Percutaneous endoscopic versus minimally invasive transforaminal lumbar interbody fusion for lumbar degenerative diseases: a meta-analysis

Yi-Fan Song[1], Hui Wang[2], Jian-Wei Zhang[2], Yi-Ming Li[2], You-Di Xue[2], Yu-Fei Fu[3], Jie Li[1,2]

[1]Graduate School, Bengbu Medical College, Bengbu, China
[2]Department of Orthopaedics, Xuzhou Central Hospital, Xuzhou Clinical School of Xuzhou Medical University, Xuzhou, China
[3]Department of Radiology, Xuzhou Central Hospital, Xuzhou Clinical School of Xuzhou Medical University, Xuzhou, China

Videosurgery Miniinv 2022; 17 (4): 591–600
DOI: https://doi.org/10.5114/wiitm.2022.118680

Abstract

Introduction: *Transforaminal lumbar interbody fusion (TLIF) is commonly used in patients with lumbar degenerative disease (LDD). The most commonly used techniques include minimally invasive TLIF (MIS-TLIF) and percutaneous endoscopic TLIF (PE-TLIF).*
Aim: *To compare the safety and clinical effectiveness of PE-TLIF and MIS-TLIF in treating LDD.*
Material and methods: *We screened for related articles in multiple scientific databases, namely, PubMed, Embase, Cochrane Library, Wanfang, VIP, and CINK, and analyzed the relative outcomes.*
Results: *Based on our inclusion criteria, we selected 8 studies for meta-analysis. There are a total of 229 patients who underwent PE-TLIF and 258 patients who underwent MIS-TLIF. MIS-TLIF and PE-TLIF have similar effectiveness in relieving leg pain and improving the Oswestry Disability Index. However, PE-TLIF is superior in relieving back pain. The pooled data of fusion rates, postoperative analgesic, and complication rates are comparable between the 2 groups. The pooled operation and intra-operative fluoroscopic time are both significantly higher in the PE-TLIF group than the MIS-TLIF group. The pooled intra-operative blood loss, incision length, duration from surgery to ambulation, and hospital stay are significantly lower in the PE-TLIF group than the MIS-TLIF group. Most of the endpoints reveal significant heterogeneity. The endpoints of operation time and intra-operative blood loss reveal significant publication bias.*
Conclusions: *Both PE-TLIF and MIS-TLIF are safe and effective interventions for patients with LDD. When compared, although MIS-TLIF results in reduced operative time, less intra-operative blood loss and enhanced post-operative recovery can be achieved by PE-TLIF.*

Key words: *transforaminal lumbar interbody fusion, lumbar degenerative disease, Oswestry Disability Index, meta-analysis.*

Introduction

Lumbar degenerative diseases (LDD), which include lumbar spinal stenosis, lumbar disc herniation, spondylolisthesis, and lumbar instability, are common causes of back and leg pain [1–3]. Transforaminal lumbar interbody fusion (TLIF) is commonly used for patients with LDD and the purposes of TLIF are to relieve the symptoms and improve the quality of life [4–6]. Nevertheless, the classical open TLIF is correlated with iatrogenic injury of the paraspinal muscle, re-

Address for correspondence
Jie Li, Graduate School, Bengbu Medical College, Department of Orthopaedics, Xuzhou Central Hospital, Xuzhou Clinical School of Xuzhou Medical University, Xuzhou, China, e-mail: lijie87919@163.com

sulting in intractable postoperative low back pain [7]. At present, minimally invasive TLIF (MIS-TLIF) is widely used to minimize the soft tissue injury and intraoperative blood loss [8]. MIS-TLIF has shown significantly less blood loss compared with open TLIF [9]. However, MIS-TLIF is usually restricted by a limited working space and it is challenging to visualize deep surgical fields through the tubular retractor [10].

To overcome MIS-TLIF shortcomings, percutaneous endoscopic TLIF (PE-TLIF) has been commonly used for patients with LDD [11–13]. PE-TLIF makes possible a complete endoscopic discectomy, spinal canal and foramina decompression, and interbody fusion via the endoscopic and working portal [14–17]. Although numerous earlier investigations explored the relative efficacies of PE-TLIF and MIS-TLIF in treating LDD [11–18], most of these studies were retrospective in nature. Since multiple factors can sway the outcomes of a retrospective investigation, and introduce unintentional bias, a meta-analysis is recommended to extensively evaluate relevant literature, reduce bias risk, and enhance the overall statistical power of the collective study outcomes.

Aim

Herein, our goal was to compare the safety and clinical effectiveness of PE-TLIF and MIS-TLIF in treating LDD.

Material and methods

Study selection

Our research abided by the guidelines of the Preferred Reporting Items for Systematic reviews and Meta-Analyses [18], and is registered at https://inplasy.com/ (Number: INPLASY202220090).

We screened for relevant publications in scientific databases, namely, PubMed, Embase, Cochrane Library, Wanfang, VIP, and CINK from the date of database establishment to November 2021. Our search terminologies were as follows: ((Endoscopic Lumbar Interbody Fusion) OR (Endo-LIF)) AND ((Minimally Invasive Transforaminal Lumbar Interbody Fusion) OR (MIS-TLIF)).

The following criteria were used to select relevant articles for analysis:

– Studies: comparing between PE-TLIF and MIS-TLIF;
– Diseases: LDD;
– Language: Unlimited.

Studies with the following criteria were eliminated from the analysis: (a) single-arm investigations; (b) non-human investigations; and (c) studies without an English title and/or abstract.

Data accumulation

Two separate authors screened eligible publications and collected baseline study data, namely, author, year of publication, country of publication, study format, and quality assessment; and patient data, namely, population size, age, gender, disk range, body mass index (BMI), and follow-up duration; and many treatment-related data. Disagreements were rectified through consultation with a third author.

Quality evaluation

Randomized controlled trials (RCTs) were evaluated using the Cochrane risk of bias tool for the potential bias in performance, attrition, detection, screening, reporting, and so on. Non-RCTs were analyzed via the 9-point Newcastle-Ottawa scale (NOS) for potential selection bias, namely, selection (4 points), comparability (2 points), and exposure (3 points), carrying either high (≥ 7), moderate (4–6), or low (< 4) risk of bias [19].

Endpoints

The endpoints of this meta-analysis included visual analog scale (VAS)-leg, VAS-back, Oswestry Disability Index (ODI), fusion rate, surgical duration, blood loss, complication rates, and postoperative hospitalization.

Statistical analysis

RevMan v5.3 and Stata 12.0 were employed in this study. Dichotomous variables were accumulated depending upon odds ratios (ORs) with 95% confidence intervals (CIs), while continuous variables are accumulated depending upon mean difference (MD) with 95% CIs. Heterogeneity was examined via I^2 tests, with $I^2 > 50\%$ representing marked heterogeneity. Random-effects models were used to analyze marked heterogeneity, while fixed-effects models were used to analyze marked homogeneity. Heterogeneity sources are analyzed through sensitivity assessment. Funnel plot and Egger test are employed for evaluating publication bias risks.

Results

Included studies

We initially found 323 relative studies by using the research strategy. After step-by-step selection, a total of 8 studies were eligible for analysis (Figure 1, Table I). Seven studies were retrospective [12–18], and 1 study was prospective [11]. Seven studies were from China [11, 12, 14–18], and 1 study was from South Korea [13].

In these 8 included studies, 229 patients underwent PE-TLIF and 258 patients underwent MIS-TLIF (Table II). The mean age, gender ratio, and mean BMI were comparable between PE-TLIF and MIS-TLIF groups in the analyzed studies. The NOS of these studies ranged between 7 and 8.

Improvement of VAS-leg

Six studies compared the VAS-leg before and after treatment [11–14, 16, 17]. The pooled ΔVAS-leg values are comparable between the 2 groups (MD = –0.31; 95% CI = –0.95–0.33; p = 0.35, Figure 2 A). Significant heterogeneity is found for this endpoint (I^2 = 98%). Sensitivity analysis suggests that removing individual studies has no impact on the detected heterogeneity. No obvious publication bias is observed (Egger test, p = 0.597).

Improvement of VAS-back

Six studies compared the VAS-back before and after treatment [11–14, 16, 17]. The pooled ΔVAS-back value is significantly higher in the PE-TLIF group

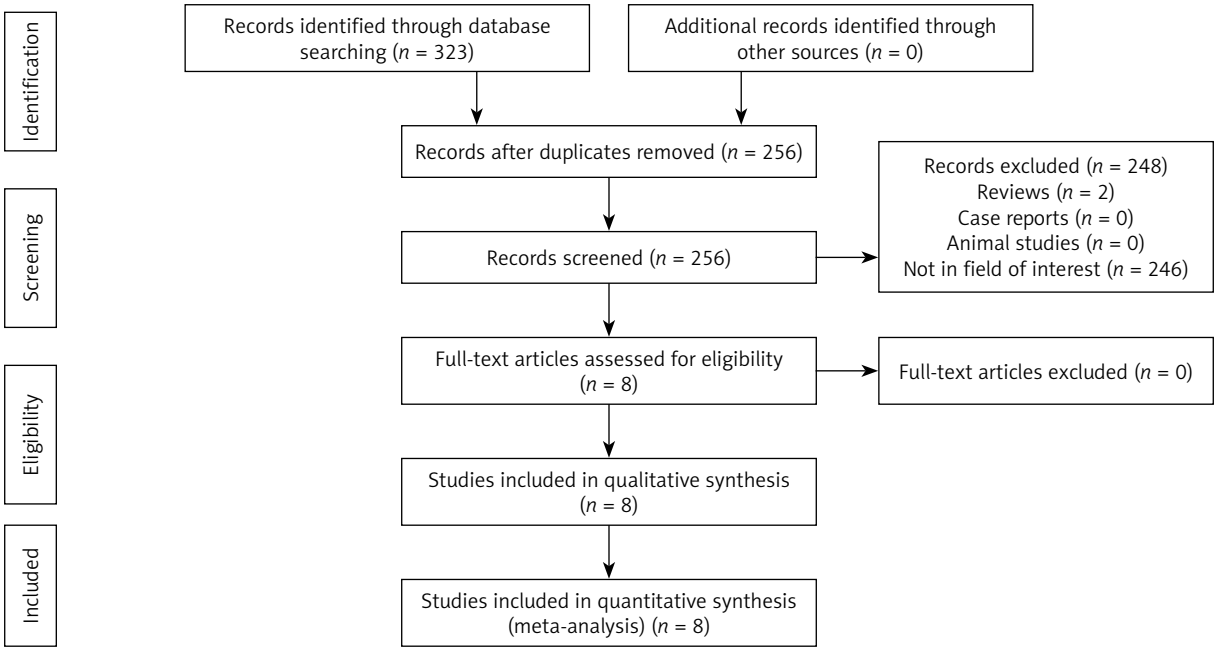


Figure 1. Flowchart of this study

Table I. Baseline data of the included studies

First author	Year	Countries	Design	Newcastle-Ottawa scale
Ao [11]	2020	China	Prospective	8
Dong [12]	2019	China	Retrospective	8
Kim [13]	2021	South Korea	Retrospective	7
Li [14]	2020	China	Retrospective	8
Wen [15]	2020	China	Retrospective	7
Xue [16]	2021	China	Retrospective	7
Zhang [17]	2021	China	Retrospective	8
Zhao [18]	2021	China	Retrospective	7

Table II. Patients' details in each study

Authors [ref.]	Disease types	Disk range	Groups	Number of patients	Age [years]	M/F	BMI	Follow-up [months]
Ao [11]	Degenerative spondylolisthesis	L3-S1	PE-TLIF	35	52.80	16/19	24.73	12
			MIS-TLIF	40	53.68	22/18	25.08	12
Dong [12]	Disc herniation, Spondylolisthesis, Spinal stenosis	L3-S1	PE-TLIF	28	58.3	17/11	23.3	24
			MIS-TLIF	25	54.8	9/16	23.0	24
Kim [13]	Degenerative/lytic spondylolisthesis	L2-S1	PE-TLIF	32	70.5	17/15	Unknown	27.2
			MIS-TLIF	55	67.3	25/30	Unknown	31.5
Li [14]	Disc herniation, Spondylolisthesis, Spinal stenosis	L4-S1	PE-TLIF	22	52.0	12/10	Unknown	14.9
			MIS-TLIF	30	50.7	18/12	Unknown	14.7
Wen [15]	Not given in detail	L4-S1	PE-TLIF	20	48.33	13/7	Unknown	12–20 for all
			MIS-TLIF	20	50.77	11/9	Unknown	
Xue [16]	Not given in detail	L3-5	PE-TLIF	20	46.3	11/9	Unknown	16.1
			MIS-TLIF	20	48.4	12/8	Unknown	15.8
Zhang [17]	Degenerative/isthmic spondylolisthesis	L3-S1	PE-TLIF	32	53.1	12/20	25.5	12
			MIS-TLIF	30	55.7	14/16	24.9	12
Zhao [18]	Not given in detail	L3-S1	PE-TLIF	40	56.93	37/17	Unknown	24
			MIS-TLIF	38	57.01	20/18	Unknown	24

BMI – body mass index, M – male, F – female, PE-TLIF – percutaneous endoscopic transforaminal lumbar interbody fusion, MIS-TLIF – minimally invasive transforaminal lumbar interbody fusion.

(MD = 1.62; 95% CI: 0.92–2.32; $p < 0.00001$, Figure 2 B). Significant heterogeneity is found for this endpoint (I^2 = 98%). Sensitivity analysis suggests that removing individual studies has no impact on the detected heterogeneity. No obvious publication bias is observed (Egger test, $p = 0.188$).

Improvement of ODI

Six studies compared the ODI before and after treatment [11–14, 16, 17]. The pooled ΔODI values are comparable between the 2 groups (MD = 3.82; 95% CI: –1.53–9.18; $p = 0.16$, Figure 2 C). Significant heterogeneity is found for this endpoint (I^2 = 98%). Sensitivity analysis suggests that removing individual studies has no impact on the detected heterogeneity. No obvious publication bias is observed (Egger test, $p = 0.074$).

Postoperative analgesic

Two studies reported the dose of postoperative analgesic [11, 12]. The pooled dose of postoperative analgesic is comparable between the 2 groups (MD = –32.45; 95% CI: –82.74–17.83; $p = 0.21$, Figure 2 D). Significant heterogeneity is found for this endpoint (I^2= 99%). Sensitivity analysis cannot be performed because there are only 2 studies. The funnel plot does not reveal any publication bias.

Fusion rates

Seven studies reported the fusion rates after treatment [11–14, 16–18]. The pooled fusion rates are comparable between the 2 groups (90.4% vs. 90.3%; $p = 0.86$, Figure 2 E). No significant heterogeneity is found for this endpoint (I^2= 0%). No obvious publication bias is observed (Egger test, $p = 0.797$).

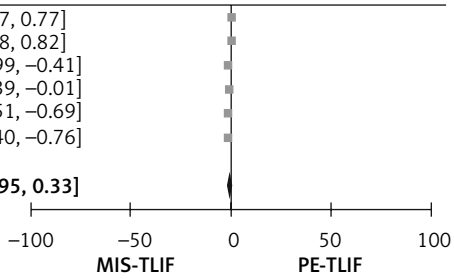
Operation time

All studies reported the operation time. The pooled operation time is significantly lower in the MIS-TLIF group than in the PE-TLIF group (MD = 22.41; 95% CI: 6.48–38.34; $p = 0.006$, Figure 2 F). Significant heterogeneity is found for this endpoint (I^2= 95%). Sensitivity analysis suggests that removing individual studies has no impact on the detected heterogeneity. We observed marked publication bias (Egger test, $p = 0.049$).

A

Study or subgroup	PE-TLIF Mean	SD	Total	MIS-TLIF Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Ao 2020	4.64	0.8	35	4.17	0.44	40	16.6	0.47 [0.17, 0.77]
Dong 2019	6	0.3	28	5.3	0.1	25	17.1	0.70 [0.58, 0.82]
Kim 2021	3.6	0.7	32	4.3	0.6	55	16.6	–0.70 [–0.99, –0.41]
Li 2020	4.2	0.3	22	4.4	0.4	30	17.0	–0.20 [–0.39, –0.01]
Xue 2021	3.4	0.8	20	4.5	0.5	20	16.1	–1.10 [–1.51, –0.69]
Zhang 2021	2.06	0.41	32	3.14	0.79	30	16.5	–1.08 [–1.40, –0.76]
Total (95% CI)			**169**			**200**	**100.0**	**–0.31 [–0.95, 0.33]**

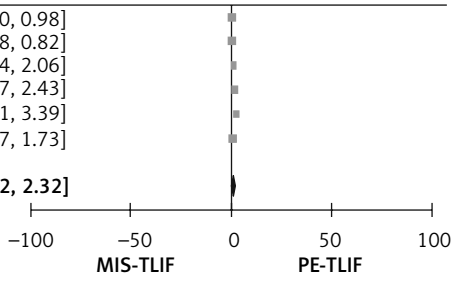
Heterogeneity: $\tau^2 = 0.62$; $\chi^2 = 226.95$; d$f = 5$ ($p < 0.00001$), $I^2 = 98\%$
Test for overall effect: $Z = 0.94$ ($p = 0.35$)



B

Study or subgroup	PE-TLIF Mean	SD	Total	MIS-TLIF Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Ao 2020	1.69	0.75	35	1	0.48	40	16.7	0.69 [0.40, 0.98]
Dong 2019	5.1	0.5	28	4.5	0.3	25	16.9	0.60 [0.38, 0.82]
Kim 2021	3.1	0.3	32	1.3	0.9	55	16.8	1.80 [1.54, 2.06]
Li 2020	3.6	0.9	22	1.6	0.6	30	16.1	2.00 [1.57, 2.43]
Xue 2021	5	0.3	20	1.9	0.6	20	16.7	3.10 [2.81, 3.39]
Zhang 2021	1.74	0.51	32	0.19	0.11	30	17.0	1.55 [1.37, 1.73]
Total (95% CI)			**169**			**200**	**100.0**	**1.62 [0.92, 2.32]**

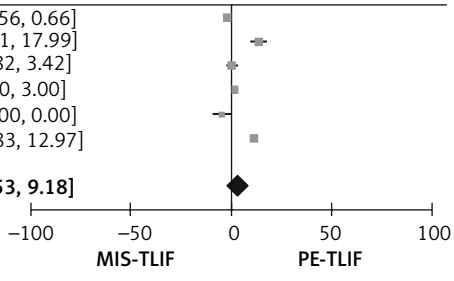
Heterogeneity: $\tau^2 = 0.74$; $\chi^2 = 218.97$; d$f = 5$ ($p < 0.00001$), $I^2 = 98\%$
Test for overall effect: $Z = 4.54$ ($p < 0.00001$)



C

Study or subgroup	PE-TLIF Mean	SD	Total	MIS-TLIF Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Ao 2020	35.2	4.83	35	36.65	4.42	40	17.0	–1.45 [–3.56, 0.66]
Dong 2019	44.1	4.1	28	30.2	9.7	25	15.9	13.90 [9.81, 17.99]
Kim 2021	26.6	6.7	32	25.8	4.6	55	16.8	0.80 [–1.82, 3.42]
Li 2020	11	2	22	8.9	0.9	30	17.4	2.10 [1.20, 3.00]
Xue 2021	34.4	7.5	20	38.9	7	20	15.6	–4.50 [–9.00, 0.00]
Zhang 2021	15.2	2.84	32	3.3	1.2	30	17.4	11.90 [10.83, 12.97]
Total (95% CI)			**169**			**200**	**100.0**	**3.82 [–1.53, 9.18]**

Heterogeneity: $\tau^2 = 42.73$; $\chi^2 = 279.94$; d$f = 5$ ($p < 0.00001$), $I^2 = 98\%$
Test for overall effect: $Z = 1.40$ ($p = 0.16$)



D

Study or subgroup	PE-TLIF Mean	SD	Total	MIS-TLIF Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Ao 2020	74.29	13.87	35	132.5	19.51	40	49.8	–58.21 [–65.80, –50.62]
Dong 2019	55.2	8.5	28	62.1	7.3	25	50.2	–6.90 [–11.15, –2.65]
Total (95% CI)			**63**			**65**	**100.0**	**–32.45 [–82.74, 17.83]**

Heterogeneity: $\tau^2 = 1306.50$; $\chi^2 = 133.47$; d$f = 1$ ($p < 0.00001$), $I^2 = 99\%$
Test for overall effect: $Z = 1.27$ ($p = 0.21$)

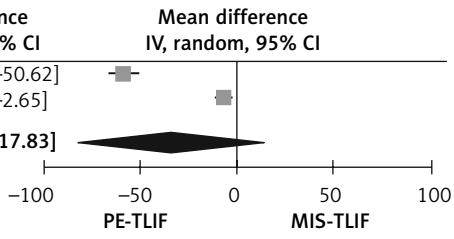
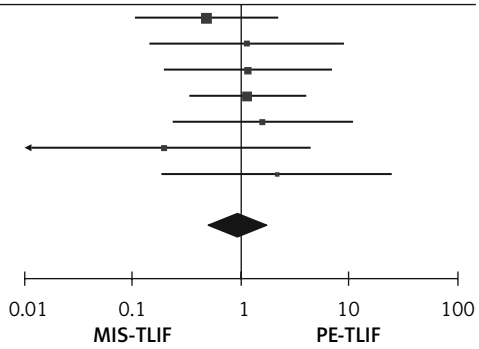


Figure 2. Pooled results of: **A** – improvement of VAS-leg, **B** – improvement of VAS-back, **C** – improvement of ODI, **D** – postoperative analgesic

E

Study or subgroup	PE-TLIF Events	PE-TLIF Total	MIS-TLIF Events	MIS-TLIF Total	Weight (%)	Odds ratio M-H, fixed, 95% CI
Ao 2020	29	34	36	39	36.1	0.48 [0.11, 2.19]
Dong 2019	26	28	23	25	9.2	1.13 [0.15, 8.68]
Kim 2021	30	32	51	55	12.4	1.18 [0.20, 6.81]
Li 2020	16	22	21	30	25.7	1.14 [0.34, 3.87]
Xue 2021	18	20	17	20	9.0	1.59 [0.24, 10.70]
Zhang 2021	30	32	30	30	12.6	0.20 [0.01, 4.34]
Zhao 2021	39	40	36	38	4.9	2.17 [0.19, 24.93]
Total (95% CI)		**208**		**237**	**100.0**	**0.94 [0.49, 1.80]**
Total events	188		214			

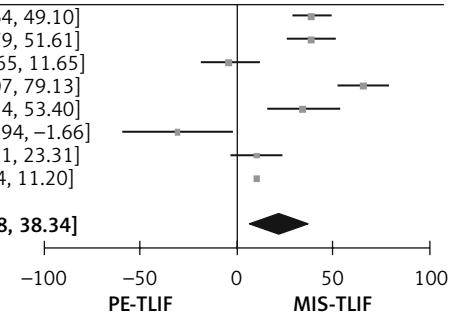
Heterogeneity: $\chi^2 = 2.64$; d$f = 6$ ($p = 0.85$), $I^2 = 0\%$
Test for overall effect: $Z = 0.17$ ($p = 0.86$)



F

Study or subgroup	PE-TLIF Mean	PE-TLIF SD	PE-TLIF Total	MIS-TLIF Mean	MIS-TLIF SD	MIS-TLIF Total	Weight (%)	Mean difference IV, random, 95% CI
Ao 2020	143	24.2	35	103.63	17.79	40	13.3	39.37 [29.64, 49.10]
Dong 2019	184.6	24.4	28	145.4	21.7	25	12.9	39.20 [26.79, 51.61]
Kim 2021	169.5	24.9	32	173	47.1	55	12.5	–3.50 [–18.65, 11.65]
Li 2020	187.7	27	22	121.6	18.2	30	12.8	66.10 [53.07, 79.13]
Wen 2020	150.45	35.87	20	115.48	21.97	20	11.8	34.97 [16.54, 53.40]
Xue 2021	140.3	35.6	20	170.6	54.8	20	9.7	–30.30 [–58.94, –1.66]
Zhang 2021	202.6	31.4	32	192.1	18.9	30	12.9	10.50 [–2.31, 23.31]
Zhao 2021	100.92	1.34	40	90.45	1.87	38	14.0	10.47 [9.74, 11.20]
Total (95% CI)			**229**			**258**	**100.0**	**22.41 [6.48, 38.34]**

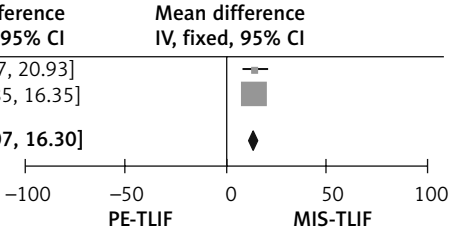
Heterogeneity: $\tau^2 = 470.24$; $\chi^2 = 141.15$; d$f = 7$ ($p < 0.00001$), $I^2 = 95\%$
Test for overall effect: $Z = 2.76$ ($p = 0.006$)



G

Study or subgroup	PE-TLIF Mean	PE-TLIF SD	PE-TLIF Total	MIS-TLIF Mean	MIS-TLIF SD	MIS-TLIF Total	Weight (%)	Mean difference IV, fixed, 95% CI
Dong 2019	68.5	15.1	28	53.7	6.4	25	11.9	14.80 [8.67, 20.93]
Zhang 2021	46.3	5.1	32	32.2	3.9	30	88.1	14.10 [11.85, 16.35]
Total (95% CI)			**60**			**55**	**100.0**	**14.18 [12.07, 16.30]**

Heterogeneity: $\chi^2 = 0.04$; d$f = 1$ ($p = 0.83$), $I^2 = 0\%$
Test for overall effect: $Z = 13.15$ ($p < 0.00001$)



H

Study or subgroup	PE-TLIF Mean	PE-TLIF SD	PE-TLIF Total	MIS-TLIF Mean	MIS-TLIF SD	MIS-TLIF Total	Weight (%)	Mean difference IV, random, 95% CI
Ao 2020	84.29	44.34	35	171.79	112.27	40	13.4	–87.50 [–125.27, –49.73]
Dong 2019	191.1	30.8	28	238.2	19.5	25	14.4	–47.10 [–60.83, –33.37]
Li 2020	49.5	12.1	22	267.7	47.1	30	14.3	–218.20 [–235.80, –200.60]
Wen 2020	90.68	22.3	20	146.78	32.45	20	14.3	–56.10 [–73.36, –38.84]
Xue 2021	65.6	15.3	20	140.5	21.5	20	14.5	–74.90 [–86.46, –63.34]
Zhang 2021	73	26.4	32	129	31.7	30	14.4	–56.00 [–70.57, –41.43]
Zhao 2021	60.56	0.36	40	65.47	0.91	38	14.6	–4.91 [–5.22, –4.60]
Total (95% CI)			**197**			**203**	**100.0**	**–77.48 [–127.05, –27.92]**

Heterogeneity: $\tau^2 = 4384.26$; $\chi^2 = 839.42$; d$f = 6$ ($p < 0.00001$), $I^2 = 99\%$
Test for overall effect: $Z = 3.06$ ($p = 0.002$)

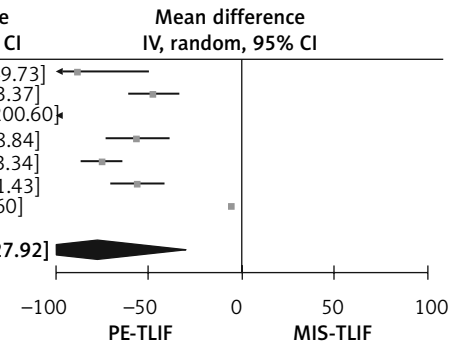
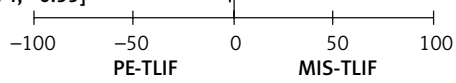


Figure 2. Cont. **E** – fusion rates, **F** – operation time, **G** – intra-operative fluoroscopic time, **H** – intra-operative blood loss

I

Study or subgroup	PE-TLIF Mean	SD	Total	MIS-TLIF Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Wen 2020	3.04	0.84	20	3.84	0.74	20	35.5	–0.80 [–1.29, –0.31]
Xue 2021	5.3	0.8	20	7.8	2.3	20	18.7	–2.50 [–3.57, –1.43]
Zhao 2021	1.46	0.24	40	2.31	0.32	38	45.8	–0.85 [–0.98, –0.72]
Total (95% CI)			**80**			**78**	**100.0**	**–1.14 [–1.74, –0.55]**

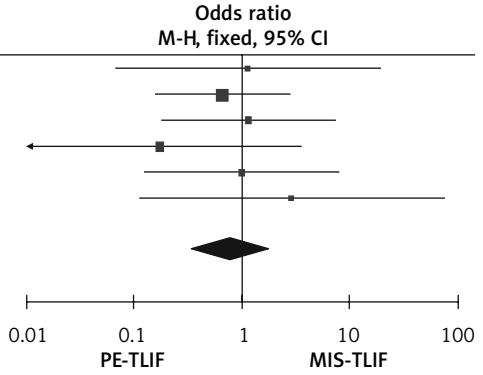
Heterogeneity: $\tau^2 = 0.20$; $\chi^2 = 9.14$; d$f = 2$ ($p = 0.01$), $I^2 = 78\%$
Test for overall effect: $Z = 3.76$ ($p = 0.0002$)



J

Study or subgroup	PE-TLIF Events	Total	MIS-TLIF Events	Total	Weight (%)	Odds ratio M-H, fixed, 95% CI
Ao 2020	1	35	1	40	7.1	1.15 [0.07, 19.05]
Dong 2019	4	28	5	25	35.6	0.67 [0.16, 2.82]
Li 2020	2	32	3	55	16.3	1.16 [0.18, 7.31]
Wen 2020	0	22	3	30	22.9	0.17 [0.01, 3.56]
Xue 2021	2	20	2	20	14.2	1.00 [0.13, 7.89]
Zhang 2021	1	32	0	30	3.9	2.90 [0.11, 74.10]
Total (95% CI)		**169**		**200**	**100.0**	**0.80 [0.35, 1.83]**
Total events	10		14			

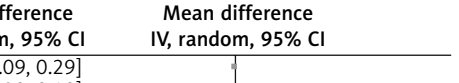
Heterogeneity: $\chi^2 = 1.91$; d$f = 5$ ($p = 0.86$), $I^2 = 0\%$
Test for overall effect: $Z = 0.53$ ($p = 0.60$)



K

Study or subgroup	PE-TLIF Mean	SD	Total	MIS-TLIF Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Dong 2019	2.8	1.8	28	3.2	0.5	25	8.6	–0.40 [–1.09, 0.29]
Kim 2021	0.58	0.17	32	0.78	0.3	55	37.6	–0.20 [–0.30, 0.10]
Wen 2020	0.82	0.22	20	1.27	0.32	20	33.1	–0.45 [–0.62, –0.28]
Zhang 2021	1.6	0.6	32	2.3	0.8	30	20.7	–0.70 [–1.05, –0.35]
Total (95% CI)			**112**			**130**	**100.0**	**–0.40 [–0.63, –0.17]**

Heterogeneity: $\tau^2 = 0.03$; $\chi^2 = 11.84$; d$f = 3$ ($p = 0.008$), $I^2 = 75\%$
Test for overall effect: $Z = 3.43$ ($p = 0.0006$)



L

Study or subgroup	PE-TLIF Mean	SD	Total	MIS-TLIF Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
Ao 2020	3.11	1.18	35	5.15	1.44	40	20.7	–2.04 [–2.63, –1.45]
Kim 2021	6	3.1	32	9.1	2.9	55	18.9	–3.10 [–4.42, –1.78]
Li 2020	2.9	0.9	22	9.3	2.1	30	20.2	–6.40 [–7.24, –5.56]
Xue 2021	2.4	1.6	20	4.5	2.1	20	19.4	–2.10 [–3.26, –0.94]
Zhao 2021	8.12	0.92	40	9.66	1.34	38	20.8	–1.54 [–2.05, –1.03]
Total (95% CI)			**149**			**183**	**100.0**	**–3.03 [–4.77, –1.29]**

Heterogeneity: $\tau^2 = 3.73$; $\chi^2 = 99.63$; d$f = 4$ ($p < 0.00001$), $I^2 = 96\%$
Test for overall effect: $Z = 3.41$ ($p = 0.0007$)

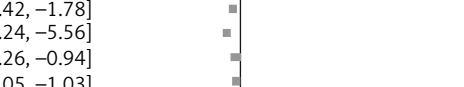


Figure 2. Cont. **I** – length of incision, **J** – complication rates, **K** – time to ambulation, **L** – hospital stay

Intra-operative fluoroscopic time

Two studies reported the intra-operative fluoroscopic time [12, 17]. The pooled intra-operative fluoroscopic time is significantly lower in the MIS-TLIF group than in the PE-TLIF group (MD = 14.18; 95% CI: 12.07–16.30; $p < 0.00001$, Figure 2 G). No significant heterogeneity is found for this endpoint ($I^2 = 0\%$). The funnel plot does not reveal any publication bias.

Intra-operative blood loss

Seven studies reported on the intra-operative blood loss [11, 12, 14–18]. The pooled intra-operative blood loss is drastically lower in the PE-TLIF group than in the MIS-TLIF group (MD = –77.48; 95% CI: –127.05–27.92; p = 0.002, Figure 2 H). Significant heterogeneity is found for this endpoint (I^2 = 99%). Sensitivity analysis suggests that removing individual studies has no impact on the detected heterogeneity. We observed marked publication bias (Egger test, p = 0.021).

Length of incision

Three studies reported the length of incision [15–17]. The pooled length of incision is significantly lower in the PE-TLIF group than in the MIS-TLIF group (MD = –1.14; 95% CI: –1.74–0.55; p = 0.0002, Figure 2 I). Significant heterogeneity is found for this endpoint (I^2 = 78%). The significant heterogeneity disappears (I^2 = 0%) when removing Xue's study [16]. No obvious publication bias is observed (Egger test, p = 0.683).

Complication rates

Six investigations reported the complication rates after treatment [11, 12, 14–17]. The collective complication rates are similar between the 2 groups (5.9% vs. 7.0%; p = 0.60, Figure 2 J). No significant heterogeneity is found for this endpoint (I^2 = 0%). No marked publication bias is observed (Egger test, p = 0.733).

Time to ambulation

Four studies reported the data of time to ambulation [12, 13, 15, 17]. The poled time to ambulation is significantly lower in the PE-TLIF group than in the MIS-TLIF group (MD = –0.40; 95% CI: –0.63–0.17; p = 0.0006, Figure 2 K). Significant heterogeneity is found for this endpoint (I^2 = 75%). The significant heterogeneity disappears (I^2 = 0%) when removing Kim's study [13]. No marked publication bias is observed (Egger test, p = 0.665).

Hospital stay

Five studies reported the data of time to ambulation [11, 13, 14, 16, 17]. The poled hospital stay time is significantly lower in the PE-TLIF group than in the MIS-TLIF group (MD = –3.03; 95% CI: –4.77–1.29; p = 0.0007, Figure 2 L). Significant heterogeneity is found for this endpoint (I^2 = 96%). Sensitivity analysis suggests that removing individual studies has no impact on the detected heterogeneity. No marked publication bias is observed (Egger test, p = 0.400).

Discussion

This meta-analysis compared the clinical efficacy between PE-TLIF and MIS-TLIF for patients with LDD. The purpose of PE-TLIF and MIS-TLIF treatments for LDD is relieving the pain and enhancing quality of life. All the included studies found that VAS-leg, VAS-back, and ODI could be significantly improved by both PE-TLIF and MIS-TLIF. Our meta-analysis reveals that the degree of improvement of VAS-leg and ODI is comparable between PE-TLIF and MIS-TLIF. Furthermore, the need for a postoperative analgesic is also comparable between the 2 groups. These findings may indicate that both PE-TLIF and MIS-TLIF can achieve appropriate clinical effectiveness in patients with LDD. However, the PE-TLIF may achieve a faster recovery of back pain than MIS-TLIF does. This finding may be attributed to the fact that PE-TLIF intervention is associated with reduced surgical trauma to surrounding soft and bone tissues, compared to the MIS-TLIF intervention [16].

Fusion rate is also an important endpoint in this meta-analysis. We found that the collective fusion rate of PE-TLIF is comparable to MIS-TLIF, at approximately 90%. Hence, both PE-TLIF and MIS-TLIF achieve suitable interbody fusion. However, Ao *et al.* [11] found that MIS-TLIF can achieve a significantly higher fusion rate than PE-TLIF. This finding may suggest inadequate bone graft and expandable cage application [10]. Nonetheless, the results from the retrospective study should be further proven by RCTs.

The pooled operation and intra-operative fluoroscopic time are both significantly higher in the PE-TLIF group. The curette-mediated endplate preparation in PE-TLIF took a considerable amount of time. Since it relies on instrument palpations, without direct vision, and with sequential endoscopic guidance, the endplate preparation required more time than MIS-TLIF [20–22].

Even though PE-TLIF is usually time consuming, it can result in significantly less intra-operative blood loss and better post-operative recovery. These re-

sults may be attributed to the shorter length of incision during PE-TLIF.

This meta-analysis shows comparable pooled complication rates between the 2 groups. Furthermore, the pooled complication rates after PE-TLIF and MIS-TLIF are only 5.9% and 7.0%, respectively. These findings indicate that both PE-TLIF and MIS-TLIF are safe for patients with LDD. If some patients experience the severe complication that is an abscess, external drainage is an effective method to treat it [23].

A similar meta-analysis reported insights into unilateral bi-portal endoscopy (UBE) in the treatment of lumbar diseases [24]. The researchers found that UBE surgery could significantly relieve the VAS scores of leg and back [24]. However, that meta-analysis only included single-arm studies [24]. Therefore, we could not find results about the comparison of UBE with other techniques. Our meta-analysis contained 2 commonly used techniques, and this is an advantage over the previous meta-analysis.

Our meta-analysis faced certain limitations. First, our analysis did not include any RCT. Furthermore, the multiple types of diseases and different disk ranges also increase the risk of bias. Therefore, further RCTs should be conducted. Second, there was a lack of homogeneity in surgical interventions and number of channels, which may influence our results. Many endpoints in this meta-analysis demonstrate significant heterogeneity. Third, there is a lack of cost-effective analysis among the included studies. Fourth, all eligible investigations were based in Asia. Therefore, additional comprehensive, global studies are warranted once stent usage becomes more prevalent worldwide.

Conclusions

Both PE-TLIF and MIS-TLIF are safe and effective strategies for patients with LDD. When compared, although MIS-TLIF results in reduced surgical duration and intra-operative blood loss, rapid post-operative recovery can be achieved by PE-TLIF.

Acknowledgments

This work is supported by the Scientific Research Project of Jiangsu Health Commission, Grant/Award (grant number: H2019023) and Youth Innovation project of Xuzhou Health Commission (grant number: XWKYHT20210557).

Conflict of interest

The authors declare no conflict of interest.

References

1. Aoki Y, Takahashi H, Nakajima A, et al. Prevalence of lumbar spondylolysis and spondylolisthesis in patients with degenerative spinal disease. Sci Rep 2020; 10: 6739.
2. Zárate-Kalfópulos B, Reyes-Tarrago F, Navarro-Aceves LA, et al. Characteristics of spinopelvic sagittal alignment in lumbar degenerative disease. World Neurosurg 2019; 126: e417-21.
3. Jermy JE, Copley PC, Poon MTC, et al. Does pre-operative multifidus morphology on MRI predict clinical outcomes in adults following surgical treatment for degenerative lumbar spine disease? A systematic review. Eur Spine J 2020; 29: 1318-27.
4. Mobbs RJ, Phan K, Malham G, et al. Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. J Spine Surg 2015; 1: 2-18.
5. de Kunder SL, van Kuijk SMJ, Rijkers K, et al. Transforaminal lumbar interbody fusion (TLIF) versus posterior lumbar interbody fusion (PLIF) in lumbar spondylolisthesis: a systematic review and meta-analysis. Spine J 2017; 17: 1712-21.
6. Uçar BY, Özcan Ç, Polat Ö, et al. Transforaminal lumbar interbody fusion for lumbar degenerative disease: patient selection and perspectives. Orthop Res Rev 2019; 11: 183-9.
7. Sihvonen T, Herno A, Paljärvi L, et al. Local denervation atrophy of paraspinal muscles in postoperative failed back syndrome. Spine 1993; 18: 575-81.
8. Foley KT, Lefkowitz MA. Advances in minimally invasive spine surgery. Clin Neurosurg 2002; 49: 499-517.
9. Li A, Li X, Zhong Y. Is minimally invasive superior than open transforaminal lumbar interbody fusion for single-level degenerative lumbar diseases: a meta-analysis. J Orthop Surg Res 2018; 13: 241.
10. Zhu L, Cai T, Shan Y, et al. Comparison of clinical outcomes and complications between percutaneous endoscopic and minimally invasive transforaminal lumbar interbody fusion for degenerative lumbar disease: a systematic review and meta-analysis. Pain Physician 2021; 24: 441-52.
11. Ao S, Zheng W, Wu J, et al. Comparison of preliminary clinical outcomes between percutaneous endoscopic and minimally invasive transforaminal lumbar interbody fusion for lumbar degenerative diseases in a tertiary hospital: Is percutaneous endoscopic procedure superior to MIS-TLIF? A prospective cohort study. Int J Surg 2020; 76: 136-43.
12. Dong J, Yang Y, Chen Z, et al. Comparative study of microendoscope-assisted and conventional minimally invasive transforaminal lumbar interbody fusion for degenerative lumbar diseases. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 2019; 33: 814-21.
13. Kim JE, Yoo HS, Choi DJ, et al. Comparison of minimal invasive versus biportal endoscopic transforaminal lumbar interbody fusion for single-level lumbar disease. Clin Spine Surg 2021; 34: E64-71.
14. Li Y, Dai Y, Wang B, et al. Full-endoscopic posterior lumbar interbody fusion via an interlaminar approach versus minimally

invasive transforaminal lumbar interbody fusion: a preliminary retrospective study. World Neurosurg 2020; 144: e475-82.
15. Wen J, Wang D, Zhang H, et al. Full endoscopic and expandable channel minimally invasive transforaminal lumbar interbody fusion in the treatment of single-segmental lumbar degenerative diseases. J Clin Orthop 2020; 23: 487-91.
16. Xue YD, Diao WB, Ma C, Li J. Lumbar degenerative disease treated by percutaneous endoscopic transforaminal lumbar interbody fusion or minimally invasive surgery-transforaminal lumbar interbody fusion: a case-matched comparative study. J Orthop Surg Res 2021; 16: 696.
17. Zhang H, Zhou C, Wang C, et al. Percutaneous endoscopic transforaminal lumbar interbody fusion: technique note and comparison of early outcomes with minimally invasive transforaminal lumbar interbody fusion for lumbar spondylolisthesis. Int J Gen Med 2021; 14: 549-58.
18. Zhao XB, Ma HJ, Geng B, et al. Early clinical evaluation of percutaneous full-endoscopic transforaminal lumbar interbody fusion with pedicle screw insertion for treating degenerative lumbar spinal stenosis. Orthop Surg 2021; 13: 328-37.
19. Cook DA, Reed DA. Appraising the quality of medical education research methods: the Medical Education Research Study Quality Instrument and the Newcastle-Ottawa Scale-Education. Acad Med 2015; 90: 1067-76.
20. Ahn Y, Youn MS, Heo DH. Endoscopic transforaminal lumbar interbody fusion: a comprehensive review. Exp Rev Med Devices 2019; 16: 373-80.
21. Kolcun JPG, Brusko GD, Wang MY. Endoscopic transforaminal lumbar interbody fusion without general anesthesia: technical innovations and outcomes. Ann Transl Med 2019; 7 (Suppl 5): S167.
22. Heo DH, Son SK, Eum JH, et al. Fully endoscopic lumbar interbody fusion using a percutaneous unilateral biportal endoscopic technique: technical note and preliminary clinical results. Neurosurg Focus 2017; 43: E8.
23. Quanping X, Niu H, Li S. Preliminary clinical study: percutaneous lumbar discectomy combined with external drainage for treatment of intervertebral disc infections with epidural abscess. Videosurgery Miniinv 2020; 15: 625-31.
24. Xie X, Zhang G, Liu N. Clinical effect of unilateral biportal endoscopy in the treatment of lumbar diseases: a systematic review and meta-analysis. Videosurgery Miniinv 2022; 17: 61-8.

Received: 25.04.2022, **accepted:** 30.05.2022.