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Meta-analysis of the operative treatment of lumbar disc herniation via transforaminal percutaneous endoscopic discectomy versus interlaminar percutaneous endoscopic discectomy in randomized trials

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Abstract

Backgrounds: Transforaminal percutaneous endoscopic discectomy (TF-PELD) and interlaminar percutaneous endoscopic discectomy (IL-PELD) are the most common alternative treatments of lumbar disc herniation. The aim of this study was to compare the operation time duration and X-ray exposure as well as outcomes of TF-PELD and IL-PELD as indicated by the published clinical evidences within randomized trials.

Methods: We included randomized, controlled studies reporting operation duration and X-ray exposure as well as clinical outcome evaluations, comparing TF-PELD to IL-PELD with a minimum of 10 patients per group. The included data measures were operation duration, X-ray exposure and postoperation evaluations. Data were synthesized and analyzed using ReviewManager version 5.3. Publication bias was evaluated via funnel plot. The Cochran *Q* test and the degree of inconsistency (I^2) were used to assess heterogeneity. Lowly biased and heterogenous dichotomous data were calculated by odds ratio and continuous data were calculated by mean difference (MD) with 95% confidence intervals (CI).

Results: Thirteen studies published from January 1970 to March 2018, with a total of 770 lumbar disc herniation patients, including 361 cases of TF-PELD and 409 cases of IL-PELD, were finally included. Meta-analysis of data extracted from these studies revealed that the postoperation outcomes of both surgery methods did not differ significantly, but the surgery duration was significantly shorter in the IL-PELD group than in the TF-PELD group (MD 21.69; 95% CI 12.94–30.27; $P = .00001$), and the fluoroscopy times demanded in the IL-PELD group was significantly fewer than those in the TF-PELD group (MD 7.57; 95% CI 6.22–8.93; $P = .00001$).

Conclusion: The main finding of the study is that IL-PELD approach can decrease radiation exposure as their demanded duration of operation and fluoroscopy times were significantly shorter and fewer in the IL-PELD group, which they achieve similar outcomes comparing to TF-PELD. The study is limited at a lack of samples with lumbar disc herniation levels out of L5/S1. The findings implicate selection of IL-PELD approach over TF-PELD at applicable circumstances for lower lumbar disc herniation. Physicians should consider this data when choosing between TF-PELD and IL-PELD.

Abbreviations: IL-PELD = interlaminar percutaneous endoscopic lumbar discectomy, LDH = lumbar disc herniation, ODI = Oswestry disability index, PELD = percutaneous endoscopic lumbar discectomy, TF-PELD = transforaminal percutaneous endoscopic lumbar discectomy, VAS = postoperative visual analog score.

Keywords: interlaminar, lumbar disc herniation, meta-analysis, percutaneous endoscopic lumbar discectomy, transforaminal

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The authors have no conflicts of interest to disclose.

All data generated or analyzed during this study are included in this published article [and its supplementary information files]

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1. Introduction

Lumbar disc herniation (LDH) is a common degenerative disease that predominantly occurs in the lower back between the fourth and fifth lumbar vertebral bodies (L4/L5) or between the fifth and the sacrum (L5/S1). In addition to low back pain, symptoms can affect the sciatic nerve, resulting in radicular sciatica.[1] Although minor cases were reported to heal with non-surgical intervention, in some circumstances, surgeries were demanded for correction.[2] Open lumbar discectomy was applied into the management of lumbar disc herniation. Nonetheless, the long incision length scarring produced in the processes makes revision surgery challenging to locate. Percutaneous endoscopic lumbar discectomy (PELD), as a minimally invasive spinal technique, avoids the problems and become an alternative to conventional mean difference (MD).[3] Currently, there are 2 operative approaches for PELD, that is, the transforaminal (TF) approach described by Kambin[3] and the interlaminar (IL) approach described by Ruetten.[4] According to accumulative studies, IL-PELD was mainly applied in L5/S1 level herniation surgeries, although in some other studies, IL-PELD was reported to successfully correct herniation at other lumbar levels. TF-PELD was originally regarded as not suitable for L5/S1 level. However, it was reported to be improved to access all lumbar levels, even L5/S1.[5,6] A practical problem for clinicians is lack of standard for decision of the endoscopic route, especially regarding the L5/S1 level. Judgements about the operations commonly include operating time, X-ray exposure during the operation and postoperation outcome evaluations.[7,8] Therefore, this study aimed to provide scientific reference for the operation route options via comparing the operation duration, X-ray exposure as well as outcomes of TF-PELD and IL-PELD to LDH patients as indicated by the published randomized clinical trials.

2. Methods

2.1. Study selection, search strategy, and inclusion criteria

MEDLINE, EMBASE, Web of Science, Cochrane databases, Chinese Biomedical Literature Database, Chinese National Knowledge Infrastructure, and Wanfang Data databases were searched to find eligible studies published from January 1970 to March 2018 for this meta-analysis. The electronic search combined the key words and Medical Subject Headings terms: TF percutaneous endoscopic discectomy, IL percutaneous endoscopic discectomy, lumbar disc herniation, and randomized. The last search date was May 25th, 2018. The search strategy followed the identification and screening guidelines established by the preferred reporting items for systematic reviews and meta-analyses statement. As relevant English publications were limited, we included Chinese publications as well. Inclusion criteria:

(1) comparing TF-PELD versus IL-PELD for treatment of LDH patients,
(2) including more than 10 patients in each group,
(3) providing clinical evaluations, including operation duration, fluoroscopy times, postoperative visual score, as well as follow-up evaluations if the last follow up is no less than 3 months, and
(4) study designs were randomized controlled trials.

There was no process for obtaining and confirming data from investigators as the data in each study was elaborative, and none of the included studies used the same data that had been reported for more than once. The qualities of the studies were assessed using the Newcastle–Ottawa cohort scale independently by 2 workers and disagreements between them were replaced by consensus decided by all the authors. Exclusion criteria:

(1) case reports;
(2) duplicate publications; and
(3) conference papers, systematic reviews, and meta-analyses.

The study was approved by the ethics committee of The Second Affiliated Hospital of Nanchang University.

2.2. Data synthesis and statistical analysis

The data we compared between TF-PELD and IL-PELD are: duration of operation, fluoroscopy times, postoperative visual analog score (VAS), last follow-up VAS, last follow-up Oswestry disability index (ODI), complications, and the MacNab evaluation based excellent/reasonable rate. The data were extracted as their reported form from each publication and then synthesized and analyzed using ReviewManager version 5.3. To avoid bias, data were extracted by researcher blind with the study purpose. Odds ratios (OR) were used to compare the dichotomous data, while the continuous data were analyzed by MD with 95% confidence intervals (CI). Publication bias was assessed by plotting funnel plot. The Cochran Q test and the degree of inconsistency (I^2) were used to assess heterogeneity among the results provided by the selected studies. The fixed-effect model was used for low heterogeneous data that was identified with $P > .05$ and $I^2 < 50\%$, and the random effect model was used for big heterogeneous data.

3. Results

3.1. Study characteristics and quality judgments

We included 13 studies,[9–21] with a total of 770 lumbar disc herniation patients, including 361 cases of TF-PELD and 409 cases of IL-PELD. Duration of operation, fluoroscopy times, postoperative VAS, last follow-up VAS, postoperative ODI, last follow-up ODI, complications, and MacNab evaluation were the analysis endpoints. The information and characteristics of these studies were summarized in Table 1. The quality judgment for each study was performed with the Newcastle–Ottawa scale and listed in Table 2. Overall, all the included studies were evaluated as being moderate to high quality. Bias assessment through funnel plot indicates that the included studies are of low risks of bias.

3.2. Duration of operation

The operation time was documented in 9 studies. Heterogeneity was high ($P < .00001$, $I^2 = 94\%$). Therefore, the random effect model was used. As illustrated in Figure 1A, the surgery duration was significantly shorter in the IL-PELD group than in the TF-PELD group (MD 21.69; 95% CI 12.94–30.27; $P = .00001$).

3.3. Fluoroscopy times

The fluoroscopy times implemented in the surgeries were available in 9 studies. Heterogeneity was high ($P < .00001$, $I^2 = 93\%$) and the random effect model was used. As depicted in Figure 1B, the fluoroscopy times demanded in the IL-PELD group was significantly fewer than those in the TF-PELD group (MD 7.57; 95% CI 6.22–8.93; $P = .00001$).

Table 1

Characteristics of the studies included in the meta-analysis.

Study	Design	Operation	No. of patients	Lumbar level	Age (yr)	Follow-up (mo)	Analysis index
Choi Kyung-Chul 2013[9]	Prospective	TF-PELD	30	L5 /S1	33.8±10.1	–	4 6
		IL-PELD	30		36.9±11.6	–	
Li Yongjin 2016[10]	Prospective	TF-PELD	52	L5 /S1	–	3–12	1 2 3 4
		IL-PELD	51		–	3–12	
Liu Chao 2017[11]	Prospective	TF-PELD	31	L3/L4, L4/L5, L5/S1	38.5±7.8	–	1 2 8
		IL-PELD	27		37.5±6.2	–	
Nie Hongfei 2016[12]	Prospective	TF-PELD	30	L5 /S1	42.3±10.4	28.2±3.9	1 2 4 6 8
		IL-PELD	30		43.2±11.5	27.2±3.7	
Sebastian Ruetten 2008[13]	Prospective	TF-PELD	41	L1/L2, L2/L3, L3/L4, L4/L5, L5/S1	–	–	7
		IL-PELD	59		–	–	
Sheng Tong 2016[14]	Prospective	TF-PELD	25	L5 /S1	35.1±9.7	12	3 5
		IL-PELD	25		38.2±11.2	12	
Tian Xiliang 2015[15]	Prospective	TF-PELD	16	L5 /S1	–	12	1 2 4 6
		IL-PELD	46		–	12	
Xu Yuanbing 2017[16]	Prospective	TF-PELD	12	L5 /S1	48.5±6.9	>6	1 2 4 6 7
		IL-PELD	18		46.3±9.3	>6	
Xu Zhou 2013[17]	Prospective	TF-PELD	31	L5 /S1		3	1 2 4 8
		IL-PELD	37			3	
Yang Fei 2015[18]	Prospective	TF-PELD	15	L4/L5	34.8±8.14	3	1 2 3 4 5 6 8
		IL-PELD	15		36.47±8.86	3	
Yin Li 2017[19]	Prospective	TF-PELD	36	L2/L3,L3/L4,L4/L5,L5/S2	38.5±7.8	12 (6–18)	3 8
		IL-PELD	31		37.5±6.2	12 (6–18)	
Zha Yuanyu 2017[20]	Prospective	TF-PELD	31	L5/S1	42.3±10.4	>3	1 2 4 6 7 8
		IL-PELD	27		43.2±11.5	>3	
Zhang Peng 2017[21]	Prospective	TF-PELD	11	L4/5, L5/S1	38.1±7.1	12 (6–18)	1 2 3 4 5 6 8
		IL-PELD	13		38.4±6.2	12 (6–18)	

Analysis index: 1. Duration of operation 2. Fluoroscopy times 3. Postoperative VAS 4. Last follow-up VAS 5. Postoperative ODI 6. Last follow-up ODI 7. Complications 8. MacNab evaluation.

3.4. Postoperative VAS

The postoperative VAS was recorded in 5 studies. Heterogeneity was high ($P < .00001$, $I^2 = 93\%$) and the random effect model was used. Based on the complete analysis, the postoperative VAS was not significantly different between the TF-PELD and the IL-PELD groups (MD −0.03; 95% CI −0.38 to 0.32; $P = .87$) (Fig. 1C).

3.5. Last follow-up VAS

The last follow-up VAS was recorded in 9 studies. Heterogeneity was low ($P = .70$, $I^2 = 0\%$). Therefore, the fixed effect model was used. As shown in Figure 1D, the last follow-up VAS was not significantly different between the TF-PELD and the IL-PELD groups (MD −0.10; 95% CI −0.24 to 0.04; $P = .15$).

3.6. Postoperative ODI

The postoperative ODI was documented in 3 studies. Heterogeneity was low ($P = .62$, $I^2 = 0\%$), and the fixed-effect model was used. As illustrated in Figure 1E, the last postoperative ODI was not significantly different between the TF-PELD and the IL-PELD groups (MD −1.31; 95% CI −3.76 to 1.14; $P = .62$).

Table 2

Quality assessment of included studies based on the Newcastle–Ottawa scale.

	Selection				Comparability	Outcome			
Study	1	2	3	4	1	1	2	3	Quality judgment
Kyung-Chul C, 2013[9]	★	★	★	★	★	★	–	–	★★★★★★
Yongjin L 2016[10]	★	★	★	★	★	★	★	★	★★★★★★★★
Chao L 2017[11]	★	★	★	★	★	★	–	–	★★★★★★
Hongfei N 2016[12]	★	★	★	★	★	★	★	★	★★★★★★★★
Sebastian R 2008[13]	★	★	★	★	★	★	–	–	★★★★★★
Sheng T 2016[14]	★	★	★	★	★	★	★	★	★★★★★★★★
Xi-liang T 2015[15]	★	★	★	★	★	★	★	★	★★★★★★★★
Yuanbin X 2017[16]	★	★	★	★	★	★	★	★	★★★★★★★★
Zhou X 2013[17]	★	★	★	★	★	★	★	★	★★★★★★★★
Fei Y 2015[18]	★	★	★	★	★	★	★	★	★★★★★★★★
Li Y 2017[19]	★	★	★	★	★	★	★	★	★★★★★★★★
Yuanyu Z 2017[20]	★	★	★	★	★	★	★	★	★★★★★★★★
Zhang P 2017[21]	★	★	★	★	★	★	★	★	★★★★★★★★

Selection (4 stars): (1) Representativeness of the Exposed Cohort, (2) Selection of the Non-Exposed Cohort, (3) Ascertainment of Exposure, 4) Demonstration That Outcome of Interest Was Not Present at Start of Study.

Comparability (2 stars): Comparability of Cohorts on the Basis of the Design or Analysis.

Outcome (3 stars): (1) Assessment of Outcome, (2) Was Follow-Up Long Enough for Outcomes to Occur, (3) Adequacy of Follow Up of Cohorts.

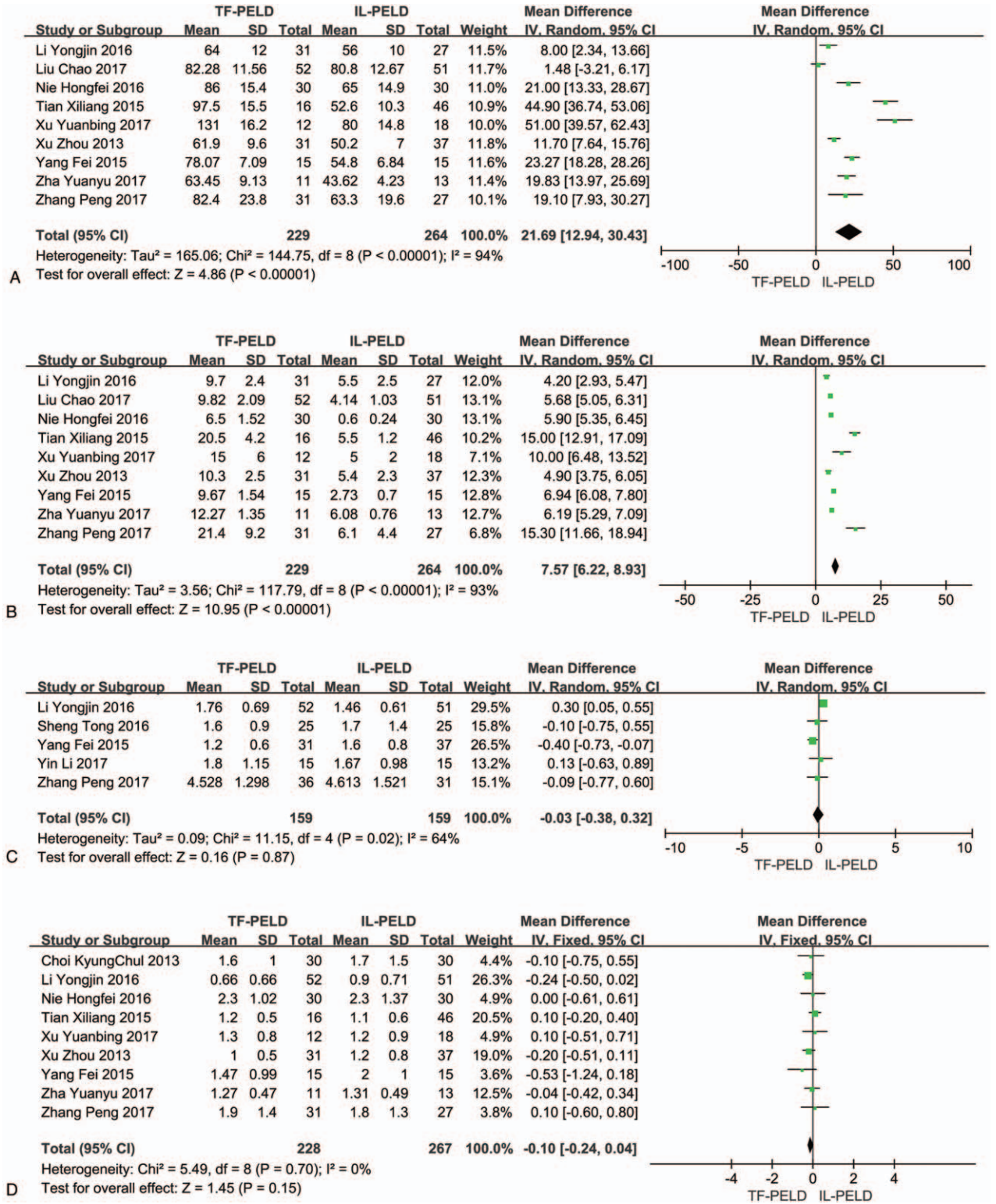

Figure 1. (A) Forest plot for duration of operation (min) between TF-PELD and IL-PELD; (B) Forest plot for fluoroscopy times between TF-PELD and IL-PELD; (C) Forest plot for postoperative visual analog score (0–10) between TF-PELD and IL-PELD; (D) Forest plot for last follow-up visual analog score (0–10) between TF-PELD and IL-PELD; (E) Forest plot for postoperative ODI (%) between TF-PELD and IL-PELD; (F) Forest plot for last follow-up ODI (%) between TF-PELD and IL-PELD; (G) Forest plot for complications between TF-PELD and IL-PELD; (H) Forest plot for excellent/good rate between TF-PELD and IL-PELD. IL-PELD = interlaminar percutaneous endoscopic lumbar discectomy, TF-PELD = transforaminal percutaneous endoscopic lumbar discectomy.

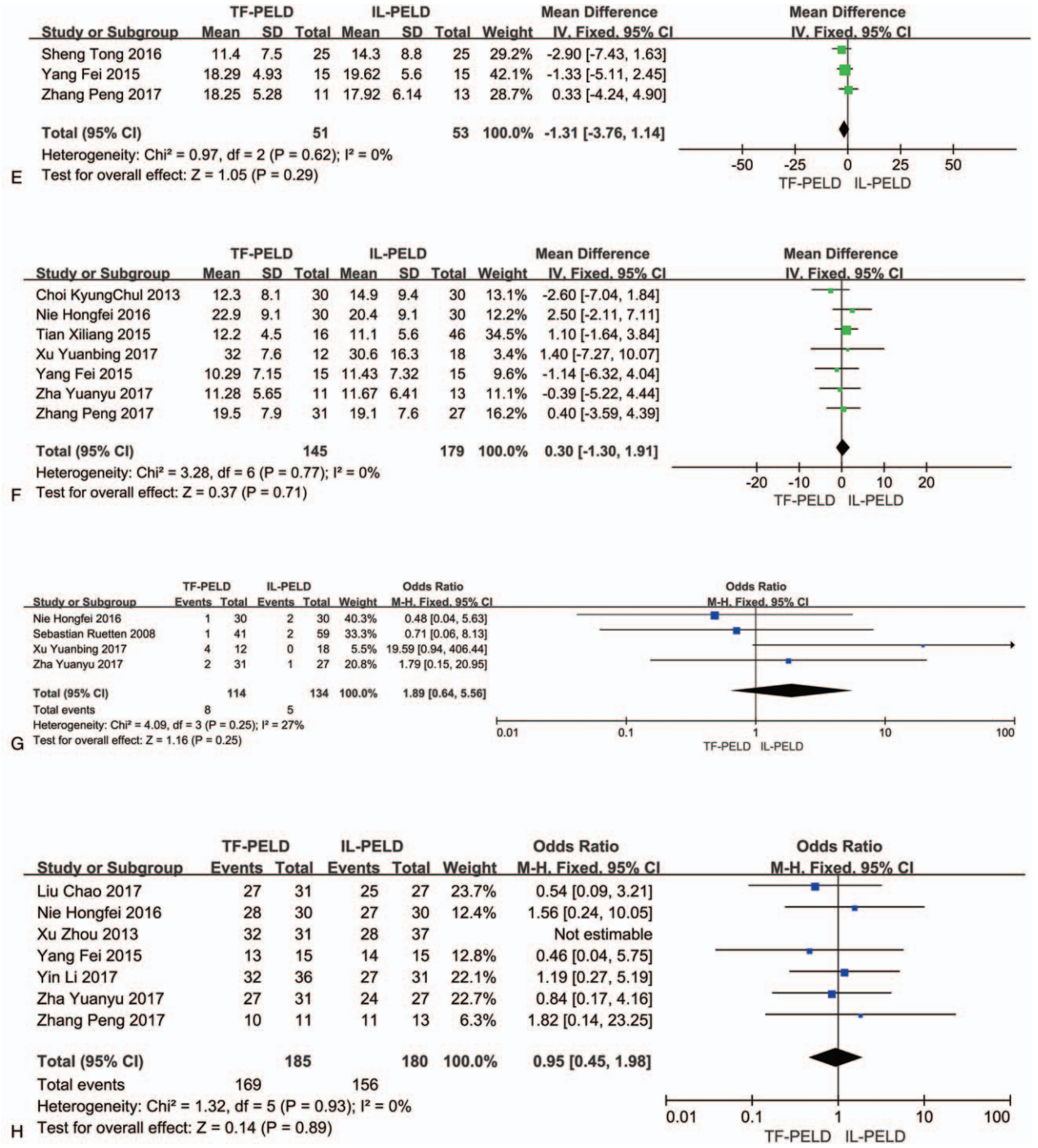

Figure 1. (Continued).

3.7. Last follow-up ODI

The last follow-up ODI was documented in 7 studies. Heterogeneity was low ($P=.77$, $I^2=0\%$) and the fixed-effect model was used. As depicted in Figure 1F, the last follow-up ODI was not significantly different between the TF-PELD and the IL-PELD groups (MD 0.30; 95% CI −1.30 to 1.91; $P=.71$).

3.8. Complications

In general, complication occurrences were controlled at low rate, except for the TF-PELD group in Xu Yuanbing 2017,[19] where 4 out of 12 patients have reported complications. The complication occurrences were available in 7 studies. Heterogeneity was low ($P=.25$, $I^2=27\%$), and the fixed-effect model was used. As depicted in Figure 1G, the complication occurrences were not significantly different between the TF-PELD and the IL-PELD groups (OR 1.89; 95% CI 0.64–5.56; $P=.25$).

3.9. The MacNab evaluation based excellent/reasonable rate

The MacNab evaluated excellent/reasonable rate was available in 7 studies. The MacNab evaluated excellent/reasonable rate was over 80% in all of these studies. Heterogeneity was low ($P=.93$,

$I^2 = 0\%$), and the fixed-effect model was used. As depicted in Figure 1H, the excellent/good rate was not significantly different between the TF-PELD and the IL-PELD groups (OR 0.95; 95% CI 0.45–1.98; $P = .89$).

4. Discussion

In this meta-analysis, we found that the clinical outcomes were generally similar for both operative routes. The complications did not differ significantly between the IL-PELD and TF-PELD groups. However, concerns about PELD being vulnerable to induce nerve root injury were raised, as the procedures are performed near the spinal nerve root with limited vision, although the patient during the surgery can provide reflections to the surgeon as they are locally anesthetized. According to the MacNab criteria, the excellence/reasonable rates in the IL-PELD and TF-PELD groups are similar. The pain was measured using a VAS score. Both the postoperative and last follow-up VAS were not significantly differed in the IL-PELD and TF-PELD groups. In addition, and functional status was assessed using the ODI and identified as also being not significantly differed in the IL-PELD and TF-PELD groups. Therefore, these 2 approaches have a similar effect in reducing the pain and restore the lumbar functions. It was reported that the IL-PELD approach had poor tolerance because the nerve root is exposed to higher risk of damages in the procedure. But this aspect was not described in the selected studies, which is a limitation of this study.

PELD is performed under local anesthesia and protects patients from surrounding tissue destruction.[20] Though the restricted operative view and the steep learning curve formed difficulties for surgeons, PELD is popularized and regarded as the best choice for surgical treatment of lumbar dis herniations. The TF and IL approaches were the most widely used and discussed approaches of PELD. TF-PELD as a common procedure is valid for correcting migrated discs, foraminal and extraforaminal discs, and recurrent discs. The TF window, however, progressively restricted from upper to lower lumbar as the facet joint becoming overlapped with the disc space. Therefore, TF-PELD for lower lumbar discectomy demands extra fluoroscopy to acquire operative vision.[6–8] The IL approach are reported to provide a large window, which is particularly evident at L5/S1 level as it provides plenty of room for direct posterior access during the surgery.[22] In despite of the evidences giving hints for clinical option regarding the 2 routines, a thorough meta-analysis comparing of TF-PELD and IF-PELD in randomized trials is still lacking. This study has filled the blank. Our study implicates the IL-PELD group is superior considering similarities of outcomes but its lower demands of surgery time and fluoroscopy. Most of the included cases in the studies were at lower lumbar segments, especially the L5/S1 level, which progressively benefited from their surgery windows for better vision and larger operating room comparing to other levels. Surgeons are therefore recommended to consider the evidence of this study when deciding operation route for LDH treatment.

The limitation of the study is that the region is mainly at L5/S1 level. In the Liu Chao 2017 study,[7] as the L3/L4 level was involved for both groups, the difference between the IL-PELD and TF-PELD groups were not as large as the other studies. Therefore, larger samples with more details about the disc herniation at other levels are needed to obtain an indicative result for selection guidance of the 2 approaches at other levels.

To conclude, the study indicated that if accessible via both TF-PELD and IL-PELD approaches, IL-PELD is suggested to be adopted, as it yielded similar clinical outcomes compared with TF-PELD, while provides more extensive space to favor anatomical procedures and decreases radiation exposure to the patients and the doctors. However, it is also worthy to mention that the study is limited to relatively low number of included articles and patients, especially at levels other than the L5/S1 level. In addition, subgroup analyses and meta-regression could be performed in the future to provide more useful insights.

Author contributions

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Writing – review and editing: Ding-Wen He, Xi-Gao Cheng.

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