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Clinical outcome measures following lateral versus posterior sacroiliac joint fusion: Systematic review and meta-analysis

Khalid Medani [a,*], Abdulrhman Alsalama [b], Rakesh Kumar [c], Shlok Patel [d], Megh Patel [d], Sunil Manjila [e]

[a] Department of Occupational Medicine, Kaiser Permanente, Downey, CA, USA
[b] University of Sharjah College of Medicine, University City, Sharjah, United Arab Emirates
[c] Department of Neurosurgery, Virginia Mason Medical Center, Seattle, WA, USA
[d] Department of Orthopedics, BJ Medical College, Ahmedabad, Gujarat, India
[e] Department of Neurosurgery, Insight Institute of Neurosurgery & Neuroscience, Flint, MI, USA

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ABSTRACT

Introduction: Sacroiliac joint fusion (SIJF) is indicated in patients with chronic Sacroiliac joint (SIJ) pain or instability and is usually performed using minimally invasive techniques through lateral or posterior approach.
Research question: Our study aims to compare the lateral approach to the posterior one in SIJF through meta-analysis of other studies. The outcome of each approach is measured using the visual analog scale (VAS), Oswestry disability index (ODI), or both.
Materials and methods: The study was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Articles were extracted using Pubmed advance search till February 27th, 2023. Articles included were those limited to either lateral, posterior or both approaches. Articles written in a non-English language, case reports and smaller-than-three case series were excluded from the study. Risk of bias was assessed using the Newcastle-Ottawa and Jadad scales. Stata-17 software program was used for statistical analysis and creation of forest plots.
Results: Forty-eight articles were available for the quantitative analysis, which represents a total of 2562 subjects. The average duration of postoperative follow-up was 21 months (3–72 months) and 17 months (6–72 months) for the VAS and ODI outcomes, respectively. The average percentage of improvement in the VAS was 57% (22–80%) in the lateral approach versus 58% (29–94%) in the posterior approach ($p = 0.986$). The average percentage of improvement in the ODI was 42% (11–75%) in the lateral approach versus 31% (11–65%) in the posterior one ($p = 0.272$). A trend towards performing posterior approaches more frequently was noted in studies published after 2017.
Discussion and conclusion: Approach selection for SIJF depends mainly on patient's characteristics and surgeon's experience. Our study demonstrated no difference in VAS outcome between lateral and posterior approach. Lateral approach appeared to be superior in ODI outcome although not statistically significant. The main limitation of the study is the selection-bias as the majority of articles included were observational. Therefore, randomized procedural trials are needed to validate these findings.

1. Introduction

Sacroiliac joint (SIJ) dysfunction is a common cause of low-back pain. Up to 30% of patients with chronic back pain experiences SIJ pain (Sembrano and Polly, 2009). Sacroiliac joint fusion (SIJF) is a surgical procedure that is indicated for patients with chronic SIJ pain and instability. SIJF includes two main approaches: posterior and lateral. Implants are placed lateral to the SIJ in the lateral approach, and

Abbreviations: SIJ, Sacroiliac Joint; SIJF, Sacroiliac Joint Fusion; MIS, Minimally Invasive Surgery; VAS, Visual Analog Scale; ODI, Oswestry Disability Index; CT, Computed Tomography; PAK, Pedicle Access Kit; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; TDI, Triangular Dowel Implants; CTI, Cylindrical Threaded Implants.

* Corresponding author.
E-mail address: khmedani@gmail.com (K. Medani).

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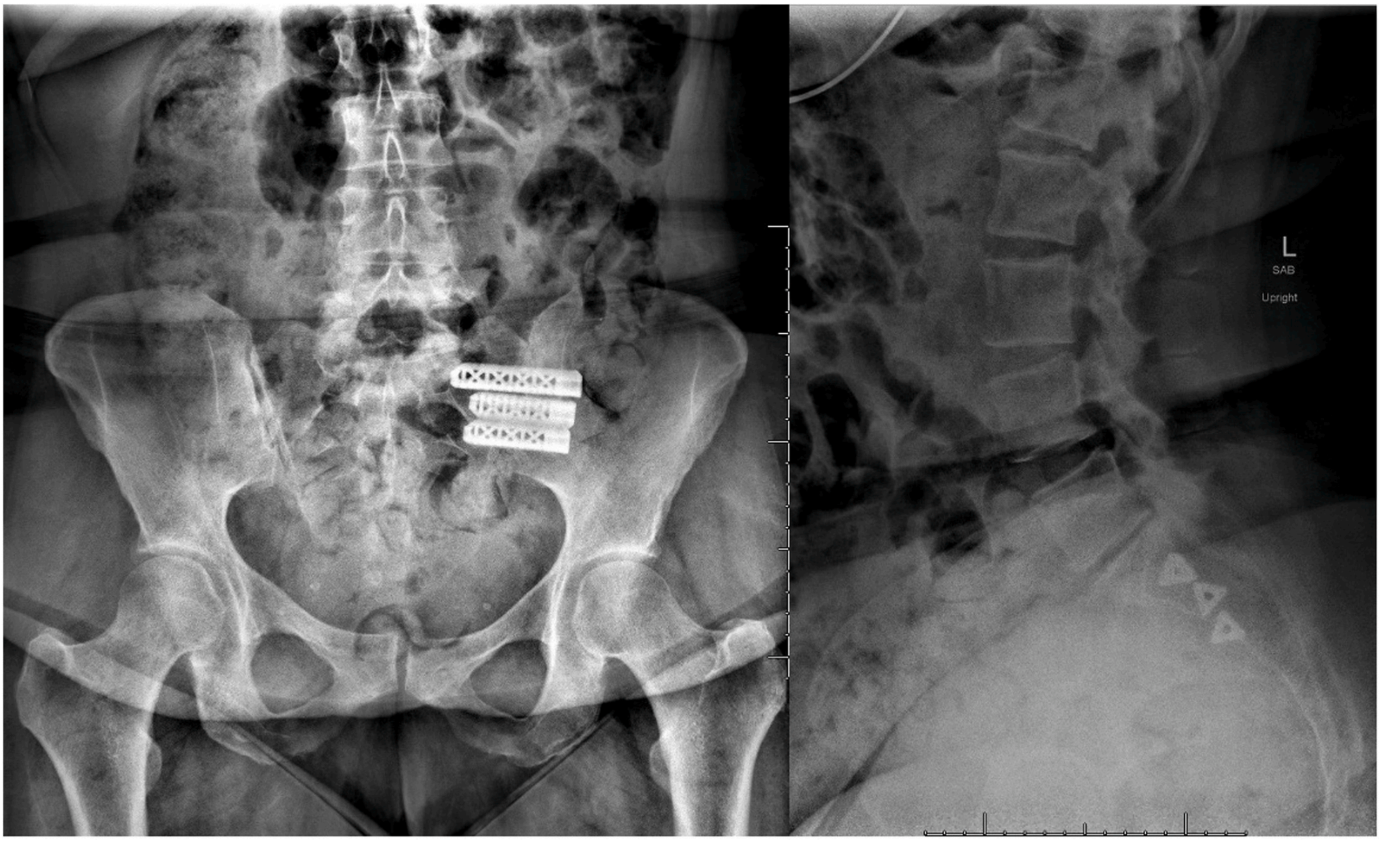

Fig. 1. Postoperative X-ray for lateral approach SIJF.

Fig. 2. Postoperative CT scan for posterior approach SIJF.

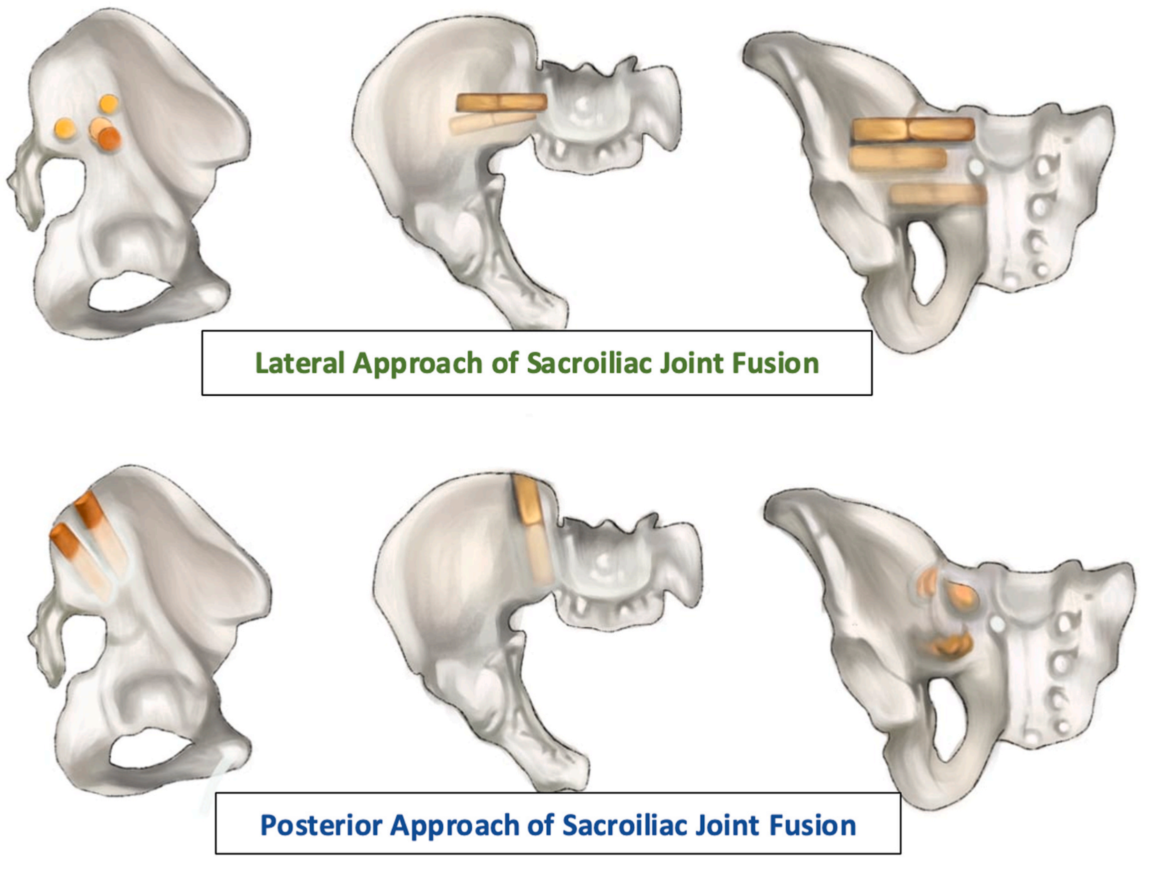

Fig. 3. Pictorial rendition for lateral and posterior approach for SIJF.

posterior to the SIJ in the posterior approach (Martin et al., 2020; Polly et al., 2015). Choice of approach depends on several factors, including the anatomy of the patient and surgeon preferences.

The SIJ is supported by various ligaments, playing a crucial role in weight-bearing and shock absorption. Understanding its intricate biomechanics, including interactions with the lumbar spine, hip joints, and pelvic floor muscles, is essential for choosing the right surgical approach for SIJF (Martin et al., 2020; Polly et al., 2015).

Two surgical approaches to SIJF are the posterior and lateral approaches. The posterior method, which is relatively a newer technique, involves a small incision on the back of the pelvis, addressing the joint through decortication, bone graft placement, and fixation with screws or rods. While effective for pain reduction and functional improvement, it can be challenging; especially, in obese or muscular patients (Ledonio et al., 2014; Cummings and Capobianco, 2013). The lateral approach accesses the joint from the side and utilizes bone graft and screws or pins for fixation (Whang et al., 2015; Dengler et al., 2019). This approach is less invasive than the posterior one, leading to reduced blood loss, shorter hospital stays, and faster recovery (Sachs and Capobianco, 2012). However, it may not be suitable for individuals with significant bony deformities or scarring on the lateral side of the pelvis. Minimally invasive surgery (MIS) shows advantages over open surgery, as demonstrated by a study indicating shorter hospital stays (2 vs. 3.2 days), reduced surgery time (68 vs. 128 min), and significantly lower blood loss (41 vs. 681 ml) (Ledonio et al., 2014).

That study found a complication rate of 11.11%, with common issues being wound infection, trochanteric bursitis, and hematoma formation after SIJF. Implants used in the procedure may fail, leading to complications like loosening, migration, or fracture, requiring additional surgery (Shamrock et al., 2019). SIJF revision may be necessary due to foramina violation causing radiculopathy, implant loosening around the sacral aspect, or implants spanning the ligamentous portion of the SIJ (Cognetti and Jorgensen, 2021).

Comparing outcomes between the lateral and posterior approaches of SIJF is challenging due to differences in patient selection, surgical techniques, and implant designs. Various studies have yielded mixed results, with some indicating superior outcomes for the lateral approach, including reduced blood loss, shorter hospital stays, and high fusion rates (Wise and Dall, 2008). Conversely, the posterior approach has been associated with higher rates of complications such as screw misplacement, nerve injury, and infection (Lorio et al., 2014). Factors influencing the choice between approaches include patient anatomy, surgeon expertise, and the availability of specialized instruments and imaging. Our study aimed to evaluate and compare the outcome of each approach to the other in terms of the reduction in both pain and disability (measured by visual analog scale (VAS) and Oswestry disability index (ODI), respectively). We aimed to provide a quantitative summary by pooling other studies previously addressed one or two of these outcomes.

2. Methods

2.1. Techniques of sacroiliac joint fusion

2.1.1. Lateral approach

A surgical procedure is performed on a patient who is under general anesthesia and lying in prone position. The procedure involves using either fluoroscopy or advanced 3D navigation techniques like cone-beam CT imaging. A specialized tool is used to determine the intended location and path for each implant. These locations are marked on the skin, and an incision of around 3–5 cm is made. The outer layer of the ilium bone is accessed by dissecting through the gluteal fascia. A guide

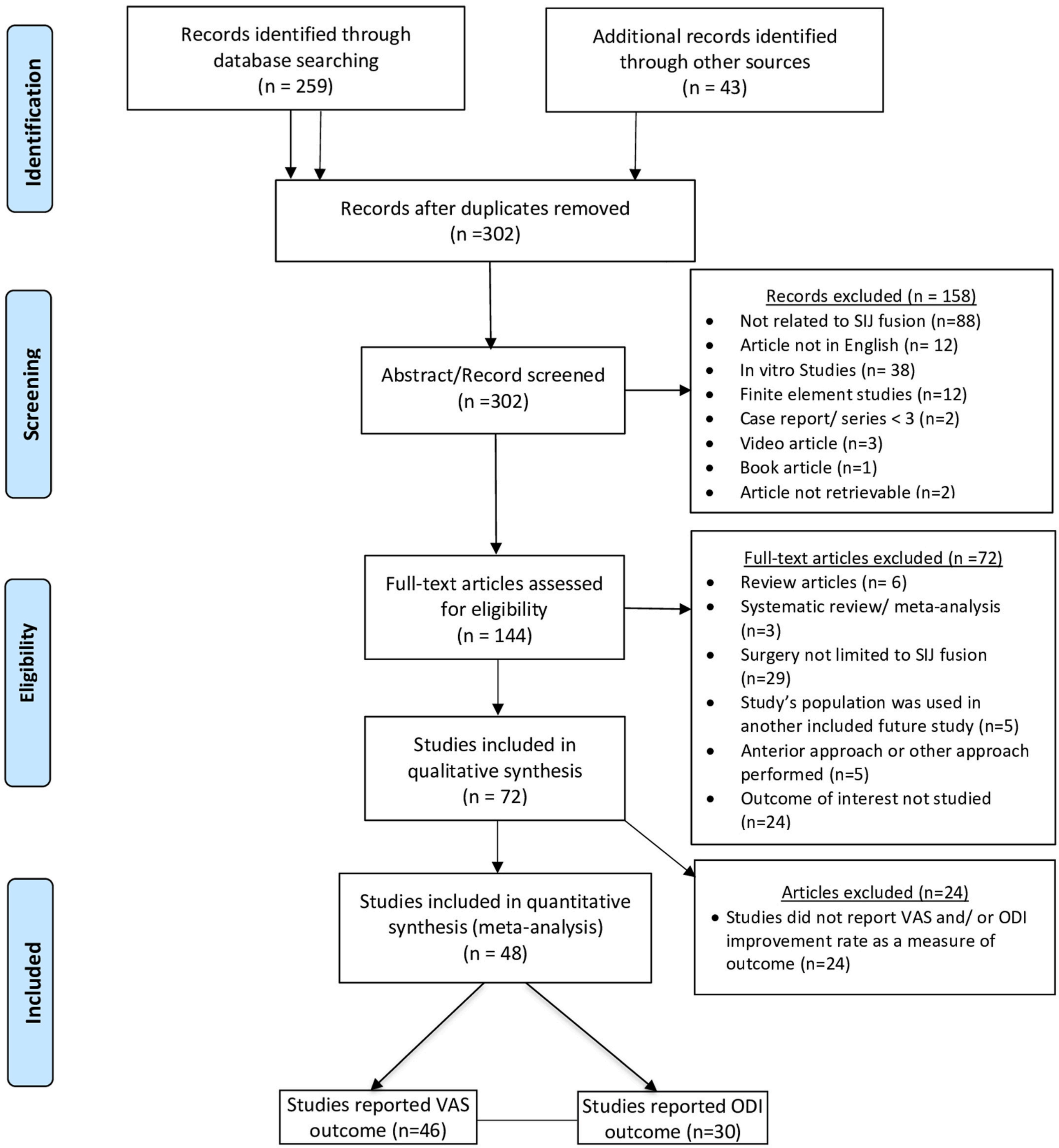

Fig. 4. PRISMA flow diagram for selecting the relevant articles.

pin is inserted through the SIJ and into the center of the sacrum, away from the nerve pathways, which is confirmed using imaging. This path is then widened using drilling and other tools. Three-sided titanium rods are inserted into these locations, usually two in the S1 area and one in S2. The topmost implant is positioned in the sacral ala. A pin-guide system assists in placing the following implants. The second implant is typically positioned above or next to the S1 foramen, while the third implant is placed between the S1 and S2 foramens. This procedure helps stabilize the SIJ. Imaging is done again to ensure proper placement. The incision site is cleaned and closed in layers. Fig. 1 demonstrates the postoperative X-Ray for lateral approach.

2.1.2. *Posterior approach*

The fluoroscope is positioned to get a view of the sacral outlet, aiming to locate the optimal area between the S1 and S2 foramina for accommodating the implants. The procedure involves approaching laterally to the posterior sacral iliac spine, pointing toward the sacral promontory. A special needle called a pedicle access kit (PAK) needle is

Table 1
Articles reported VAS and/or ODI improvement rates following SIJF.

	Author	Year	No. of Patients (% females)	Approach (lateral vs posterior)	MIS vs Open	Mean F/up duration (months)	VAS improvement rate	ODI improvment rate	diagnoses
1.	Calodney, AK (Calodney et al., 2022)	2022	69 (65%)	Posterior	MIS	6	47	35	sacroilitis
2.	Sayed, D (Sayed et al., 2022)	2022	7 (57%)	Posterior	MIS	10	78	NA	SIJ dysfunction (failed lateral surgery)
3.	Montenegro, TS (Montenegro et al., 2022)	2022	96 (69%)	Lateral	MIS	3	22	NA	Traumatic and degenerative SIJ dysfunction
4.	Sarkar, M (Sarkar et al., 2022)	2022	43 (63%)	posterior	MIS	12	81	NA	SIJ dysfunction
5.	Kasapovic, A (Kasapovic et al., 2022)	2021	26 (73%)	Lateral	MIS	48	45	45	Chronic SIJ pain
6.	Abbasi, H (Abbasi et al., 2021)	2021	55	Lateral	MIS	12	NA	33	SIJ pain
7.	Lee, DW (Lee et al., 2021)	2021	21	Posterior	MIS	3	73.2	NA	SIJ pain
8.	Pyles, S (Pyles and Lam, 2020)	2020	7	Posterior	MIS	5.1	94.2	NA	SIJ pain
9.	Lam, CM (Lam et al., 2020)	2020	62	Posterior	MIS	3	83.3	NA	SIJ pain
10.	Claus, CF (Claus et al., 2020)	2020	74 (73%)	Posterior	MIS	12	35	15	Degenerative sacroilitis, SIJ disruption, and pseudoarthrosis
11.	Claus, CF (Claus et al., 2020)	2020	82 (73%)	Lateral	MIS	12	30	11%	SIJ dysfunction
12.	Whang, PG (Whang et al., 2019)	2019	93 (73%)	Lateral	MIS	60	54	26	degenerative sacrolitis, SIJ disruption
13.	Patel, V (Patel et al., 2019)	2019	24 (82%)	Lateral	MIS	6	51	23.6	SIJ dysfunction
14.	Rajpal, S (Rajpal and Burneikiene, 2019)	2019	24 (88%)	Posterior	MIS	19	44	NA	Sacroilitis and SIJ disruption
15.	Mann, D (Lee et al., 2021; Mann et al., 2019)	2019	10	Posterior	MIS	12	79.2	NA	SIJ pain
16.	Pyles, S (Lee et al., 2021; S, 2019)	2019	20	Posterior	MIS	6	72	NA	SIJ pain
17.	Kim, D (Lee et al., 2021; Kim et al., 2019)	2019	16	Posterior	MIS	6.3	87	NA	SIJ pain
18.	Cleveland, AW 3rd (Cleveland et al., 2019)	2019	50 (76%)	Lateral	Open or MIS	14	55	60	SIJ dysfunction
19.	Rainov, NG (Rainov et al., 2019)	2019	160 (68%)	Lateral	MIS	12	69	64%	SIJ dysfunction
20.	Murakami, E (Murakami et al., 2018)	2018	21	Anterior	open	113	68.4	NA	refractory SIJ pain
21.	Fuchs, W (Fuchs and Ruhl, 2018)	2018	171 (67%)	Posterior	MIS	24	50	65	SIJ pain
22.	Cross, WW (Cross et al., 2018)	2018	19 (63%)	Lateral	MIS	24	73	NA	SIJ degeneration
23.	Vanaclocha, V (Vanaclocha et al., 2018)	2018	27 (70%)	Lateral	MIS	72	75	53	SIJ osteoarthritic degeneration, SIJ disruption
24.	Kancherla, VK (Kancherla et al., 2017)	2017	45	Lateral	MIS	32.6	54	NA	SIJ pain
25.	Dengler, J (Dengler et al., 2017)	2017	21 (70%)	Lateral	MIS	6	49	56	SIJ dysfunction
26.	Sturesson, B (Sturesson et al., 2017)	2017	52 (73%)	Lateral	MIS	6	56	45	Chronic disabling SIJ pain
27.	Bornemann, R (Bornemann et al., 2017)	2017	24 (92%)	Lateral	MIS	24	69	60	Refractory SIJ syndrome
28.	Rappoport, LH (Rappoport et al., 2017)	2017	32 (63%)	Lateral	MIS	12	41	38	SIJ dysfunction
29.	Araghi, A (Araghi et al., 2017)	2017	50 (58%)	Lateral	MIS	6	54	36	SIJ dysfunction
30.	Sachs, D (Sachs et al., 2014)	2016	107 (71%)	Lateral	MIS	44.4	65	NA	degenerative sacrolitis, SIJ disruption
31.	Duhon, BS (Duhon et al., 2016)	2016	149 (70%)	Lateral	MIS	24	76	43	SIJ dysfunction
32.	Kube, RA (Kube and Muir, 2016)	2016	18 (56%)	Lateral	MIS	12	46	34	SIJ dysfunction
33.	Capobianco, R (Capobianco et al., 2015)	2015	172 (70%)	Lateral	MIS	12	61	44	SIJ dysfunction, postpartum, posterior pelvic girdle pain

(*continued on next page*)

Table 1 (*continued*)

Author	Year	No. of Patients (% females)	Approach (lateral vs posterior)	MIS vs Open	Mean F/up duration (months)	VAS improvement rate	ODI improvment rate	diagnoses
34. Polly, DW (Polly et al., 2015)	2015	98 (74%)	Lateral	MIS	12	66	51	degenerative sacrolitis, SIJ disruption
35. Whang, P (Whang et al., 2015)	2015	100 (74%)	Lateral	MIS	6	64	49	degenerative sacroilitis, SIJ dysfunction
36. Polly, DW (Polly et al., 2015)	2015	35 (57%), crossover	Lateral	MIS	6	54	47%	SIJ dysfunction
37. Vanaclocha V (Vanaclocha et al., 2014)	2014	24 (63%)	Lateral	MIS	23	76	70	degenerative sacrolitis, SIJ disruption
38. Rudolf, L (Rudolf and Capobianco, 2014)	2014	17 (77%)	Lateral	MIS	60	71	NA	degenerative sacroilitis, SIJ disruption
39. Sachs, D (Sachs et al., 2014)	2014	144 (71%)	Lateral	MIS	12	69	NA	degenerative sacrolitis, SIJ disruption
40. Ledonio, CGT (Ledonio et al., 2014)	2014	22 (77%)	Lateral	MIS	15	NA	15	SIJ dysfunction
41. Ledonio, CGT (Ledonio et al., 2014)	2014	22 (59%)	Anterior	Open	13	NA	23	SIJ dysfunction
42. Endres, S (Endres and Ludwig, 2013)	2013	19 (26%)	Posterior	MIS	13.2	29	11	SIJ degeneration
43. Duhon, B (Duhon et al., 2013)	2013	32 (21%)	Lateral	MIS	6	64	29	degenerative sacrolitis, SIJ disruption
44. Cummings, J Jr (Cummings and Capobianco, 2013)	2013	18 (67%)	Lateral	MIS	12	74	75	degenerative sacroilitis, SIJ disruption
45. Gaetani, P (Gaetani et al., 2013)	2013	12 (100%)	Lateral	MIS	10	61	62	SIJ disruption
46. Schroeder, JE (Schroeder et al., 2014)	2013	6 (100%)	Lateral	MIS	10.25	66	52	SIJ degeneration
47. Mason, LW (Mason et al., 2013)	2013	55 (81%)	Lateral	MIS	36	44	NA	SIJ pain
48. McGuire, RA (McGuire et al., 2012)	2012	37 (92%)	Posterior	MIS	52	63	NA	Refractory
49. Al-Khayer, A (Al-Khayer et al., 2008)	2008	9 (100%)	Lateral	MIS	40	43	24	SIJ pain

used to penetrate through the ilium, across the SIJ, and into the sacrum. A guidewire is exchanged with the PAK needle, and then a drilling process is carried out. Subsequently, a threaded implant is carefully inserted through the prepared channel, crossing the SIJ, until the implant's head is aligned with the ilium's surface. These steps can be repeated as needed, with up to three implants being placed, based on the surgeon's judgment. Fig. 2 demonstrates the postoperative CT scan for posterior approach.

Fig. 3 demonstrates the screw trajectory for both techniques.

2.2. *Data collection and statistical analysis*

2.2.1. *Inclusion and exclusion criteria*

The systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021; Shamseer et al., 2015). PubMed advance search was used to identify related articles. Queries used to identify related articles were: ("sacroiliac" OR "sarco-iliac") AND ("fusion" OR "arthrodesis") AND ("posterior" OR "lateral" OR "posterolateral"). The end-date of article search was February 27th, 2023.

All non-English articles were excluded to avoid erroneous translation of the information. Case reports and case series which describe less than 3 cases were also removed due to lack of power needed for statistical comparison in these articles. Articles which describe surgeries not limited to SIJ were also removed. Articles which describe anterior approach or other approaches of SIJF were also excluded from the final quantitative analysis (study was meant to compare lateral with posterior approach). The screening process was done by 2 reviewers who worked independently.

2.2.2. *Data extraction*

The eligible articles were examined for data extractions. Variables extracted included the number of patients, percentage of females, diagnoses, procedure approach, and the mean duration of follow up. The outcome variables were the percentage of improvement in the VAS and the percentage of improvement in the ODI. These percentages were calculated by subtracting the *postoperative* VAS (or ODI) average value from the corresponding *preoperative* average value and dividing it by the *preoperative* average value. All the data extracted were placed in MS Excel datasheet to be used for the appropriate analysis. The quality of the papers and risk of bias were assessed using the Newcastle-Ottawa Scale (NOS) for observational studies (Luchini et al., 2021), and Jadad scale for randomized clinical trials (Jadad et al., 1996) (Supplemental Tables 1–3). This quality assessment was also done by two independent reviewers and discrepancies were resolved consensually.

2.2.3. *Statistical analysis*

A meta-analysis was performed using Stata® (Release 17) (Stata Statistical Software, 2021). Funnel plots were produced to assess for possible publication biases. Random effect models were created to compare both the percentage of improvement in VAS and in ODI between the lateral and posterior approaches. Meta regression was also performed against the studies published in or after 2018 (about half of the studies) versus studies published prior to 2018 to evaluate if this dichotomy would explain some of the results' heterogeneity.

3. Results

A total of 259 articles met the search criteria in the PubMed and were pulled for the screening phase. Additional 43 articles were added from the bibliography of related articles and were also screened. After duplicates removal, 158 articles were excluded during the abstract screening phase for the reasons explained in PRISMA flow diagram (Fig. 4) and 144 articles were included for full full-text screening and

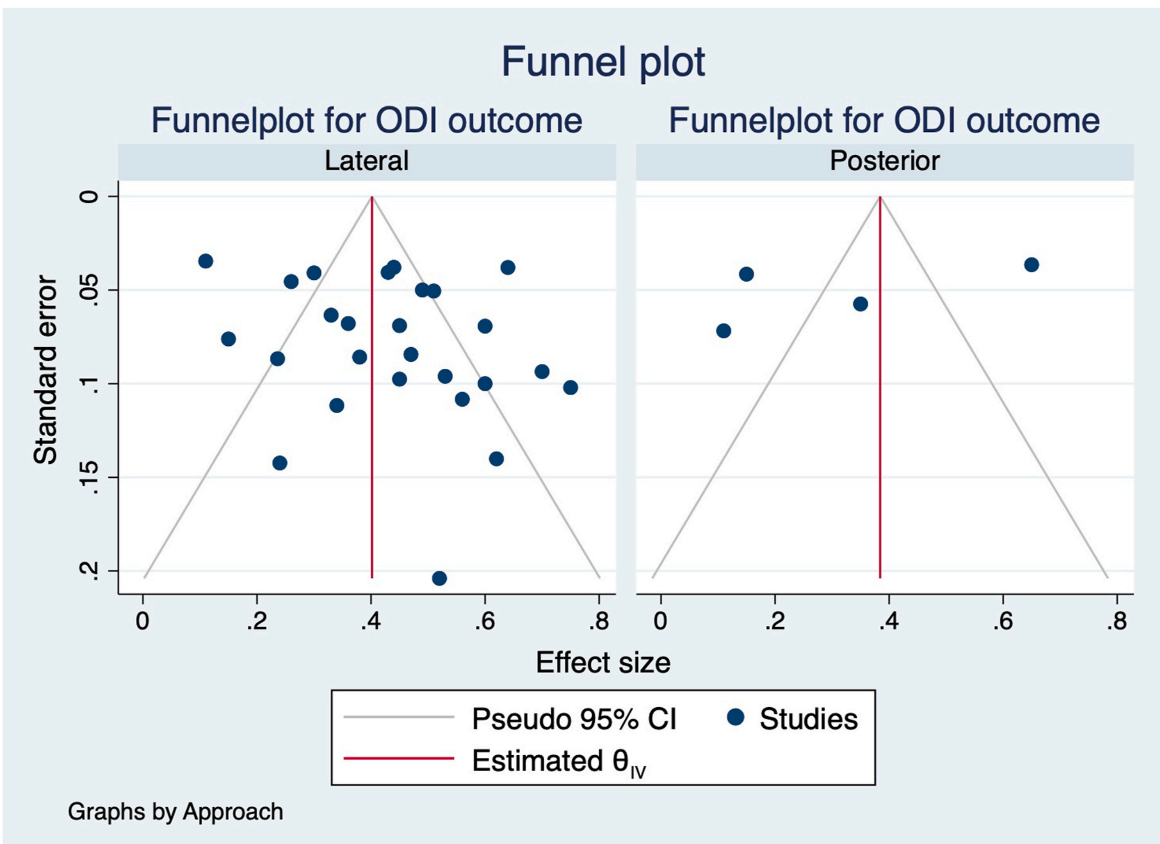

Fig. 5. Funnel plot for ODI outcome in both lateral and posterior approaches.

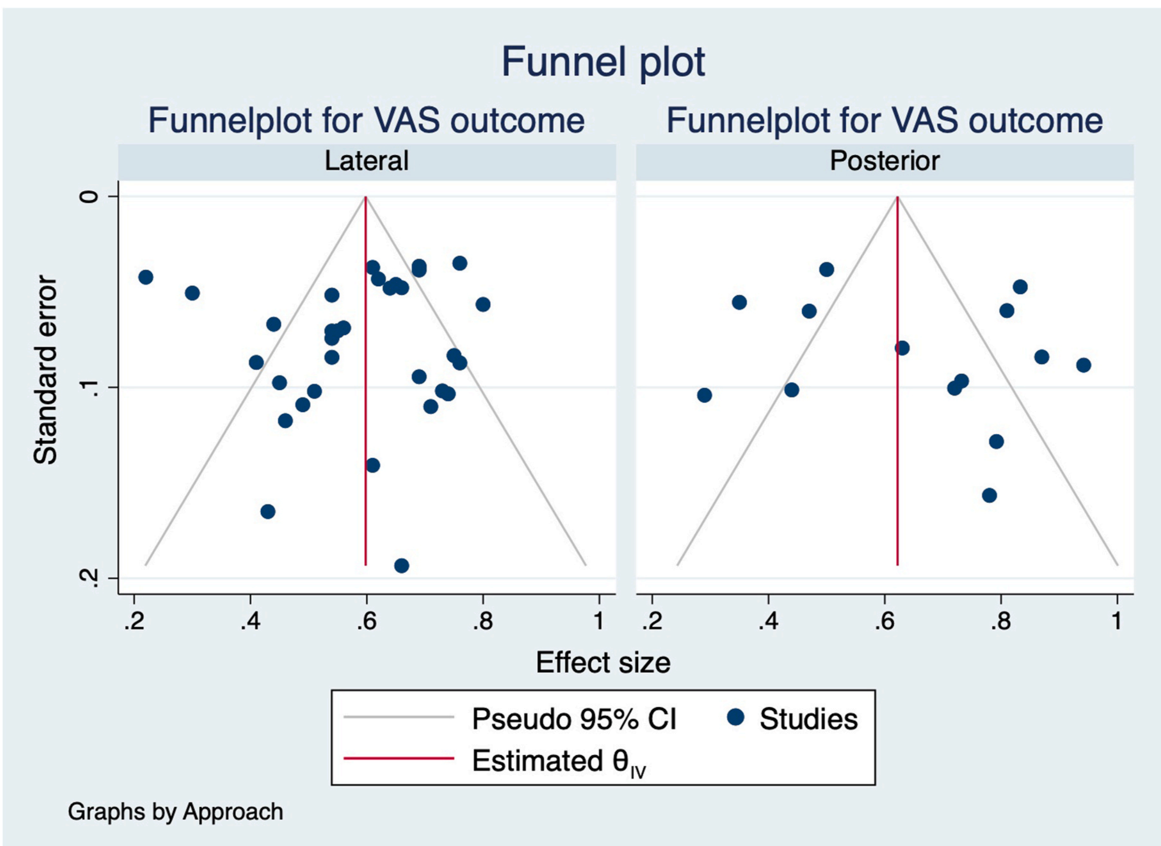

Fig. 6. Funnel plot for VAS outcome in both lateral and posterior approaches.

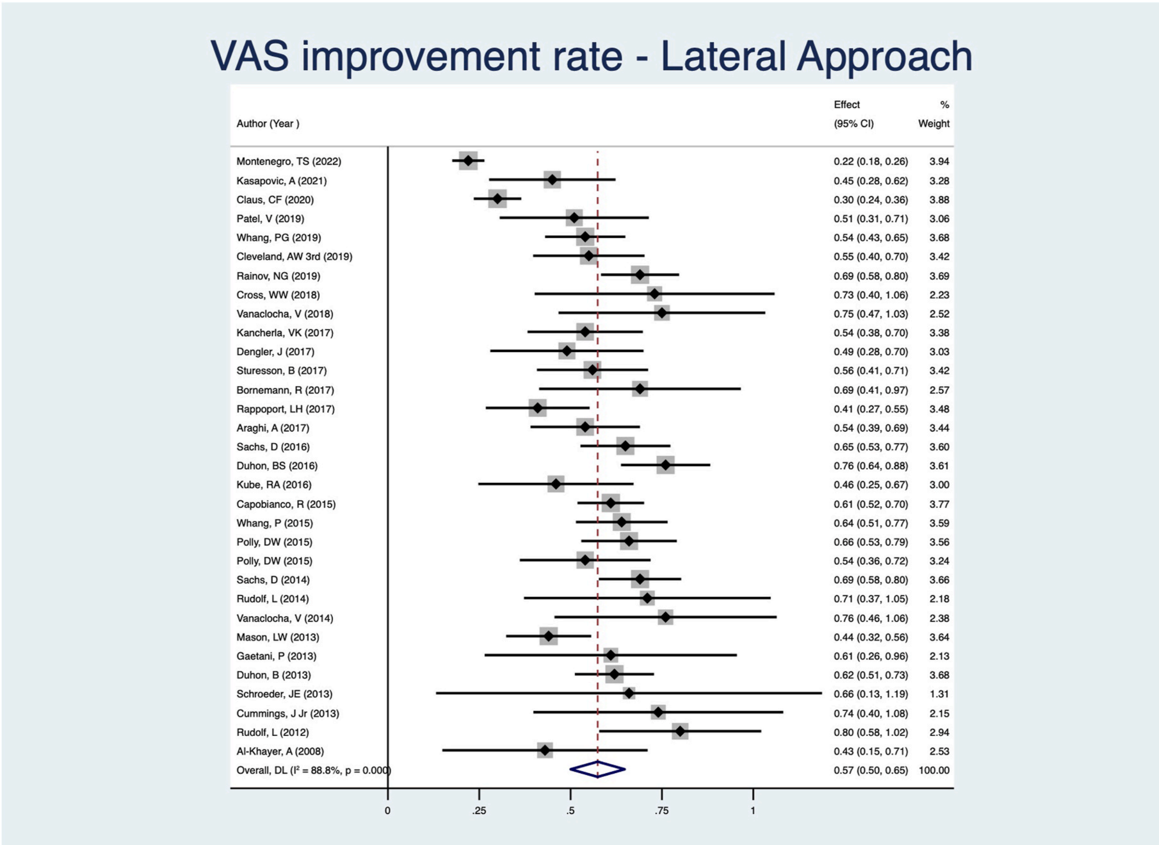

Fig. 7. Forest plot for VAS improvement rate in lateral approach.

were obtained through either the PubMed Central repository or the University of Sharjah's digital library. Half of these manuscripts was also excluded for reasons such as: surgeries not limited to SIJ, different approach was performed such as anterior approach and when there was lack of reporting of the VAS or ODI outcome in the manuscript. From the reminder 72 articles included for the systematic review, 48 articles were used for the quantitative analysis since the specific measure of the outcome (percentage of improvement in VAS or ODI) was clearly stated or could be directly calculated from the article (see Table 1). These total number of subjects studied in these 48 articles was 2564. Forty-six out of the 48 articles mentioned the percentage of VAS improvement, while 30 reported the percentage of ODI improvement (Fig. 4).

Four funnel plots were produced to evaluate for possible publication bias (1 for each outcome with each approach). According to these funnel plots publication bias was minimal (Figs. 5 and 6).

In our meta-analysis for VAS improvement rate, a total of 2542 patients' data was included with an average duration of follow up of 21 months (range 3–72 months). VAS has improved by an average of 57% (range: 22–80%) among the patients who underwent lateral approach procedures (Fig. 7), versus 58% (range: 29–94%) among those who underwent posterior approach procedures (Fig. 8) ($p = 0.986$). The VAS improvement showed 88.8% heterogeneity in the lateral approach ($p < 0.001$) and 74.7% in the posterior approach ($p < 0.001$).

Regarding the ODI improvement rate, a total 1840 patients' data with 17-month average duration of follow up was included (range 6–72 months). The ODI improved by an average of 42% (range: 11–75%) in the lateral approach group (Fig. 9) versus 31% (range: 11–65%) in the posterior approach group (Fig. 10) ($p = 0.272$). The ODI improvement showed 93.9% heterogeneity in the lateral approach ($p < 0.001$) and 97.4% in the posterior approach ($p < 0.001$).

We performed meta-regression analysis after we dichotomized the studies per their year of publication (those who were done during or after 2018 versus prior to 2018) to evaluate if this dichotomy would explain the large heterogeneity noted in both VAS and ODI improvement rates. This dichotomy did not explain the heterogeneity in either outcome ($p = 0.4410$ and 0.7279 for the VAS and ODI improvement respectively). However, a trend towards performing more posterior approach was noticed in or after 2018 (52% of approaches were posterior in 2018 or after compared to only 8% prior to 2018).

4. Discussion

This systemic review and meta-analysis provide a quantitative summary of the current outcomes comparing two well-established minimally invasive approaches of SIJF. As per our best knowledge, this is the first study to pool-compare the percentages of VAS and ODI improvement between the lateral and posterior approach.

The posterior SIJF approach is proposed to be less invasive and hypothetically safer due to avoidance of neurovascular bundle complications which are often associated with lateral approach (Collinge et al., 2005). Our study has demonstrated a trend towards posterior approach in or after 2018.

SIJF using posterior-oblique approach is also a promising new technique. The strength point of this technique is the fact that it avoids dissection through gluteal tissue and SIJ ligaments, an advantage that is missing with lateral and posterior approaches (Sachs et al., 2014). Nevertheless, we preferred to remove this approach from the comparison in this analysis due to lack of sufficient evidence addressing this emerging technique.

Claus et al. compared the outcomes of SIJF with Triangular Dowel Implants (TDI) or Cylindrical Threaded Implants (CTI) and concluded that both offer a significant improvement in pain, disability, and quality of life; but no difference was observed between devices to suggest a superior clinical outcome. Increased revision rates were also observed in

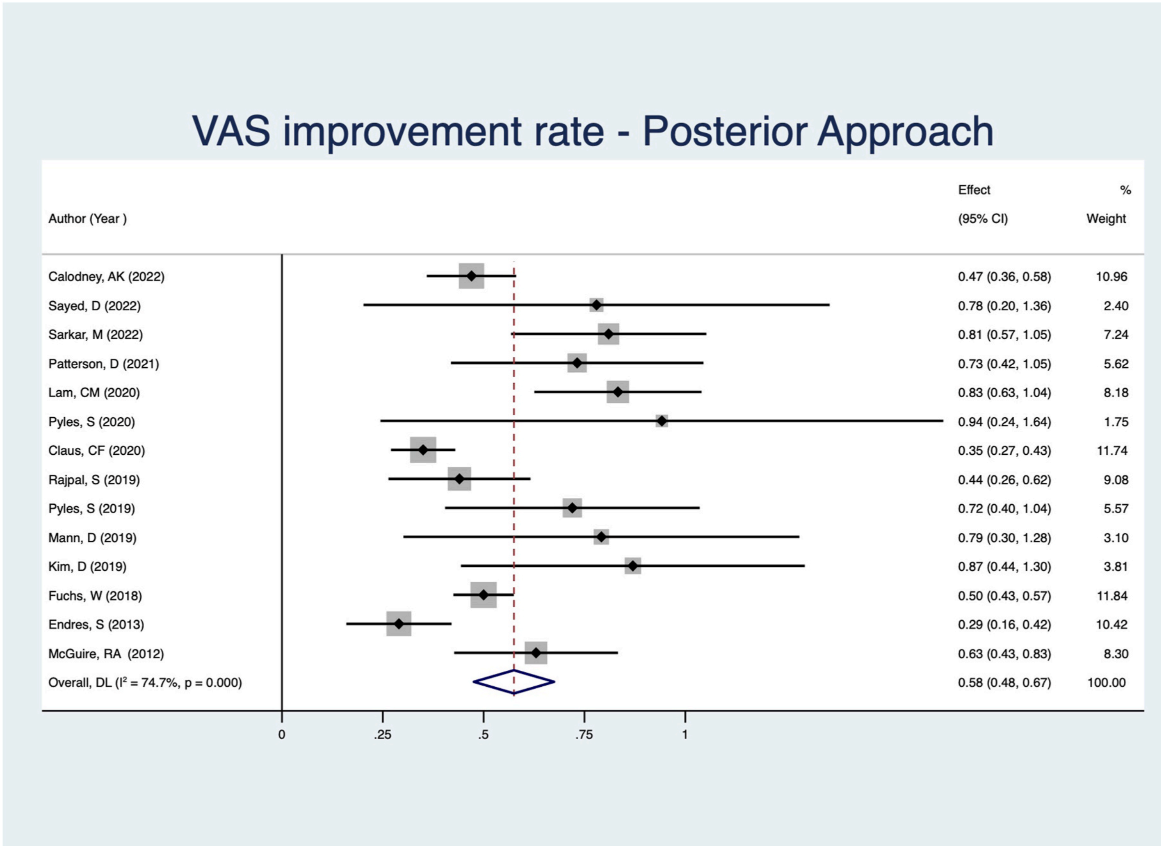

Fig. 8. Forest plot for VAS improvement rate in posterior approach.

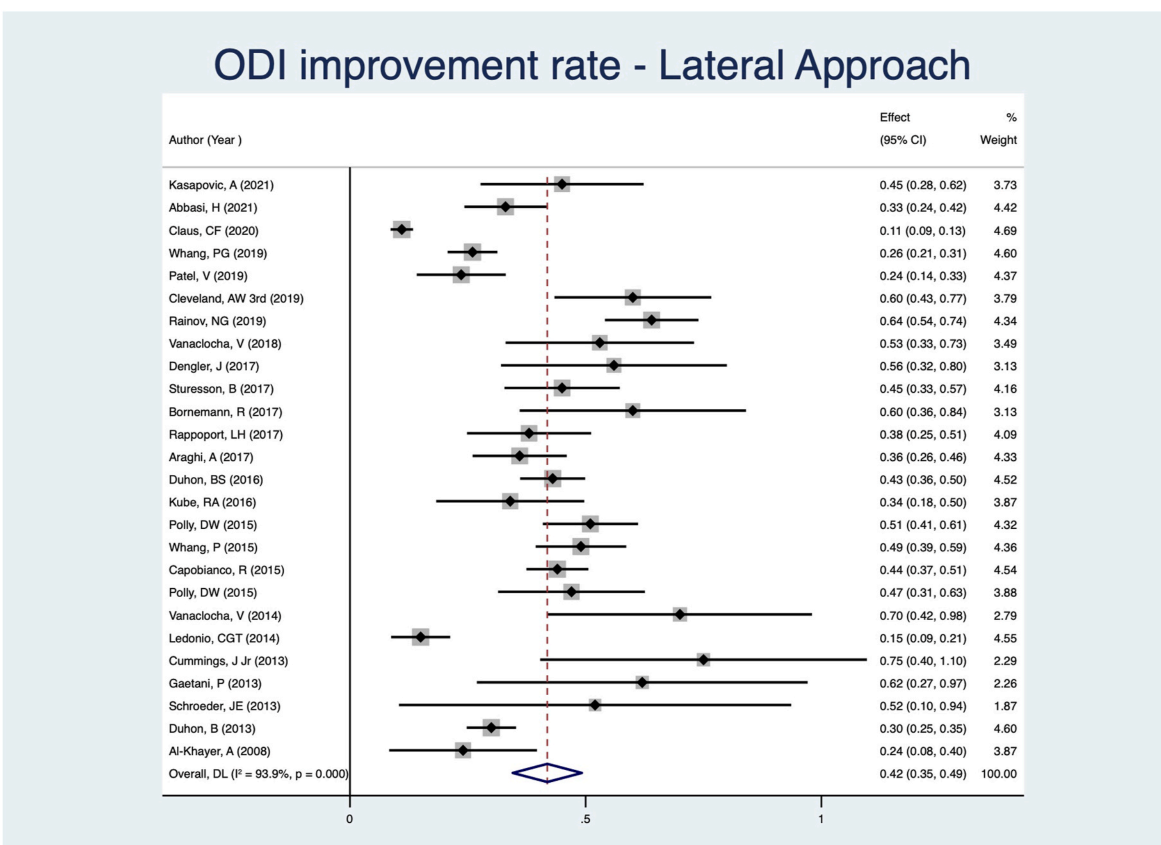

Fig. 9. Forest plot for ODI improvement rate in lateral approach.

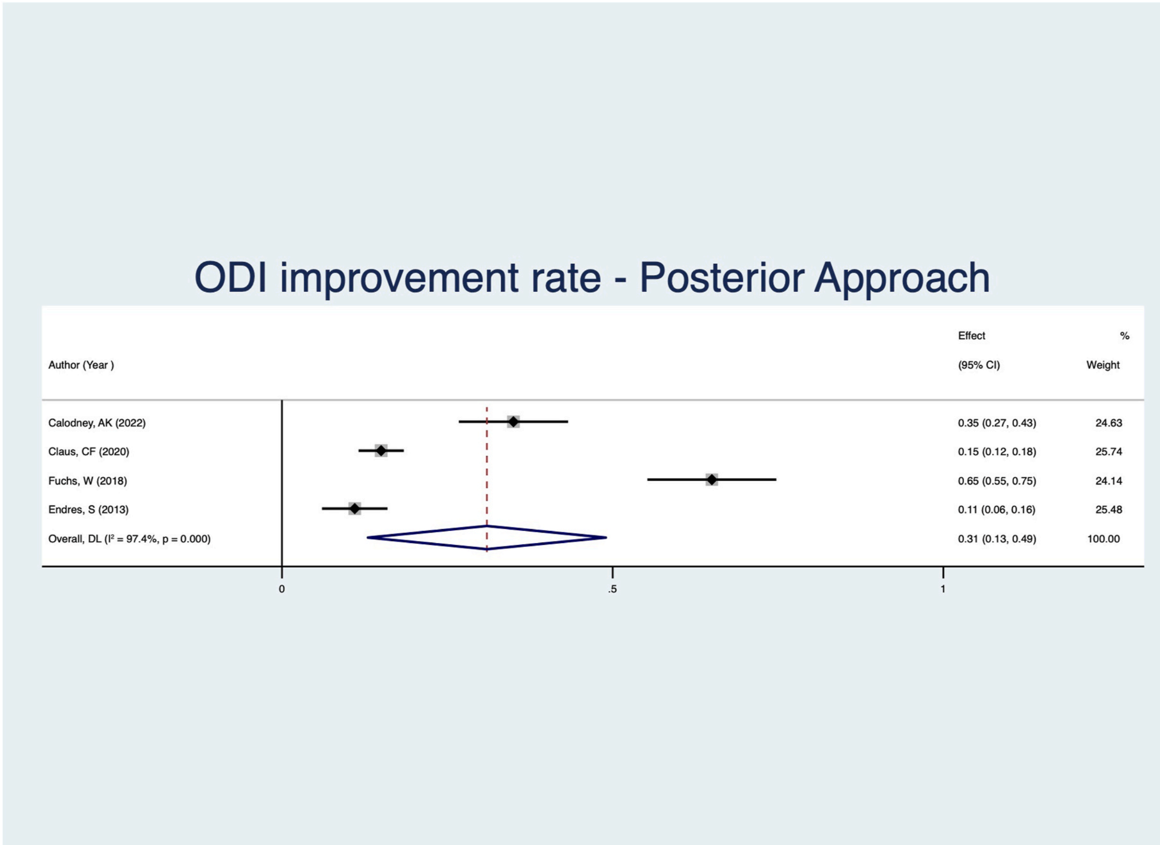

Fig. 10. Forest plot for ODI improvement rate in posterior approach.

CTI (Rialto) group as compared with TDI implants (Claus et al., 2020).

There is no consensus regarding the number of implants needed for fusion across the SIJ, but a three-screw constructs provide complete stability compared with any two-screw constructs as shown by finite element analysis by Lindsey et al. (2018)

Despite the fact that minimally invasive approach for SIJF is generally considered a safe and effective treatment for SIJ pain, complications can occur in up to 15 % of patients (Shamrock et al., 2019). Complications can be related to the procedure itself such as wound infection or drainage, trochanteric bursitis or hematoma formation. Complications can also occur due to misplacement of the implant, leading to nerve root impingement and hairline fracture of the ilium. Long-term complications include SIJ nonunion and novel lumbar pathology. The latter can occur in up to 5.5% of patient at 6 months following fusion surgery. Interestingly, nonunion, which is lack of SIJF on follow up imaging, didn't show any significant association with clinical findings (Rudolf and Capobianco, 2014).

The strength of our meta-analysis study is that it is the first to compare outcomes of two MIS approaches for SIJF with a large number of patient population included, and been carried out according to the Cochrane guidelines (Page et al., 2021). The study indicates a slightly better (although not statistically significant) ODI improvement in lateral approach with no deference in VAS improvement between lateral and posterior approach. In addition, the means of the follow-up periods were relatively long (21 months for the VAS and 17 months for the ODI outcomes).

The limitation of our study is that the results may not be generalizable due to the large heterogeneity of the patient population. This heterogeneity could be attributed to the demographic diversity, different diagnoses, intraprocedural variations and device selection, subjectivity of VAS and ODI measurement, and the different durations of follow-up. Additionally, there may be some biases in measuring the VAS and ODI outcomes due to influence of the industry in some of the studies included in the meta-analysis.

5. Conclusion

The meta-analysis showed no difference in VAS improvement rate after SIJF using lateral versus posterior approach. Although not statistically significant, the ODI improvement rate in patients with lateral approach was slightly higher than posterior approach. The approach selection for SIJF can be dependent on the patient's characteristics, surgeon's experience, and operation set-up. Further randomized clinical trials are needed to better evaluate the clinical outcome between the two approaches of the SIJF.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bas.2025.104212.

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