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An updated meta-analysis of clinical outcomes comparing minimally invasive with open transforaminal lumbar interbody fusion in patients with degenerative lumbar diseases

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Abstract

Background & Aims: Open-transforaminal lumbar interbody fusion (O-TLIF) is regarded as the standard (S) approach which is currently available for patients with degenerative lumbar diseases patients. In addition, minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) has proposed and gradually obtained popularity compared with O-TLIF procedures due to its beneficial outcomes in minimized tissue injury and quicker recovery. Nonetheless, debates exist concerning the use of MI-TLIF with its conflicting outcomes of clinical effect and safety in several publications. The purpose of the current study is to conduct an updated meta-analysis to provide eligible and systematical assessment available for the evaluation of the efficacy and safety of MI-TLIF in comparison with O-TLIF.

Methods: Publications on the comparison of O-TLIF and MI-TLIF in treating degenerative lumbar diseases in last 5 years were collected. After rigorous reviewing on the eligibility of publications, the available data was further extracted from qualified trials. All trials were conducted with the analysis of the summary hazard ratios (HRs) of the interest endpoints, including intraoperative and postoperative outcomes.

Results: Admittedly, it is hard to run a clinical RCT to compare the prognosis of patients undergoing O-TLIF and MI-TLIF. A total of 10 trials including non-randomized trials in the current study were collected according to our inclusion criteria. The pooled results of surgery duration indicated that MI-TLIF was highly associated with shorter length of hospital stay, less blood loss, and less complications. However, there were no remarkable differences in the operate time, VAS-BP, VAS-LP, and ODI between the 2 study groups.

Conclusion: The quantitative analysis and combined results of our study suggest that MI-TLIF may be a valid and alternative method with safe profile in comparison of O-TLIF, with reduced blood loss, decreased length of stay, and complication rates. While, no remarkable differences were found or observed in the operate time, VAS-BP, VAS-LP, and ODI. Considering the limited available data and sample size, more RCTs with high quality are demanded to confirm the role of MI-TLIF as a standard approach in treating degenerative lumbar diseases.

Abbreviations: HRs = hazard ratios, MeSH = Medical Subject Heading, MIS-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion, TLIF = transforaminal lumbar interbody fusion.

Keywords: degenerative lumbar diseases, meta-analysis, minimally invasive, transforaminal lumbar interbody fusion

1. Introduction

Degenerative lumbar spine disease is a chronic and progressive disease associated with radiating pain or paresthesias down the lower extremities, low back pain, decreased function of the legs, neurogenic claudication, or bowel and bladder incontinence.[1] Patients with the disease should seek surgical intervention if the conservative treatments fail.[2–5]

The most common surgical management to achieve both decompression of the neural elements and bony stabilization benefit is the standard (S) transforaminal lumbar interbody fusion (TLIF)[6] which was initially developed by Harms and Rolinger in 1982.[7] TLIF has superior advantage in decompressing both central and interbody fusion through a single posterior approach.[8]

Beneficial outcomes have been obtained through the use of traditional open TLIF, even though it often requires a long and midline incision with dissection of bilateral paraspinal soft tissue as well as the posterior tension band for surgical exposure.[9,10]

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However, multiple studies have reported the destructive disadvantages of the extensive muscle dissection, protracted hospital stays, and postoperative complications associated with traditional open TLIF procedures.[11,12]

Major development in the field of tissue retractors, microscopy, as well as other specialized instruments, spine surgeons over the past decade contribute to great progression where the O-TLIF has been transformed to minimally invasive TLIF (MI-TLIF). Compared with O-TLIF, MIS-TLIF have effects in reducing trauma to paraspinal muscles, improving perioperative outcomes, and decreasing operative morbidity.[13–16]

Unfortunately, the use of MI-TLIF approach remains a drawback with several disadvantages, including limited operative view and space,[16,17] hard learning curve,[18] and high rate of perioperative complications.[19] Thus, the procedure is technically quite different from O-TLIF and the crucial implications are needed to use MI-TLIF over the standard approach.

Conflicting results have been demonstrated in terms of the postoperative and perioperative metrics for MI-TLIF with O-TLIF in several studies and trials. The current meta-analysis is to offer eligible and updated assessment based on aggregated results of benefit effect and risks of O-TLIF and MI-TLIF.

2. Methods and materials

2.1. Search strategy

The following electronic databased were identified and searched by 2 studiers separately: Embase, PubMed, Cochrane library in latest 5 years up to June 2018. The data searching process was conducted in search of all publications with the keywords: "Minimally invasive," "Transforaminal lumbar interbody fusion," and "Degenerative lumbar diseases." We also screened and checked relevant Medical Subject Heading (MeSH) terms (("transforaminal lumbar interbody fusion"OR "TLIF") AND ("minimally invasive spine surgery" OR "minimally invasive" OR "MIS") AND (Degenerative lumbar diseases). In addition, we hand-searched the references of eligible publications that dealt with the topic of interest with an attempt to search associated studies.

2.2. Study selection

To be included in the present meta-analysis, studies should meet the following criteria: the studies were designed comparing MI-TLIF versus O-TLIF; articles that enrolled patients with degenerative lumbar diseases; studies providing data of surgery-related outcomes and postoperative specimens for both 2 groups; only the original literature and the full texts that provide complete data were included. Only publications with most complete information were included if there were any duplications or overlapped data.

2.3. Quality assessment

The retrieved studies were evaluated independently by 2 investigators. Observational studies quality was assessed through the use of Newcastle-Ottawa Quality Assessment Scale.[20]

2.4. Data extraction

Two reviewers conducted and evaluated the data extraction separately. Any arising differences were settled through discussion to reach general consensus. The main categories from selected studies were based on the following items: family name of first author, year of publication, number of recruited participants, study design, study period, pathology of the patients, the outcomes of interest including intraoperative parameters, complications parameters, and pain scores parameters.

2.5. Statistical analysis

The present meta-analysis was conducted through pooling the results of reported incidence of intraoperative parameters and postoperative parameters. We applied Review Manager version 5.3 software (Revman; The Cochrane collaboration Oxford, United Kingdom) to conduct the statistical analyses. Heterogeneity of the trial results was assessed with the I^2 statistic to select ideal analysis model[22]:$I^2 > 50\%$ reflected a moderate to high heterogeneity and random-effects model was utilized; $I^2 \leq 50\%$ reflected a low heterogeneity data with the assessment of fixed-effects model.[23] Studies with a P value $<.05$ was thought to have statistical significance.

Since animal experiment or human was not involved in this study, the ethical approval was not necessary.

3. Results

3.1. Literature search process and study characteristics

Totally, 434 publications were identified originally for study assessment. On basis of abovementioned criteria, there were a total of 15 studies in search of further details. Finally, 10 studies[6,24–32] were included in the present analysis due to 5, 15 publications failed to offer sufficient outcome data of 2 approaches. Figure 1 described the detailed search process.

The abovementioned studies were on the bases of the evidence with moderate to high quality. Table 1 described the major characteristics of the qualified studies in more detail.

3.2. Clinical and methodological heterogeneity

3.2.1. Operation parameters. Pooled analysis of operative time with the comparison of O-TLIF versus MI-TLIF.

Pooling the data from 8 studies showed that no differences in the operate time (SMD = –0.51, 95% CI –1.84–0.81; $P = .45$) compared MI-TLIF with the O-TLIF group (Fig. 2).

Pooled analysis of blood loss with the comparison of O-TLIF versus MI-TLIF.

Blood loss rate was available for 8 trials. The pooled data showed that MI-TLIF had strong link to less blood loss (SMD = −2.64, 95% CI −3.62 to −1.65; $P < .00001$ with O-TLIF) (Fig. 3).

Pooled analysis of the hospital duration with the comparison of O-TLIF versus MI-TLIF.

In the analysis of the length of hospital stay, 7 studies were included, as shown in Fig. 4. Results showed that there was shorter rate of length of hospital stay with MI-TLIF (SMD = −0.86, 95% CI −1.70 to −0.02; $P = .04$).

3.2.2. Complications parameters. Pooled analysis of overall complications rate with the comparison of O-TLIF versus MI-TLIF.

We pooled the overall complications rate data with the use of the fixed-effect model, since there was low heterogeneity across the studies. The pooled data showed that MI-TLIF had less overall complications rate (RR = 0.52, 95% CI 0.31–0.86; $P = .01$) with O-TLIF (Fig. 5).

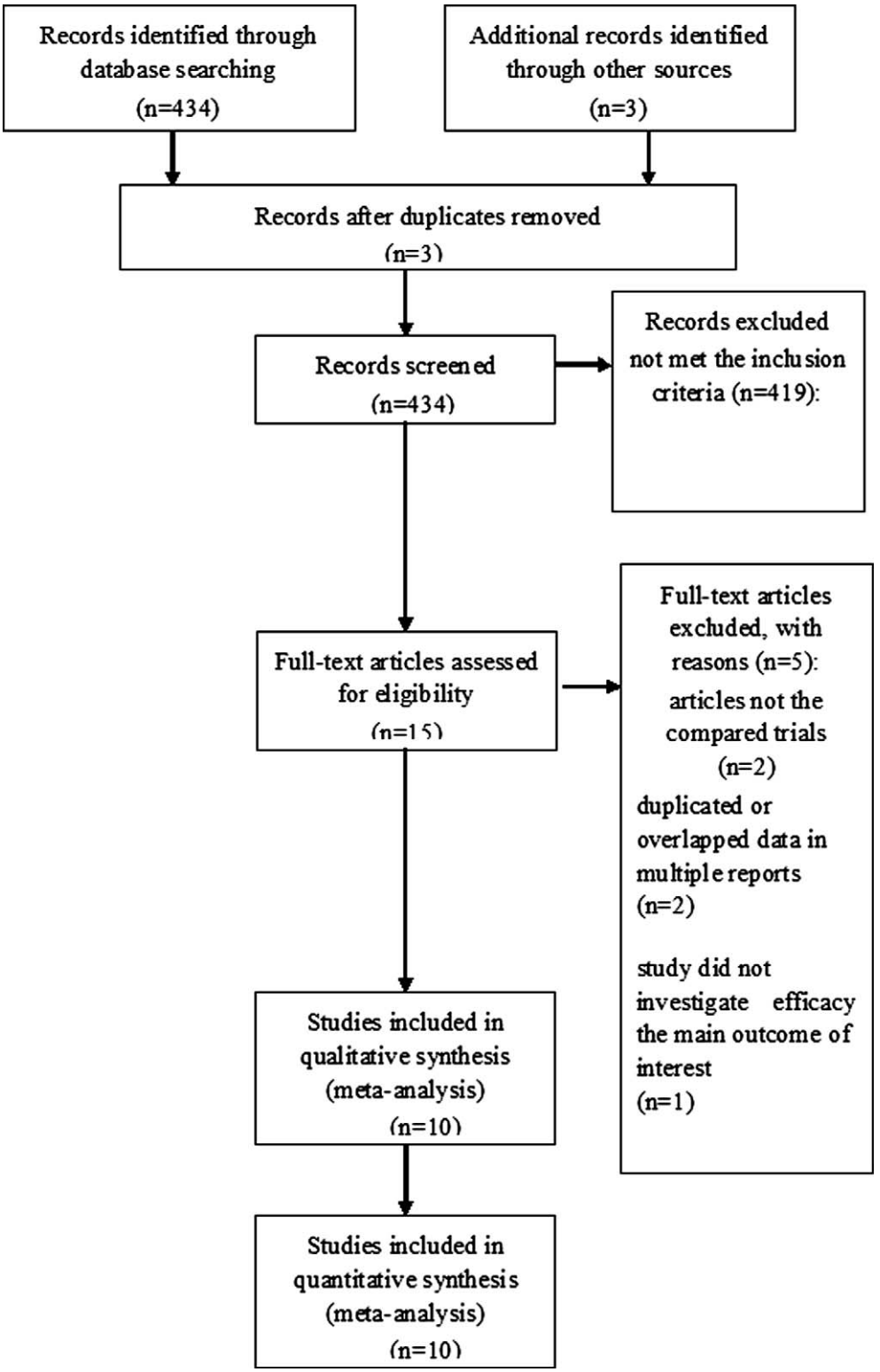

Figure 1. PRISMA flow chart of selection process to identify studies eligible for pooling.

3.2.3. Pain scores parameters. Pooled analysis of VAS-BP and VAS- with the comparison of O-TLIF versus MI-TLIF.

For the incidence of pain scores, no significant differences were observed in terms of VAS-BP when comparing MI-TLIF with O-TLIF (SMD = −0.42, 95% CI −1.13–0.28; $P = .24$) (Fig. 6), and VAS-LP (SMD = 0, 95% CI −0.22–0.22; $P = 1.00$) (Fig. 7).

Pooled analysis of ODI with the comparison of O-TLIF versus MI-TLIF.

The pooling analysis revealed no significant statistical difference in the rate of ODI when comparing MI-TLIF with O-TLIF (SMD = −0.28, 95% CI −0.69–0.13; $P = .19$) (Fig. 8).

Table 1

The major characteristics of the qualified studies in more detail.

Study	Publication year	Study design	Study period	Sample size		Pathology
				MI-TLIF	O-TLIF	
Tian	2014	Prospective observational study	2010–2011	30	31	Symptomatic degenerative disease of the lumbosacral spine (L2–S1)
Sulaiman	2014	Prospective observational study	2009–2012	57	11	Degenerative spondylolisthesis
Singh	2014	Retrospective observational study	2008–2010	33	33	Lumbar degenerative disc disease (DDD), degenerative spondylolisthesis, or spinal stenosis
Parker	2014	Prospective observational study	Not report	50	50	Lumbar spondylolisthesis
Gu	2014	Prospective observational study	2010–2011	44	38	Two-level lumbar degenerative disease
Terman	2014	Retrospective observational study	2007–2011	53	21	Lumbar degenerative disc disease (DDD), herniated disc, listhesis, stenosis
Zhang	2017	Retrospective observational study	2014–2017	48	59	Single-level lumbar instability or degenerative disk disease
Kulkarmi	2016	Prospective observational study	2011–2013	36	25	Back and leg pain secondary to degenerative disease
Serban	2017	Prospective randomized study	2011–2015	40	40	Symptomatic with low back pain plus radicular pain and/or neurogenic clau- dication
Wu	2018	Retrospective observational study	2010–2015	79	88	Grade I or II single segmental spondylolisthesis

MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

4. Discussion

Various fusion technologies have been generally applied to treat patients harboring degenerative lumbar diseases.[32] According to earlier reports, the traditional open-TLIF technology is regarded as one of the most commonly used surgical approach, with beneficial effect in decreasing relative nervous complication rate.[10,33,34] However, it was also reported to cause neurologic and vascular damage of the lumbar muscles and low back pain.[35]

Given the paramedian incision during MI-TLIF process, the attachments of the paraspinal musculature as well as the posterior tension band are preserved.[36,37] Thus, the use of the minimally invasive posterior lumbar technique exerts evidential superior outcomes as compared with the open-TLIF approach, such as comparatively less damage to the spinal soft tissues, diminished postoperative pain, and reduced recovery time.[38–40]

Although the perioperative benefits of MI-TLIF have been well documented in the previous literatures, concerns still exist due to its limited operative view and space, hard learning curve and higher costs associated with performing MIS procedures.[16–18] Therefore, high-level data are warranted to assess the overall benefits as well as the risks of O-TLIF and MI-TLIF.

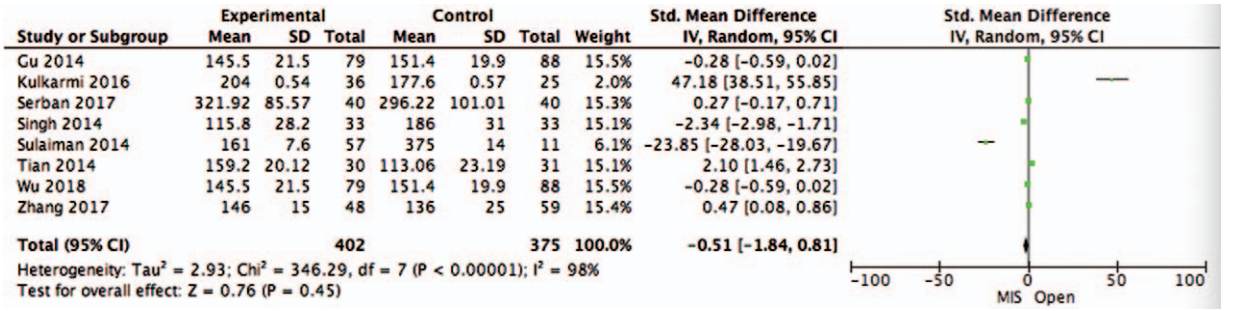

Figure 2. Pooled analysis of operative time with the comparison of O-TLIF versus MI-TLIF. MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

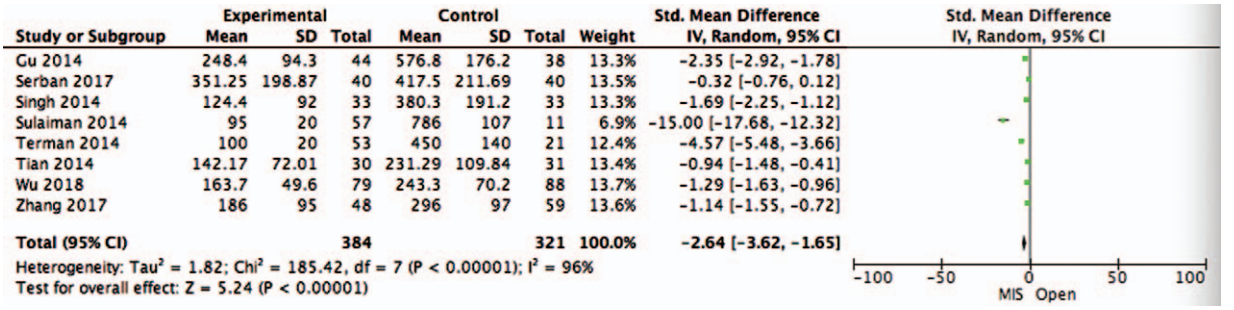

Figure 3. Pooled analysis of blood loss with the comparison of O-TLIF versus MI-TLIF. MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

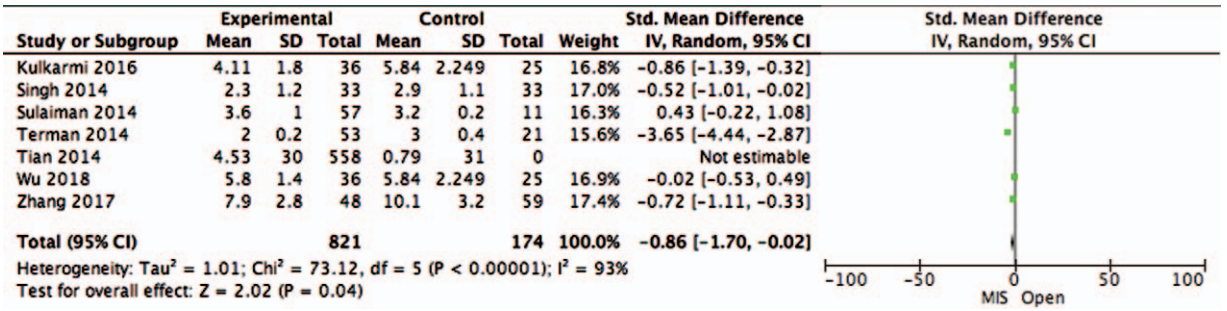

Figure 4. Pooled analysis of the length of hospital stay with the comparison of O-TLIF versus MI-TLIF. MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

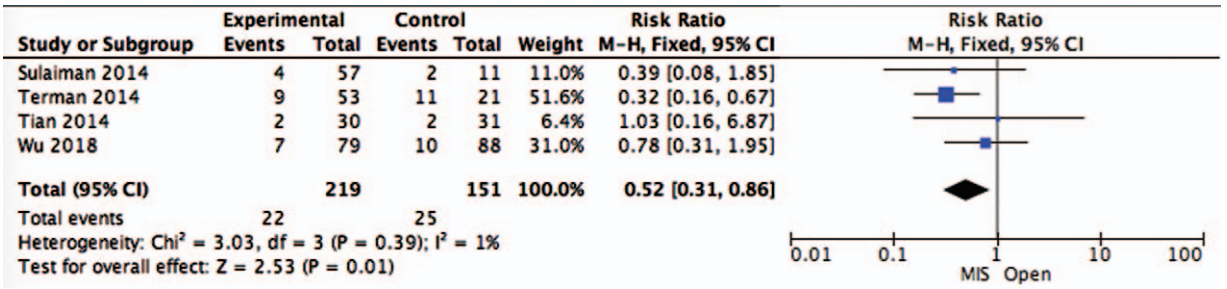

Figure 5. Pooled analysis of overall complications rate with the comparison of O-TLIF versus MI-TLIF. MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

Based on the results of current study and several publications, less dissection of the psoas muscle was required with the use of MI-TLIF, which may contribute to less intraoperative blood loss and shorter duration in hospital compared with open TLIF.[41] However, it must be noted that MI-TLIF has high association with increased operative times according to some studiers.[16,38,42]

The overall results in the present analysis indicated MI-TLIF can be conducted with safe profile without prolonging the operate time compared with conventional open approaches. In this regard, differences are considered to be focused on the learning curve, which is the feature of surgical technique. This may be particularly true of MI-TLIF requires not only anatomy

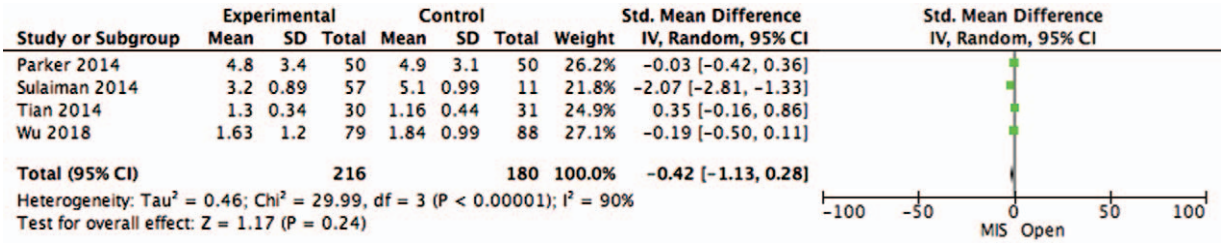

Figure 6. Pooled analysis of VAS-BP with the comparison of O-TLIF versus MI-TLIF. MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

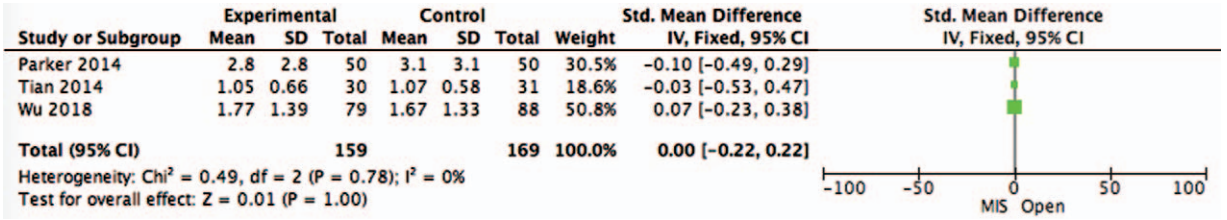

Figure 7. Pooled analysis of VAS-LP with the comparison of O-TLIF versus MI-TLIF. MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

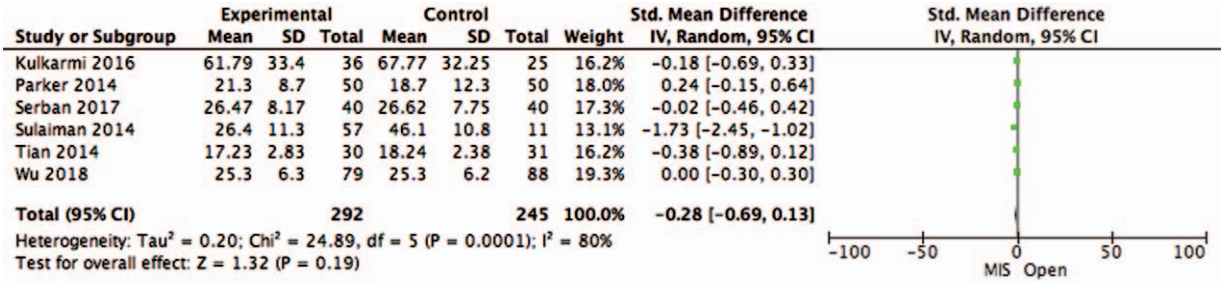

Figure 8. Pooled analysis of ODI with the comparison of O-TLIF versus MI-TLIF. MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, O-TLIF = open-transforaminal lumbar interbody fusion.

skills, the familiarity with novel instrument with restricted view offered by the tubular retractor system are also demanded. Moreover, during pedicle screw placement, the operation time could be affected due to the increased application of navigation imaging that may attribute to potential exposure to ionizing radiation.[43,44] Common use of MI procedure allows cumulative experience of surgeons and less time for operation.

In terms of the complications parameters, lower rate was observed in the MIS group in comparison of open-TLIF group. The following reasons were believed to potentially contribute to the abovementioned phenomenon: spine surgeons' progression along the learning curve requires years of practice to gain skill of minimally invasive surgery[45–47]; surgical devices and the equipment improvement may be related to decreased infections. Overall results of minimized intraoperative surgical trauma as well as complications confirmed the shorter hospital duration based on MI-TLIF cohort.

With regard to pain scores outcomes, the differences were reported inconsistently in the publications supported by Seng et al.[40] They have showed worse outcomes in pain with MI-TLIF. Nonetheless, according to Tian et al,[45] there was a trend towards significant reduction in VAS and ODI pain scores in the MI-TLIF group. In our present study, there was no difference between the 2 groups as regard to VAS for leg pain, VAS for back pain, and ODI, which were also consistent with earlier studies.[23,31] Traditionally, MI-TLIF procedures have been performed to have superior benefits over the traditional open procedure in terms of minimizing injury to the nerve roots and decreasing the postoperative back pain. Theoretically, this advantage should result in beneficial outcomes in pain during the perioperative period.[25] In our analysis, the temporal extent of the improvement in pain scores is rather difficult to ascertain due to the heterogeneity in the follow-up protocols among the included studies. According to previous studies, beneficial outcomes in pain as well as disability results were meaningful for long-term follow-ups, but without further improvement.[48,49]

We must point out that the current studies were focused on the use of an updated and well-maintained database. Nevertheless, due to retrospective nature of all included studies', bias still exists, which may affect of clinical outcomes. While, considering that the preferred surgical procedure varies among different surgeons and serious ethical issue are demanded, it is difficult to set up a clinical RCT to compare the prognosis of patients undergoing O-TLIF and MI-TLIF for the treatment of degenerative lumbar diseases. Furthermore, according to the gold standard for an optimal literature search in surgical systematic reviews,[50] the web of science should be searched. While, we did not search the web of science that may miss the eligible publications.

5. Conclusion

Given the overall results of our analysis, the current study offers moderate evidence to prove the beneficial effect of MI-TLIF on reduced intraoperative blood loss, shorter infection rates during hospital stay, and decreased complications. While no significant differences were observed between 2 study groups in terms of postoperative VAS and ODI pain scores.

Therefore, further acquisition of the minimized intraoperative surgical approach by enhanced skill is necessary to operate for better education as well as safety profile of technics. Additionally, considering the high cost of the current available approach, it is always important to select specific patients for surgery.

Given the beneficial outcomes of MI-TLIF as a valid and alternative method to treat patients with degenerative lumbar diseases, more evidence with sufficient data are demanded to confirm the superiority of MI-TLIF over O-TLIF.

Author contributions

Conceptualization: Ying-Chun Chen.
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Project administration: Er-Nan Li.
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Visualization: Heng-Yuan Zhang.
Writing – original draft: Ying-Chun Chen.
Writing – review & editing: Ying-Chun Chen.

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