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Comparison of percutaneous transforaminal endoscopic discectomy and open lumbar discectomy for lumbar disc herniations: A systematic review and meta-analysis

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Purpose: In order to compare the outcomes of percutaneous transforaminal endoscopic discectomy (PTED) and open lumbar discectomy (OLD) for lumbar disc herniation (LDH).

Methods: The Pubmed, Cochrane Library, Web of Sience, Embase, Clinicaltrials.gov, CBM, CNKI, VIP, Wangfang databases were searched from inception to April 30, 2022 to collect the published studies about PTED vs. OLD for treatment of LDH. The Revman 5.2 was used for data analysis. The primary outcomes were excellent rates, complication rates and reoperation rates. The secondary outcomes were length of incision, length of operation, length of hospital stay, and the amount of intraoperative blood loss.

Results: A total of nine studies were included, of which, eight randomized controlled trials and one retrospective study involving 1,679 patients with LDH (755 patients for PTED, and 924 patients for OLD) were included. According to meta-analysis, there were no significant difference in excellent rates (odds ratio [OR] = 1.47, 95% confidence intervals [CI]: 0.94-2.28, P = 0.09), reoperation rates (OR = 0.96, 95% CI: 0.50-1.84, P = 0.90), length of operation [standardized mean differences (SMD) = -17.97, 95%CI: -54.83-18.89, P = 0.34], and the amount of intraoperative blood loss (SMD = -128.05, 95%CI: -258.67-2.57, P = 0.05), respectively. There were significant differences in complication rates (OR = 0.22, 95% CI: 0.14-0.33, P < 0.001), length of incision (SMD = -2.76, 95%CI: -2.88--2.65, P < 0.001), and length of hospital stay (SMD = -5.19, 95%CI: -5.36--5.01, P < 0.001), respectively. Conclusions: PTED can achieve better outcomes with respect to the complication rates, length of incision, and length of hospital stay compared with OLD.

KEYWORDS

lumbar disc herniation, open lumbar discectomy, percutaneous transforaminal endoscopic discectomy, meta-analysis, treatment outcome

Introduction

The prevalence of sciatica or radiculitis ranging from 1.2% to 43% worldwide (1). Sciatica is commonly caused by lumbar disc herniation (LDH), and the typical clinical presentation is pain radiating from the waist to the lower extremities, often accompanied by sensory or motor disturbances (2, 3). Most patients with sciatica have a good prognosis with conservative treatment. However, when conservative treatment fails, surgery may be required to relieve symptoms (4). In 1934, the first case of spinal surgery for the treatment of lumbar disc herniation was reported using open lumbar discectomy (OLD) (5). With the development of spine surgery techniques, spine surgeons are increasingly pursuing the treatment of LDH with less trauma (6). Therefore, traditional open minimally invasive surgery has gradually become the standard for the treatment of LDH (5, 7). With the development of endoscopic technology, its application in spine surgery is more and more extensive. Especially after Kambin et al. proposed the spinal safety zone, its combination with the endoscopic technique made various spinal minimally invasive techniques emerge as the times require (8, 9). Percutaneous transforaminal endoscopic discectomy (PTED) is one of spinal minimally invasive surgeries. Compared with traditional incision, PTED does not require dissection of paravertebral muscles, preserves the original bone anatomy, and can be performed with local anesthesia. It has a shorter hospital stay, less trauma, faster postoperative recovery, and better relief of pain, sensory, and motor symptoms (10). However, some scholars believe that PTED is not significantly different from traditional incisional discectomy (11-15). Therefore, the conclusions remain inconsistent. Previously, some meta-analyses comparing the effectiveness of endoscopic discectomy with OLD for LDH was performed. However, in those studies, some kinds of discectomy such as micro-endoscopic discectomy, PTED, and full-endoscopic discectomy together into endoscopic discectomy group and compared them with OLD surgery, which was actually not provided robust evidence (16, 17).

Herein, we aimed to conduct a comprehensively and systematically systematic literature review and meta-analysis to estimate pooled effect sizes, and compare the efficacy of PTED vs. OLD approach in the treatment of LDH.

Methods

Study selection

A systematic review of the English literature available on Pubmed, Cochrane Library, Web of Sience, Embase, and Clinicaltrials.gov was performed, along with a review of Chinese literature available on Chinese Biomedical database (CBM), Chinese National Knowledge Infrastructure (CNKI), Chinese Science and Technology Periodical database (VIP) and WanFang databases from inception to April 30, 2022. The query utilized in the search was designed to include as many literatures as possible pertaining to the outcomes of interest. The final search string was: "percutaneous transforaminal endoscopic discectomy" OR "open lumbar discectomy" OR "traditional discectomy" AND "lumbar disc herniation". Articles which investigated operative approaches on LDH were identified without language restrictions. This study was performed according to the version of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (www.prisma-statement. org). The PRISMA Checklist was shown in Additional File 1.

Inclusion and exclusion criteria

Articles were included according to the following criteria: (1) performed the comparison between PTED and OLD; (2) participants were adults who suffer LDH; (3) contained at least one outcome of interest; (4) patients without recurrent reoperation. Articles were excluded if: Interventions were different from the previous description; or insufficient data such as any outcome of interest; or not human studies. Additionally, patients with multi-segmental lumbar disc herniation, cauda equina syndrome, malignancy, or spinal deformity were also excluded. PTED introduced in 2002, is more minimally invasive, with posterior column lumbar structures preserved.

The primary outcomes were excellent rates, complication rates and reoperation rates. The secondary outcomes were length of incision, length of operation, length of hospital stay, and the amount of intraoperative blood loss.

Literature screening

The literature obtained after searching the database was imported into the EndNote X9 literature management software, and the "Find Duplication" function of the software was used to remove the duplicated literature. Two researchers independently screened the titles and abstracts of the literature one by one according to the inclusion and exclusion criteria, and excluded those that did not meet the criteria. For the literatures with the inclusion criteria, the full text of the initially included literatures and the literatures that could not be determined to meet the inclusion criteria were reviewed. In case of disagreements, they were discussed and resolved to determine the final included literatures.

Data extraction

Two researchers independently extracted data, and entered statistical software for statistical analysis. The data extraction



includes characteristics of included studies: first author, publication year, study design, number of cases, age, and outcomes. The Jadad scoring tool was employed to assess the quality of evidence (18, 19). A Jadad scale score of 4–7 was classified as high-quality literature, and 1–3 was classified as low-quality literature. If there is a disagreement, a decision will be made through mutual consultation.

Statistical analysis

The acquired data were analyzed using RevMan 5.2 software (The Nordic Cochrane Center, The Cochrane Collaboration,

Denmark). The continuous outcomes were analyzed using standardized mean difference (SMD) and 95% confidence interval (CI). Odds ratio (OR) and 95% CI were used for dichotomous outcomes. *P*-value less than 0.05 was considered to be statistically significant. The heterogeneity analysis of the included literature was evaluated using Q-test (χ^2) and I^2 . If the *P*-value was >0.05, and $I^2 < 50\%$, it was considered that there was no significant statistical heterogeneity among different studies, and a fixed effect model was used. If the *P* value <0.05 and $I^2 > 50\%$, statistical heterogeneity exists, and a random-effects model was used. In case of large heterogeneity, sensitivity analysis or subgroup analysis was performed. A funnel chart was used to evaluate possible publication bias qualitatively.

Studies	Publication year	Study design	Procedures	Sample size	Age (years)	Gender (male/ female)	Outcomes	Jadad Scores
Gadjradj PS et al. (20)	2022	RCT	PTED OLD	179 309	45.3 ± 12.4 45.7 ± 11.3	99/55 180/58	(1)(3)(4)(7)	7
Zhang et al. (21)	2019	RCT	PTED OLD	94 94	74.46 ± 6.01 73.02 ± 5.23	46/48 44/50	(2)(3)(6)(7)	7
Pan et al. (22)	2016	RCT	PTED OLD	48 58	39.5 (22–58) 42.8 (27–61)	26/22 31/27	(1)(2)(3)(6) (7)	6
Xu et al. (23)	2017	RS	PTED OLD	58 87	38.16 ± 5.93 36.75 ± 5.48	34/24 48/39	(5)(7)	6
Mayer et al. (14)	1993	RCT	PTED OLD	20 20	41 41	12/8 14/6	(1)(4)(5)(7)	7
Hermantin et al. (13)	2018	RCT	PTED OLD	30 30	39 (15–66) 40 (18–67)	22/8 17/13	(4)(5)(7)	6
GibsonR et al. (15)	2019	RCT	PTED OLD	70 70	$\begin{array}{c} 42\pm9\\ 39\pm9 \end{array}$	30/40 40/30	(4)(7)	7
Tao et al. (23)	2018	RCT	PTED OLD	231 231	$\begin{array}{c} 45.5\pm4.8\\ 44.8\pm4.6\end{array}$	126/105 133/98	(1)(2)(5)(6) (7)	6
Tacconi et al. (24)	2016	RCT	PTED OLD	25 25	43 (25–64) 45 (21–69)	13/12 12/13	(1)(4)(7)	7

TABLE 1 Characteristics of including studies.

PTED, percutaneous transforaminal endoscopic discectomy; OLD, open lumbar discectomy; RCT, randomized controlled trial.

Outcomes: (1) complication rates; (2) length of incision; (3) the amount of intraoperative blood loss; (4) length of operation; (5) excellent rates; (6) reoperation rates; (7) length of hospital stay.

Results

Search results

The initial search retrieved 1,568 studies. Of which, 91 were duplicates and 1,441 studies were excluded based on the titles, and abstracts screening, leaving 36 potential articles. After critical evaluation, 27 studies were further excluded, of which 13 were excluded because the review type; the other 14 studies were excluded because some the patients received percutaneous endoscopic interlaminar discectomy (PEID) or full-endoscopic interlaminar approach discectomy, which may introduce potential bias to our study. Finally, a total of nine studies were included, of which, eight randomized controlled trials (RCTs) and one retrospective study involving 1,679 patients with LDH (755 patients for PTED, and 924 patients for OLD) were included (**Figure 1**). The characteristics of the included studies were shown in **Table 1**.

Primary outcomes

Four studies reported excellent rates, which did not differ between PTED and OLD approaches (odds ratio [OR] = 1.47, 95% confidence intervals [CI]: 0.94–2.28, P = 0.09) (**Figure 2A**). Two studies reported on reoperation rates and did not find a difference between PTED and OLD groups (OR = 0.96, 95% CI: 0.50–1.84, P = 0.90) (**Figure 2B**). Notably, nine studies indicated that patients underwent PTED acquired less complications than those with OLD (OR = 0.27, 95% CI: 0.18–0.40, P < 0.001) but there was high heterogeneity (I^2 = 68%, P = 0.009) (Figure 2C). After sensitivity analysis, the pooled OR of complication rates was 0.22 (95% CI: 0.14–0.33, P < 0.001) but without significant heterogeneity (I^2 = 38%, P = 0.14) (Figure 2D).

Secondary outcomes

Length of operation [standardized mean differences (SMD) = -17.97, 95%CI: -54.83-18.89, P = 0.34], and the amount of intraoperative blood loss (SMD = -128.05, 95%CI: -258.67-2.57, P = 0.05) among patients who underwent PTED and OLD were insignificant, respectively (**Figures 3A,B**). Three RCTs reported the differences in length of incision, and patients who underwent PTED had smaller incision than patients who underwent OLD (SMD = -2.76, 95%CI: -2.88-2.65, P < 0.001, **Figure 3C**). Same three RCTs also indicated that patients who underwent PTED had shorter hospital stay than patients who underwent OLD (SMD = -5.19, 95%CI: -5.36-5.01, P < 0.001. **Figure 3D**).

Publication bias

Funnel charts showed that there was no significant publication bias in all analysis (Figures 4A–G).

4	PTED		OPE			Odds Ratio	Odds Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% Cl	M-H, Fixed, 95% Cl	
By 1999	29	30	28	30	2.8%	2.07 [0.18, 24.15]		
Mayer 1993	14	20	11	20	10.0%	1.91 [0.52, 7.01]	•	
Tao 2018	203	231	196	231	71.8%	1.29 [0.76, 2.21]		
Xu 2019	53	58	74	87	15.4%	1.86 [0.63, 5.54]		
Total (95% CI)		339		368	100.0%	1.47 [0.94, 2.28]	•	
Total events	299	555	309	500	100.070	1.47 [0.54, 2.20]	Ť	
Heterogeneity: Chi ² =		2 /D -		0%				
Test for overall effect:				0.00			0.01 0.1 1 10 1 PTED OP	100
В	PTED		OPE	J		Odds Ratio	Odds Ratio	
Study or Subgroup					Weight	M-H, Fixed, 95% Cl	M-H, Fixed, 95% Cl	
By 1999	0	30	2	30	13.3%	0.19 [0.01, 4.06]	4	
Gadiradi 2022	9	171	14	249	58.6%			
						0.93 [0.39, 2.21]		
Gibson 2017	5	70	2	70	10.1%	2.62 [0.49, 13.96]		
Mayer 1993	1	20	3	20	15.5%	0.30 [0.03, 3.15]		
Tacconi 2020	1	25	0	25	2.6%	3.12 [0.12, 80.39]		_
Total (95% CI)		316		394	100.0%	0.96 [0.50, 1.84]	+	
Total events	16		21					
Heterogeneity: Chi ² =				0%				100
Test for overall effect:	Z=0.12 (F	P = 0.9	10)				PTED OP	.00
C	PTED		OPE	J		Odds Ratio	Odds Ratio	
Study or Subgroup					Moight	M-H, Fixed, 95% Cl	M-H, Fixed, 95% Cl	
By 1999						a section of the sect	M-H, FIXEd, 55% CI	+
	2	30	0	30		5.35 [0.25, 116.31]		,
Gadjradj 2022	0	171	13	249	10.2%	0.05 [0.00, 0.87]		
Gibson 2017	6	70	1	70	0.8%	6.47 [0.76, 55.21]		
Mayer 1993	0	20	5	20	5.0%	0.07 [0.00, 1.34]	• • • • • • • • • • • • • • • • • • •	
Pan 2016	3	38	12	42	9.7%	0.21 [0.06, 0.83]		
Tacconi 2020	0	25	0	25		Not estimable	_	
Tao 2018	14	231	63	231	54.9%	0.17 [0.09, 0.32]		
Xu 2019	5	58	24	87	16.3%	0.25 [0.09, 0.69]		
Zhang 2020	3	94	3	94	2.7%	1.00 [0.20, 5.09]		
Total (95% CI)		737		040	100.0%	0.27 [0.18, 0.40]	•	
Total events	33	151	121	040	100.070	0.27 [0.10, 0.40]	•	
Heterogeneity: Chi ² =		- 7 /0 -		Z = 000	v			_
Test for overall effect:				- 03	20			100
	2 - 0.40 (i	.0.0	.0001,7				PTED OP	
D	BTFS		000					
Study or Subgroup	PTED		OPEN		Woight	Odds Ratio M-H, Fixed, 95% Cl	Odds Ratio M-H, Fixed, 95% Cl	
stady of Subgroup	2	30	O	30		5.35 [0.25, 116.31]		+
By 1000		171	13	249	10.3%	0.05 [0.00, 0.87]	←	
By 1999 Gadiradi 2022								
Gadjradj 2022	0	70	1	70 20	0.0%	6.47 [0.76, 55.21]		
Gadjradj 2022 Gibson 2017	6	70		211	5.0%	0.07 [0.00, 1.34]		
Gadjradj 2022 Gibson 2017 Mayer 1993	6 0	20	5		0.001			
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016	6 0 3	20 38	12	42	9.8%	0.21 [0.06, 0.83]		
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020	6 0 3 0	20 38 25	12 0	42 25		Not estimable		
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020 Tao 2018	6 0 3 0 14	20 38 25 231	12 0 63	42 25 231	55.3%	Not estimable 0.17 (0.09, 0.32)	-	
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020	6 0 3 0 14 5	20 38 25	12 0	42 25		Not estimable	-	
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020 Tao 2018	6 0 3 0 14	20 38 25 231	12 0 63	42 25 231	55.3%	Not estimable 0.17 (0.09, 0.32)		
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020 Tao 2018 Xu 2019 Zhang 2020	6 0 3 0 14 5	20 38 25 231 58 94	12 0 63 24	42 25 231 87 94	55.3% 16.4% 2.7%	Not estimable 0.17 (0.09, 0.32) 0.25 (0.09, 0.69) 1.00 (0.20, 5.09)		
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020 Tao 2018 Xu 2019 Zhang 2020 Total (95% CI)	6 0 3 0 14 5 3	20 38 25 231 58	12 0 63 24 3	42 25 231 87 94	55.3% 16.4%	Not estimable 0.17 (0.09, 0.32) 0.25 (0.09, 0.69)	•	
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020 Tao 2018 Xu 2019 Zhang 2020 Total (95% CI) Total events	6 0 14 5 3 27	20 38 25 231 58 94 667	12 0 63 24 3 120	42 25 231 87 94 778	55.3% 16.4% 2.7%	Not estimable 0.17 (0.09, 0.32) 0.25 (0.09, 0.69) 1.00 (0.20, 5.09)		
Gadjradj 2022 Gibson 2017 Mayer 1993 Pan 2016 Tacconi 2020 Tao 2018 Xu 2019 Zhang 2020 Total (95% CI)	6 0 3 0 14 5 3 27 9.75, df = 1	20 38 25 231 58 94 667 6 (P =	12 0 63 24 3 120 0.14); I²=	42 25 231 87 94 778	55.3% 16.4% 2.7%	Not estimable 0.17 (0.09, 0.32) 0.25 (0.09, 0.69) 1.00 (0.20, 5.09)	0.01 0.1 0.1 10 10 10	100

FIGURE 2
Pooling results of the PTED group and the OLD group. (A) Excellent rates; (B) Reoperation rates; (C) Complication rates; (D) Complication rates after sensitivity analysis.

Gadjradj 2022 Mayer 1993 4 Pan 2016 6 Tacconi 2020 7 Tao 2018 7 Total (95% CI) 1 Heterogeneity: Tau² = 17/1 7 Test for overall effect: Z = 9 Study or Subgroup Mer Pan 2016 13 Tao 2018 13	30 33 40.7 11.3 64.8 16.2 65 58.5 55 8 707.00; Chi = 0.96 (P = PTED ean <u>SD</u> 3.8 3.6 15 5 1.63 5.86	171 20 38 25 231 485 ² = 638. 0.34) <u>Total</u> 38 231	30 58.2 72 56 125 23, df = 4	32.5 15.2 12.6 64 22 4 (P < 1)P <u>SD</u> 32.3 35	249 20 42 25 231 567 0.0000	100.0%	Mean Difference IV, Random, 95% CI	IV, Random, 95% Cl
Mayer 1993 4 Pan 2016 6 Tacconi 2020 7 Tao 2018 5 Total (95% CI) 1 Heterogeneity: Tau ² = 171 7 Test for overall effect: Z = 7 S 5 Study or Subgroup Mer Pan 2016 13 Tao 2018 7 Zhang 2020 49. Total (95% CI) 1 Heterogeneity: Tau ² = 133: 1	40.7 11.3 64.8 16.2 65 58.5 55 8 707.00; Chi = 0.96 (P = PTED ean SD 3.8 3.6 15 5 1.63 5.86	20 38 25 231 485 ² = 638. 0.34) <u>Total</u> 38 231 94 1	58.2 72 56 125 23, df = 4 0 <u>Mean</u> 87.2 260	15.2 12.6 64 22 4 (P < 1 9 SD 32.3 35	20 42 25 231 567 0.0000	20.5% 20.6% 17.6% 20.7% 100.0% (1); I ² = 99 <u>Weight</u>	-17.50 [-25.80, -9.20] -7.20 [-13.61, -0.79] 9.00 [-24.99, 42.99] -70.00 [-73.02, -66.98] -17.97 [-54.83, 18.89] % Mean Difference IV, Random, 95% CI	PTED OP Mean Difference IV, Random, 95% CI
Pan 2016 B Tacconi 2020 Tacconi 2020 Tao 2018 Total (95% CI) Heterogeneity: Tau ² = 170 Test for overall effect: Z = S Study or Subgroup Mer Pan 2016 13 Tao 2018 Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133:	64.8 16.2 65 58.5 55 8 707.00; Chi = 0.96 (P = PTED ean <u>SD</u> 3.8 3.6 15 5 1.63 5.86	38 25 231 485 7 = 638. 0.34) <u>Total</u> 38 231 94 1	72 56 125 23, df = 4 0 <u>Mean</u> 87.2 260	12.6 64 22 4 (P < 1 0P <u>SD</u> 32.3 35	42 25 231 567 0.0000	20.6% 17.6% 20.7% 100.0% (1); I ² = 99 <u>Weight</u>	-7.20 [-13.61, -0.79] 9.00 [-24.99, 42.99] -70.00 [-73.02, -66.98] - 17.97 [-54.83, 18.89] % + Mean Difference IV, Random, 95% CI	PTED OP Mean Difference IV, Random, 95% CI
Tacconi 2020 Tao 2018Total (95% CI)Heterogeneity: Tau ² = 170Test for overall effect: Z =SStudy or SubgroupMeaPan 201613Tao 2018Zhang 202049.Total (95% CI)Heterogeneity: Tau ² = 133:	65 58.5 55 8 707.00; Chi = 0.96 (P = <u>PTED</u> ean <u>SD</u> 3.8 3.6 15 5 1.63 5.86	25 231 485 ² = 638. 0.34) <u>Total</u> 38 231 94 1	56 125 23, df = 4 0 <u>Mean</u> 87.2 260	64 22 4 (P < 1)P <u>SD</u> 32.3 35	25 231 567 0.0000	17.6% 20.7% 100.0% 11); I ² = 99 <u>Weight</u>	9.00 [-24.99, 42.99] -70.00 [-73.02, -66.98] - 17.97 [-54.83, 18.89] % + Mean Difference IV, Random, 95% CI	PTED OP Mean Difference IV, Random, 95% CI
Tao 2018 Total (95% CI) Heterogeneity: Tau ² = 170 Test for overall effect: Z = 3 Study or Subgroup Mer Pan 2016 13 Tao 2018 2 Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133:	55 8 207.00; Chi = 0.96 (P = PTED ean SD 3.8 3.6 15 5 1.63 5.86	231 485 ² = 638. 0.34) <u>Total</u> 38 231 94 1	125 23, df = 4 0 <u>Mean</u> 87.2 260	22 4 (P <) 9P <u>SD</u> 32.3 35	231 567 0.0000	20.7% 100.0 % 11); I ² = 99 <u>Weight</u>	-70.00 [-73.02, -66.98] -17.97 [-54.83, 18.89] % + Mean Difference N, Random, 95% CI	PTED OP Mean Difference IV, Random, 95% CI
Total (95% CI) Heterogeneity: Tau ² = 170 Test for overall effect: Z = 3 Study or Subgroup Mer Pan 2016 13 Tao 2018 2 Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133:	207.00; Chi = 0.96 (P = PTED ean SD 3.8 3.6 15 5 163 5.86	485 ² = 638. 0.34) <u>Total</u> 38 231 94 1	23, df = 4 0 <u>Mean</u> 87.2 260	4 (P < 1)P <u>SD</u> 32.3 35	567 0.0000 Total	100.0% 1); ² = 99 <u>Weight</u>	-17.97 [-54.83, 18.89] %	PTED OP Mean Difference IV, Random, 95% CI
Heterogeneity: Tau ² = 170 Test for overall effect: Z = Study or Subgroup Mer Pan 2016 13 Tao 2018 Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133:	= 0.96 (P = PTED <u>ean SD</u> 3.8 3.6 15 5 163 5.86	² = 638. 0.34) <u>Total</u> 38 231 94 1	0 <u>Mean</u> 87.2 260	0P <u>SD</u> 32.3 35	0.0000 <u>Total</u>	11); I² = 99 <u>Weight</u>	% + Mean Difference IV, Random, 95% CI	PTED OP Mean Difference IV, Random, 95% CI
Test for overall effect: Z = Study or Subgroup Mer Pan 2016 13 Tao 2018 Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133 ²	= 0.96 (P = PTED <u>ean SD</u> 3.8 3.6 15 5 163 5.86	0.34) <u>Total</u> 38 231 94 1	0 <u>Mean</u> 87.2 260	0P <u>SD</u> 32.3 35	Total	Weight	Mean Difference IV, Random, 95% CI	PTED OP Mean Difference IV, Random, 95% CI
B Study or Subgroup Mer Pan 2016 13 Tao 2018 2 Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133:	PTED ean SD 3.8 3.6 15 5 .63 5.86	<u>Total</u> 38 231 94 1	<u>Mean</u> 87.2 260	SD 32.3 35			Mean Difference IV, Random, 95% Cl	PTED OP Mean Difference IV, Random, 95% CI
Study or Subgroup Mean Pan 2016 13 Tao 2018 2 Zhang 2020 49. Total (95% Cl) 49.	e <u>an SD</u> 3.8 3.6 15 5 1.63 5.86	38 231 94 1	<u>Mean</u> 87.2 260	SD 32.3 35			IV, Random, 95% Cl	IV, Random, 95% Cl
Study or Subgroup Mean Pan 2016 13 Tao 2018 2 Zhang 2020 49. Total (95% Cl) 49.	e <u>an SD</u> 3.8 3.6 15 5 1.63 5.86	38 231 94 1	<u>Mean</u> 87.2 260	SD 32.3 35			IV, Random, 95% Cl	IV, Random, 95% Cl
Pan 2016 13 Tao 2018 13 Zhang 2020 49. Total (95% Cl) 13 Heterogeneity: Tau ² = 133: 133:	3.8 3.6 15 5 1.63 5.86	38 231 94 1	87.2 260	32.3 35				
Tao 2018 Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133 ²	15 5 1.63 5.86	231 94 1	260	35	42		72 /0[02 2/ 62 661	• · · · · · · · · · · · · · · · · · · ·
Zhang 2020 49. Total (95% CI) Heterogeneity: Tau ² = 133 ²	1.63 5.86	94 1			224		-73.40 [-83.24, -63.56] -245.00 [-249.56, -240.44]	
Total (95% CI) Heterogeneity: Tau ² = 133			110.32	14 46	231 94		-245.00 [-249.56, -240.44] -65.69 [-68.29, -63.09]	· · · ·
Heterogeneity: Tau ² = 133	312.78; Chi ^a	363		11.40	94	33.4%	-03.09 [-08.29, -03.09]	_
Heterogeneity: Tau ² = 133	312.78; Chi ^a				367	100.0%	-128.05 [-258.67, 2.57]	
		²= 4531	.75, df = 1	2 (P < 1	0.0000	1); I ² = 100)%	
	1.92 (P = 0.)			,				-200 -100 Ó 100 200 PTED OP
C Study or Subgroup M	PTED Aean SD			open Sd	Tota	l Weight	Mean Difference IV, Fixed, 95% Cl	Mean Difference IV, Fixed, 95% Cl
	1.17 0.92		the set of				-2.67 [-2.90, -2.44]	+
Pan 2016	0.8 0.1			0.8			-2.90 [-3.14, -2.66]	+
	0.82 0.32			0.75			-2.75 [-2.91, -2.59]	
Total (95% CI)		303	1		385	5 100.0%	-2.76 [-2.88, -2.65]	•
Heterogeneity: Chi ² = 1.8	85, df = 2 (l	P = 0.40	0); l ² = 09	Ж			Ŀ,	
Test for overall effect: Z =							-4	-2 0 2 PTED OP
_								
Cturks or Subgroups Ma	PTED	Tetal		PEN	Total	Moinht	Mean Difference	Mean Difference
			Mean			Weight	IV, Fixed, 95% Cl	IV, Fixed, 95% Cl
	7.2 1.6		12.8	3.8	42	2.0%	-5.60 [-6.86, -4.34]	
Tao 2018	3 1.5			1.8			-11.00 [-11.30, -10.70]	- <u>-</u>
Zhang 2020 2	2.55 0.71	94	4.62	0.83	94	63.9%	-2.07 [-2.29, -1.85]	
Total (95% CI)		363			367	100.0%	-5.19 [-5.36, -5.01]	
Heterogeneity: Chi ² = 218	87.75, df =	2 (P < 0	.00001);	² = 10	00%		-	
Test for overall effect: Z =								-10 -5 Ó Ś 10 PTED OP
	-							FIED VF

Discussion

Our comprehensive systematic review which evaluated the effect of PTED vs. OLD for the treatment of LDH indicated that there is high quality evidence among included studies, and further meta-analysis suggests that complications were less frequently occurred in patients who underwent PTED. Furthermore, length of incision and length of hospital stay in PTED groups were significantly different from OLD groups. This may be because PTED approach does not require stripping the paravertebral muscles, preserves the original



bone anatomy, and can perform the operation under local anesthesia, so it can be faster and more accurate than OLD approach. PTED can easily reach the responsible segment, and induce less trauma to the tissue so as to provide advantages for early postoperative recovery and discharge. Moreover, no superiority was found between PTED and OLD procedures with regard to excellent rates, reoperation rates, length of operation, and the amount of intraoperative blood loss.

Previously, other systematic reviews with different inclusion criteria and outcomes have been published (25-28). The current systematic review differs in that we only compared the studies which compared the effects of PTED vs. OLD approach. Study by Gadjradj et al., mainly focused on the comparison of pain scores and postoperative functional scores between PTED and traditional surgery for LDH (29), while study by Li et al., mainly focused on comparing the outcomes between foraminoscopic and no intervertebral discectomy (30). Our study is different from theirs, which systematically and comprehensively compared the PTED and OLD from seven postoperative indicators between PTED and OLD approach for LDH, including excellent rates, complication rates, reoperation rates, length of incision, length of operation, length of hospital stay, and the amount of intraoperative blood loss. Differences in outcomes between endoscopic discectomy and conventional surgery for lumbar disc herniation. Furthermore, the central-located high-canal compromised and high-grade migration herniations indicated a high rate of incomplete decompression treated with

percutaneous interlaminar endoscopic discectomy (PIED) (31) for LDH. PIED has larger scope of the manipulation of the working cannula compared with PTED. Herein, it is better to use PIED in the treatment of migratory herniations. Further evidence based study on the effectiveness and safety of PIED in treatment of LDH should be performed.

Interestingly, there were only significant heterogeneity in meta-analysis on complication rates. This may be due to methodology such as study design, inclusion criteria, ethnicities and clinical characteristics such as lumbar intervertebral disc herniation and skill levels of surgical operators. In current study, after sensitivity analysis, there was no significant heterogeneity in field of pooled complication rates among including studies.

Present comprehensive systematic review and meta-analysis provided high quality evidence on the comparison of two procedure (PTED vs. OLD) for the treatment of LDH. However, there were some limitations in current study. First, although we performed that at least three studies are included in the comparison for each indicator, the number of trials involved in some comparisons are relatively small. Second, subgroup analysis disparity on the inclusion criteria, the baseline characteristics of patients and the follow-up period in different trials were not conducted due to insufficient data. Third, none of the included studies reported postoperative survival rate, and mortality, thus, long-term efficacy and safety evaluation could not be performed. In view of this, the effect of PTED procedure in the treatment of LDH still needs to be confirmed by long term, large sample size, high quality, rigorous study design, and future research should strictly follow the CONSORT-2010 standard to report relevant information. Furthermore, we only evaluated the publication bias, but without risk of bias analysis due to the limited including studies. Last but not least, although there are some comparative studies between minimally invasive endoscopic surgery and open surgery in the treatment of LDH. Importantly, some of the advantages of minimally invasive endoscopic surgery, including less paravertebral muscle injury, rapid recovery, shorter hospital stay, and less blood loss, are well established, it makes more sense to do a transforaminal approach and a translaminar approach for lumbar discectomy in future.

Conclusion

PTED can be considered sufficient to achieve good clinical outcomes on the complication rates, length of incision, and length of hospital stay compared with OLD. Both PTED and OLD are able to achieve similar outcomes on excellent rates, reoperation rates, length of operation, and the amount of intraoperative blood loss for patients with LDH. For patients who meet surgical indications, we recommend the use of PTED approach for the treatment of LDH.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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