

Meta-Analysis

Effect of smoking on hip arthroscopy outcomes: a systematic review and meta-analysis

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ABSTRACT

Hip arthroscopy is an increasingly utilized procedure for treating various hip pathologies. However, patient-related factors, such as smoking, may significantly impact postoperative outcomes. Smoking is known to impair tissue healing and increase the risk of complications, potentially leading to poorer surgical results. This meta-analysis aims to evaluate the effect of smoking on outcomes following hip arthroscopy, focusing on functional scores, pain levels, and patient satisfaction. A comprehensive search was conducted in PubMed, Web of Science, Scopus, Medline, the Cochrane Library, and Google Scholar to identify studies assessing hip arthroscopy outcomes in smokers and nonsmokers. After removing duplicates, screening titles and abstracts, and assessing full-text eligibility, five studies were included in the quantitative synthesis. Outcomes were pooled using a fixed-effect model to calculate mean differences and 95% confidence intervals (CIs). The meta-analysis included data from five studies with a total of 618 patients (234 smokers and 384 nonsmokers). The hip outcome score-sports specific (HOS-SS) was significantly lower in smokers, with a mean difference of -8.63 (95% CI: -12.71, -4.54), indicating worse sports-specific function. The modified Harris hip score (mHHS) was also significantly lower in smokers (mean difference: -4.47, 95% CI: -7.50, -1.44). Pain levels measured by the visual analog scale (VAS) were higher in smokers (mean difference: 0.62, 95% CI: 0.17, 1.06). However, there was no significant difference in satisfaction VAS scores between smokers and nonsmokers (mean difference: -0.13, 95% CI: -0.61, 0.34). In conclusion, smoking is associated with significantly worse functional outcomes and higher pain levels following hip arthroscopy. These findings highlight the importance of smoking cessation programs for patients undergoing hip arthroscopy to improve surgical outcomes. Despite the worse functional and pain outcomes, patient satisfaction did not differ significantly, which may indicate a disparity between objective outcomes and subjective satisfaction in smokers.

Keywords: Hip arthroscopy, Smoking, Functional outcomes, Patient satisfaction, Meta-analysis, Sports-specific hip function, mHHS

INTRODUCTION

Hip arthroscopy has emerged as a pivotal technique in the management of a variety of hip disorders, including femoroacetabular impingement, labral tears, and hip dysplasia.¹ This minimally invasive procedure has gained popularity due to its advantages over traditional open

surgeries, such as reduced postoperative pain, shorter recovery times, and lower complication rates.^{1,2} As with any surgical procedure, various patient-related factors can influence the outcomes of hip arthroscopy, and smoking has been identified as a significant risk factor in orthopedic and other surgical procedures.³

Smoking is well-documented to have detrimental effects on surgical outcomes. The adverse effects of smoking on wound healing, bone metabolism, and the immune response are well-established in the literature. Nicotine and other harmful substances in tobacco smoke impair tissue oxygenation, reduce collagen formation, and decrease fibroblast proliferation, all of which are crucial for wound healing.^{4,5} Additionally, smoking induces a state of chronic inflammation and oxidative stress, further compromising the body's ability to repair tissues post-surgery.⁴ These biological mechanisms suggest that smokers may experience poorer outcomes after hip arthroscopy compared to nonsmokers.⁶

In orthopedic surgery, smoking has been associated with a range of negative outcomes. Studies have shown that smokers have higher rates of complications, including infections, delayed union or nonunion of fractures, and increased pain and disability postoperatively.^{4,5} Specifically, in hip surgery, smoking has been linked to poorer results in total hip arthroplasty and hip fracture repair. Glassman et al reported that smokers had a significantly higher risk of pseudarthrosis following spinal fusion surgery, underscoring the broader implications of smoking on bone healing and surgical success.⁷

Despite the clear evidence linking smoking to adverse outcomes in other orthopedic procedures, the specific impact of smoking on hip arthroscopy outcomes remains less well-defined. The minimally invasive nature of hip arthroscopy might suggest a different risk profile compared to more invasive procedures like total hip arthroplasty.⁸ However, the same biological mechanisms that impair healing and increase complications in other surgeries are likely to be relevant.^{8,9}

Given the potential for smoking to negatively impact these outcomes, it is important to quantify this effect through a comprehensive meta-analysis.¹⁰⁻¹³ Such an analysis will help in forming evidence-based guidelines for preoperative counseling and postoperative management of smokers undergoing hip arthroscopy. It can also highlight the importance of smoking cessation programs and interventions tailored to improve surgical outcomes for smokers. This meta-analysis aims to evaluate the impact of smoking on postoperative outcomes following hip arthroscopy, focusing on functional scores, pain levels, and patient satisfaction.

METHODS

This systematic review and meta-analysis adheres to the PRISMA guidelines 2020.¹⁴ It was conducted during the period from February 2024 to August 2024. To conduct a comprehensive meta-analysis, we developed a robust search strategy to identify relevant studies examining the impact of smoking on hip arthroscopy outcomes. We performed systematic searches in five major electronic databases: PubMed, Web of Science, Scopus, Medline,

the Cochrane Library, and Google Scholar. The search terms combined keywords and MeSH terms related to hip arthroscopy ("hip arthroscopy," "hip surgery"), smoking ("smoking," "smokers," "tobacco use"), and outcomes ("functional outcomes," "pain," "satisfaction," "postoperative outcomes"). The search was limited to articles published in English up to June 2023. Additionally, the reference lists of included studies and relevant reviews were hand-searched to identify any further eligible studies.

Study selection

All identified records were imported into EndNote, and duplicates were removed. The titles and abstracts of the remaining articles were screened independently by two reviewers to determine their eligibility. Studies were included if they met the following criteria: involved patients undergoing hip arthroscopy, compared outcomes between smokers and nonsmokers, and reported quantitative data on functional outcomes, pain, or patient satisfaction. We excluded studies that did not provide separate data for smokers and nonsmokers, review articles, case reports, conference abstracts, and non-English publications. Discrepancies between reviewers were resolved through discussion, and a third reviewer was consulted when necessary.

Data extraction

Data extraction was performed independently by two reviewers using a pre-designed extraction form. The following information was extracted from each included study: author names, publication year, study design, duration, evidence level, country, sample size, number of smokers and nonsmokers, mean age of smokers and nonsmokers, percentage of female patients, mean body mass index (BMI) of smokers and nonsmokers, and follow-up duration. For outcomes, we extracted mean and standard deviation (SD) values for the HOS-SS, mHHS, pain VAS, and satisfaction VAS for both smokers and nonsmokers. Any disagreements in data extraction were resolved by consensus or by consulting a third reviewer.

Quality assessment

The quality of the included studies was assessed using the Newcastle-Ottawa scale (NOS) for observational studies.¹⁵ The NOS evaluates studies based on three broad criteria: selection of study groups, comparability of groups, and ascertainment of the outcome. Each study was independently assessed by two reviewers, and discrepancies were resolved through discussion. Studies scoring six or more out of a possible nine points were considered high quality.

Statistical analysis

Statistical analyses were performed using review manager (RevMan) version 5.4. For each outcome, we calculated

the mean difference and 95% CIs between smokers and nonsmokers using a fixed-effect model. The choice of a fixed-effect model was based on the assumption that the studies were estimating the same underlying effect and the relatively low heterogeneity observed in the preliminary analysis. Heterogeneity was assessed using the Chi-squared (χ^2) test and the I-squared (I^2) statistic. An I^2 value greater than 50% was considered indicative of substantial heterogeneity. Sensitivity analyses were conducted to assess the robustness of the results by excluding individual studies one at a time and recalculating the pooled estimates.

Outcome measures

The primary outcomes of interest were the HOS-SS, mHHS, pain VAS, and satisfaction VAS. The HOS-SS measures sports-related hip function, with higher scores indicating better function. The mHHS assesses overall hip function and pain, with higher scores representing better outcomes. The pain VAS is a subjective measure of pain intensity, where higher scores denote greater pain. The satisfaction VAS evaluates patient satisfaction with the surgical outcome, with higher scores indicating greater satisfaction.

Ethical considerations

As this meta-analysis utilized data from previously published studies, no ethical approval or patient consent was required. However, ethical considerations were adhered to by ensuring accurate representation of the data and proper citation of the original sources.

RESULTS

The comprehensive search strategy employed for this meta-analysis identified a total of 403 records across multiple databases including PubMed, Web of Science, Scopus, Medline, the Cochrane Library, and Google Scholar. After the removal of 202 duplicates, 201 unique records were subjected to title and abstract screening. Of these, 154 records were excluded based on irrelevance or failing to meet the inclusion criteria. This left 47 records for full-text retrieval. Three records could not be retrieved, leaving 44 articles for detailed assessment of eligibility. After rigorous evaluation, 39 articles were excluded due to reasons such as lack of relevant data, inadequate study design, or failure to meet other inclusion criteria. Ultimately, five studies met all criteria and were included in the quantitative data synthesis (Figure 1).

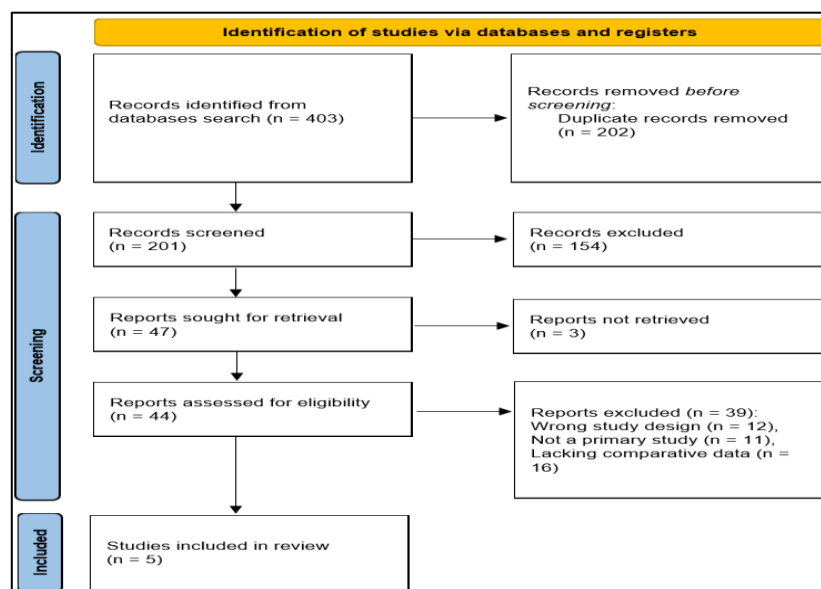


Figure 1: PRISMA flow chart summarizing the study search and screening processes.

Characteristics of the included studies

Study design and duration

All five included studies utilized a retrospective design, with the exception of one study by Lall et al which was prospective.¹⁹ The durations of the studies spanned from as early as 2008 to as recent as 2019, reflecting a considerable range of data collection periods. Specifically, Cancienne et al and Jimenez et al covered the periods from 2012-2016 and 2011-2019, respectively, while Jimenez et al and Lall et al collected data from

2009-2016 and 2008-2015, respectively.¹⁶⁻¹⁹ The study by Lee et al covered the longest duration, from 2008 to 2017.²⁰

Geographic location and evidence level

All five studies were conducted in the United States, contributing to the homogeneity in terms of geographic location. Each study was categorized at an evidence level of 3, indicating that they are based on retrospective or prospective comparative studies without the randomization.

Sample size and group distribution

The total sample sizes varied across the studies, with Lall et al having the largest sample size of 225 participants, and Jimenez et al having the smallest at 80 participants. In terms of group distribution, smokers and nonsmokers were distinctly categorized, with the number of smokers ranging from 20 in the study by Jimenez et al to 84 in the study by Lee et al.^{17,19,20} Correspondingly, the number of nonsmokers ranged from 60 to 150 across the studies.

Age, BMI, and sex distribution

The age of participants in the smoking groups varied, with the mean age ranging from 35.5±6.4 years in Cancienne et al to 45.0±13.5 years in Lee et al.^{16,20} Nonsmokers' ages showed similar range, from 31.6±12.3 years to 45.9±14.1 years. Notably, Lall et al reported identical mean ages for both groups at 41.7±11.1 years.¹⁹

BMI was reported in all studies, with smokers' BMI ranging from 26.6 [24.2-30.8] in Lee et al to 30.2±6.0 in Jimenez et al.^{17,20} For nonsmokers, BMI ranged from 23.9±9.2 in Cancienne et al to 35.0±10.8 in Jimenez et al.^{16,17}

Sex distribution showed that the percentage of female participants among smokers varied, with the highest being 73.8% in Lee et al and the lowest at 44% in Lall et al.^{19,20} Among nonsmokers, the female percentage ranged from 48% in Lall et al to 69% in Lee et al.^{19,20} Notably, Jimenez et al and Jimenez et al did not report the sex distribution of their participants.^{17,18}

Follow-up duration

Follow-up periods also varied, with the shortest average follow-up being 33.7±3.1 months reported for the total sample by Cancienne et al and the longest being 64.6±4.1 months for smokers in Jimenez et al.^{16,18} The follow-up for nonsmokers similarly varied, with durations from 35.0±10.8 months in Jimenez et al to 67.3±10.4 months in Jimenez et al.^{17,18}

Quantitative data synthesis

HOS-SS

The comparison of HOS-SS between smokers and nonsmokers, as depicted in Figure 2, indicates a significant reduction in HOS-SS among smokers. Cancienne et al reported a mean difference of -9.80 (95% CI: -15.93, -3.67) with smokers having a mean score of 65.8 (SD: 17.1) compared to 75.6 (SD: 14.1) in nonsmokers.¹⁶ Similarly, Jimenez et al showed a mean difference of -11.50 (95% CI: -22.81, -0.19) with means of 70.4 (SD: 30.4) and 81.9 (SD: 22) for smokers and nonsmokers, respectively.¹⁸ Lall et al also demonstrated a lower HOS-SS in smokers with a mean difference of -8.80 (95% CI: -16.04, -1.56).¹⁹ However, Lee et al found

no significant difference between the two groups (mean difference: 0.20, 95% CI: -12.25, 12.65).²⁰ The overall pooled analysis yielded a mean difference of -8.63 (95% CI: -12.71, -4.54), with negligible heterogeneity ($I^2=0\%$, $p=0.51$), indicating a consistent pattern of lower HOS-SS scores among smokers across studies ($Z=4.14$, $p<0.0001$).

mHHS

The forest plot for the mHHS in Figure 3 shows a significant reduction in mHHS among smokers. Cancienne et al reported a mean difference of -5.80 (95% CI: -13.24, 1.64) while Jimenez et al found a non-significant mean difference of -1.70 (95% CI: -10.06, 6.66).^{16,17} Jimenez et al also showed a decrease in mHHS for smokers with a mean difference of -6.70 (95% CI: -13.92, 0.52).¹⁸ Lall et al reported a significant reduction with a mean difference of -7.10 (95% CI: -12.41, -1.79).¹⁹ Lee et al observed a slight, non-significant increase in mHHS among smokers (mean difference: 1.00, 95% CI: -5.74, 7.74).²⁰ The overall pooled mean difference was -4.47 (95% CI: -7.50, -1.44), with low heterogeneity ($I^2=9\%$, $p=0.36$), indicating that smokers tend to have worse mHHS outcomes compared to nonsmokers ($Z=2.89$, $p=0.004$).

Pain VAS

The forest plot for the pain VAS in Figure 4 indicates that smokers reported significantly higher pain levels post-arthroscopy. Cancienne et al demonstrated a mean difference of 1.40 (95% CI: 0.38, 2.42) with smokers reporting higher pain (mean: 3.2, SD: 2.9) compared to nonsmokers (mean: 1.8, SD: 2.2).¹⁶ Jimenez et al reported a non-significant reduction in pain among smokers (mean difference: -0.40, 95% CI: -1.55, 0.75).¹⁷ Lall et al found smokers experienced significantly more pain (mean difference: 0.80, 95% CI: 0.09, 1.51).¹⁹ Lee et al observed a non-significant increase in pain among smokers (mean difference: 0.36, 95% CI: -0.49, 1.21).²⁰ The overall pooled mean difference was 0.62 (95% CI: 0.17, 1.06), with moderate heterogeneity ($I^2=49\%$, $p=0.12$), indicating a significant overall effect ($Z=2.73$, $p=0.006$).

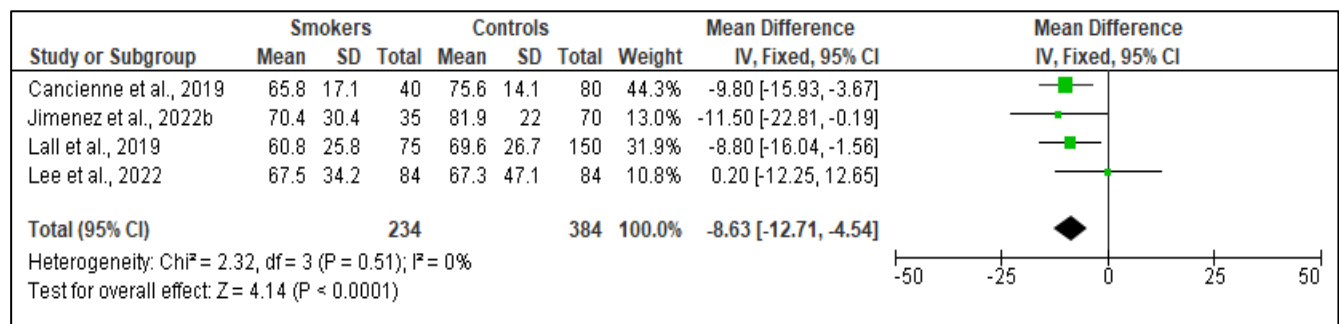
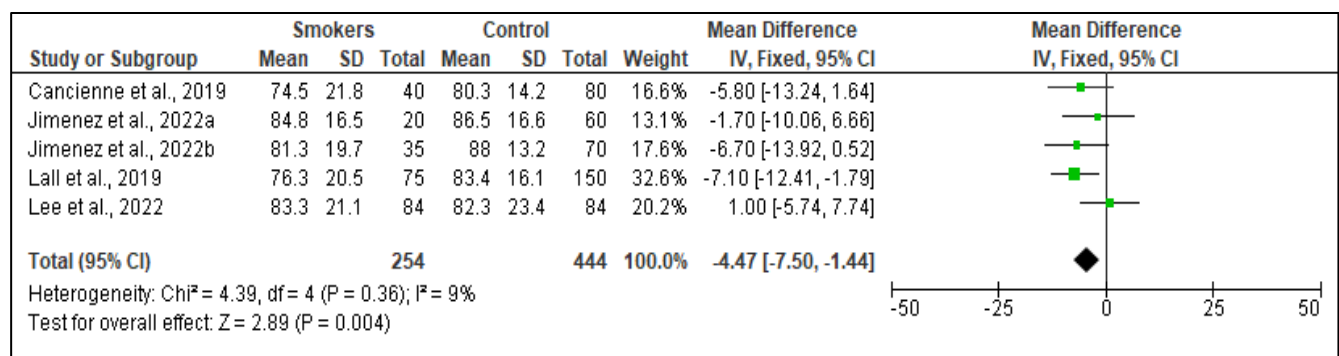
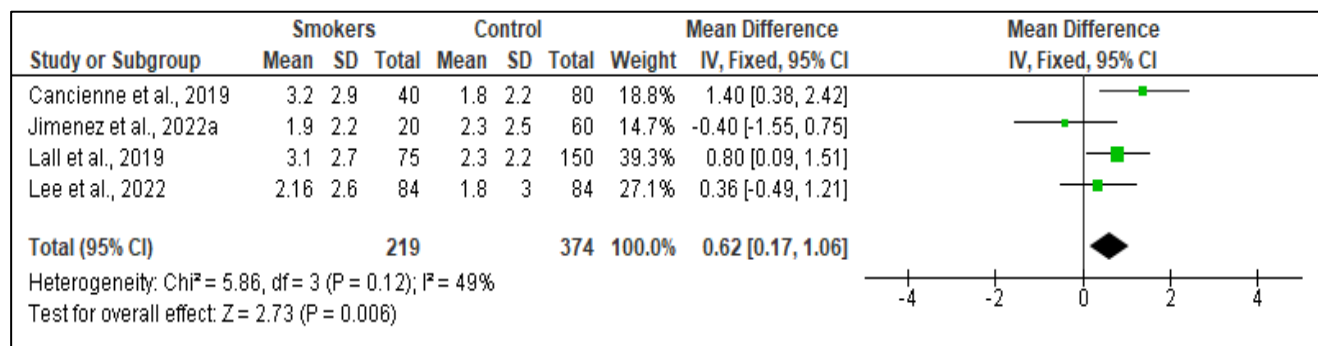
Satisfaction VAS

The forest plot for satisfaction VAS in Figure 5 shows no significant difference in satisfaction levels between smokers and nonsmokers. Cancienne et al found a mean difference of -0.80 (95% CI: -1.83, 0.23), suggesting lower satisfaction among smokers.¹⁶ Conversely, Jimenez et al reported a non-significant increase in satisfaction among smokers (mean difference: 0.40, 95% CI: -0.58, 1.38).¹⁷ Lall et al found minimal difference in satisfaction levels (mean difference: -0.10, 95% CI: -0.74, 0.54).¹⁹ The overall pooled mean difference was -0.13 (95% CI: -0.61, 0.34), with low heterogeneity ($I^2=28\%$, $p=0.25$), and no significant overall effect ($Z=0.55$, $p=0.58$). This suggests that smoking status does not significantly impact patient satisfaction post-arthroscopy.

Table 1: Characteristics of the included studies (n=5, all of the studies were level 3 and were conducted in USA).

Study	Design	Duration	Total sample	S number	NS number	Age, S (in years)	Age, NS (in years)	Female (%) _S	Female (%) _{NS}	BMI, (kg/m ²), S	BMI, (kg/m ²), NS	Months of follow up, S	Months of follow up, NS	NOS score
Cancienne et al, 2019 ¹⁶	Retro	2012-16	120	40	80	35.5±6.4	31.6±12.3	60	65.7	27.0±7.9	23.9±9.2	Total sample: 33.7±3.1		8
Jimenez et al, 2022a ¹⁷	Retro	2011-19	80	20	60	41.4±10.4	42.5±10.1	NR	NR	30.2±6.0	35.0±10.8	39.9±13.0	35.0±10.8	8
Jimenez et al, 2022b ¹⁸	Retro	2009-16	105	35	70	39.4±13.0	38.1±15.2	NR	NR	27.2±5.4	27.4±5.1	64.6±4.1	67.3±10.4	8
Lall et al, 2019 ¹⁹	Retro	2008-15	225	75	150	41.7±11.1	41.7±11.1	44	48	27.6±5.0	27.3±4.9	42.5±18.6	47.6±19.5	9
Lee et al, 2022 ²⁰	Retro	2008-17	168	84	84	45±13.5	45.9±14.1	73.8	69	26.6 [24.2-30.8]	28.0 [23.2-31.2]	38.6 [27.5-48.2]	39.0 [28.3-48.1]	9

Retro- Retrospective, BMI: Body mass index, NR-Not reported, S: Smoker, NS: Non-smoker, NOS: Newcastle-Ottawa scale

**Figure 2: Forest plot of HOS-SSS scores among smokers versus non-smokers.****Figure 3: Forest plot of mHHS among smokers versus non-smokers.****Figure 4: Forest plot of pain VAS among smokers versus non-smokers.**

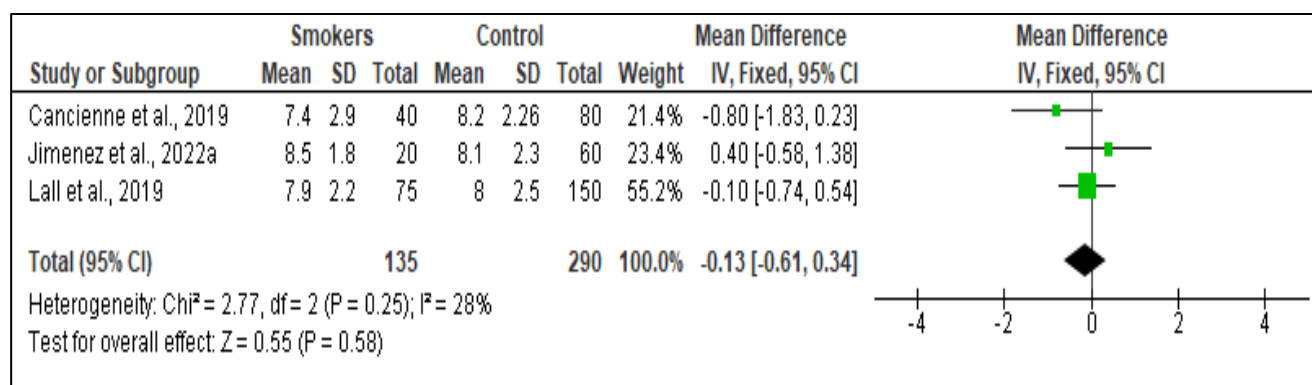


Figure 5: Forest plot of satisfaction VAS among smokers versus non-smokers.

DISCUSSION

Hip arthroscopy is a minimally invasive surgical procedure used to diagnose and treat a variety of hip pathologies, including labral tears, femoroacetabular impingement, and cartilage damage. Despite its growing popularity and the technological advancements in surgical techniques, the outcomes of hip arthroscopy can vary significantly based on patient-related factors.^{1,2} One such factor is smoking, which has been implicated in the impairment of tissue healing and increased risk of postoperative complications. Smoking's deleterious effects on vascularity and cellular function are well-documented, but its specific impact on hip arthroscopy outcomes requires further elucidation.¹⁰⁻¹² This meta-analysis aims to quantify the effect of smoking on hip arthroscopy outcomes, including functional scores, pain levels, and patient satisfaction.

This meta-analysis synthesized data from five studies to evaluate the impact of smoking on hip arthroscopy outcomes. The primary outcomes assessed were the HOS-SS, mHHS, pain measured by the VAS, and patient satisfaction measured by VAS. The pooled analysis revealed that smokers had significantly lower HOS-SS (mean difference: -8.63, 95% CI: -12.71, -4.54), indicating worse sports-specific hip function compared to nonsmokers. Similarly, the mHHS was significantly lower in smokers (mean difference: -4.47, 95% CI: -7.50, -1.44), reflecting poorer overall hip function. Pain VAS scores were significantly higher in smokers (mean difference: 0.62, 95% CI: 0.17, 1.06), suggesting more pain postoperatively. However, there was no significant difference in satisfaction VAS scores between smokers and nonsmokers (mean difference: -0.13, 95% CI: -0.61, 0.34).

The findings from this meta-analysis indicate that smokers experience worse functional outcomes after hip arthroscopy compared to nonsmokers. The significant reduction in HOS-SS among smokers suggests that smoking negatively impacts sports-specific hip function. This is corroborated by the study by Cancienne et al which reported a mean difference of -9.80 (95% CI: -

15.93, -3.67) in HOS-SS between smokers and nonsmokers.¹⁶ Jimenez et al also found a substantial reduction in HOS-SS for smokers (mean difference: -11.50, 95% CI: -22.81, -0.19).¹⁸ The consistency of these findings across multiple studies reinforces the detrimental effect of smoking on hip function.

The mHHS, which measures overall hip function including pain and daily activities, was also significantly lower in smokers. This aligns with the findings of Lall et al who reported a mean difference of -7.10 (95% CI: -12.41, -1.79) in mHHS.¹⁹ The lower mHHS in smokers could be attributed to the impaired healing capacity and increased inflammation associated with smoking. Studies have shown that smoking adversely affects bone metabolism and soft tissue healing, which are critical for successful postoperative recovery.²¹

The pain VAS scores in this meta-analysis were significantly higher in smokers, indicating that smokers experience more pain after hip arthroscopy. Cancienne et al found a mean difference of 1.40 (95% CI: 0.38, 2.42) in pain VAS scores, suggesting that smokers report higher levels of pain postoperatively.¹⁶ This finding is supported by Lall et al who also observed increased pain in smokers (mean difference: 0.80, 95% CI: 0.09, 1.51).¹⁹ The higher pain levels in smokers could be due to nicotine-induced vasoconstriction, which reduces blood flow to the surgical site, thereby impairing healing and increasing pain.

Interestingly, the satisfaction VAS scores did not differ significantly between smokers and nonsmokers. This suggests that despite experiencing worse functional outcomes and higher pain levels, smokers' overall satisfaction with the surgical outcome is comparable to that of nonsmokers. This finding is consistent with Jimenez et al who reported no significant difference in satisfaction VAS scores between the two groups (mean difference: 0.40, 95% CI: -0.58, 1.38).¹⁷ One possible explanation for this could be that smokers have lower baseline expectations or are less likely to report dissatisfaction due to the psychosocial effects of smoking.

The findings of this meta-analysis are consistent with the broader literature on the impact of smoking on surgical outcomes. Smoking has been shown to adversely affect the outcomes of various orthopedic surgeries, including spinal fusion, total joint arthroplasty, and fracture healing.^{7,10,11} The negative impact of smoking on bone and soft tissue healing, coupled with increased inflammation and reduced immune response, contributes to poorer surgical outcomes. For instance, Glassman et al demonstrated that smokers had a higher rate of pseudarthrosis after lumbar spine fusion compared to nonsmokers.⁷

The impact of smoking on hip arthroscopy outcomes specifically has been less well-studied. However, the available evidence aligns with the findings of this meta-analysis.^{4,5,10,11} Our meta-analysis extends these findings by providing pooled estimates that quantify the extent of the impact of smoking on various hip arthroscopy outcomes.

The underlying mechanisms through which smoking affects surgical outcomes are multifaceted. Nicotine, a major component of cigarette smoke, causes vasoconstriction, reducing blood flow to tissues and impairing oxygen delivery. This can delay wound healing and increase the risk of infection. Additionally, smoking increases the levels of carboxyhemoglobin in the blood, further reducing oxygen delivery to tissues. The chronic inflammatory state induced by smoking, characterized by elevated levels of pro-inflammatory cytokines, can exacerbate tissue damage and hinder healing process.^{21,22}

Furthermore, smoking has been shown to impair fibroblast function, which is crucial for collagen synthesis and wound healing. Adverse effects of smoking on bone metabolism are also well-documented. Smoking decreases osteoblast activity and increases osteoclast activity, leading to reduced bone formation and increased bone resorption. This imbalance can impair the integration of surgical implants and delay bone healing.^{22,25}

The findings of this meta-analysis have important implications for clinical practice. Given the significant impact of smoking on hip arthroscopy outcomes, it is essential for healthcare providers to counsel patients on the risks associated with smoking and encourage smoking cessation prior to surgery. Preoperative smoking cessation programs have been shown to improve surgical outcomes and reduce complications.²⁶ Patients should be informed that quitting smoking even a few weeks before surgery can significantly enhance their postoperative recovery and overall outcomes.

Additionally, perioperative management strategies should be tailored to address the specific needs of smokers. Enhanced pain management protocols, including the use of multimodal analgesia, may be necessary to manage the increased pain levels in smokers. Close monitoring for

postoperative complications, such as infection and delayed healing, is also crucial in this patient population.

This meta-analysis has several limitations that should be acknowledged. First, the included studies were all observational, which may introduce selection bias and limit the ability to establish causality. The retrospective nature of most studies also means that the data quality is dependent on the accuracy of medical records.

Future research should focus on prospective, randomized controlled trials to better establish the causal relationship between smoking and hip arthroscopy outcomes. Additionally, studies with larger sample sizes and standardized outcome measures are needed to confirm these findings. Investigating the biological mechanisms through which smoking impairs hip arthroscopy outcomes could also provide valuable insights and inform targeted interventions to mitigate these effects.

CONCLUSION

This meta-analysis provides robust evidence that smoking is associated with worse functional outcomes, higher pain levels, and comparable patient satisfaction after hip arthroscopy. Smokers have significantly lower HOS-SS and mHHS scores, indicating impaired hip function, and report higher pain VAS scores compared to nonsmokers. These findings underscore the importance of smoking cessation and tailored perioperative management strategies to improve surgical outcomes in smokers. Further research is needed to explore the underlying mechanisms and develop effective interventions to mitigate the negative impact of smoking on hip arthroscopy outcomes.

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Ethical approval: Not required

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