Journal of Pain Research

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REVIEW

Comparison of Perioperative and Postoperative Outcomes of Minimally Invasive and Open TLIF in Obese Patients: A Systematic Review and Meta-Analysis

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Purpose: Previous studies have demonstrated that minimally invasive (MI) transforaminal lumbar interbody fusion (TLIF) is comparable to the open approach in terms of efficacy and safety. However, few comparative studies of surgical procedures in patients with obesity show that they may react differently to open-TLIF (O-TLIF) and MI-LTIF approaches.

Patients and Methods: The main indicators were complications, visual analog scale (VAS) score, and Oswestry Disability Index (ODI) score, and secondary indicators were operative time, blood loss, and hospital stay.

Results: No significant differences in the VAS and ODI scores for back pain at the last follow-up and wound infection rates were observed between the two groups. Dural tear incidence and complication rate were significantly lower in the MI-TLIF group than that in the O-TLIF group (P = 0.002 and 0.001, respectively). No significant difference in operative time was found between the two groups. There was less blood loss and shorter hospital stay (P = 0.001 and 0.002, respectively) in the MI-TLIF group than that in the O-TLIF group.

Conclusion: Compared with O-TLIF, MI-TLIF is an effective and safe surgical option for patients with obesity, which resulted in similar improvements in pain and functional disability, as well as a lower complication rate.

Keywords: minimally invasive, transforaminal lumbar interbody fusion, overweight, obesity, lumbar degenerative diseases

Introduction

According to the World Health Organization (WHO) regulations, a body mass index (BMI) >30 is defined as obese.[1] According to related reports,[2] the obesity rate has been increasing. In 2008, the obesity rate was almost double that of 1980. By 2025, approximately two-thirds of the population will be overweight or obese, which has become the focus of global attention. Obesity is associated with a variety of chronic complications such as hypertension and diabetes,[3,4] which not only increases the difficulty of spinal surgery but also increases the risk of surgical complications.[5–8] Several studies have shown that patients with obesity have a significantly higher risk of perioperative complications, such as wound infection, deep venous thrombosis, and pulmonary embolism. They also have an increased risk of readmission due to revision surgery and postoperative complications.[7,9,10]

Received: 17 July 2021
Accepted: 21 December 2021
Published: 6 January 2022

Several studies have pointed out that obesity is a risk factor for a variety of diseases,[11–14] including cervical spondylosis, lumbar disc herniation, lumbar spondylolisthesis, and spinal canal stenosis, which need to be treated surgically, if necessary. Patients with obesity are susceptible to difficulty in intubation and have a higher risk of postoperative infection rate, and thromboembolic events, and thus demand more awareness from anesthesiologists and surgeons.[15–20] Spinal surgery requires high precision, but for spinal fusion in patients with obesity, surgeons must perform precise operations in a limited surgical space, with indistinct anatomical landmarks. Therefore, it is important to strictly follow protocols and choose a suitable surgical treatment option for patients with obesity.

Transforaminal lumbar interbody fusion (TLIF) has become a routine surgical treatment for lumbar degenerative diseases, with a widely recognized clinical effect, making it a preference by many surgeons. Traditional TLIF is performed using an open approach (O-TLIF). The invention and improvement of the minimally invasive approach (MI-TLIF) have brought more beneficial choices for patients in the last 20 years. In general, MI-TLIF and O-TLIF yield good results for patients without obesity, but MI-TLIF provides less tissue trauma, less postoperative pain, and shorter hospital stay, as confirmed by several researchers.[21–24] However, the advantages of MI-TLIF over O-TLIF in patients with obesity have not been fully and effectively confirmed. It is meaningful to verify which surgical methods will bring higher benefits to patients.

Our meta-analysis aimed to further evaluate the efficacy of MI-TLIF and O-TLIF in the treatment of obese lumbar disease. This may provide useful information for spinal surgeons in making surgical plans for patients with obesity.

Materials and Methods

A meta-analysis of this article was conducted based on the standard principles set by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines,[25,26] and referred to the checklist and flow diagram.

Literature Search

Systematic literature retrieval was carried out on electronic databases such as PubMed, Embase, Web of Science, and Cochrane Library, and the period was set from the establishment of the database to September 2020. Literature retrieval was based on the Cochrane Handbook and PRISMA guidelines.[27]

The following terms with appropriate operator combinations "AND," "OR," and "NOT" were used in the search strategy: "obesity," "obese and overweight," "BMI," "fusion," "transforaminal lumbar interbody fusion," "TLIF," "minimally invasive transforaminal lumbar interbody fusion," "MIS-TLIF," and "MI-TLIF." The titles and abstracts of all reports were independently reviewed by two researchers (CX and GXL), and full texts of suitable studies were retrieved. Moreover, a manual search was carried out for the reference list of the selected literature, as well as similar literature and previous similar meta-analyses. A list of references of all included target articles was reviewed to identify potentially relevant studies. The language used in the literature was limited to English. The retrieval strategy (eg, PubMed), is provided in supplementary file (Table S1).

Inclusion and Exclusion Criteria

The inclusion criteria for this meta-analysis were as follows: (1) original clinical studies that compared outcomes of MI-TLIF and O-TLIF in patients with obesity and (2) the report data including at least one outcome indicator (perioperative parameters, functional outcomes, and complications).

The following studies were excluded: (1) animal studies, reviews, comments, technique papers, case reports, and cadaver studies; (2) unrelated to TLIF, such as other methods of interbody fusion comparison studies; and (3) studies examining patients who received any surgical intervention in the cervical or thoracic vertebrae.

Data Collection

Patient demographic data, functional outcomes, complications, and other analyzable data were extracted and summarized from the included studies, such as estimated intraoperative blood loss, operative time, length of hospitalization stay, peri- and postoperative complications, and clinical outcomes (visual analog scale [VAS] pain and Oswestry Disability Index [ODI] scores) pre- and postoperatively.

Data Extraction and Quality Assessment

The study design, country, year of publication, duration of the study, clinical outcome, and follow-up time for each surgical group were independently recorded using data extraction forms. The corresponding authors were contacted by e-mail to seek out study details not mentioned in the published versions of their papers. In addition, a quality assessment of

the included observational clinical controlled studies was performed using the Newcastle–Ottawa Quality Assessment Scale (NOS). The scale evaluates studies on the three items of selection, comparability, and exposure. For RCTs, the risk of bias was evaluated using the domain-based Cochrane Collaboration tool. Observational studies were of high quality if they obtained scores of 7–9, whereas RCTs were considered of high quality if they satisfied three or more criteria. In addition, the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) standard recommended by the Cochrane Library was used to evaluate the quality of evidence of the main outcome indicators.

Statistical Analysis

All meta-analyses were conducted using the Review Manager software (RevMan version 5.3, Cochrane Collaboration). The continuous variables were statistically analyzed using weighted mean difference (WMD) or standard mean difference, and dichotomous variables were calculated and analyzed by odds ratio (OR). Noteworthily, for studies that do not provide the mean and standard deviation directly, they were estimated according to the method described by Hozo et al.[28]

The chi-square test was used to test the heterogeneity of the study, and the I^2 statistics was calculated as a reference index. When $P < 0.05$, and $I^2 > 50\%$, the heterogeneity was considered statistically significant. A random-effects or fixed-effects model was used for the meta-analysis. When $I^2 \geq 50\%$ and $P < 0.05$, the combined study showed high heterogeneity. A random-effects model was used for analysis. When $I^2 < 50\%$ and $P > 0.05$, the fixed-effects model was used.[29] Moreover, if a study had significant heterogeneity, a sensitivity analysis was performed, and one study at a time was excluded to check the heterogeneity of the study. Subgroup analyses, performed by reporting the clinical outcomes of the differential diagnosis of segments (single or multiple), were applied to find the source of heterogeneity among the studies. The bias risk in this study was evaluated according to the Cochrane Back Review Group,[30] and because of the insufficient number of studies ($n < 10$), the assessment of publication bias was not applicable. P values < 0.05 were considered statistically significant.

Results

Study Selection

A total of 1422 studies were selected in the preliminary research, including 465 from PubMed, 565 from Web of Science, 331 from Embase, 61 from the Cochrane Library, and 13 from other sources. After reviewing the duplications, 331 duplicate studies were excluded. After cross-browsing the title and abstracts, 37 potential articles were included, and after reading the full text, only six articles were selected. The manually retrieved articles did not include any other studies. This meta-analysis consisted of the remaining six studies[24,31–35] (Figure 1).

Studies based on the inclusion and exclusion criteria were critically evaluated. Among the six included studies, one study[24] was an RCT with CONSORT 22 with a maximum score of 25. Studies with surgical intervention as a random condition may be ethically challenging, making it difficult for subjects to be randomized. Based on the NOS (supplementary file; Table S2), the non-randomized controlled trials involved in this study were considered to be of high quality (5–9 points).[36] Two studies[32,35] received 8/9, two studies[31,34] received 7/9, and the last study[33] received 6/9 (supplementary file; #2). In addition, the GRADE standard quality classification principle showed that low back pain VAS score, ODI index score, and complication rate were medium-quality evidence.

Demographic Results

A total of 654 patients were identified, of whom 273 (41.7%) underwent O-TLIF and 381 (58.3%) underwent MI-TLIF. Of these, 267 (40.8%) were men and 387 (59.2%) were women. There was no difference in demographic characteristics between the two groups. The collected age was 57.29 ± 12.47 years for the O-TLIF group and 54.01 ± 10.78 years for the MI-TLIF group. The pooled BMI was 32.42 ± 5.59 kg/m^2 for the O-TLIF group and 33.33 ± 5.41 kg/m^2 for the MI-TLIF group. The percentage of males in the O-TLIF group was 55.8%, and the percentage of males in the MI-TLIF group was 44.2%. The most common surgical indications were lumbar spondylolisthesis and spinal canal stenosis, which are difficult to treat surgically. Up to 1036 spinal levels were fused. Except for the article by Abbasi et al, the most commonly operated level was at L4/5 (39.3%) and L5/S1 (31.8%), followed by L3/4 (13.8%), L2/3 (9.0%), and L1/2 (6.1%) (Tables 1–3).

Comparison of Perioperative Outcomes

Operative Time

The pooled operative time of the O-TLIF group came from three eligible inclusion studies, involving 304 patients, which was 146.17 ± 99.65 min, whereas the

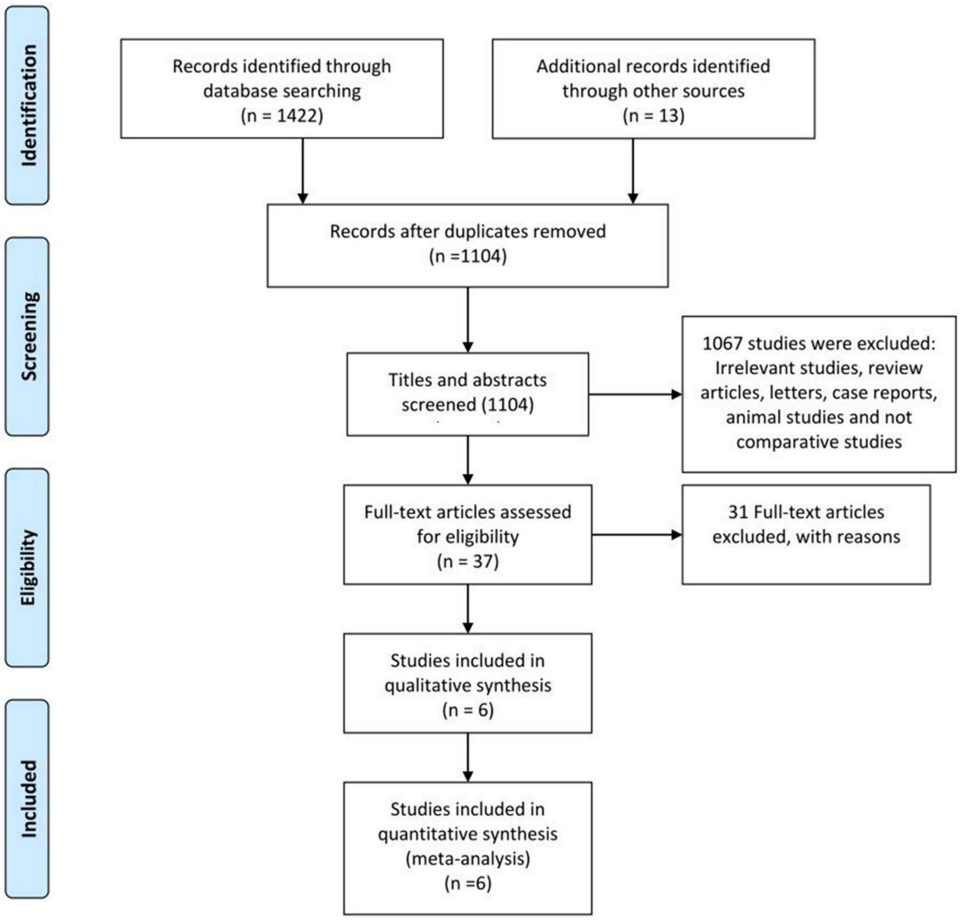

Figure 1 Study selection flow diagram for the meta-analysis.

pooled operative time in the MI-TLIF group, involving 110 patients, was 192.37 ± 114.70 min. Significant heterogeneity could be observed among the studies (I^2 = 85% P = 0.001), the random-effects model was used for analysis, and the results indicated no significant difference in operative time between the two groups (WMD = −13.29 min; 95% CI: −45.18 to 18.59; P = 0.41) (Figure 2A).

Estimate of Intraoperative Blood Loss

Five studies involved estimated intraoperative blood loss, including 374 patients in the O-TLIF group at 302.88 ± 348.06 mL and 241 patients in the MI-TLIF group at 194.36 ± 167.05 mL. Significant heterogeneity was detected among the studies (I^2 = 96%, P < 0.00001), the random-effects model was used for analysis, and the blood loss was significantly lower in the MI-TLIF group than that in the O-TLIF group (WMD = −252.71 mL; 95% CI: −422.55 to −62.87; P = 0.009) (Figure 2B).

Length of Hospital Stay

Four studies reported that the length of hospital stay, including 335 patients in the O-TLIF group, was 3.25 ± 1.41 days, whereas the combined hospitalization of 199 patients with obesity included in the MI-TLIF group was 2.45 ± 1.50 days. At the same time, significant heterogeneity was observed (I^2 = 82%, P = 0.02), and the random-effects model was used for analysis. The length of hospitalization was significantly shorter in the MI-TLIF group (WMD = −1.33 days; 95% CI: −2.19 to −0.48; P = 0.002) (Figure 2C).

Visual Analog Scale (VAS)

Three studies included the visual analog scale (VAS) score, and two studies provided sufficient data on the VAS score of early low back pain (early BP-VAS), with the O-TLIF group including 60 patients with obesity with a score of 3.98 ± 2.99 and the MI-TLIF group including 95 patients with a score of 3.25 ± 2.93. A significant heterogeneity was noted (I^2 = 82%, P = 0.02). Using the random-effects model for combined analysis, no significant difference was observed in the VAS

Table 1 Characteristics of Studies Included in the Meta-Analyses

Study	Study Type	Country	Surgical Approach	Sample	Age(y) (Mean ± SD)	Sex (M/F)	BMI (kg/m2) (Mean ± SD)	Follow-Up (mo)
Lau[31] 2013	Retrospective cohort	USA	MI-TLIF	78	52.2±9.8	38/40	37.4±2.2	1
			O-TLIF	49	57.0±13.2	23/26	38.6±2.6	1
Wang[32] 2014	Prospective cohort	China	MI-TLIF	42	56.4 ± 10.7	13/29	29.5 ± 3.4	36.1 (25–57)
			O-TLIF	39	54.2 ± 9.1	12/27	28.3 ± 2.9	36.1 (25–57)
Terman[34] 2014	Retrospective cohort	USA	MI-TLIF	53	52.4 ± 12.74	24/29	35.2 ± 4.30	31 (6–77)
			O-TLIF	21	58.2 ± 15.11	13/8	33.8 ± 3.70	28 (7–64)
Adowa[35] 2015	Prospective cohort	USA	MI-TLIF	40	56.62 ± 11.69	20/20	34.48 ± 4.39	>24
			O-TLIF	108	56.12 ± 10.68	51/57	35.63 ± 4.74	>24
Serban[24] 2017	Randomized controlled trial	Romania	MI-TLIF	40	51.3±9.36	16/24	28.97±5.18	12
			O-TLIF	40	50.12±11.09	17/23	29.92±5.7	12
Abbasi[33] 2018	Retrospective cohort	USA	MI-TLIF	20	58.21±8.99	NR	28.75±6.34	NR
			O-TLIF	124	59.64±13.00	NR	30.56±5.84	NR

Abbreviations: MI-TLIF, minimally invasive transnormal lumbar interbody fusion; O-TLIF, open transnormal lumbar interbody fusion; NR, not reported; BMI, body mass index; M, male; F, female; mo, month.

score for early postoperative low back pain between the two groups (WMD = −1.17; 95% CI: −3.78 to 1.43; P = 0.38) (Figure 3A).

Two studies mentioned sufficient data from the back pain VAS score on the last follow-up (last BP-VAS), with 147 patients in the O-TLIF group (2.97 ± 3.76 scores) and 82 patients in the MI-TLIF group (2.78 ± 3.44 scores). For the heterogeneity analysis (I^2 = 39%, P = 0.20), fixed-effects model was selected, and a significant difference in the late BP-VAS scores was found between the two groups (WMD = −0.81; 95% CI: −0.41 to 0.06; P = 0.14) (Figure 3B).

Oswestry Disability Index (ODI)

Four articles reported the ODI score of the last follow-up, including 384 patients: 208 patients in the O-TLIF group (27.85 ± 24.81 scores) and 175 patients in the MI-TLIF group (29.53 ± 26.00 scores). A nonsignificant heterogeneity was observed between the two groups (I^2 = 0%, P = 0.85). Therefore, the fixed-effects model was selected for statistical analysis, showing no significant difference in the ODI score between the two groups at the last follow-up (WMD = 0.44; 95% CI: −1.5 to –2.38; P = 0.66) (Figure 3C).

Complications

Five studies reported information regarding perioperative complications, including 510 patients. A total of 257 patients in the O-TLIF group had a complication rate of 19.1%, and 253 patients in the MI-TLIF group had complication rate of 10.7%. A nonsignificant heterogeneity was noted (I^2 = 0%, P = 0.81). The incidence of complications in the MI-TLIF group was significantly lower than that in the O-TLIF group (OR = 0.41; 95% CI: 0.24 to 0.70; P = 0.001) (Figure 4).

Dural Tear

Dural tears and wound infections are the most common complications. The incidence of dural tear in the O-TLIF group was 9.3% and in the MI-TLIF group was 2.8%. A nonsignificant heterogeneity was found (I^2 = 0%, P = 0.81), the fixed-effects model was used for combined analysis, and the dural tear incidence was significantly lower in the MI-TLIF group (OR = 0.24; 95% CI: 0.10 to 0.59; P = 0.002) (Figure 5A).

Wound Infection

According to the combined statistics, the wound infection rate in the O-TLIF and MI-TLIF groups was 3.5% and 4.7%, respectively, the heterogeneity of the two groups was nonsignificant (I^2 = 0%, P = 0.46), and the fixed-effects model was used for combined analysis. No significant difference was observed in the wound infection rate

Table 2 Diagnosis of Included Studies

Study	Surgical Approach	Diagnosis [No. Patients (%)]			
Lau[31] 2013	MI-TLIF	Spondylolisthesis 24 (63.2)	DDD alone 5 (13.2)	DDD w/ stenosis 5 (13.2)	DDD w/ disc herniation 4 (10.5)
	O-TLIF	Spondylolisthesis 11 (47.8)	DDD alone 8 (34.8)	DDD w/ stenosis 3 (13.0)	DDD w/ disc herniation 1 (4.3)
Wang[32] 2014	MI-TLIF	Stenosis 23 (54.8)	Spondylolisthesis 14 (33.3)	Postoperative instability 5 (11.9)	
	O-TLIF	Stenosis 20 (51.3)	Spondylolisthesis 15 (38.5)	Postoperative instability 4 (10.2)	
Terman[34] 2014	MI-TLIF	DDD or spondylosis 10 (19.0)	Disc herniation 3 (6.0)	Spondylolisthesis 32 (60.0)	Stenosis 8 (15.0)
	O-TLIF	DDD or spondylosis 5 (24.0)	Disc herniation 0 (0.0)	Spondylolisthesis 14 (67.0)	Stenosis 2 (10.0)
Adogwa[35] 2015	MI-TLIF	DDD 27 (67.5)	Spondylolisthesis 29 (72.5)		
	O-TLIF	DDD 81 (75.0)	Spondylolisthesis 81 (75.0)		
Serban[24] 2017	MI-TLIF	Spondylolisthesis (Grade I) 19 (47 0.5)	Spondylolisthesis (Grade II) 21 (52.5)		
	O-TLIF	Spondylolisthesis (Grade I) 20 (50.0)	Spondylolisthesis (Grade II) 20 (50.0)		
Abbasi[33] 2018	MI-TLIF	DDD/Spondylolisthesis/Spondylosis/Disc herniation/Stenosis/Scoliosis; Not reported details			
	O-TLIF				

Abbreviations: MI-TLIF, minimally invasive transnormal lumbar interbody fusion; O-TLIF, open transnormal lumbar interbody fusion; DDD, degenerative disc disease.

Table 3 Fused Level of Included Studies

Study	Approach	L1/2 [No. Patients (%)]	L2/3 [No. Patients (%)]	L3/4 [No. Patients (%)]	L4/5 [No. Patients (%)]	L5/S1 [No. Patients (%)]
Lau[31] 2013	MI-TLIF	0 (0.0)	2 (10.5)	4 (21.1)	7 (36.8)	6 (31.6)
	O-TLIF	0 (0.0)	2 (10.5)	4 (21.1)	7 (36.8)	6 (31.6)
Wang[32] 2014	MI-TLIF	0 (0.0)	0 (0.0)	3 (7.1)	21 (50.0)	18 (42.9)
	O-TLIF	0 (0.0)	0 (0.0)	2 (5.1)	20 (51.3)	17 (43.6)
Terman[34] 2014	MI-TLIF	0 (0.0)	1 (2.0)	2 (4.0)	26 (49.0)	24 (45.0)
	O-TLIF	0 (0.0)	2 (10.0)	4 (19.0)	8 (38.0)	7 (33.0)
Adogwa[35] 2015	MI-TLIF	1.0 (2.5)	7.0 (17.5)	7.0 (17.5)	24 (60.0)	21 (52.5)
	O-TLIF	34 (31.5)	38 (35.2)	41 (38.0)	83 (76.9)	62 (57.4)
Serban[24] 2017	MI-TLIF	0 (0.0)	0 (0.0)	2 (5.0)	14 (35.0)	24 (60.0)
	O-TLIF	0 (0.0)	0 (0.0)	2 (5.0)	15 (37 0.5)	23 (57 0.5)
Abbasi[33] 2018	MI-TLIF	Single or multiple levels; but no specific segment information is provided.				
	O-TLIF					

Abbreviations: MI-TLIF, minimally invasive transnormal lumbar interbody fusion; O-TLIF, open transnormal lumbar interbody fusion.

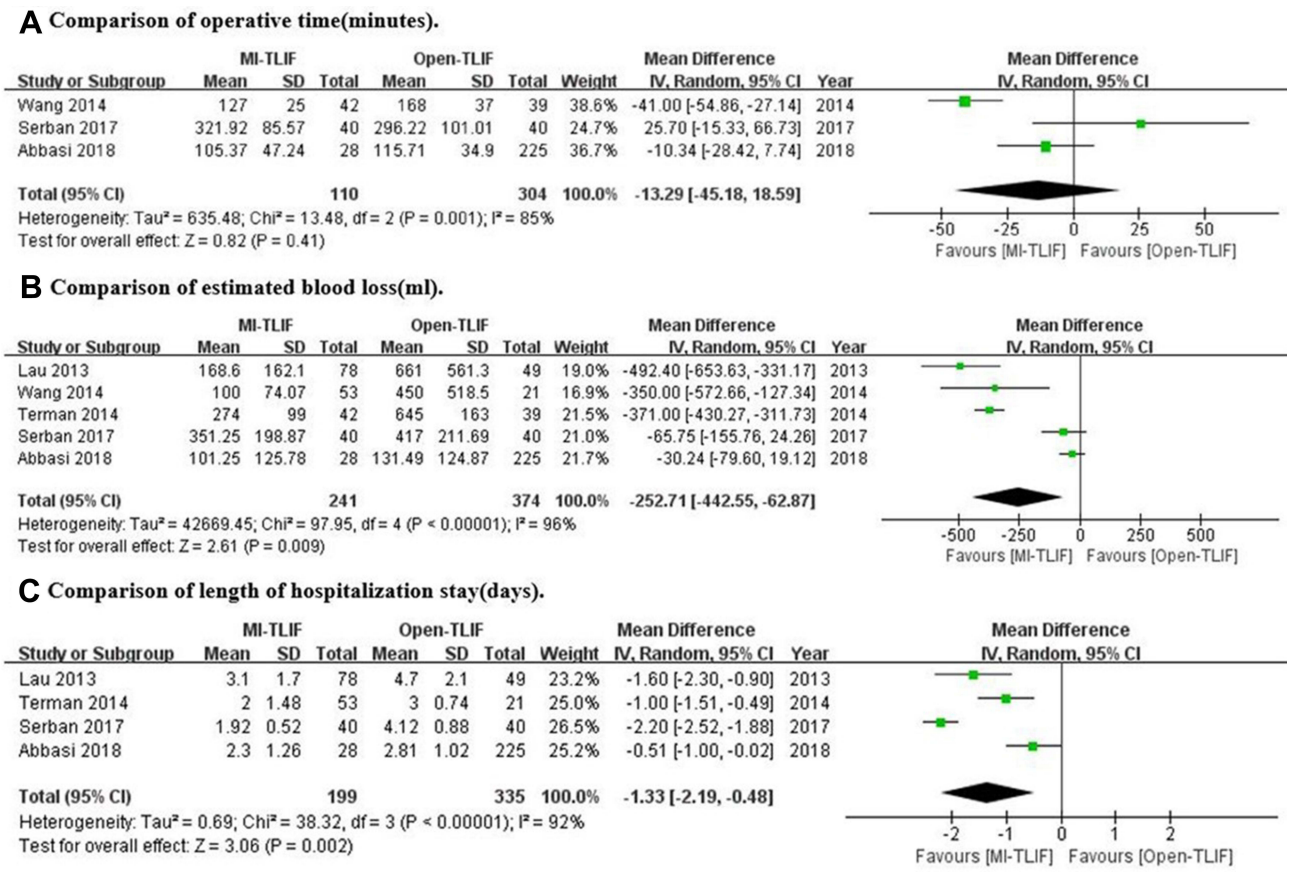

Figure 2 Forest plots comparing of perioperative outcomes. (**A**) Comparison of operative time (minutes), (**B**) comparison of estimated blood loss (mL), (**C**) comparison of length of hospitalization stay (days).

between the two groups (OR = 1.09; 95% CI: 0.45 to 2.62; P = 0.85) (Figure 5B).

Sensitivity Analysis and Publication Bias

In the sensitivity analysis, one experiment was excluded one by one, and the forest plot was not reversed. Switching between the fixed-effects and random-effects models in the merger analysis and sensitivity analysis reduced the bias. In addition, a funnel plot was used to evaluate publication bias. The incidence of complications was used as an indicator of publication bias. Distinct asymmetry is not observed in Figure 6, indicating no risk of bias. However, considering the insufficient number of studies (<10), the results should be treated with caution.

Discussion

Foley et al[37] first described MI-TLIF in 2003, which uses muscle space to split the approach and insert a tubular retractor to reduce soft tissue injury, which is an alternative to the traditional open approach. After continuous verification and development of the concept of MI surgeries, MI-TLIF technology has made great progress.[38] In recent years, some surgeons have summarized the comparison between MI-TLIF and O-TLIF,[39] as well as the comparison of the two procedures in patients with obesity. Therefore, a meta-analysis was carried out to provide more objective and relatively fair results to guide clinical practice.

In this meta-analysis, an extensive literature search was conducted, finally including only six articles that met the inclusion criteria. Nevertheless, the sample size collected was relatively large, data were extracted for statistical analysis, and meaningful results were obtained. The current meta-analysis a nonsignificant difference in operative time between the O-TLIF and MI-TLIF groups and a nonsignificant difference between the VAS and ODI scores after the operation; however, there was less intraoperative bleeding and shorter hospital stay in the MI-TLIF group than that in the O-TLIF. Moreover, the incidence of intraoperative dural tear and total complications in the MI-

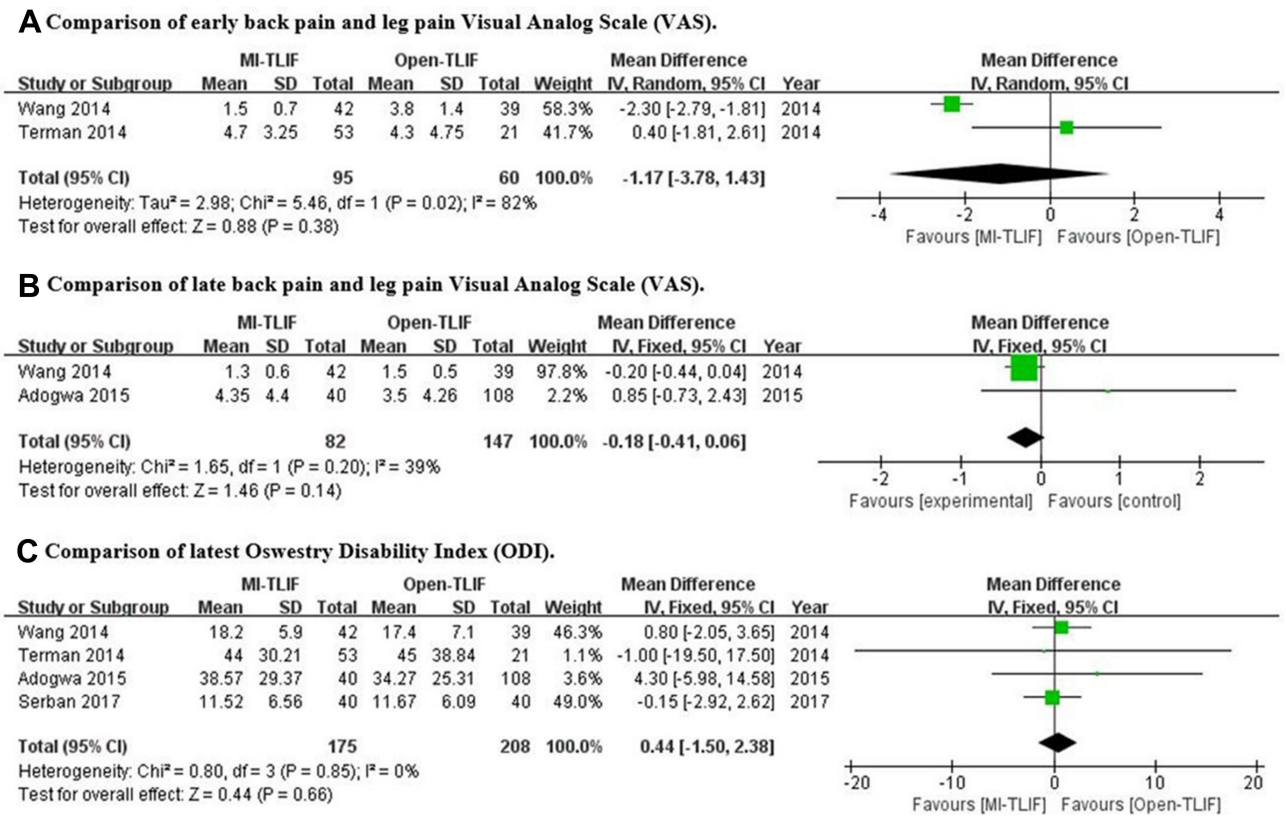

Figure 3 Forest plots comparing final pain outcomes between MI-TLIF and Open-TLIF with (**A**) comparison of early back pain and leg pain Visual Analog Scale (VAS), (**B**) comparison of late back pain and leg pain of VAS, (**C**) comparison of latest Oswestry Disability Index (ODI).

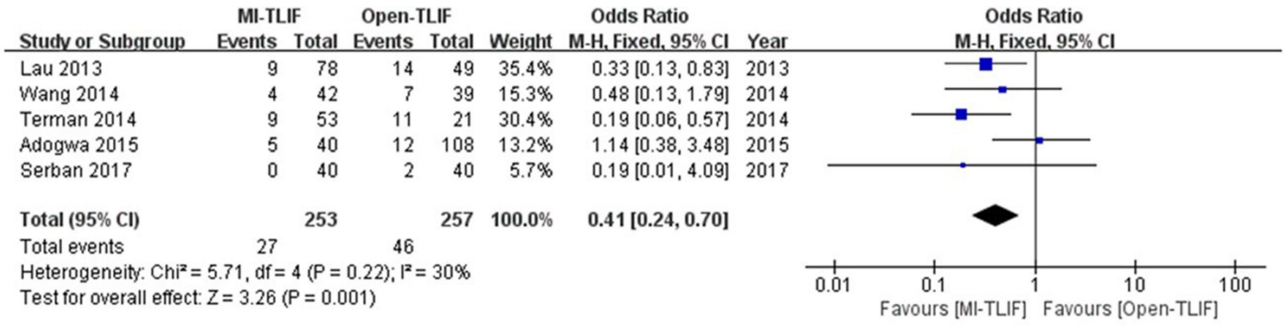

Figure 4 Comparison of the total number of complications.

TLIF group was lower than that in the O-TLIF group, and no significant difference in the incidence of postoperative infection was noted between the two groups. However, there is not enough follow-up information to compare the incidence of long-term complications of O-TLIF and MI-TLIF in patients with obesity. Larger samples and longer follow-up periods are required for further comparison.

Our meta-analysis showed that the estimated intraoperative blood loss and hospitalization stay were shorter in the MI-TLIF group than that in the O-TLIF group, which were roughly the same as those of other studies.[40,41] Regarding the operative time, different results were obtained from most studies, and the difference in operative time between the two groups may not be significant, which is probably due to the fewer studies included and the different learning curves of the doctors included in the study. In this article, Serban et al[24] pointed out that the operative time of MI-TLIF is not superior to that of O-TLIF, or even longer. No significant difference in postoperative VAS and ODI scores were found between the two groups. These two indicators relatively intuitively show the benefits of patients; thus, it can be considered that the two surgical methods improved

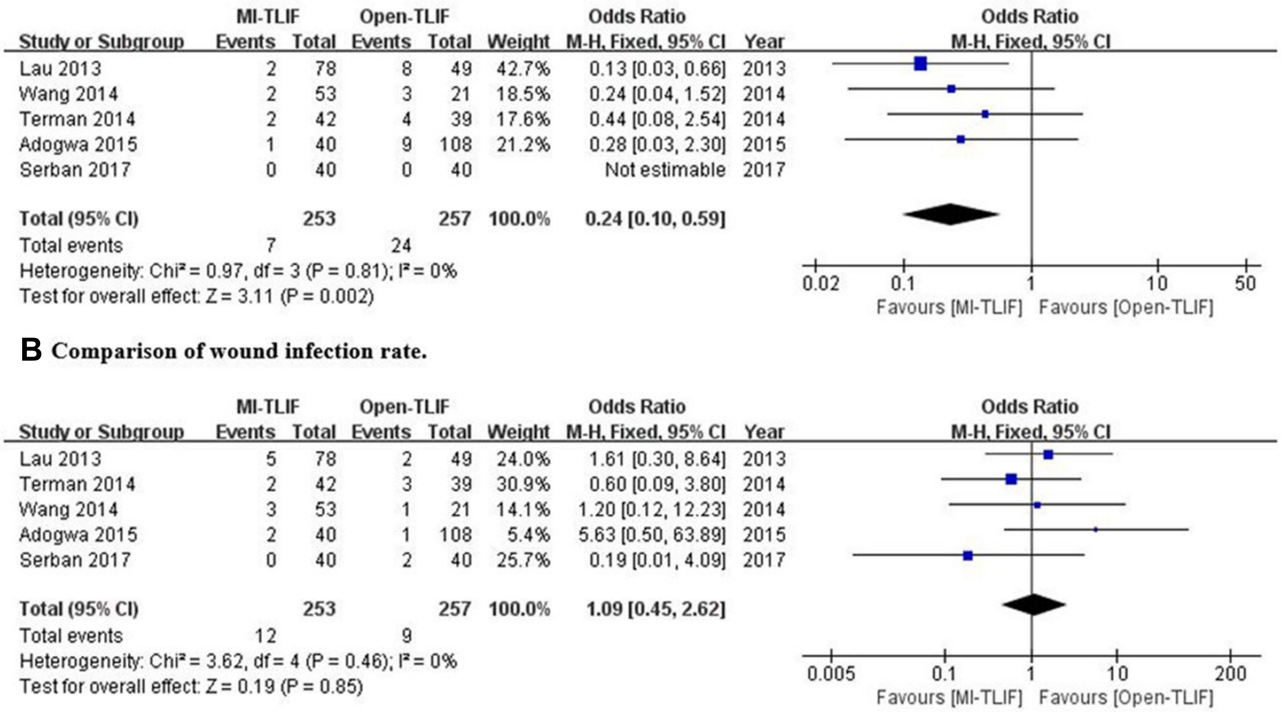

Figure 5 Forest plots comparing complications outcomes between MI-TLIF and Open-TLIF with (**A**) comparison of dural tear rate, (**B**) comparison of wound infection rate.

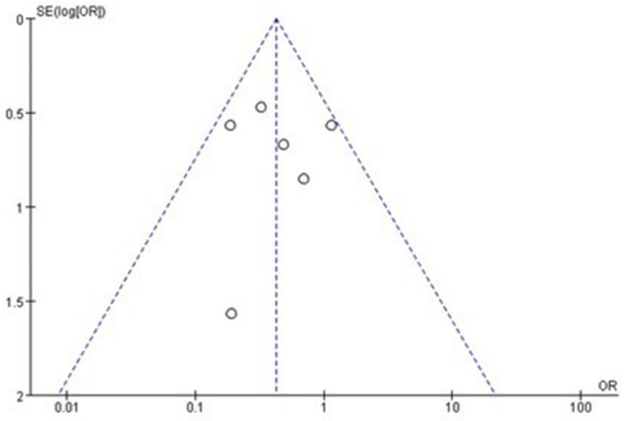

Figure 6 Funnel plot to detect publication bias.

symptoms significantly. At present, the surgical instruments and consumables of MI-TLIF are more expensive; nevertheless, it has notable economic benefits to patients by reducing the length of hospital stay and reducing the incidence of complications. We can draw from the experience that technological innovation and development need social tolerance, and doctors need to comprehensively consider the pros and cons, combined with the actual situation to solve patients' problems.

Some studies[42–44] have confirmed that patients with obesity have a higher risk of complications from O-TLIF than that in patients without obesity. The occurrence of infection may be owing to a thicker subcutaneous fat layer and less blood circulation in patients with obesity, resulting in slower healing. Concurrently, larger incisions in open surgery are more likely to form a dead space, thus increasing the risk of infection and poor vascularization of adipose tissue. It has been confirmed that fat layer thickness is related to the healing time.[45] Several studies[46–50] subdivide patients with obesity into classes I, II, III, and IV. The study and analysis of MI-TLIF surgery showed that more severe obesity may be associated with a higher occurrence of complications, showing that the risk of complications in this population is much higher than that in normal-weight patients. However, the results of our analysis showed that no significant difference in the risk of wound infection was observed in patients with obesity undergoing O-TLIF or MITLIF. Infection, a surgeon's ordeal, remains an important problem to be solved.

Owing to the difference between surgical procedures and instruments, the surgical incision in O-TLIF is larger, the scope of exposure is wider, and the risk of dural tear is higher.[51] Studies have indicated that patients with obesity

still have a higher risk of dural tear than on those with normal weight, regardless of MI or open surgery.[52–54] According to the analysis of the incidence of dural tear after an operation, a significant difference was found between the two surgical methods. The occurrence of a dural tear in the MI-TLIF group was significantly lower than that in the O-TLIF group. However, regarding complications, except for dural tear and wound infection, the MI-TLIF group had a lower incidence of complications, and the difference was statistically significant. According to our meta-analysis, the total number of complications in the MI-TLIF group was significantly lower than that in the O-TLIF group. However, according to the situation of each study, the follow-up period summarized in our current analysis is not long enough, some long-term complications are inevitably ignored, and studies with longer (5- or 10-year) follow-up are expected to be reported.

Moreover, Xie et al[55] published a similar meta-analysis, which included PLIF (Posterior Lumbar Interbody Fusion). The reasons mentioned above limit the quality and credibility of the study. Both Othman et al[40] and Tan et al[41] included four studies to analyze perioperative outcomes, whereas we conducted a combined analysis of six studies. It is noteworthy that our inclusion of Abbasi et al and Lau et al's study only conducted a statistical analysis of the perioperative efficacy and the part that can be combined for analysis was extracted and relatively high-quality credibility was obtained. Using the "one-by-one elimination method" for sensitivity analysis, the results were not reversed, which proved that the results were reliable, but the number of cases in Abbasi et al's study was quite different from that in the TLIF control group (28/225). It is difficult to unify the diagnoses and surgical segments of the patients, and its heterogeneity and statistical rigor are worthy of discussion. Our research was conducted in strict accordance with the Cochrane Handbook, exploring the heterogeneity among the studies as much as possible, fully considering the possible confounding factors, and presenting the research results as objectively as possible.

Only Serban et al[24] reported the fusion rate between the two groups, which were very high and similar. The fusion rate is often a key index to measure spinal fusion surgery; it is also an important factor in determining recurrence and repair rates. Only Lau et al[31] mentioned the cost of patient treatment, and patients hope to obtain a good treatment effect, while considering the cost of treatment, which is an important determinant of patient satisfaction. Recent technologies often need expensive support to develop, and after verifying the efficacy of surgery, they will be further promoted and developed to reduce the cost of surgery and bring well-being to critically ill patients.[56,57] Comparative studies on the fusion rates of MI-TLIF and O-TLIF in patients with obesity are required to further evaluate their efficacy.

Study Limitations

Too few RCTs comparing MI-TLIF and O-TLIF in people with obesity are available. Second, significant heterogeneity was observed in the analysis of some indicators. Wang et al and Serban et al included patients with a BMI <30 kg/m^2. According to the WHO definition of obesity, they are not obese patients, but overweight patients. The comorbidities of patients with obesity often include hypertension, coronary heart disease, diabetes, and kidney disease. Third-degree patients with obesity have a higher risk of venous thrombosis. Of the six studies included in the meta-analysis, the follow-up period in two studies was not long enough (6 months). In addition, unpublished studies were not included because of difficulty in obtaining their data, but no evidence of publication bias was found. Another limitation is the lack of reported data that have been followed up for more than 5 years, which may provide more convincing evidence.

Conclusion

When comparing the results of MI-TLIF and O-TLIF in patients with obesity, the clinical effects were similar in both techniques with regard to the postoperative VAS score and the final ODI score. It was found that MI-TLIF was superior to O-TLIF in terms of complications, incidence of dural tears, estimated blood loss, and shorter hospital stays. However, randomized controlled trials with large samples and long-term follow-up are still lacking, which is necessary to reflect the real value of such a technique.

Abbreviations

BMI, body mass index; BP, back pain; GRADE, Grades of Recommendation, Assessment, Development and Evaluation; NOS, Newcastle-Ottawa Quality Assessment Scale (NOS); MI, minimally invasive; ODI, Oswestry disability index; O-TLIF, open TLIF; OR, odds ratio; PRISMA, preferred reporting item for systematic reviews and meta-analyses; SMD, standard mean difference; TLIF, transforaminal lumbar interbody fusion; VAS, visual analog scale; WHO, World Health Organization; WMD, weighted mean difference.

Acknowledgments

Guang-Xun Lin and Gang Rui are co-corresponding authors.

Funding

This research was funded by the Natural Science Foundation of Fujian Province, grant number 2021J05282; funded by the "Xiamen Health High-Level Talent Training Program".

Disclosure

The authors report no conflicts of interest in this work.

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