



OPEN

Efficacy and safety of arthroscopy in femoroacetabular impingement syndrome: a systematic review and meta-analysis of randomized clinical trials

José María Lamo-Espinosa¹, Gonzalo Mariscal¹ , Jorge Gómez-Álvarez¹ & Mikel San-Julián¹

This study aimed to compare the efficacy and safety of arthroscopy with physiotherapy or joint lavage in patients with femoroacetabular impingement (FAI). A meta-analysis using PubMed, Embase, Scopus, and the Cochrane Collaboration Library databases was performed in September 2022. We included studies focusing on patients with FAI who underwent arthroscopic surgery versus those who underwent physiotherapy or arthroscopic lavage. The outcomes were functional scores (iHOT-33 and HOS ADL) and adverse events. Randomized clinical trials were included in the study. The risk of bias in each study was assessed according to Cochrane guidelines for clinical trials. The data were combined using Review Manager version 5.4 (PROSPERO CRD42022375273). Six RCTs were included, from a pool of 839 patients (407 females). The iHOT-33 and HOS ADL scales showed significant differences at 12 months in favor of the arthroscopy group (MD, 10.65; 95% CI 6.54–14.76) and (MD, 8.09; 95% CI 3.11–13.07). MCID was not achieved through arthroscopy in functional variables. The rates of osteoarthritis (OR, 5.18; 95% CI 1.06–36.00) and numbness (OR, 73.73; 95% CI 10.00–43.92) were significantly higher in the arthroscopy group. Arthroscopic surgery showed statistical superiority over the control group without exceeding the MCID in most studies; however, the results might have been influenced by secondary variables. Finally, arthroscopic surgery results in a high rate of conversion to osteoarthritis.

Femoroacetabular impingement (FAI) is a painful hip disorder characterized by premature and abnormal contact between the proximal femur and acetabulum, damaging the labrum and cartilage, with a potential risk of developing osteoarthritis^{1,2}. The diagnosis of FAI is both clinical and radiological, with three types: cam (loss of the femoral head sphere), pincer (excessive coverage of the acetabulum), or mixed³.

Treatment is usually staggered and has two main objectives: pain control and osteoarthritis prevention. Over the last few years, arthroscopy has gained importance, and its use has exponentially increased in the USA and UK^{4,5}, especially in young patients⁶. Hip arthroscopy has become popular because it is minimally invasive, causes less tissue damage, and allows early rehabilitation⁷. The aim of surgery is to restore the cam/pincer morphology together with osteoplasty and to reestablish, repair, or reconstruct the labrum or cartilage. However, the protective role of arthroscopy in osteoarthritis has not been established because of the short-term follow-up of comparative studies. Physical therapy is the primary treatment for FAI and is based on increasing strength and stabilizing the hip and pelvic musculature, as well as education, activity modification, and muscle coordination^{8,9}.

Several meta-analyses have evaluated the efficacy of arthroscopic surgery versus conservative treatment for femoroacetabular impingement syndrome^{10–16}. However, these meta-analyses have reported conflicting results, with some concluding in favor of arthroscopy and others finding no significant differences between interventions. Despite these findings, these meta-analyses have been criticized for their limitations. The limitations of previous RCTs and meta-analyses must be considered when evaluating the efficacy of arthroscopic surgery and

¹Hip, Tumors and Pediatric Orthopedic Unit, University Clinic of Navarra, Navarra, Spain. ²Institute for Research on Musculoskeletal Disorders, Valencia Catholic University, Carrer de Quevedo, 2, 46001 Valencia, Spain. ✉email: Gonzalo.mariscal@mail.ucv.es

physiotherapy or arthroscopic lavage for femoroacetabular impingement syndrome^{10–16}. Specifically, the lack of studies on patient loss in both groups and different times since randomization to the start of treatment, as well as the absence of analysis on how moderating or demographic variables affect outcomes, make it difficult to draw definitive conclusions about the effectiveness of each intervention^{10,14}. Additionally, the lack of demonstration on whether the superiority of either technique is clinically relevant is a significant gap in literature^{10–16}. Moreover, previous studies have not included all the available evidence and have conducted meta-analyses of only a few studies in most cases^{11–16}. This approach may limit the generalizability of the results and prevent comprehensive understanding of the efficacy of each intervention. Therefore, it is essential to conduct a new comparative meta-analysis that addresses these limitations and includes all the available evidence to provide a more robust and comprehensive analysis of the efficacy of arthroscopic surgery and physiotherapy or arthroscopic lavage for femoroacetabular impingement syndrome.

The objectives of this study were (1) to compare arthroscopy with a more conservative treatment (physiotherapy and joint lavage) in FAI patients in terms of efficacy and safety, and (2) to clarify whether the superiority of either technique is clinically relevant and analyze demographic or secondary variables that may influence the results.

Materials and methods

Eligibility criteria

This meta-analysis was registered in PROSPERO (CRD42022375273). The current study followed PRISMA guidelines (Fig. 1)¹⁷. The research question was conducted following the PICO strategy: (P) patients with clinical and radiologic diagnoses of femoroacetabular impingement syndrome; (I) interventions were arthroscopic surgery; (C) comparisons were more conservative procedures. More conservative procedures were considered the following: physiotherapy therapy or arthroscopic lavage alone; (O) outcomes were efficacy assessed by functional

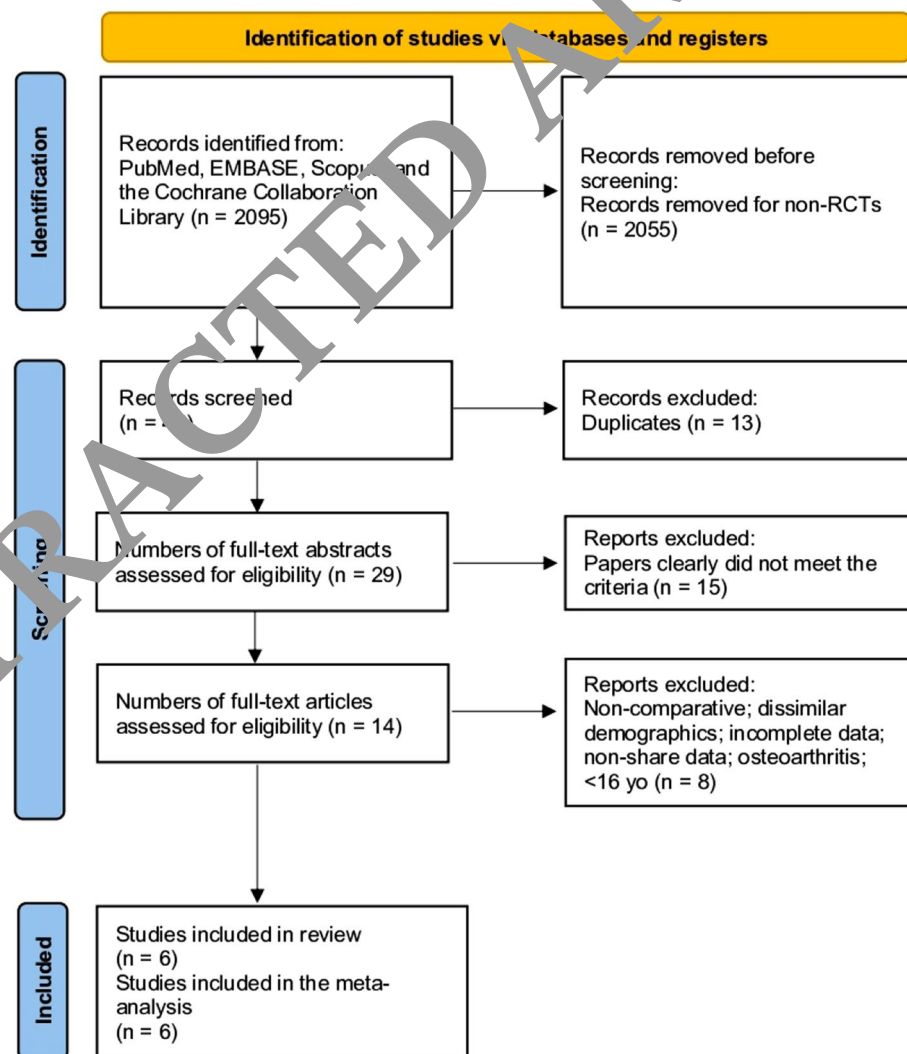


Figure 1. Study selection flow diagram (Preferred Reporting Items for Systematic reviews and Meta-Analysis).

scores and safety evaluated by adverse events; (S) we included randomized controlled trials and meta-analyses to assess the quality of previous published level I evidence studies. The diagnosis of the femoroacetabular impingement syndrome was made clinically and by image (X-rays, MRI and/or CT). To maintain sample homogeneity and minimize potential confounding factors, we excluded studies that enrolled < 16 yo patients or those with systemic disease. Furthermore, studies that initially enrolled patients with osteoarthritis, one of the variables under investigation, were excluded. To ensure the precision of the sample size and estimates, we removed duplicate studies as well as those with incomplete data that could not be analyzed in the statistical program or did not share relevant variables, which could have hindered the meta-analysis.

Information sources

A systematic search of the literature using PubMed, EMBASE, Scopus, and the Cochrane Collaboration Library database was carried out. No date limit was specified. Language was not limited. Studies of interest that appeared in the references of the included studies in the first search were also evaluated by manual searching.

Search methods for identification of studies

We used the following search terms to search all trials registers and databases: “femoroacetabular impingement AND arthroscop*” the (Supplementary File 1). Two reviewers independently agreed on selection of eligible studies and achieved consensus on which studies to include. Regarding data extraction, two authors also independently reviewed the studies. If consensus was not reached, a third reviewer was asked to complete the data extraction form. We analyzed the records of the RCTs as well as their complementary material. We consulted expert opinion to assess which variables would be of most interest.

Data extraction and data items

The following baseline characteristics of each study were obtained: number of participants, type of study, journal, age, %female, %right hip, morphology (pincer, cam, or mixed), and follow-up. The lost follow-up rate and time since randomization were also analyzed. Funding and conflict of interest were also evaluated. The primary efficacy outcomes were iHOT-33, HOS ADL (activities of daily living), and HOS S (sports). These measurements were taken at 6 months, and 12 months. The minimal clinically important difference (MCID) was included in the outcomes, based on previous studies that analyzed these scales. The MCID for iHOT-33, HOS ADL, and HOS S were six, 14, and 11 points, respectively^{18,19}. We then assessed whether MCID was achieved using the confidence intervals of the mean difference between the experimental and control groups (yes/no).

Regarding safety outcomes, we assessed infection, numbness, additional surgery, osteoarthritis, and nerve injury. Studies evaluating complications were assessed up to the end of follow-up. Although some of the complications almost exclusively occur with arthroscopic surgery, since they are related to surgery and will not occur with physical therapy (e.g., infection), they were also compared to see if such a complication is more frequent. This is because some complications may potentially have negative consequences.

To assess the quality of the previously published meta-analyses, we extracted the variables required by the AMSTAR-2 scale. AMSTAR-2 is a tool that allows for a detailed assessment of meta-analyses and systematic reviews of randomized controlled trials (RCTs) and nonrandomized studies. AMSTAR-2 is a questionnaire with 16 domains and simple answers: yes (positive result), no (insufficient information), or partial yes (partial information to standard)²⁰.

Assessment of risk of bias in included studies

The quality of the RCT was evaluated in accordance with Review Manager by two reviewers. The evaluation method consisted of the following steps: (A) random sequence generation, (B) allocation concealment, (C) blinding patients and personnel, (D) blinding of data extraction, (E) incomplete outcome data, and (F) selective outcome reporting. The justification for the rating for each item is provided in the Supplementary File 2 (Fig. 2). In addition, we provide the risk of bias for each item within each forest plot to facilitate critical reading of the article.

Assessment of results

The meta-analysis was performed using the Review Manager 5.4 software package provided by the Cochrane Collaboration. For dichotomous variables, odds ratios with a confidence interval (CI) of 95% were calculated. In this study, the odds ratio was preferred over the risk ratio because of its ease of interpretation and usefulness when the data are skewed. This decision was considered appropriate given the low frequency of the outcome of interest and the relatively infrequent occurrence of complications. The mean difference (MD) and the 95% CI were calculated for the continuous variables. Heterogeneity was checked with both the χ^2 and the I^2 test. I^2 varies from 0 to 100%, considering the values of 25, 50 and 75% as low, moderate, and high heterogeneity, respectively. A fixed effects model was adopted if there was no statistical evidence of heterogeneity, and a random effects model was adopted if significant heterogeneity was observed. WebPlotDigitizer version 13.1.4 was used to obtain accurate information from the figures in the articles.

Risk of bias across the studies

We assessed the possibility of publication bias by evaluating a funnel plot (Review Manager 5.4) of the trial mean differences for asymmetry, which can result from the non-publication of small trials with negative results. We acknowledge that other factors, such as differences in trial quality or true study heterogeneity, could produce asymmetry in funnel plots.

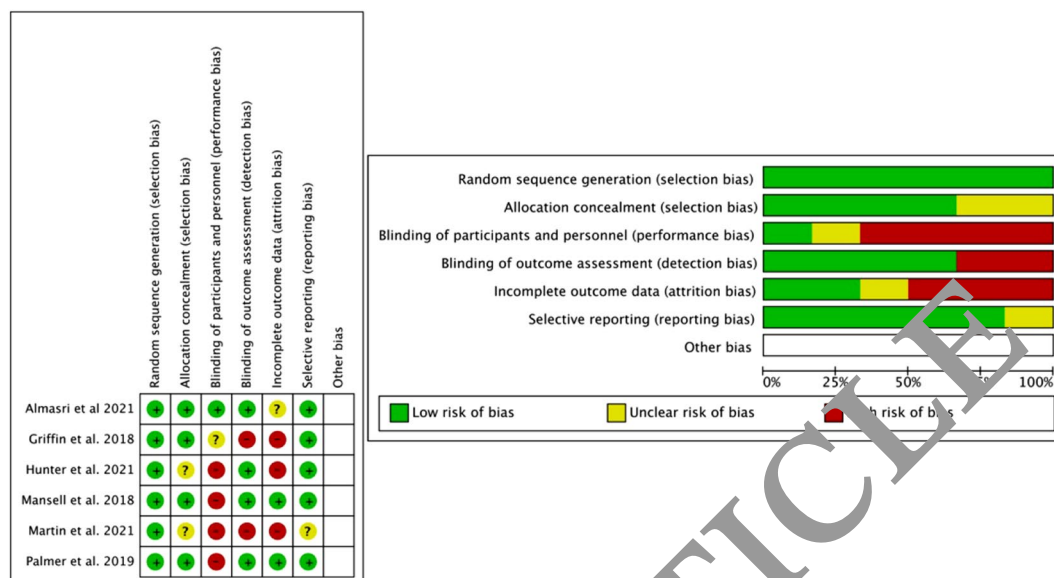


Figure 2. Risk of bias (green = low risk; red = high risk; yellow = unknown).

Additional analyses

A sensitivity analysis was also carried out using Review Manager 5.4 eliminating the top-weight study from the comparisons of all outcomes.

Regression analysis was also performed to examine the impact of the moderating variables in the effect size study. Different moderators and demographic variables were also included. Qualitative variables were assigned a numerical value to carry out the analysis. The dependent variables were efficacy outcomes (iHOT-33 and HOS ADL), whereas the independent variables were morphology, risk of bias, loss to follow-up, time since randomization, and direct funding from arthroscopic foundations or societies. Regression analysis using ordinary least squares method was conducted using the SPSS package v. 24.0 (IBM, USA), and $p < 0.05$ was considered statistically significant. Thus, to complement this analysis, a subgroup analysis of the aforementioned variables was performed using the Review Manager 5.4 software package.

The GRADE system was used to assess the quality of the evidence and grade the strength of the recommendations, the Grade of Recommendation, Assessment, Development, and Evaluation (GRADE) system was used using GRADEpro. This system assesses study design, risk of bias, inconsistency, indirectness, imprecision, and summary of findings²¹.

Results

Study selection

The searches in PubMed, EMBASE, Scopus, and the Cochrane Collaboration Library provided a total of 2095 citations and 142 randomized clinical trials. After adjusting for duplicates 29 remained. Of these, 15 studies were discarded because, after reviewing the abstracts, it appeared that these papers clearly did not meet the criteria. The full texts of the remaining 14 citations were examined in more detail. Eight of the 8 studies did not meet the inclusion criteria. Six studies met the inclusion criteria and were included in the systematic review and meta-analysis^{22–27} (Fig. 1).

Study characteristics

A total of six randomized clinical trials published between 2018 and 2021 were included (Table 1)^{22–27}. A total of 839 patients were included, with 418 in the arthroscopy group and 421 in the control group. The mean age ranged from 29.7 to 39.6 years in the arthroscopy group and from 30.6 to 49.1 in the control group. The mean % of females was 48.5%, while in the control group, it was 48%. The follow-up varied between 8 months and 2 years, with a mean follow-up of 13.3 months. Regarding the number of patients lost in each study, the physiotherapy group presented a higher rate of loss than the arthroscopy group (48/421, 11.4% in the physiotherapy group vs. 33/418, 7.9% in the arthroscopy group). Three studies evaluated the mean time since randomization to the start of treatment: 38.0 days in the physiotherapy group, varying between 33 and 44 days, and 98.5 days in the arthroscopy group, varying between 86 and 122 days. The funding for each article was analyzed. Two studies received direct funding through foundations or arthroscopy associations, and conflicts of interest were present in five of the six included studies. In two studies, there was a conflict of interest between arthroscopy associations and societies.

Outcomes

The iHOT-33 scale showed significant differences at six and 12 months in favor of arthroscopy (MD 3.98, 95% CI 0.19–7.77; and MD 10.65, 95% CI 6.54–14.76, respectively). HOS ADL assessed at six and 12 months also showed

	Journal type	n		Age		% female		% right		% pincer		% cam		% mixed		Follow-up	Funding	Conflict of interest
		AS	CT	AS	CT	AS	CT	AS	CT	AS	CT	AS	CT	AS	CT			
Hunter et al. 2021 ²²	Orthopedic	49	50	32.9 ± 11.8	32.9 ± 9.1	37.0	48.0	45.0	48.0	18.0	18.0	61.0	62.0	20.0	18.0	12	Yes*	Yes
Mansell et al. 2018 ²³	Sports	40	40	29.7 ± 7.4	30.6 ± 7.4	47.5	35.0	72.5	47.5	NA	NA	NA	NA	NA	NA	24	Yes	No
Martin et al. 2021 ²⁴	Sports	46	44	49.6	49.1	50.0	55.0	43.0	59.0	61.0	48.0	48.0	52.0	NA	NA	12	Yes*	Yes**
Palmer et al. 2019 ²⁵	Medical	112	110	36.4 ± 9.6	36.0 ± 9.9	66.0	66.0	60.0	54.0	0.9	0.0	93.0	94.0	6.0	5.0	8	Yes	Yes
Griffin et al. 2018 ²⁶	Medical	171	177	35.4 ± 9.7	35.2 ± 9.4	42.0	36.0	56.0	58.0	8.0	8.0	75.0	75.0	17.0	17.0	12	Yes	Yes**
Almasri et al. 2021 ²⁷	Orthopedic	108	106	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12	Yes	Yes

Table 1. Characteristics of the included studies. AS arthroscopic surgery, CT control group, NA not applicable. *Funding directly from arthroscopic foundation/association. **Conflict of interest from arthroscopic associations/societies.

superiority in the arthroscopy group (MD 5.19, 95% CI 0.77–9.61, and MD 8.09, 95% CI 3.11–13.07, respectively) (Fig. 3). For HOS ADL, arthroscopy did not exceed the MCID in any case, both at six and 12 months. For HOS S at six and 12 months, arthroscopy did not exceed the MCID in any case (Table 2). Complications forest plots are shown in Figs. 4 and 5. There were no significant differences regarding infection rate (OR 4.14, 95% CI 0.87–19.59), or nerve injury (OR 2.32, 95% CI 0.34–15.8). Significant differences were found in additional

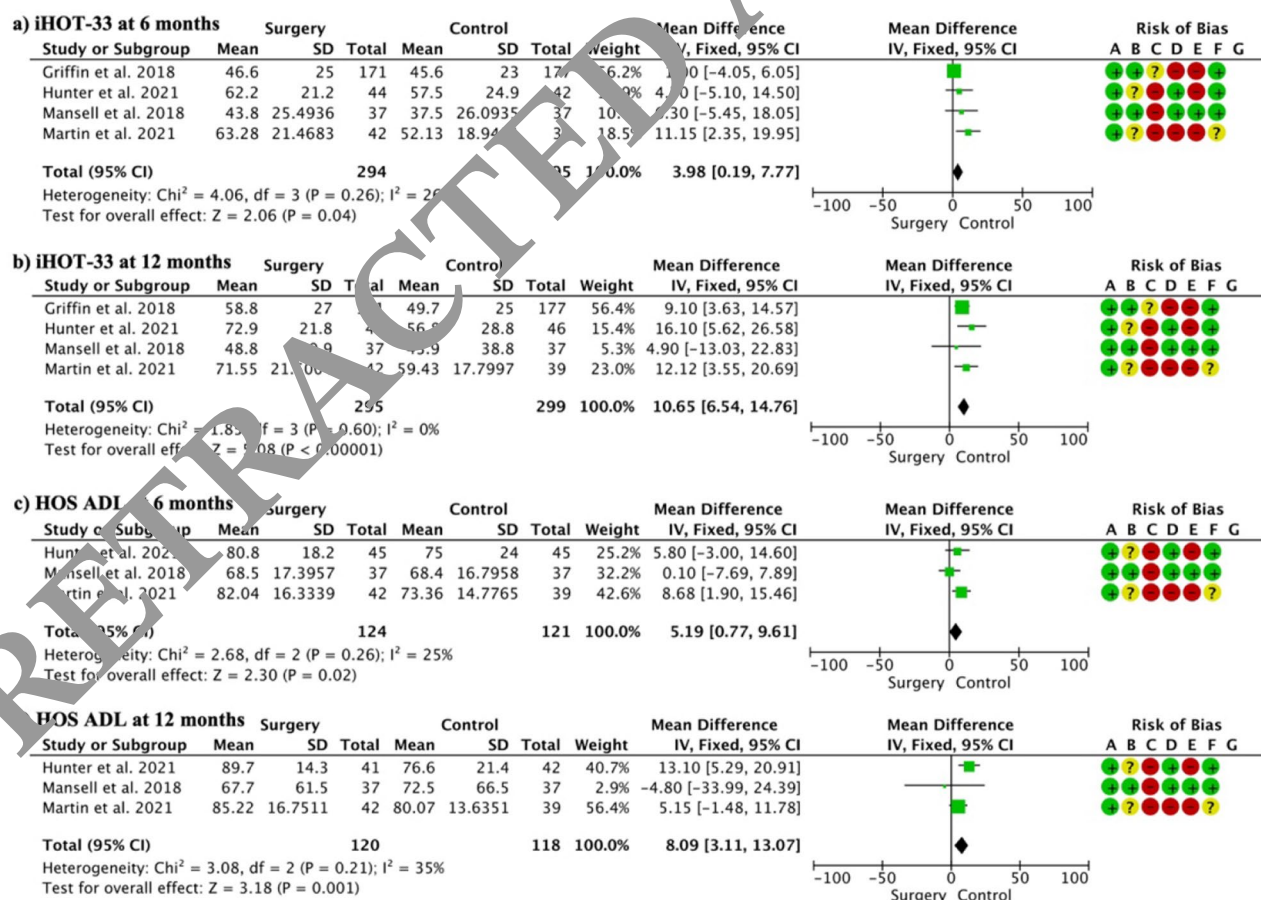


Figure 3. Forest plot showing functional and disability outcomes. AT group showed a statistically significant difference in iHOT-33 at six (a) and 12 (b) months. Regarding the HOS ADL there were significant differences in favor of AT group at 6 (c) and 12 (d) months. No significant heterogeneity was observed in these comparisons.

	MCID iHOT 6 m	MCID iHOT 12 m	MCID HOS ADL 6 m	MCID HOS ADL 12 m	MCID HOS S 6 m	MCID HOS S 12 m
Hunter et al. 2021 ²²	No	No	No	No	No	No
Mansell et al. 2018 ²³	No	No	No	No	No	No
Martin et al. 2021 ²⁴	No	No	No	No	No	No
Palmer et al. 2019 ²⁵	No	NA	No	NA	No	NA
Griffin et al. 2018 ²⁶	No	No	NA	NA	NA	NA

Table 2. Assessment of MCID between the confidence intervals between two groups. NA not applicable, No MCID not achieved.

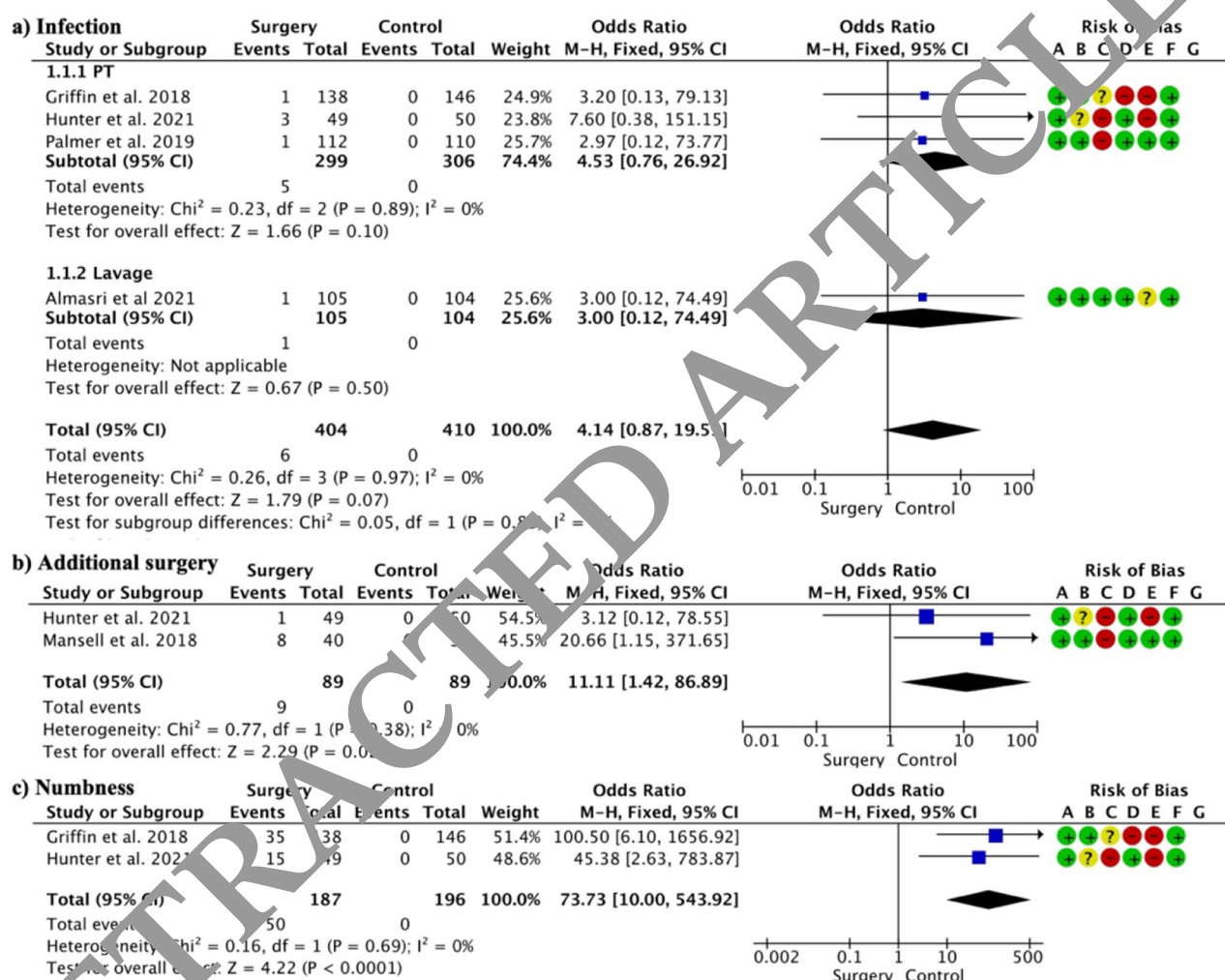


Figure 4. Forest plot showing complications. There were no differences regarding infection rate (1.5%) (a) or additional surgery (6.7%) (b). The numbness rate was higher in the AT group (26.7%; $p < 0.0001$).

surgery (OR 11.11, 95% CI 1.42–86.89), osteoarthritis (OR 6.18, 95% CI 1.06–36.00) and numbness (OR 73.73, 95% CI 10.00–543.92).

Risk of bias within studies

Strong evidence of heterogeneity (I^2), greater than 70, was not observed in any of the outcomes. However, the publication bias of the main variables considered by the RCTs (iHOT-33 and HOS ADL) was also examined. A sensitivity analysis was performed by eliminating the top-weight studies from the comparisons of all outcomes. Only one variable changed the direction of the results by eliminating the heaviest studies. This outcome was the HOS ADL at 6 months (Fig. 6). Regarding publication bias, the values were within the acceptable range (Fig. 7).

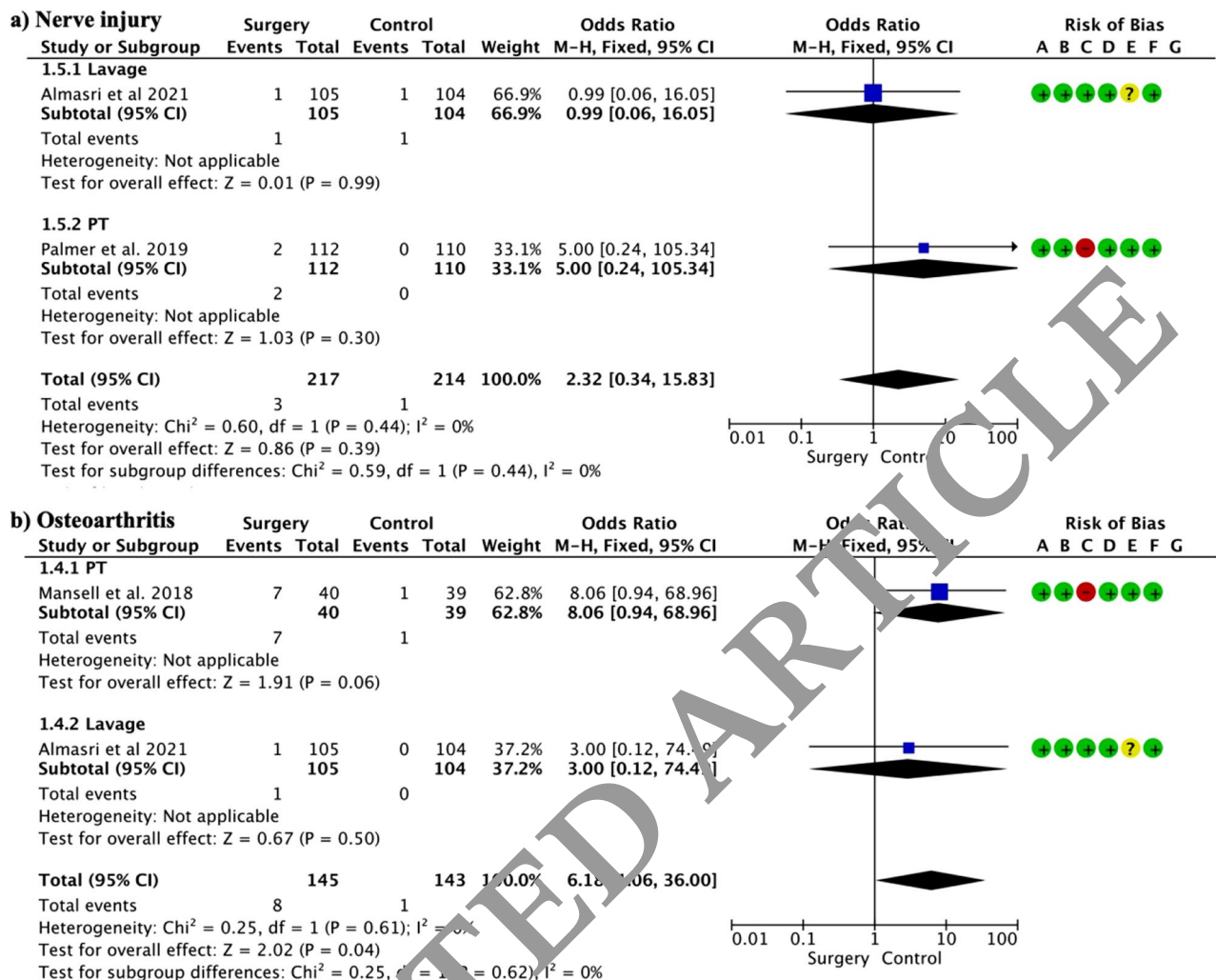


Figure 5. Forest plot showing nerve injury rate (a) and osteoarthritis rate (b). A significant difference was observed with respect to osteoarthritis rate (5.5% in AT group versus 0.7% in control group; $p = 0.04$).

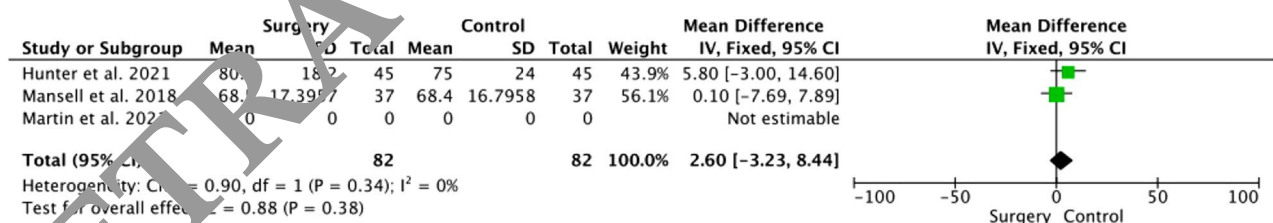


Figure 6. Sensitivity analysis showing statistically significant differences regarding the iHOT-33 at 6 months outcome.

Additional analyses and risk of bias across the studies

The following moderating variables were analyzed to assess the percentage of efficacy variables that could be explained by morphology, risk of bias, loss to follow-up, time since randomization, and funding. There was a significant association between iHOT-33 at 6 months and the time since randomization, with an explained variance of 99.9%, $p = 0.01$ (adjusted R-squared). There was also an association between iHOT-33 at 6 months and pincer-type morphology, with an explained variance of 86.4%, $p = 0.46$ (adjusted R-squared).

Regarding the subgroup analysis, there were significant differences in the independent variable of direct funding from arthroscopic foundations or societies in the iHOT-33 at six and 12 months and the HOS ADL at six and 12 months. The subgroup analyses are provided in Supplementary Fig. 1.

The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) summary of the results of these three comparisons is shown in Table 3.

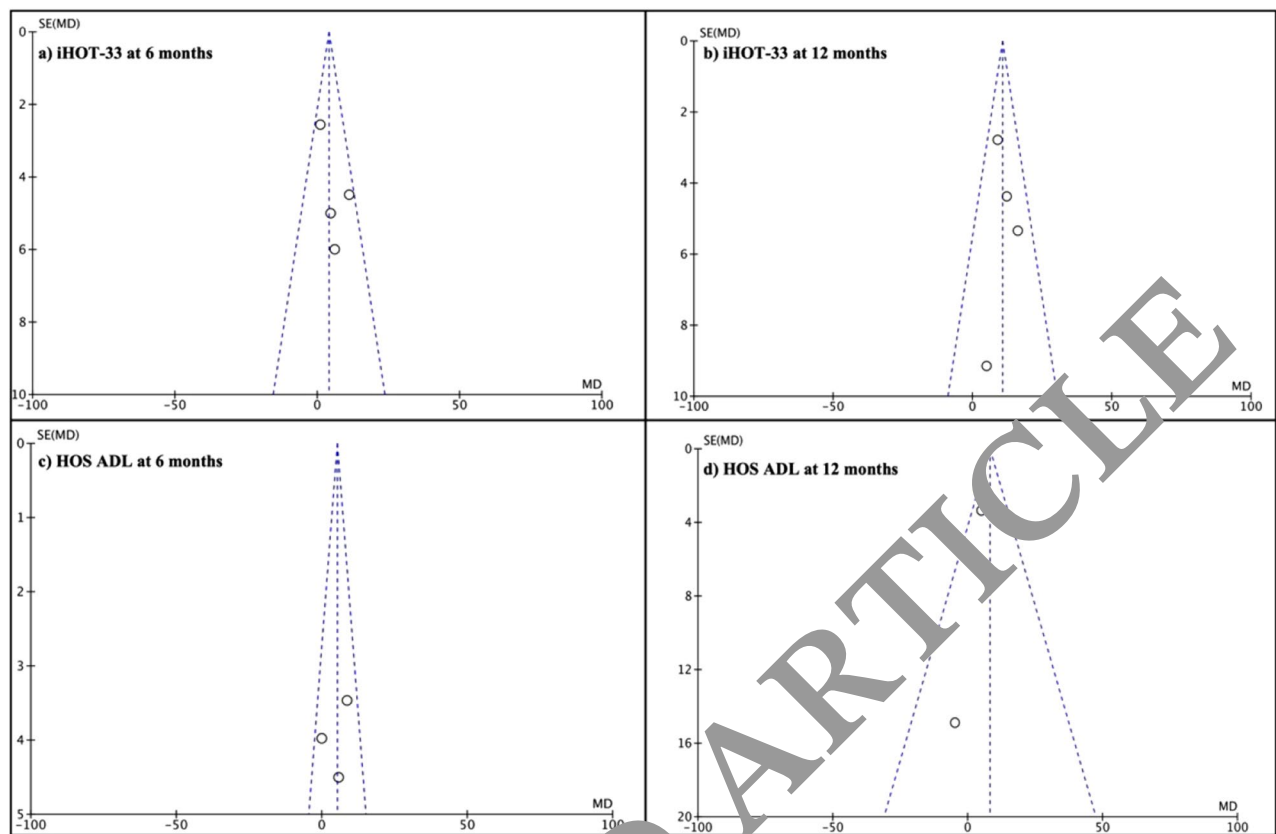


Figure 7. Funnel plot evaluating the publication bias regarding the main functional outcomes: (a) iHOT-33 at 6 months; (b) iHOT-33 at 12 months; (c) HOS ADL at 6 months; (d) HOS ADL at 12 months.

The results of the AMSTAR-2 assessment are shown in Supplementary Table 1^{10–16}. Further alteration of the standards was observed with respect to duplicate data extraction, lack of discussion or interpretation of the results according to the risk of bias of the articles, and lack of discussion of the influence of individual article funding or conflict of interest on the overall results.

Discussion

In this meta-analysis, we compared the use of arthroscopic surgery with a control group for the treatment of femoroacetabular impingement syndrome. We also included articular lavage because of the need to compare RCTs with placebo¹⁶. In our study, we observed that arthroscopic surgery was significantly superior to the control group in iHOT-33 and HOS ADL; however, this superiority did not reach the minimum clinically relevant improvement. The rate of complications was higher in the arthroscopy group and presented a higher risk of conversion to osteoarthritis than in the control group. The risk of bias between RCTs was high in terms of performance and attrition bias.

Regarding MCID, arthroscopy was not superior to physical therapy in any of the cases. It should be noted that MCID may vary among different articles. Nwachukwu et al.²⁸ was more demanding with respect to iHOT-33 and HOS S, setting the MCID at 12.1 and 14.5, while the MCID of the HOS ADL is set at 8.3, with only one of the studies exceeding the MCID²⁸. On the other hand, another study by Nwachukwu et al.²⁹ established a higher MCID requirement for iHOT-33 and HOS S of 10.7 and 12.1, respectively. The HOS ADL was also lower (9.8), and only one of the studies exceeded the MCID²⁹. Studies that established the MCID limits were based on statistical methods such as distribution-based methods or receiver operating characteristic (ROC) analysis. In addition, the area under the curve (AUC) determined the validity of the identified threshold for predicting the probability of a patient reaching the MCID, considering an acceptable strength of association for AUC 0.7^{28,29}.

In addition, the quality of the evidence and the strength of the recommendations were low or very low for the efficacy variables assessed using the GRADE system. The meta-analysis by Zhu et al.¹⁰, the one with the highest number of studies, also included six RCTs concluding in favor of the statistical superiority of arthroscopy; however, one of the included studies was a duplicate of the UK FASHioN trial. Furthermore, it did not include the analysis of clinical superiority in the main variables of these RCTs, grade the evidence according to GRADE, and discuss the impact of different moderating or demographic variables on the main results of the meta-analysis²¹. This meta-analysis concluded that “arthroscopy treatment is recommended for patients who need improvement in a shorter period of time, but did not consider the time lag since randomization between groups, which was almost 3 months. Consistent with and in favor of arthroscopy are the meta-analyses of Gatz et al.¹¹, Dwyer et al.¹², Mok et al.¹⁴, Casartelli et al.¹⁵, and Ferreira et al.¹⁶, although these included three RCTs.

Certainty assessment				№ of patients			Effect		Certainty		Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	[Comparación]	Relative (95% CI)	Absolute (95% CI)		
iHOT 6 months											
4	Randomised trials	Serious ^a	Not serious	Serious ^b	Not serious	None	294	NA	MD 3.98 higher (0.19 higher to 7.77 higher)	⊕⊕⊕ low	Important
iHOT 12 months											
5	Randomised trials	Serious ^a	Not serious	Serious ^b	Serious ^c	None	295	NA	MD 10.65 higher (6.54 higher to 14.76 higher)	⊕⊕⊕ very low	Critical
HOS ADL 6 months											
3	Randomised trials	Serious ^a	Not serious	Serious ^b	Not serious	None	124	NA	MD 5.19 higher (0.77 higher to 9.61 higher)	⊕⊕⊕ Low	Important
HOS ADL 12 months											
5	Randomised trials	Serious ^a	Not serious	Serious ^b	Serious ^c	None	120	NA	MD 8.09 higher (3.11 higher to 13.07 higher)	⊕⊕⊕ very low	Critical
Infection rate											
4	Randomised trials	Serious ^a	Not serious	Not serious	Not serious	None	6/404 (1.5%)	OR 4.14 (0.87 to 19.59)	0 fewer per 1000 (from 0 to 0 fewer)	⊕⊕⊕ moderate	Important
Osteoarthritis rate											
2	Randomised trials	Not serious	Not serious	Serious ^b	Not serious	None	8/444 (1.8%)	OR 6.18 (1.06 to 36.00)	11 more per 100 (from 0 fewer to 72 more)	⊕⊕⊕ moderate	Critical

Table 3. GRADE assessment of the quality of the evidence and the strength of the recommendations. *CI* confidence interval, *MD* mean difference, *OR* odds ratio, *NA* not applicable. ^aThere were several risk of bias items with high risk of bias among the studies included in this outcome. ^bThe examined patients are similar but not identical. ^cComparing the lower and upper limit of the confidence interval, there were demonstrated clinical differences.

Mok et al.¹⁴, found the superiority of arthroscopy but highlighted the importance of demographic variables or factors that could affect outcomes²⁵. In our meta-analysis, we were only able to perform regression analysis of the main demographic variables contributed by the studies without finding differences, except for time since randomization and pincer morphology with respect to iHOT-33 at 6 months. Regarding subgroup comparisons, funding played an important role in some functional outcomes, although these analyses were of limited value because of the small number of studies included. Furthermore, Bastos et al.¹³, including the same three RCTs, concluded that surgery is not more effective, criticizing the lack of cost-type outcomes and adverse events in the longer term, such as osteoarthritis³¹.

Regarding complications, recent meta-analyses have not analyzed these results and have focused on functional scales. Long-term studies are important to assess conversion to osteoarthritis, as this is one of the most relevant concerns in FAI. In patients undergoing arthroscopy and osteochondroplasty, one out of six patients over 40 years of age opted for total hip arthroplasty at 2 years³⁰. Meanwhile, the prognosis is better³¹. Some risk factors for conversion to arthroplasty include age, level of chondral damage, femoral osteoplasty, smoking, and inflammatory joint diseases, among others^{32,33}. The conversion rate to osteoarthritis remains relevant since the early development of osteoarthritis, less than 5 years, has been shown to decrease the cost-effectiveness of arthroscopy³⁴. In our study, we found that 6% of patients in the arthroscopy group developed OA.

The difference in time since randomization between the arthroscopy and control groups is a crucial factor to consider when interpreting study results. The assessment of the outcome scales was performed from the time of randomization, not at the start of treatment, which means that the difference in treatment initiation time could have potentially affected the outcomes of interest. For instance, in the evaluation of time at 12 months, the effect of the intervention in the arthroscopy group was observed 2 months earlier than in the physiotherapy group. Griffin et al.²⁶ reported a difference of 85 days, almost 3 months¹⁹. This difference in treatment initiation time could have led to differences in the progression of the condition, severity of symptoms, and efficacy of interventions. Moreover, the regression analysis of randomization time showed that the time since randomization explained 99.9% of the iHOT-33 variable at 6 months. Overall, the difference in time since randomization could have potentially affected the efficacy of the intervention, progression of the condition, and observed outcomes. Therefore, the importance of time since randomization cannot be underestimated in the analysis and interpretation of study results.

Two studies received direct funding from foundations for arthroscopy. When subgroups were performed, studies funded directly by foundations or arthroscopy societies showed better results, although subgroup analysis was underpowered.

The need for high-quality reviews is evident and necessary when the AMSTAR-2 scale was reviewed objectively and independently review two authors. Almost all the studies were of low or critically low quality. This study had several limitations. Our meta-analysis included a small number of articles, and the sensitivity analysis was affected by the study with the highest weight in the case of HOS ADL at 6 months. In addition, regression analysis was performed. Although Cochrane recommends including at least ten studies to perform this type of analysis, caution should be exercised when interpreting these results. In addition, because of the limited number of articles, the statistical program was unable to assess the subgroup analyses of these variables in many cases.

This meta-analysis has several strengths. First, it included the highest number of randomized controlled trials conducted on the topic, which enhances the statistical power of the analysis and increases confidence in the results. Second, the meta-analysis emphasized the importance of considering the difference in time since randomization between the arthroscopy and control groups, which can potentially affect the efficacy of interventions and observed outcomes. Third, this study provides a more comprehensive comparison by including articular cartilage, which offers a better understanding of the efficacy of different interventions for femoroacetabular impingement syndrome. In addition, this meta-analysis has a potential impact on various stakeholders in the field of orthopedics. The results of this study will likely be of interest to researchers, clinicians, and policymakers. Researchers may find valuable findings in informing future studies or meta-analyses, and clinicians can use these results to make informed decisions when considering treatment options for patients with femoroacetabular impingement syndrome. Policymakers can also use these results to develop healthcare policies and guidelines related to the use of arthroscopic surgery and physical therapy for this condition. Furthermore, the results of this study provide valuable information on the safety and efficacy of different treatment options, which can ultimately benefit patients with femoroacetabular impingement syndromes. Therefore, this meta-analysis holds significant importance and can contribute to the advancement of knowledge in the field of orthopedics.

Conclusion

We have conducted analyses that justify a new review on this topic and enhance the evidence of the findings. Therefore, we can conclude that in terms of efficacy, arthroscopic surgery showed statistical superiority over the control group; however, the clinical difference is controversial, and arthroscopy did not show MCID in all cases. These results were observed both at six and twelve months. In addition, the efficacy of arthroscopy was related in many cases to secondary variables such as time since randomization and funding received although these analyses must be taken with caution given the low number of articles. In terms of safety, arthroscopic surgery showed a higher rate of conversion to osteoarthritis than the control group. Future research should focus on analyzing how these moderator, or demographic variables affect the results.

Data availability

All data generated or analysed during this study are included in this published article (and its supplementary information files).

Received: 28 January 2023; Accepted: 24 September 2023

Published online: 01 October 2023

References

- Ganz, R. *et al.* Femoroacetabular impingement: A cause for osteoarthritis of the hip. *Clin. Orthop. Relat. Res.* **417**, 112–120 (2003).
- Todd, J. N., Maak, T. G., Anderson, A. E., Ateshian, G. A. & Weiss, J. A. How does chondrolabral damage and labral repair influence the mechanics of the hip in the setting of cam morphology? A finite-element modeling study. *Clin. Orthop. Relat. Res.* **480**(3), 602–615 (2022).
- Frank, J. M. *et al.* Prevalence of femoroacetabular impingement imaging findings in asymptomatic volunteers: A systematic review. *Arthroscopy* **31**(6), 1199–1204 (2015).
- Kremers, M. *et al.* Trends in utilization and outcomes of hip arthroscopy in the United States between 2005 and 2013. *J. Arthroplasty* **32**(3), 750–755 (2017).
- Palmer, A. J. *et al.* Past and projected temporal trends in arthroscopic hip surgery in England between 2002 and 2013. *BMJ Open Sport Exerc. Med.* **2**(1), e000082 (2016).
- Bozic, K. J., Chan, V., Valone, F. H. 3rd., Feeley, B. T. & Vail, T. P. Trends in hip arthroscopy utilization in the United States. *J. Arthroplasty* **28**(S8), 140–143 (2013).
- Botser, I. B., Smith, T. W., Nasser, R. M. & Domb, B. G. Open surgical dislocation versus arthroscopy for femoroacetabular impingement: A comparison of clinical outcomes. *Arthroscopy* **27**(2), 270–278 (2011).
- Fairley, J. *et al.* Management options for femoroacetabular impingement: A systematic review of symptom and structural outcomes. *Osteoarthr. Cartil.* **24**(10), 1682–1696 (2016).
- Diamond, L. E. *et al.* Physical impairments and activity limitations in people with femoroacetabular impingement: A systematic review. *Br. J. Sports Med.* **49**(4), 230–242 (2014).
- Zhu, Y., Su, P., Xu, T., Zhang, L. & Fu, W. Conservative therapy versus arthroscopic surgery of femoroacetabular impingement syndrome (FAI): A systematic review and meta-analysis. *J. Orthop. Surg. Res.* **17**(1), 296 (2022).
- Gatz, M., Driessen, A., Eschweiler, J., Tingart, M. & Miglioni, F. Arthroscopic surgery versus physiotherapy for femoroacetabular impingement: A meta-analysis study. *Eur. J. Orthop. Surg. Traumatol.* **30**(1), 115–1162 (2020).
- Dwyer, T. *et al.* Operative versus nonoperative treatment of femoroacetabular impingement syndrome: A meta-analysis of short-term outcomes. *Arthroscopy* **36**(1), 263–273 (2020).
- Bastos, R. M. *et al.* Surgery is no more effective than conservative treatment for Femoroacetabular impingement syndrome: Systematic review and meta-analysis of randomized controlled trials. *Orthop. Res. Res.* **35**(3), 332–341 (2021).
- Mok, T. N. *et al.* Arthroscopic hip surgery versus conservative therapy for femoroacetabular impingement syndrome: A meta-analysis of RCTs. *Orthop. Surg.* **13**(6), 1755–1764 (2021).
- Casartelli, N. C., Valenzuela, P. L., Maffiuletti, N. A. & Leunig, M. Effectiveness of hip arthroscopy on treatment of femoroacetabular impingement syndrome: A meta-analysis of randomized controlled trials. *Arthritis. Care. Res. (Hoboken)* **73**(8), 1140–1145 (2021).
- Ferreira, G. E. *et al.* The effectiveness of hip arthroscopic surgery for the treatment of femoroacetabular impingement syndrome: A systematic review and meta-analysis. *J. Sci. Sport* **24**(1), 21–29 (2021).
- Liberati, A. *et al.* The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Med.* **6**(7), e1000100 (2009).
- Harris-Hayes, M. *et al.* Clinical outcomes assessment in clinical trials to assess treatment of femoroacetabular impingement: Use of patient-reported outcome measures. *J. Am. Acad. Orthop. Surg.* **21**(1), S39–46 (2013).
- Röling, M. A., Hesselting, B., Jansen, S. A. L., Bloem, R. M. & Mathijssen, N. M. C. Validation of the Dutch version of the Hip Outcome Score; validity, reliability, and responsiveness in patients with femoroacetabular impingement syndrome. *J. Hip. Preserv. Surg.* **8**(3), 298–304 (2020).
- Shea, B. J. *et al.* AMSTAR 2: A critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, both. *BMJ* **358**, j4008 (2017).
- Guyatt, G. H. *et al.* GRADE guidelines: 13. Preparing summary of findings tables and evidence profiles-continuous outcomes. *J. Clin. Epidemiol.* **66**(2), 173–183 (2013).
- Hunter, D. J. *et al.* Multi-centre randomised controlled trial comparing arthroscopic hip surgery to physiotherapist-led care for femoroacetabular impingement (FAI) syndrome on hip cartilage metabolism: The Australian FASHIoN trial. *BMC Musculoskelet. Disord.* **22**(1), 697 (2021).
- Mansueti, P., Rhon, D. I., Marchant, B. G., Slevin, J. M. & Meyer, J. L. Two-year outcomes after arthroscopic surgery compared to physical therapy for femoroacetabular impingement: A protocol for a randomized clinical trial. *BMC Musculoskelet. Disord.* **17**, 60 (2016).
- Martin, S. D. *et al.* Hip arthroscopy versus physical therapy for the treatment of symptomatic acetabular labral tears in patients older than 40 years: A randomized controlled trial. *Am. J. Sports. Med.* **49**(5), 1199–1208 (2021).
- Palmer, A. J. R. *et al.* Arthroscopic hip surgery compared with physiotherapy and activity modification for the treatment of symptomatic femoroacetabular impingement: Multicentre randomised controlled trial. *BMJ* **364**, 1185 (2019).
- Griffin, D. R. *et al.* Hip arthroscopy versus best conservative care for the treatment of femoroacetabular impingement syndrome (UK FASHIoN): A multicentre randomised controlled trial. *Lancet* **391**(10136), 2225–2235 (2018).
- Almasri, M., Simunovic, N., Heels-Ansdell, D. & Ayenil, O. R. FIRST investigators. Osteochondroplasty benefits the pragmatic patient with femoroacetabular impingement: Analysis from the embedded prospective cohort of the Femoroacetabular Impingement Randomised Controlled Trial (FIRST). *Arthroscopy* **38**(3), 818–830.e1 (2022).
- Nwachukwu, B. U. *et al.* Preoperative outcome scores are predictive of achieving the minimal clinically important difference after arthroscopic treatment of femoroacetabular impingement. *Am. J. Sports. Med.* **45**(3), 612–619 (2017).
- Nwachukwu, B. U. *et al.* Arthroscopic treatment of femoroacetabular impingement in adolescents provides clinically significant outcome improvement. *Arthroscopy* **33**(10), 1812–1818 (2017).
- Yacovelli, S., Sutton, R., Vahedi, H., Sherman, M. & Parvizi, J. High risk of conversion to THA after femoroacetabular osteoplasty for femoroacetabular impingement in patients older than 40 years. *Clin. Orthop. Relat. Res.* **479**(5), 1112–1118 (2021).
- Büchler, L., Grob, V., Anwänder, H., Lerch, T. D. & Haefeli, P. C. Good outcome scores and low conversion rate to THA 10 years after hip arthroscopy for the treatment of femoroacetabular impingement. *Clin. Orthop. Relat. Res.* **479**(10), 2256–2264 (2021).
- Redmond, J. M. *et al.* What factors predict conversion to THA after arthroscopy? *Clin. Orthop. Relat. Res.* **475**(10), 2538–2545 (2017).
- Yao, J. J., Cook, S. B., Gee, A. O., Kweon, C. Y. & Hagen, M. S. What is the survivorship after hip arthroscopy for femoroacetabular impingement? A large-database study. *Clin. Orthop. Relat. Res.* **478**(10), 2266–2273 (2020).
- Shearer, D. W., Kramer, J., Bozic, K. J. & Feeley, B. T. Is hip arthroscopy cost-effective for femoroacetabular impingement? *Clin. Orthop. Relat. Res.* **470**(4), 1079–1089 (2012).

Author contributions

Contributors: G.M. is corresponding author for this article. Contributor Roles: conceptualization: J.M.L.E., G.M., J.G.A., M.S.J.; data curation: J.M.L.E., G.M., J.G.A., M.S.J.; formal analysis: J.M.L.E., G.M., J.G.A., M.S.J.; investigation: J.M.L.E., G.M., J.G.A., M.S.J.; methodology: J.M.L.E., G.M., J.G.A., M.S.J.; project administration: J.M.L.E., G.M.; software: J.M.L.E., G.M., J.G.A., M.S.J.; supervision: J.M.L.E., M.S.J.; validation: J.M.L.E., G.M., J.G.A., M.S.J.; visualization: J.M.L.E., G.M., J.G.A., M.S.J.; writing original draft: J.M.L.E., G.M., J.G.A., M.S.J.; writing–review and editing: J.M.L.E., G.M., J.G.A., M.S.J.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1038/s41598-023-43441-y>.

Correspondence and requests for materials should be addressed to G.M.

Reprints and permissions information is available at www.nature.com/reprints

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2023