannast M, Kim YJ, Buly R, Millis MB. Debridement of the adult hip for femoroacetabular impingement: indications and preliminary clinical results. Clin Orthop Relat Res. 2004;429:178-181.
80. Naal FD, Miozzari HH, Wyss TF, No¨ tzli HP. Midterm results of surgical hip dislocation for the treatment of femoroacetabular impingement. Am J Sports Med. 2012;40(7):1501-1510.
81. Naal FD, Miozzari HH, Wyss TF, N¨oztli HP. Surgical hip dislocation for the treatment of femoroacetabular impingement in high-level athletes. Am J Sports Med. 2011;39(9):544-550.
82. Navabi DH, Degen RM, Fields KG, et al. Outcomes after arthroscopic treatment of femoroacetabular impingement for patients with borderline hip dysplasia. *Am J Sports Med.* 2016;44(4):1017-1023.

83. Nho SJ, Magennis EM, Singh CK, Kelly BT. Outcomes after the arthroscopic treatment of femoroacetabular impingement in a mixed group of high-level athletes. *Am J Sports Med.* 2011;39:14S-195.

84. Nielsen TG, Miller LL, Lund B, Christiansen SE, Lind M. Outcome of arthroscopic treatment for symptomatic femoroacetabular impingement. *BMC Musculoskelet Disord.* 2014;15:394.

85. Novais EN, Heyworth BE, Stamoulis C, et al. Open surgical treatment of femoroacetabular impingement in adolescent athletes: preliminary report on improvement of physical activity level. *J Pediatr Orthop.* 2014;34(3):287-294.

86. Nwachuku BU, Rebollodeo BJ, McCormick F, et al. Arthroscopic versus open treatment of femoroacetabular impingement: a systematic review of medium- to long-term outcomes. *Am J Sports Med.* 2016;44(4):1062-1068.

87. Palmer DH, Ganesh V, Comfort T, Tatman P. Midterm outcomes in patients with cam femoroacetabular impingement treated arthroscopically. *Arthroscopy.* 2012;28(11):1671-1681.

88. Perets I, Gupta A, Chaharbakhshi EO, et al. Does bony regrowth occur after arthroscopic femoroplasty in a group of young adolescents? *Arthroscopy.* 2017;33(5):988-995.

89. Perets I, Hartigan DE, Chaharbakhshi EO, et al. Clinical outcomes and return to sport in competitive athletes undergoing arthroscopic iliopectos fractional lengthening compared with a matched control group without iliopectos fractional lengthening. *Arthroscopy.* 2018;34(2):456-463.

90. Perets I, Rybakto D, Chaharbakhshi EO, et al. Minimum five-year outcomes of hip arthroscopy for the treatment of femoroacetabular impingement and labral tears in patients with obesity: a match-controlled study. *J Bone Joint Surg Am.* 2018;100(11):965-973.

91. Peters CL, Erickson JA. Treatment of femoroacetabular impingement with surgical dislocation and debridement in young adults. *J Bone Joint Surg Am.* 2006;88(8):1735-1741.

92. Peters CL, Schabel K, Anderson L, Erickson J. Open treatment of femoroacetabular impingement is associated with clinical improvement and low complication rate at short-term followup. *Clin Orthop Relat Res.* 2010;468(2):504-510.

93. Philippou MJ, Briggs KK, Yen YM, Kuppersmith DA. Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondroplbral dysfunction: minimum two-year follow-up. *J Bone Joint Surg Br.* 2009;91(1):16-23.

94. Philippou MJ, Ejnisman L, Ellis HB, Briggs KK. Outcomes 2 to 5 years following hip arthroscopy for femoroacetabular impingement in the patient aged 11 to 16 years. *Arthroscopy.* 2012;28(9):1255-1261.

95. Philippou MJ, Maxwell RB, Johnston TL, Schenker M, Briggs KK. Clinical presentation of femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc.* 2007;15(8):1041-1047.

96. Philippou MJ, Schroder ESBG, Briggs KK. Hip arthroscopy for femoroacetabular impingement in patients aged 50 years or older. *Arthroscopy.* 2012;28(1):59-65.

97. Philippou MJ, Stubbs AJ, Schenker ML, et al. Arthroscopic management of femoroacetabular impingement: osteoplasty technique and literature review. *Am J Sports Med.* 2007;35(9):1571-1580.

98. Philippou MJ, Weiss DR, Kuppersmith DA, Briggs KK, Hay CJ. Arthroscopic labral repair and treatment of femoroacetabular impingement in professional hockey players. *Am J Sports Med.* 2010;38(1):99-104.

99. Polesello GC, Lima FR, Guimaeres RP, Ricioli W, Queiroz MC. Arthroscopic treatment of femoroacetabular impingement: minimum five-year follow-up. *Hip Int.* 2014;24(4):381-386.

100. Polesello GC, Queiroz MC, Ono NK, et al. Arthroscopic treatment of femoroacetabular impingement. *Rev Bras Ortop.* 2009;44(3):230-238.

101. Rafols C, Monckeberg JE, Numair J, Botello J, Rosales J. Platelet-rich plasma augmentation of arthroscopic hip surgery for femoroacetabular impingement: a prospective study with 24-month follow-up. *Arthroscopy.* 2015;31(10):1886-1892.

102. Rego PA, Mascarenhas V, Oliveira FS, et al. Arthroscopic versus open treatment of cam-type femoro-acetabular impingement: retropective cohort clinical study. *Int Orthop.* 2018;42(4):791-797.

103. Rhee SM, Kang SY, Jang EC, Kim JY, Ha YC. Clinical outcomes after arthroscopic acetabular labral repair using knot-tying or knotless suture technique. *Arch Orthop Trauma Surg.* 2016;136(10):1411-1416.

104. Roos BD, Roos MV, Camisa Junior A, Lima EMU, Betto MD. Open versus arthroscopic approach in the treatment of femoroacetabular impingement: a case-control study with two-years follow-up. *Rev Bras Ortop.* 2017;52(suppl 1):21-28.

105. Sanders TL, Reardon P, Levy BA, Krych AJ. Arthroscopic treatment of global pincer-type femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(1):31-35.

106. Sansone M, Ahldén M, Jonasson P, et al. Outcomes after hip arthroscopy for femoroacetabular impingement in top-level athletes. *Orthop J Sports Med.* 2015;3(2):2325967115569691.

107. Sansone M, Ahldén M, Jonasson P, et al. Outcome after hip arthroscopy for femoroacetabular impingement in 289 patients with minimum 2-year follow-up. *Scand J Med Sci. Sports.* 2017;27(2):230-235.

108. Sansone M, Ahldén M, Jonasson P, et al. Outcome of hip arthroscopy in patients with mild to moderate osteoarthritis—a prospective study. *J Hip Preserv Surg.* 2016;3(1):61-67.

109. Schairer WW, Nwachuku BU, McCormick F, Lyman S, Mayman D. Use of hip arthroscopy and risk of conversion to total hip arthroplasty: a population-based analysis. *Arthroscopy.* 2016;32(4):587-593.

110. Schilders E, Dimitrakopoulou A, Bismil Q, Marchant P, Cooke C. Arthroscopic treatment of labral tears in femoroacetabular impingement: a comparative study of refixation and resection with a minimum two-year follow-up. *J Bone Joint Surg Br.* 2011;93(8):1027-1032.

111. Singh PJ, O’Donnell JM. The outcome of hip arthroscopy in Australian football league players: a review of 27 hips. *Arthroscopy.* 2010;26(6):743-749.

112. Sink EL, Fabricant PD, Pan Z, Dayton MR, Novais E. Results of treatment of femoroacetabular impingement in adolescents with a surgical hip dislocation approach. *Clin Orthop Relat Res.* 2013;471(8):2563-2569.

113. Skendzel JG, Philippou MJ, Briggs KK, Goljan P. The effect of joint space on midterm outcomes after arthroscopic hip surgery for femoroacetabular impingement. *Am J Sports Med.* 2014;42(5):1127-1133.

114. Skowronek P, Synder M, Polguj M, Marczak D, Sibinski M. Treatment of femoroacetabular impingement. *Am J Sports Med.* 2013;41(10):2302-2307.

115. Steppacher SD, Huemmer C, Schwab JM, Tannast M, Siebenrock KA. Surgical hip dislocation for treatment of femoroacetabular impingement: factors predicting 5-year survivorship. *Clin Orthop Relat Res.* 2014;472(1):337-348.

116. Tjong VK, Cogan CJ, Riederman BD, Terry MA. A qualitative assessment of return to sport after hip arthroscopy for femoroacetabular impingement. *Orthop J Sports Med.* 2016;4(11):2325967116671940.

117. Tjong VK, Gombera MM, Kahlenberg CA, et al. Isolated acetabuloplasty and labral repair for combined-type femoroacetabular impingement. *Am J Sports Med.* 2013;41(8):1886-1892.
impingement: are we doing too much? Arthroscopy. 2017;33(4):773-779.

120. Tran P, Pritchard M, O’Donnell J. Outcome of arthroscopic treatment for cam type femoroacetabular impingement in adolescents. ANZ J Surg. 2013;83(5):382-386.

121. Wang WG, Yue DB, Zhang NF, Hong W, Li ZR. Clinical diagnosis and arthroscopic treatment of acetabular labral tears. Orthop Surg. 2011;3(1):28-34.

122. Wu CT, Mahameed M, Lin PC, et al. Treatment of cam-type femoroacetabular impingement using anterolateral mini-open and arthroscopic osteochondroplasty. J Orthop Surg Res. 2019;14(1):222.

123. Zingg PO, Ulbrich EJ, Buehler TC, et al. Surgical hip dislocation versus hip arthroscopy for femoroacetabular impingement: clinical and morphological short-term results. Arch Orthop Trauma Surg. 2013;133(1):69-79.