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Minimally invasive versus open Transforaminal lumbar Interbody fusion in obese patients: a meta-analysis

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Abstract

Background: Minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) has been employed in increasing cases compared with open TLIF (Open-TLIF). However, it is uncertain whether the advantages of MI-TLIF can also be specifically applied in obese patients. Therefore, the current study was thereby carried out aiming to compare the outcomes of MI-TLIF with those of Open-TLIF in obese patients with lumbar degenerative diseases.

Methods: Electronic databases were systemically retrieved from construction to May 2017. Meanwhile, the odds ratio (OR), mean difference (MD) and 95% confidence intervals (CI) were determined.

Results: A total of 7 observational cohort studies were enrolled into the current meta-analysis. The results indicated that, compared with Open-TLIF group, MI-TLIF could remarkably reduce the operative time ($P = 0.002$), intraoperative blood loss ($P < 0.001$), postoperative drainage ($P = 0.01$), length of stay ($P < 0.001$) and incidence of complications ($P < 0.001$). In addition, MI-TLIF could also lead to markedly lower early back pain-Visual Analog Scale (BP-VAS) score than that of Open-TLIF ($P < 0.001$), but no statistically significant differences were found in Oswestry Disability Index (ODI), late BP-VAS, early leg pain-VAS (LP-VAS) and late LP-VAS scores.

Conclusion: MI-TLIF may be a more preferred choice for obese patients undergoing spinal surgery. However, differences in the long-term functional and pain outcomes between MI-TLIF and Open-TLIF remain a source of controversy, which should be further verified in future randomized-control trials.

Keywords: Transforaminal lumbar interbody fusion, Obese, Lumbar degenerative diseases, Meta-analysis

Background

The economic development and changes in people's work and lifestyle have rendered obesity an independent risk factor of low back pain (LBP), which has become the health care crisis worldwide [1]. According to the National Institutes of Health [2], the obese patients are those with a body mass index (BMI) of over 30 without significant comorbidity. Strikingly, the prevalence of severe obesity has been steadily rising; therefore, the proper surgical management for the severely obese population remains an increasingly important issue.

Currently, spine surgeons are encountered with a new challenge in managing the obese ([BMI] > 30) and morbidly obese (BMI > 35) patients undergoing lumbar spinal fusion surgery, which can be attributed to the poor operative corridors and difficult access to necessary anatomical landmarks [3, 4]. Specifically, obese patients have posed unique technical operative challenges due to the increased complexity and greater complications compared with those in nonobese patients, which may thus result in different association between operative approach and clinical outcomes [5–7]. However, traditional open transforaminal lumbar interbody fusion procedure (Open-TLIF) will result in greater damage to muscle and soft tissue, in the meantime of adding to blood loss and the risk of infection in obese patients with lumbar disc herniation, since it frequently requires extensive line of incision [8, 9]. Fortunately, the minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) technique has emerged within the last decade. MI-TLIF is superior

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to Open-TLIF in its less postoperative pain, less intraoperative blood loss, and shorter length of stay [10, 11].

Systematic evidences have investigated the efficacy of spinal fusion [12–14], laminectomy [15], discectomy [16], and pedicle screw fixation [17] between MI-TLIF and Open-TLIF. However, to the best of our knowledge, no review has analyzed the perioperative, functional, and pain outcomes between MI-TLIF and Open-TLIF in obese population. Consequently, it remains unclear whether MI-TLIF or open-TLIF procedure will result in superior postoperative functional outcomes in treating obese population with degenerative lumbar diseases. Therefore, the current study was thereby carried out aiming to explore which surgical technique was more beneficial for obese patients.

Methods

Retrieval strategy

Electronic databases, including Pubmed, Web of Science, the Cochrane database, China National Knowledge Internet (CNKI) and the Wanfang Database, were systemically retrieved from construction to May 2017 using the following terms, transforaminal lumbar interbody fusion, minimally invasive, TLIF, minimally invasive spine surgery, obesity, obese, body mass index, BMI. and spinal fusion. Specifically, only English-language or Chinese-language citations were taken into account. All pooled analyses were independently conducted by two investigators, and any disagreement was settled by mutual discussion. A flowchart illustrating information identification, screening, eligibility, and the finally enrolled studies was constructed according to *Preferred Reporting Items for Systematic Reviews and Meta-analyses* (PRISMA) guidelines [18]. The current systematic review was not registered, and no protocol was available. Moreover, the meta-analysis was checked using the terms presented in the PRISMA list (Additional file 1: Table S1).

Selection criteria

The study inclusion criteria were as follows: (i) study with the minimum sample size in each group of 10; (ii) study including a comparative design (MI-TLIF versus open-TLIF); (iii) studies mentioning at least one of the following outcomes: operative time, blood loss, postoperative drainage, length of stay, complications, and pre- and postoperative functional and pain scores assessed by Oswestry Disability Index (ODI) and visual analog scale (VAS); (iv) study enrolling the population of adult patients classified as obesity; and (v) comparative study (randomized controlled trial (RCT), cohorts, case-controls and observational studies). Specifically, obesity was defined as a BMI of > 30 kg/m2 [19]. Exclusion criteria were as follows: (i) review articles, editorial comments, meta-analyses; duplicated studies and guidelines, (ii) study with the sample size in each group of less than 10, and (iii) study with no placebo agent control group.

Data extraction

Data were extracted by two reviewers independently. Any disagreement between the two reviewers in data extraction was settled by the opinion of a third reviewer. Briefly, the following information was extracted from the trials: study design, patient demographics, performed interventions, outcomes of interest, statistical methods, and study results. Moreover, for dichotomous outcomes, the number of participants experiencing the outcome and the number assessed in each treatment group were recorded.

Study outcomes

In the current meta-analysis, the primary outcomes were mean improvements in back and/or leg pain Visual Analog Scale (VAS) scores, and mean improvement in Oswestry Disability Index (ODI) score. Outcomes were categorized into early (≤6 months after surgery) and late (≥ 1 year after surgery) [12] depending on the above 2 primary outcomes at the end of follow-up. In addition, secondary outcomes include operative time, intraoperative blood loss, postoperative drainage, length of stay (LOS), and number of complications.

Quality assessment

Two authors had independently assessed the quality of each trial to evaluate the risk of bias in the included studies. Meanwhile, the quality of nonrandomized studies was evaluated using the Newcastle–Ottawa Scale (NOS), discriminating between case-control trials and cohort studies [20]. NOS is a scale recommended by the Cochrane Non-Randomized Studies Methods Working Group. NOS will address 3 areas when analyzing case-control trials, including selection, comparability and exposure. In comparison, it will deal with selection, comparability and outcome in cohort studies. Specifically, a quality score of 0–9 points is allocated to each nonrandomized study, and those achieving ≥7 points are considered to be of high quality. Notably, such scale had been developed for application in systematic reviews and meta-analyses.

Statistical analysis

Dichotomous and continuous variables were analyzed using odds ratios (ORs) and mean differences (MDs) [21]. Meanwhile, inter-study heterogeneity was assessed using Cochran's Q-statistic test and heterogeneity between the studies included was evaluated using chi-square test, with a $P < 0.05$ indicating significant

heterogeneity. The random effects model would be employed in the presence of heterogeneity between studies, which would provide a more conservative effect than the fixed-effects model [22]. In addition, sensitivity analysis would also be performed in the case of heterogeneity by eliminating one study at a time, so as to check for the resolution of heterogeneity. Besides, the publication bias was assessed using the visual funnel plot [23]. Data were analyzed using the Review Manager (RevMan version 5.3; Cochrane Collaboration, Oxford, UK).

Results

Study selection

A total of 647 potential trials were identified in the initial retrieval strategy, among which, 431 duplicates were eliminated. Meanwhile, some additional studies were excluded based on the inclusion criteria. Meanwhile, altogether 33 citations were retrieved for detailed evaluation of the full text, 26 of which were excluded due to their nature of case series and review articles or without the involvement of obese patients. Finally, 7 observational studies were identified in the final analysis [24–30]. All studies were identified and the number of studies subsequently included or excluded was illustrated as a flow chart (Fig. 1).

Characteristics of trials

One out of the 7 identified studies was prospective comparative study, whereas the remaining 6 were retrospective comparative studies. A total of 638 patients were enrolled in the identified observational studies, which were published between 2013 and 2017. The NOS was employed to evaluate the quality of nonrandomized studies, among which, a majority were considered to be of moderate quality. The detailed information of the enrolled studies was presented in Tables 1 and 2.

Visual analog scale (VAS)

Altogether 4 studies [26, 28–30] harbored sufficient data about the early back pain-visual analog scale (BP-VAS) scores (≤6 months after surgery) and 3 [24, 27, 28] mentioned sufficient data regarding the late BP-VAS scores(≥ 1 year after surgery). Moreover, 2 studies [26, 30] covered enough data on the early leg pain-visual analog scale (LP-VAS) scores (≤6 months after surgery) and 1 [24] on the late LP-VAS scores (≥ 1 year after surgery). Meanwhile, no differences were founded in late BP-VAS,

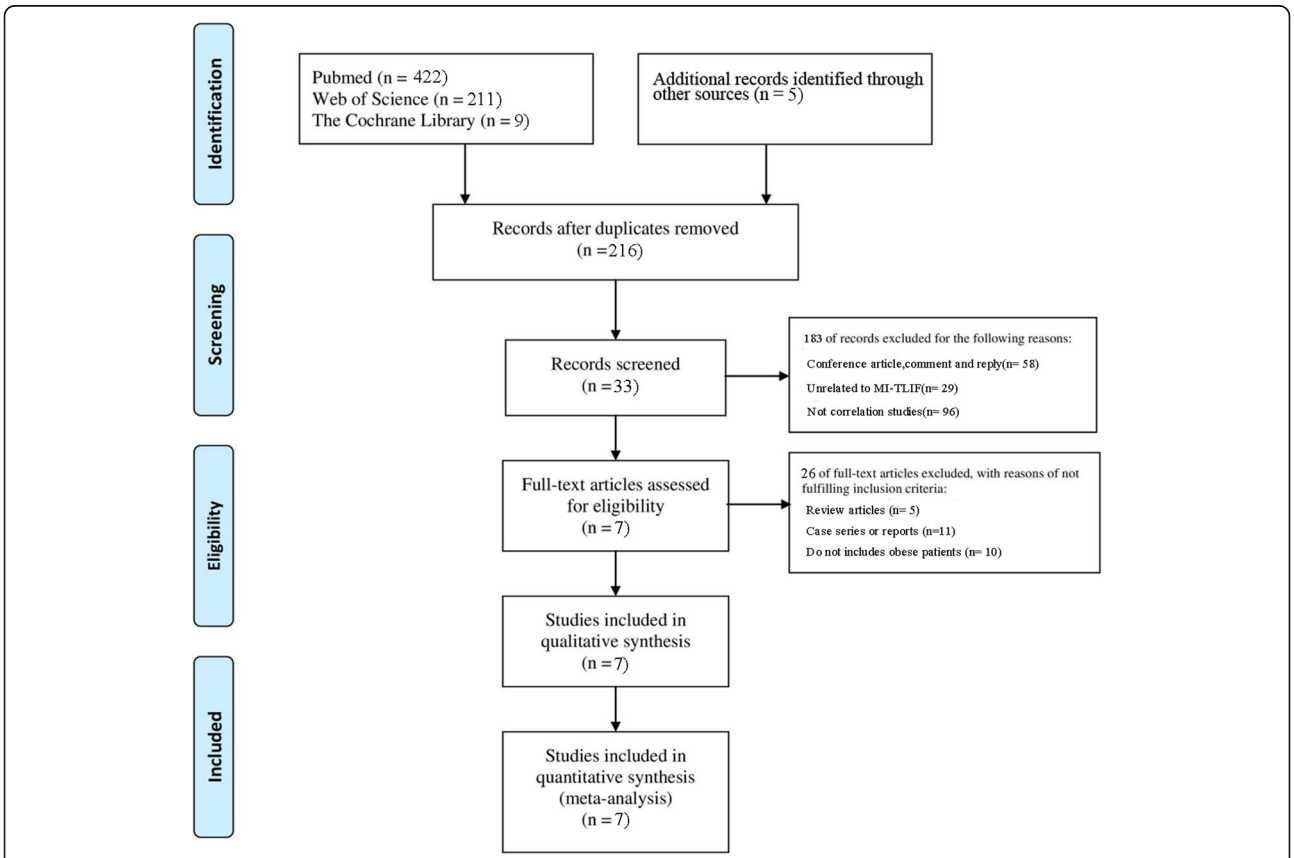

Fig. 1 Study selection flow diagram for the meta-analysis

Table 1 Characteristics of studies included in the meta-analyses

Study	Study design	No. of patients (MI: Open)	Mean follow up (mo)	Meanage (y) (MI: Open)	Gender (% male) (MI: Open)	Mean BMI (kg/m2) (MI: Open)	Diagnosis	NOS score
Adogwa [24], USA	retrospective cohort study	40/108	24	56.62/56.12	50/47	34.48/35.63	DDD, Spondylolisthesis	7
Wang [29], China	retrospective cohort study	35/37	6	51.3/52.3	54/68	34.8/33.7	LDP	6
Lau [25], USA	retrospective cohort study	78/49	NP	50.5/57.4	46.2/42.1	36.9/37.2	spondylolisthesis, DDD, LDH, stenosis, deformity	7
Wang [28], China	prospective cohort study	42/39	36.1	56.4/54.2	69.1/69.2	29.5/28.3	spondylolisthesis,	6
Terman [27], USA	retrospective cohort study	53/21	30	52.4/58.2	45/62	35.2/33.8	spondylolisthesis, DDD, stenosis, LDH	7
Zhang [30], China	retrospective cohort study	32/24	6	42/45	41/39	31.3/33.2	LDH	5
Mao [26], China	retrospective cohort study	46/33	6	40.8/43.3	41.3/36.3	32.8/33.6	LDH	5

DDD Degenerative disc disease, *LDH* Lumbar disc herniation, *NOS* Newcastle Ottawa Scale, *MI* Minimally invasive surgery, *Open* Open surgery, *NP* Not provided, *mo* Month, *y* Year

early LP-VAS or late LP-VAS scores between two groups. However, significant differences were found in early BP-VAS (MD = − 1.09; 95%CI = − 1.98, − 0.21; $p = 0.02$) between MI-TLIF and Open-TLIF groups. Furthermore, significant heterogeneity was detected among the studies only in the early BP-VAS group (I2 = 90%, $P < 0.001$). (Fig. 2).

Oswestry disability index

In total, 3 studies [26, 29, 30] covered sufficient data on the early ODI scores(≤6 months after surgery) and 3 [24, 27, 28] on the late ODI scores(≥ 1 year after surgery). No differences were founded in early ODI or late ODI. At the same time, significant heterogeneity was observed among the studies only in the early ODI group (I2 = 100%, $P < 0.001$). (Fig. 3).

Operative time

In total, 5 studies [26–30] mentioned enough information on the estimated operative time. The pooled results indicated that patients undergoing MI-TLIF had less operative time (MD = − 104.2; 95%CI = − 169.63, − 38.76; $p = 0.002$), and the difference was statistically significant. Meanwhile, significant heterogeneity was also observed among the studies (I2 = 98%, $P < 0.001$). (Fig. 4).

Intraoperative blood loss

Five studies [25, 26, 28–30] covered enough information on the estimated intraoperative blood loss. The pooled results demonstrated that patients receiving MI-TLIF had less intraoperative blood loss (MD = − 317.97; 95%CI = − 381.08, − 254.80; $p < 0.001$), with the difference being statistically significant. In the meantime, significant heterogeneity was detected among the studies (I2 = 94%, $P < 0.001$). (Fig. 4).

Postoperative drainage

Two studies [28, 29] had sufficient data on the estimated postoperative drainage. The pooled results suggested that patients experiencing MI-TLIF had less postoperative drainage (MD = − 230.97; 95%CI = − 412.26, − 49.67; $p < 0.001$), and the difference was statistically significant. Also, significant heterogeneity could be observed among the studies (I2 = 99%, $P < 0.001$). (Fig. 4).

Length of stay (LOS)

Five studies [25–27, 29, 30] reported the LOS. The pooled results indicated that patients receiving MI-TLIF had shorter LOS (MD = − 2.85; 95%CI = − 4.08, − 1.61; $p < 0.001$), and the difference was statistically significant. Significant heterogeneity was also detectable among the studies (I2 = 92%, $P < 0.001$). (Fig. 4).

Complications

All the 7 trials had reported the incidence of complications in the MI-TLIF group and Open-TLIF group of 9.5% (31/327) and 16.7% (52/311), respectively. Notably, patients undergoing MI-TLIF had markedly lower rates of complications (OR 0.42; 95% CI 0.25–0.68; $p < 0.001$). There was no heterogeneity among the selected studies evaluating the clinical treatment ($I^2 = 5\%$, $P = 0.39$). (Fig. 5).

Table 2 Summary of MI-TLIF and O-TLIF Studies Eligible for Analysis

Study	Complication(s)		Measures of Functional and Pain Outcomes		Operative Time (min),Blood Loss(ml), LOS (d),and Postoperative drainage(ml)	
	MI-TLIF	Open-TLIF	MI-TLIF	Open-TLIF	MI-TLIF	Open-TLIF
Adogwa [24], USA	5(2 surgical-site infection; 1 Spinal cord/nerve root injury; 1 Durotomy;1 Hardware failure)	12(1 surgical-site infection; 1 Spinal cord/nerve root injury; 9 Durotomy;1 adjacent segment disease)	BP-VAS(1 year,2 year) = 2.62 ± 3.82,2.42 ± 3.81; LP-VAS(1 year,2 year) = 3.35 ± 4.77,3.77 ± 4.53; ODI(1 year,2 year) = 17.09 ± 26.73,11.61 ± 25.52	BP-VAS(1 year,2 year) = 3.50 ± 3.70,2.33 ± 3.67; LP-VAS(1 year,2 year) = 3.03 ± 4.34,2.67 ± 4.10; ODI(1 year,2 year) = 18.43 ± 22.41,14.88 ± 22.1	NP	NP
Wang [16], China	0	3(2 fat liquefaction;1 infection)	BP-VAS(3mo,6mo) = 1.6 ± 0.9, 1.0 ± 0.4; ODI(3mo,6mo) = 19.9 ± 3.0, 17.1 ± 2.3	BP-VAS(3mo,6mo) = 2.4 ± 1.2,1.8 ± 0.5; ODI(3mo,6mo) = 20.8 ± 1.0, 16.5 ± 2.2	Time = 152 ± 56; BL = 136 ± 18; LOS = 4.7 ± 1.2; PD = 52 ± 10	Time = 103 ± 31; BL = 364 ± 23; LOS = 8.6 ± 3.1; PD = 375 ± 26
Zhang [30], China	2fat liquefaction	2fat liquefaction	BP-VAS(5d) = 2.11 ± 1.25; LP-VAS(5d) = 1.86 ± 1.11; ODI (5d) = 15.9 ± 1.23	BP-VAS(5d) = 2.8 ± 1.6; LP-VAS(5d) = 2.3 ± 1.9; ODI (5d) = 2.4 ± 1.1	Time = 118 ± 26; BL = 126 ± 49; LOS = 6 ± 2.7	Time = 188 ± 41; BL = 430 ± 76; LOS = 10 ± 4.2
Mao [26], China	3fat liquefaction	3(1dural laceration,2fat liquefaction)	BP-VAS(5d,3mo,6mo) = 2.09 ± 1.23, 1.39 ± 0.23, 0.39 ± 0.13; LP-VAS(5d,3mo,6mo) = 1.78 ± 1.03,1.09 ± 1.03, 0.46 ± 0.21; ODI(5d,3mo,6mo) = 27.3 ± 3.01, 15.9 ± 1.23, 7.2 ± 0.98	BP-VAS(5d,3mo,6mo) = 2.6 ± 1.40, 1.78 ± 0.33, 1.09 ± 0.13; LP-VAS(5d,3mo,6mo) = 2.3 ± 1.90,1.79 ± 0.23, 0.89 ± 0.12; ODI(5d,3mo,6mo) = 30.2 ± 2.01, 18.2 ± 2.21, 12.2 ± 0.92	Time = 120 ± 28.26; BL = 110.83 ± 50.51; LOS = 5 ± 2.5	Time = 200 ± 43.05; BL = 420 ± 86; LOS = 9.3 ± 3.4
Wang [28], China	4(2 Superficial wound infection 2 Dural tear)	7(4 Superficial wound infection 3 Dural tear)	BP-VAS (1 day,30mo) = 1.5 ± 0.7, 1.3 ± 0.6; ODI (30mo) = 18.2 ± 5.9	BP-VAS (1 day,30mo) = 3.8 ± 1.4, 1.3 ± 0.6; ODI (30mo) = 17.4 ± 7.1	Time = 127 ± 25; BL = 274 ± 99; PD = 52 ± 23	Time = 168 ± 37; BL = 645 ± 163; PD = 190 ± 84
Terman [27], USA	9(1 cardiopulmonary; 2 durotomy; 1 K-wire fracture; 2 urinary tract infection; 1pneumonia;1 ileus; 1 urinary retention)	11(3durotomy; 5 excessive blood loss; 1 seroma; 1 wound infection;1 urinary retention)	BP-VAS (30mo) = 2.4 ± 2.35; ODI (30mo) = 15 ± 23.3	BP-VAS (30mo) = 2.8 ± 2.087;ODI (30mo) = 13 ± 21.969	Time = 100 ± 25; LOS = 2 + 0.5;	Time = 550 ± 175;LOS = 3.25 + 0.25;
Lau [25], USA	9(2 durotomy 1 fractured K-wire in L-5 vertebral body 1 wound dehiscence atrial fbrillation w/ rapid ventricular 1response 2 UTI(urinary tract infection) 1 tachycardia associated w/ respiratory failure 1 deep vein thrombosis)	14(8 durotomy 1valium w/drawal 1development of seroma 1reoperation for screw revision 1 UTI (urinary tract infection) 1 tachycardia associated w/ respiratory failure; 1 wound infection)	NP	NP	BL = 168.6 ± 162.1; LOS = 3.1 ± 1.7;	BL = 661.0 ± 561.3; LOS = 4.7 ± 2.1

BP-VAS Back pain-visual analog scale, *LP-VAS* Leg pain-visual analog scale, *ODI* Oswestry disability index, *BL* Blood Loss, *LOS* Length of stay, *PD* Postoperative drainage, *MI-TLIF* Minimally invasive transforaminal lumbar interbody fusion surgery, *Open-TLIF* Open transforaminal lumbar interbody fusion surgery, *NP* Not provided

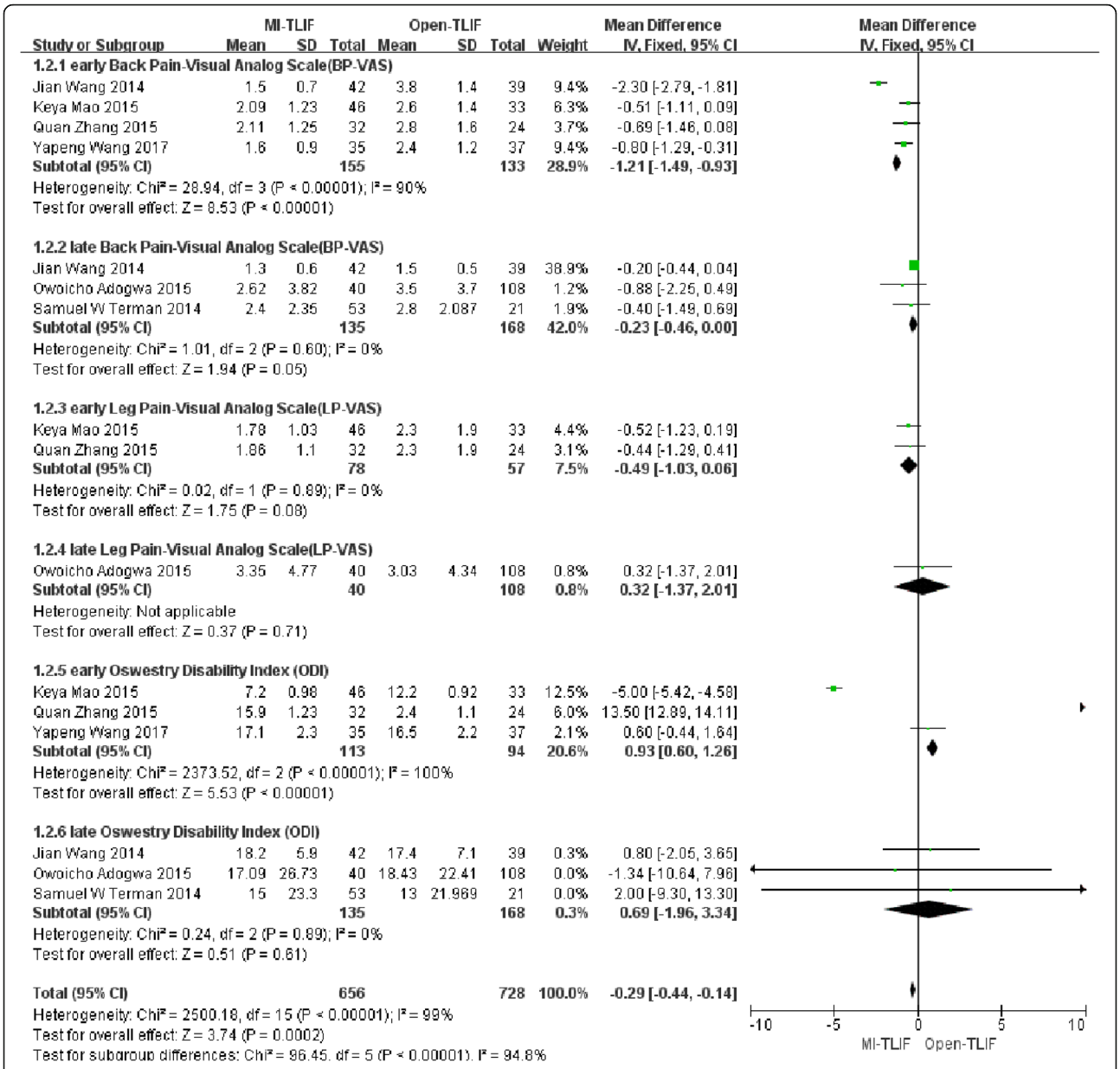

Fig. 2 Forest plots comparing final pain outcomes between minimally invasive and open spinal fusion treatments with (1) early back pain-visual analog scale (BP-VAS), (2) late BP-VAS, (3)early leg pain-visual analog scale(LP-VAS) and (4) late LP-VAS

Sensitivity analysis and publication bias

Sensitivity analysis was performed through randomly excluding one trial as well as interchanging the fixed-effects model with the random-effects model from pooled analysis. The outcomes were confirmed to be stable upon sensitivity analysis. Meanwhile, publication bias was assessed using funnel plots. Specifically, complication was treated as an exemplary indicator for publication bias assessment. No distinct asymmetry could be observed from the shape of funnel plot, suggesting no proof of publication bias. (Fig. 6).

Discussion

It is demonstrated in the current meta-analysis that, obese patients undergoing MI-TLIF have experienced shorter operative time, less intraoperative blood loss, less postoperative drainage, and shorter LOS than those in Open-TLIF group. Moreover, our study also discovers that MI-TLIF can reduce the early BP-VAS score compared with Open-TLIF. However, no differences are founded in ODI, late BP-VAS, early LP-VAS and late LP-VAS scores. Furthermore, MI-TLIF therapy can also evidently decrease the complication rates.

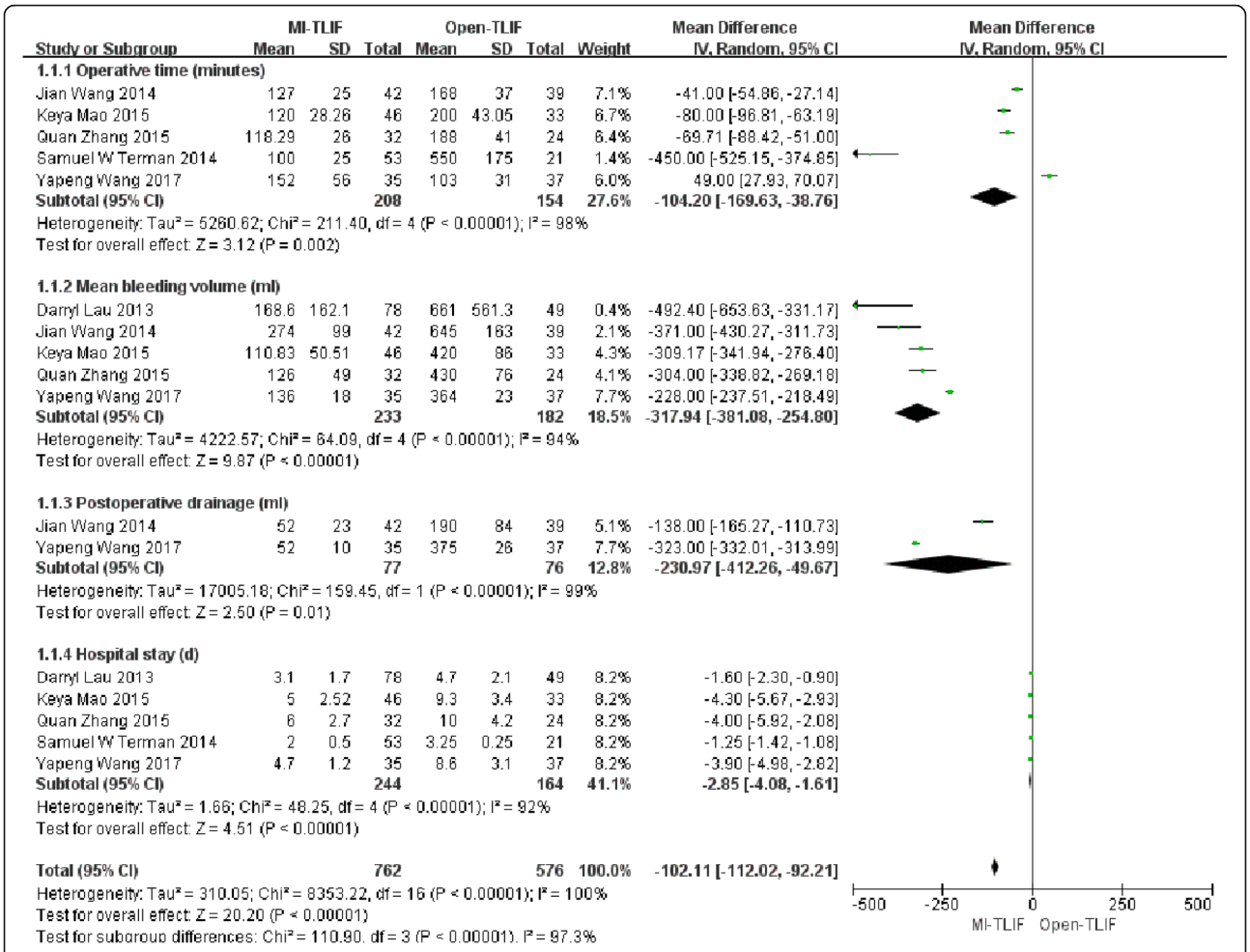

Fig. 3 Forest plots comparing final functional outcomes between minimally invasive and open spinal fusion treatments with (1) early oswestry disability index (ODI) and (2) late ODI

Additionally, this review also suggests marked reduction in operative time and LOS in patients receiving MI-TLIF, which is consistent with systematic reviews [12–14] reporting lumbar disease in general. For instance, Lee et al. [31] and Schizas et al. [32] had indicated markedly decreased operative time accompanied by the increase in number of MI-TLIFs performed. However, several studies have reported a trend of longer operative time for MI-TLIF group [33–35]. Such inconsistency may be ascribed to the fact that MI-TLIF is a more technically demanding procedure in the limited space. In addition, spine surgeons have accumulated their experience with the growingly popular MI procedure, thus resulting in less reported operative time. Moreover, the less blood loss and postoperative drainage may benefit from the less muscle damage in MIS-TLIF than in Open-TLIF. Obese patients undergoing MI-TLIF can initiate the off-bed activity early, which is highlighted by the following reasons. Firstly, there is less spinal muscle atrophy and blood supply disturbances in MI-TLIF than those observed in Open-TLIF. Secondly, smaller incision and less retraction may promote faster recovery, which is particularly applicable for those with hematologic and immune-related conditions who especially benefit from less blood loss and less infection exposure risk. In addition, MI-TLIF therapy has outstandingly reduced the complication rates, which is consistent with the results reported by Khan in 2015 [12]. In fact, the difference in complication rates becomes increasingly pronounced with the increase in obesity [25], which may be mainly related to the decreased infection and lower blood loss [27, 28].

In terms of the functional and pain outcomes, this review demonstrates that MI-TLIF can only reduce the early BP-VAS score when comparing the ODI and VAS measures. In contrast, Goldstein et al. [13] and Tian et al. [14] noted a trend toward more marked improvements in VAS and ODI for MI-TLIF at long-term follow-up. However, normal weight patients were also enrolled in their trails. Similar to our findings, Lu et al.

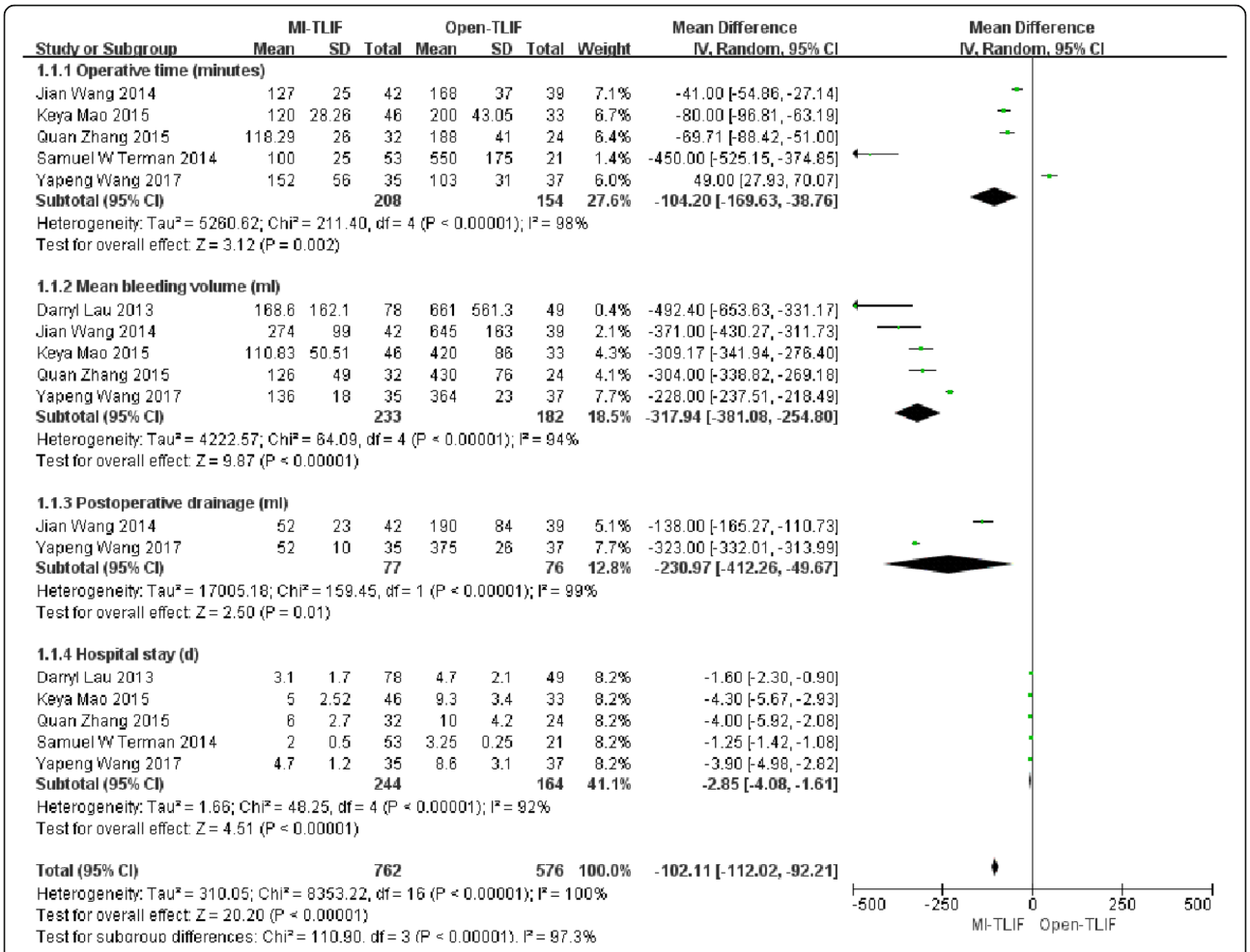

Fig. 4 Forest plots comparing perioperative outcomes between minimally invasive and open spinal fusion treatments for (1) operative time (minutes), (2) intraoperative blood loss (mL), (3) postoperative drainage and (4) length of stay (days)

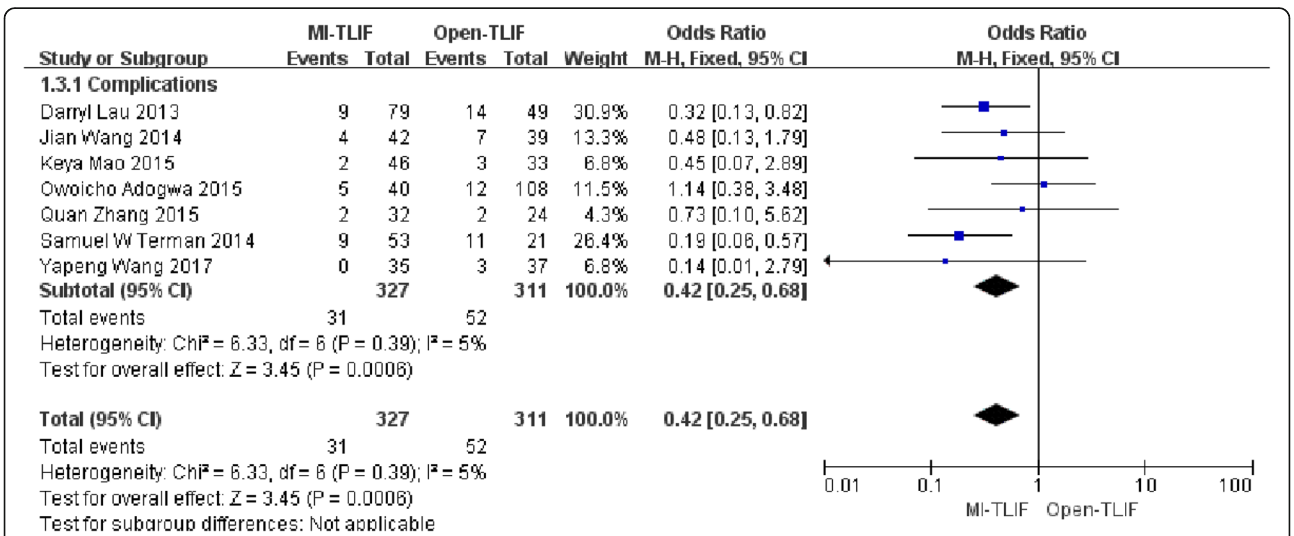

Fig. 5 Forest plot comparing complications between minimally invasive and open spinal fusion treatment

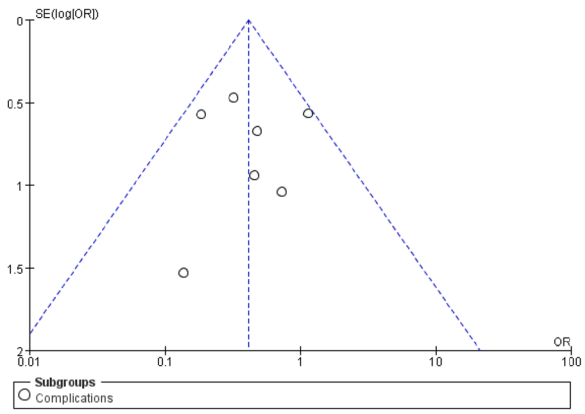

Fig. 6 Funnel plot to detect publication bias. No significant funnel asymmetry that could indicate publication bias was observed

[36] reported no obvious overall difference between MI-TLIF and Open-TLIF in terms of functional and pain outcomes (≥12 mo). Nevertheless, the early VAS and early ODI (≤6mo) were not analyzed in their research. In our study, no more prominent improvement can be observed in early BP-VAS score after MI-TLIF, which is also limited by the low number of studies enrolled. Therefore, we propose that early and late VAS and ODI scores should also be included as standard reported measures of outcomes for future studies defining these important patient-reported variables.

Nonetheless, the current study is inevitably associated with certain limitations. Firstly, all the included studies are observational trials and no RCT is enrolled in this analysis, which is responsible for the low level of evidence for this meta-analysis. Secondly, heterogeneity can be observed in some of the analyses, and efforts have been made to determine the cause using sensitivity analysis. Thirdly, 4 of the 7 studies enrolled in the meta-analysis do not carry out follow-up for a long enough period. Additionally, unpublished studies are not included because of the difficulty in accessing their data, but no evidence of publication bias is observed in the results.

Conclusion

In conclusion, findings in current study demonstrate that MI-TLIF is associated with shorter operative time, less intraoperative blood loss, less postoperative drainage, fewer complications and shorter LOS in obese patients, despite of the above limitations. MI-TLIF can lower the early BP-VAS score; nevertheless, the long-term functional and pain outcomes are similar between MI-TLIF and Open-TLIF groups. Therefore, large double-blind and randomized-control trials are required to evaluate the safety, efficacy and quality of life in obese patients following lumbar spinal fusion surgery.

Additional file

Additional file 1: Table S1. The detail of Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist. (DOC 64 kb)

Abbreviations

BMI: Body mass index; BP-VAS: Back pain-Visual Analog Scale; CI: Confidence interval; CNKI: China National Knowledge Internet; LOS: Length of stay; MD: Mean difference; MI-TLIF: Minimally invasive transforaminal lumbar interbody fusion; NOS: Newcastle–Ottawa Scale; ODI: Oswestry Disability Index; Open-TLIF: Open transforaminal lumbar interbody fusion surgery; OR: Odds ratio

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Availability of data and materials

The datasets supporting the conclusions of this article are included within the article.

Authors' contributions

Conceived and designed the analysis: QSX JZ. Performed the analysis: QSX JZ FL HW. Revised the paper/Analysis tools: QSX JZ FL HW ZC FZJ. Wrote the paper: QSX. All authors read and approved the final manuscript.

Ethics approval and consent to participate

No ethical approval or patient consent was required because all analyses were based on previous published studies.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

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