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Review Article

Percutaneous transforaminal endoscopic discectomy versus fenestration discectomy in treatment of lumbar disc herniation: a meta-analysis

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Abstract: Objective: To perform a comparison of the efficacy of percutaneous transforaminal endoscopic discectomy (PTED) versus fenestration discectomy (FD) in the treatment of Lumbar disc herniation (LDH). Methods: The randomized controlled trials (RCT) for the comparison of the PTED and FD, while treating the LDH, were retrieved from the MEDLINE, EMbase, PubMed, Cochranc library, CBM, CNKI, WANFANG, and VIP databases by computer. The related orthopedic documents and conference papers were accumulated with the help of manual retrieval. Evaluation of all the data is performed by NOS Scale (The Newcastle-Ottawa Scale); the RevMan5.3 statistical software (supplied by Cochrane collaboration) was employed for carrying out the meta-analysis. Results: Twenty-four RCTs are included, involving 1795 patients, wherein, 914 cases are treated with the help of PTED whereas 881 cases are treated by FD. PTED offers benefits, together with the blood loss, incision length, and bed rest time, but FD, being a conventional and classic operation, is capable of shortening the operation time. Furthermore, the VAS indexes of both the FD and PTED exhibit no difference in the evaluation of curative impact, but forward ODI index of FD is better than PTED's; moreover, it is thought that PTED manifests better final curative efficacy in comparison with FD. Conclusion: PTED and FD are currently popular operations, yet sharing differences in characteristics, which can be chosen clinically in accordance with the specific situation.

Keywords: Lumbar disc herniation, percutaneous transfouraminal endoscope discectomy, fenestration discectomy, meta-analysis

Introduction

With aging population, together with accelerating life pace, the LDH has emerged as a common disease and frequently-occurring disease of orthopaedics. Patients who could not get satisfactory conservative treatment require having operation actively if it permits [1]. FD is termed as the standardized operation modality for the treatment of LDH, having definitive impact and fewer traumas, meanwhile still being in use [2].

As of now, with the development of the microinvasive technology, from TFSE system in the beginning to YESS and present PTED, developed from indirect decompression to direct decompression, and also from treating simple LDH to varied kinds of LDH in the direct vision. PTED, being an emerging mainstream technology, has been recognized in both the clinical and scientific researches [3]. The literature collected by this research sheds light on the fact that PTED offers the benefits of smaller length of incision, together with less blood loss, and less postoperative bedridden, meanwhile being difficult to distinguish between the merits and demerits in VAS and ODI. Until Nov 2016, there was no meta-analysis about this subject, despite the fact that each database has sufficient clinical reports regarding this research. Accordingly, the author is about to carry out clinical research about this project in a bid to provide some evidences for the evidence-based medicine [4-6].

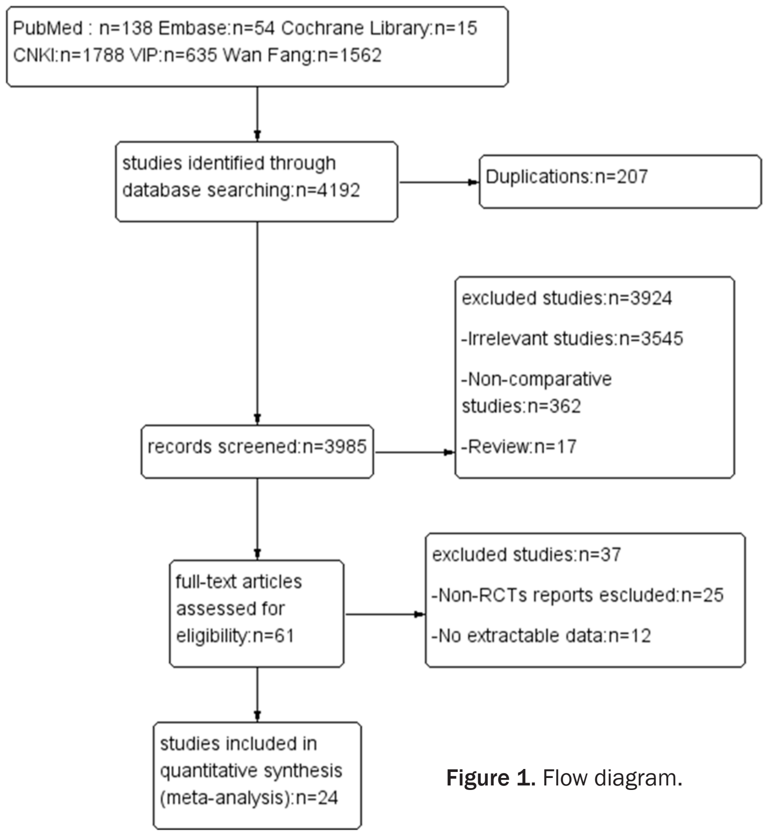

Figure 1. Flow diagram.

Materials and methods

Search strategy

In accordance with the search strategy of the Cochrane Handbook for Systematic Reviews of Interventions, a systematic literature search was carried out in the electronic databases, PubMed, Medline, Embase, Web of Science, CBM, CNKI, WANFANG, and VIP for the retrieval of relevant clinical research works. The following keywords were put to use for the search purpose: lumbar disk herniation (protrusion or prolapse), endoscopic, discectomy, open discectomy, randomized controlled trial, Percutaneous transfouraminal endoscope discectomy, PTED, fenestration discectomy.

The computer search was supplemented with the manual searches of reference lists of all the retrieved studies, review articles, and conference abstracts. If we discover that the research appears matching our objectives, we are going to contact the corresponding author(s) for the missing information, in addition to enquiring about the existence of further trials.

Two of the authors performed independent screening of the titles and abstracts of the articles that were retrieved and applied the selection criteria for the identification of the relevant material to be read in full. The reviewers' selections were compared and, in cases of disagreement, decisions were made through consensus. The reviewers independently read the complete articles, together with applying the selection criteria for the determination of whether the studies would be included in the meta-analysis. The selections were again compared and, in the cases of disagreement, decisions were made by consensus.

Filtration strategy inclusion criteria: ① The language of studies: Chinese or English; ② *Patients*: adults ≥18 years old who have LDH; ③ Treatment: PTED and FD; ③ Not less than 6-month follow-up time; ④ Randomized controlled trials or semi-randomized controlled trials.

Exclusion criteria: ① Review, pathology reports, conference papers, etc.; ② Grouping scheme chaos, no normal control group; ③ With other methods in the treatment; ④ The mean has obvious difference in comparison with the other group; Observational index for the evaluation of the relative situations during the intraoperative and postoperative, gathering indicators associated with the operation: amount of bleeding (ml), length of incision (cm), operation time (min), postoperative bedrest (h), hospital stays (days), VAS, and ODI. In the literature conforming to the inclusion criteria, only one study reported a total hospitalization expenses; accordingly, we excluded this study.

Statistical analysis

All the statistical analyses were carried out with the help of the RevMan5.3 software and STATA14.0 software. HRs, together with their 95% Cis, were employed for the calculation of the overall effects. Heterogeneity among the

Table 1. Characteristics of selected studies

Study	Year	Study location	Study design	Published Language	Number of cases PTED/FD (n)	Average age PTED/FD (year)	Follow up PTED/FD (month)	Outcome measures	NOS
Cui W [8]	2014	China	Retrospective cohort	Chinese	38/40	37.7/41.7	36.7/41.4	③⑩	☆☆☆☆☆☆☆☆☆
Gong C [9]	2016	China	Retrospective cohort	Chinese	55/30	40.5	15.5	①②⑥⑦⑧⑩	☆☆☆☆☆☆☆☆
Han K [10]	2015	China	Retrospective cohort	Chinese	142/74	36.5	13.8	⑤⑨⑩	☆☆☆☆☆☆☆
Pan ZM [11]	2016	China	RCT	English	48/58	39.5/42.8	16.7/17.3	②⑥⑨⑩	☆☆☆☆☆☆☆☆☆
Su JC [12]	2016	China	Retrospective cohort	Chinese	36/40	50.3	19.4	④⑤⑥⑧⑩	☆☆☆☆☆☆☆☆
Shi YM [13]	2016	China	RCT	Chinese	10/10	31.6/30.8	-	⑩	☆☆☆☆☆☆
Xuan TH [14]	2016	China	Retrospective cohort	Chinese	18/24	44.5	10.7	⑤⑥⑩	☆☆☆☆☆☆☆
Zhang Y [15]	2016	China	RCT	Chinese	31/31	38.2/40.21	29.1/32.1	③⑤⑦	☆☆☆☆☆☆☆☆
Tao ZQ [16]	2016	China	RCT	Chinese	28/28	43.3/48.6	-	④⑥⑧	☆☆☆☆☆☆
Liu JL [17]	2014	China	RCT	Chinese	40/40	-	19	①②③⑤⑥⑧	☆☆☆☆☆
Li J [18]	2015	China	Retrospective cohort	Chinese	30/26	-	-	①②③⑥⑧	☆☆☆☆☆☆
Wang SC [19]	2015	China	RCT	Chinese	28/28	42.80/47.20	-	①②⑥⑧	☆☆☆☆☆☆
Ren JB [20]	2015	China	Retrospective cohort	Chinese	13/10	16.2/15.8	13.7	④⑤⑥	☆☆☆☆☆☆
Wang JS [21]	2016	China	Retrospective cohort	Chinese	63/71	48.3/45.8	16.8	④⑥⑧	☆☆☆☆☆☆☆
Ding WG [22]	2016	China	Retrospective cohort	Chinese	16/14	43.5	28.4	③④⑥	☆☆☆☆☆☆☆☆
Zhao CH [23]	2014	China	RCT	Chinese	36/36	48.5	-	③⑤	☆☆☆☆☆☆
Zhao XW [24]	2015	China	Retrospective cohort	Chinese	118/74	39.1/40.3	14.6	⑤	☆☆☆☆☆☆☆
Wu S [25]	2014	China	Retrospective cohort	Chinese	23/23	35.78/37.86	19.13/21.86	⑦⑧⑨	☆☆☆☆☆☆☆
Zhou JS [26]	2015	China	Retrospective cohort	Chinese	30/32	39.93/40.78	32/30	⑤⑥⑦⑧	☆☆☆☆☆☆☆
Li SW [27]	2013	China	Retrospective cohort	Chinese	14/14	39.86/43.43	5/6	④⑨	☆☆☆☆☆☆☆
Liu YG [28]	2015	China	Retrospective cohort	Chinese	22/22	41.5	3	④	☆☆☆☆☆☆
Choi K.C [29]	2016	Korea	Retrospective cohort	English	20/23	33.9/38	27.5	⑥⑧⑩	☆☆☆☆☆☆☆☆
Lee D.Y [30]	2009	Korea	Retrospective cohort	English	25/29	42/47.7	34/34.3	③⑥⑧⑨⑩	☆☆☆☆☆☆☆
Ahn S.S [31]	2016	Korea	Retrospective cohort	English	32/34	22.41/22.18	13.69/13.41	③⑥⑦⑧⑨⑩	☆☆☆☆☆☆☆

① amount of bleeding, ② length of incision, ③ operation time, ④ postoperative bedrest, ⑤ VAS (3 days after operation), ⑥ VAS (1 year after operation), ⑦ ODI (6 months after operation), ⑧ ODI (final follow-up), ⑨ complication.

Table 2. The meta-analysis results of comparison of PTED and FD

Outcomes of studies	Study no.	PTED	FD	MD/OR (95% CI)	*p* value	Study heterogeneity			
		Patient no.	Patient no.			x^2	df	I^2, %	*p* value
Amount of bleeding	4	173	144	-40.43 (41.81, -39.04)	< 0.00001	5.34	3	44	0.15
Length of incision	5	221	202	-40.43 (41.81, -39.04)	< 0.00001	5.34	3	44	0.15
Operation time	8	248	250	13.7 (1.83, 25.56)	0.02	234.77	7	97	< 0.00001
Postoperative bed rest time	7	192	199	-6.19 (-7.15, -5.23)	< 0.00001	134.7	6	96	< 0.00001
VAS (3 days after operation)	9	474	361	0.02 (-0.06, 0.10)	0.56	11.79	8	32	0.16
VAS (1 year after operation)	15	425	421	-0.03 (-0.12, 0.05)	0.45	21.35	11	48	0.03
ODI (6 months after operation)	5	171	150	-0.60 (-1.21, 0.01)	0.05	7.2	4	44	0.13
ODI (final follow-up)	12	430	424	-0.26 (-0.56, -0.05)	0.1	14.77	11	26	0.19
Complications	6	284	232	0.62 (0.35, 1.22)	0.11	2.65	5	0	0.75
Hospitalization days	5	424	362	-5.32 (-6.22, -3.80)	< 0.00001	65.71	9	86	< 0.00001

included studies was evaluated with the help of I^2 statistics test. The value of I^2 ranges from 0% to 100%. I^2>50% or P < 0.05 was considered indicating substantial heterogeneity, and random effects model was employed for the calculation of the pooled HRs, together with their 95% CI. I^2 < 50% or P>0.05 was considered indicating a lack of substantial heterogeneity; moreover, the fixed effects model was employed for the statistical analysis [7].

We performed the assessment of the possibility of publication bias through the development of a funnel plot of each trial's impact size against the standard error (appendix). We performed the assessment of the funnel plot asymmetry with the use of the Egger tests, in addition to defining the substantial publication bias as a *p* value < 0.1.

Results

The literature search initially yielded 4192 relevant trials

We deleted 207 articles owing to the duplicate data, etc. Subsequent to reading the titles and abstracts, 135 articles were selected for a complete reading. Eventually, the remaining 24 trials were selected in the meta-analysis. The study selection mechanism has been summarized in the **Figure 1**. The 24 trials represented an aggregate of 1795 LDH patients, 916 of whom experienced PTED and 811 experienced PFD. The characteristics of the studies accepted for the meta-analysis are presented in the **Table 1** [8-31].

Main outcome

Amount of bleeding (ml): Four studies reported the amount of bleeding, with *p* value = 0.15, and I^2 = 44% (**Table 2**). Fixed effects modelling demonstrated a MD of -40.43 [-41.81, -39.04], suggesting that PTED could lower the intraoperative blood loss (Supplementary Figure 1). There was no significant heterogeneity (Q-statistic *p* value = 0.25), together with low-to-moderate inconsistency (I^2 = 44%).

Length of incision (cm): Five studies reported the length of incision, with *p* value = 0.15, and I^2 = 44% (**Table 2**). Fixed effects modelling demonstrated a MD of -40.43 [-41.81, -39.04], suggesting that the length of incision with PTED is smaller (Supplementary Figure 2). There was no significant heterogeneity (Q-statistic *p* value = 0.25), together with lower-than-moderate inconsistency (I^2 = 44%).

Operation time (min): Eight studies reported the length of incision, with *p* value < 0.00001, and I^2 = 97% (**Table 2**), suggesting that the FD is capable of shortening the operation time in comparison with PTED (Supplementary Figure 3). Random effects modelling demonstrated a MD amounting to 13.70 [1.83, 25.56]. There was no significant heterogeneity (Q-statistic *p* value < 0.00001), together with high-to-moderate inconsistency (I^2 = 97%).

Postoperative bed rest time (h): Seven studies reported the postoperative bedrest time, with *p* value < 0.00001, and I^2 = 96% (**Table 2**), suggesting that the FD is capable of shortening the postoperative bedrest time in comparison with PTED (Supplementary Figure 4). Random effects modelling demonstrated a MD of -6.19 [-7.15, -5.23]. There was significant heterogeneity (Q-statistic *p* value < 0.00001), together with high-to-moderate inconsistency (I^2 = 95%).

VAS (3 days after operation): Nine studies reported the VAS (3 days following the opera-

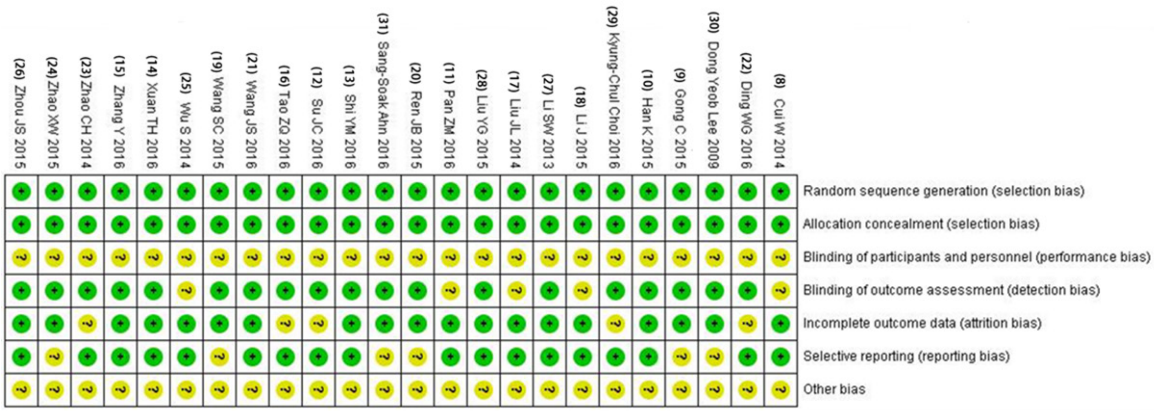

Figure 2. Risk of bias summary.

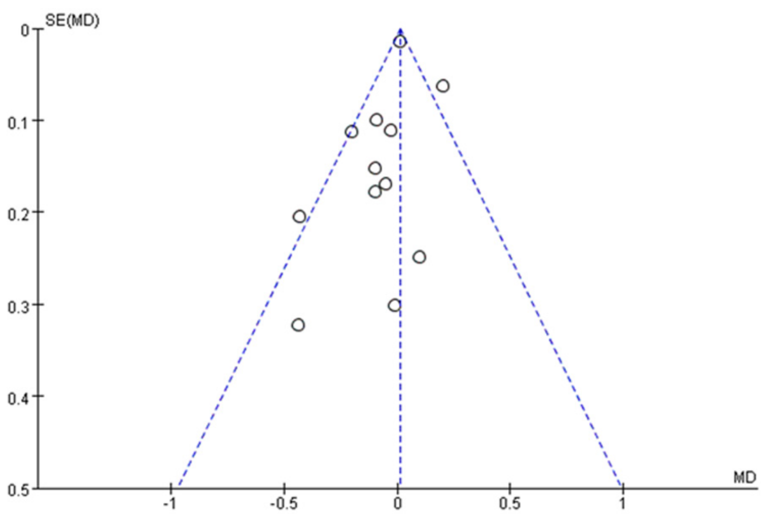

Figure 3. The funnel plot.

tion), with p value = 0.16 and I^2 = 32% (**Table 2**), which indicates that there is no difference between FD and PLED in VAS (3 days following the operation) (Supplementary Figure 5). Fixed effects modelling demonstrated a MD of 0.02 [-0.06, 0.10]. There was no significant heterogeneity (Q-statistic p value = 0.16), together with low-to-moderate inconsistency (I^2 = 32%).

VAS (1 year after operation): Fifteen studies reported the VAS (1 year following the operation), with p value = 0.03 and I^2 = 48% (**Table 2**), which suggests that there is no difference between FD and PLED in VAS (1 year following the operation) (Supplementary Figure 6). Random effects modelling demonstrated a MD of -0.03 [-0.12, 0.05]. There was no significant heterogeneity (Q-statistic p value = 0.03), together with high-to-moderate inconsistency (I^2 = 48%).

Oswestry disability index (6 months after operation): Five studies reported the ODI (6 month following the operation), with p value = 0.13 and I^2 = 44% (**Table 2**), suggesting that there is no difference between FD and PLED in ODI (6 months after operation) (Supplementary Figure 7). Fixed effects modelling demonstrated a MD of -0.60 [-1.21, 0.01]. There was no significant heterogeneity (Q-statistic p value = 0.13), in addition to low-to-moderate inconsistency (I^2 = 44%).

Twelve studies reported the ODI (final follow-up), with p value = 0.19, and I^2 = 26%. Random effects modelling demonstrated a MD of -0.26 [-0.56, -0.05], suggesting that PTED can improve ODI (final follow-up) better as compared with FD (Supplementary Figure 8). There was observed no significant heterogeneity (Q-statistic p value = 0.19), together with low-to-moderate inconsistency (I^2 = 26%).

Complications: Six studies reported complications, for instance, nerve root allergic, epidermal infection, with p value = 0.75, and I^2 = 0%. Fixed effects modelling demonstrated a MD of 0.62 [0.35, 1.22]. There was observed no significant heterogeneity (Q-statistic p value = 0.75), together with low-to-moderate inconsistency (I^2 = 0%). The data in the Supplementary Figure 9 suggest that the PTED lowers the complications better than FD.

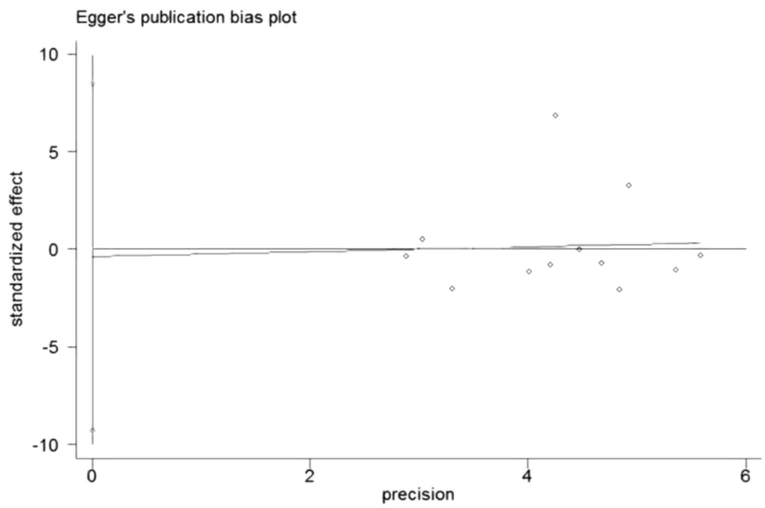

Figure 4. The Egger's publication bias plot.

Egger's test

Std_Eff	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
slope	.1279171	.9115615	0.14	0.891	-1.903169	2.159003
bias	-.3888707	3.991523	-0.10	0.924	-9.282538	8.504797

Figure 5. Egger's result.

hospitalization days: Five studies reported the hospitalization days, with p value < 0.00001, and I^2 = 86%. Random effects modelling demonstrated a MD of -5.32 [-6.22, -3.80]. There was observed no significant heterogeneity (Q-statistic p value < 0.00001), together with high-to-moderate inconsistency (I^2 = 86%). The data in the Supplementary Figure 10 highlight the fact that PTED is capable of shortening the hospitalization days in comparison with FD.

Publication bias

The summary risk of the bias in the included trials was presented in the **Figure 2**. We included 21 references in this paper. For instance, VAS (1 year following the operation), the funnel plot does not manifest symmetry, evidencing that this study has certain publication bias; moreover, there are two studies suggesting the existence of heterogeneity (**Figure 3**). Nevertheless, documents are in the top division, suggesting that they are high quality papers and I^2 = 48%≤50%, which is termed as acceptable [32]. And the p value of Egger tests = 0.924>0.1 (**Figures 4**, **5**). In general, we are in a good position to draw the conclusion that Publication bias does not significantly impact the result.

Discussion

Meta-analysis is termed as among the key methodologies of the evidence-based medicine, with the major purpose involving the performance of system-analysis and quantitative-analysis on some of the independent research works, aiming at the same research purpose. It enhances the power of test, in addition to evaluating the heterogeneity of the research findings. It is capable of evaluating the single research quality with both the merits and demerits, together with synthesizing the sporadic individual research into multi-central large sample research; in addition, it plays a pivotal role in the clinical diagnosis, treatment, evaluation of the risk, preventive intervention, healthy services and decision [33].

In the year 1975, Hijikata [34] adopted PLD for the treatment of LDH, which belonged to the non-orthoptic technology. Moreover, it was a kind of indirect decompression. With Fibre, optic endoscope and surgical instruments developing, Ditsworth manufactured TFSE in the year 1996, allowing the instruments to operate neatly in the tunes. In the year 1997, Yeung manufactured YESS, sharing the same approach as that of Chemonucleolysis. In the year 2003, Hoogland manufactured THESSYS, which is regarded as a more thoroughgoing direct decompression technology. The approach of THESSYS resembled YESS, but the difference lies in the entrance between entry point and posterior median line, which become farther as compared with YESS, and the included angle with coronal section becomes smaller. Accordingly, it applies to the liber and prolapsed LDH [35]. Currently, this technology is applied to extensive medical research works.

Open operation has a more mature technology, which is more visible, and simpler, with shorter operation time, etc., which are considered to be the PTED's advantages. Minimally invasive surgery is based on the open operation. All through the years, the doctors have gained abundant experience in the open operations, and they have become more familiar with the local anatomy of spine as well as intraoperative and postoperative complications.

In addition to that, majority of the doctors feel more proficient, together with being kind to FD. Nevertheless, the PTED combines minimally invasive surgery and endoscopy on the open operation basis, demanding that the doctor requires being more skilled in the open operations and operating systems under microscope, in particular, puncturing. Endoscopic surgery demands more local anatomy understanding, in addition to higher operation requirements to the doctors as well as more precise operation, which is not a small challenge to the young doctors. The choice of operation is impacted by numerous factors, for instance, patient's condition and requirement, doctor's mastery and familiarity with the operation, surgical instruments, etc. The choice of operation is impacted by numerous factors, depending on the doctor' skills and experience, and the patient. PTED has advantage in anaesthesia over FD, which can make use of topical anaesthesia. Also, making use of the PTED can resume a normal diet in short time subsequent to the operation and communicating with the patient while being operated. FD typically takes general anaesthesia, and removes part of the vertebral plate and small joint, affecting the animal mechanics stability of spine. Simultaneously, spine revision surgery is a huge challenge to the doctor. Consequent to a result of scar tissue adherent in the surgery part, secondary surgery is also extensively difficulty to the doctor, and the secondary surgery is expected to increase the postoperative complications. Nowadays, the clinical reports of postoperative revision rate in the PTED and FD are not sufficient; accordingly, we are going to require more data for the composition and analysis at the next stage.

Being a new minimally invasive technique for a spinal surgery, PTED has evident superiority in the hospital stays, amount of bleeding, the length of incision and postoperative bedrest. But, being a conventional technology, the operation time of FD is shorter. Nevertheless, in the aspect of the therapeutic impact, there exists no difference between PTED and FD. PTED is better than FD in the ODI (final follow-up), suggesting that PTED has some superiority in the final curative effect. Additionally, PanZM [11] have reported the fee of staying in hospital, in comparison of FD with PTED. The fee of FD is higher than that of PTED. It can be a reference for the surgery conversation.

There are some inadequacies regarding the record: 1. Some parts of the studies adapted are prospective or retrospective cohort study. 2. There is heterogeneity in the analysis of the time of the postoperative bedrest. Despite the fact that we have confirmed that it does not impact the conclusion, yet it impacted the precision to a specific level. There are still required more multi-centre, large simple area RCT trial as supplemented.

In addition, PTED learning curve, together with the contrast of FD and PTED regarding the complications are expecting further analysis in the prospective research. FD and PTED are operating methods used in the clinical practices, at present. Accordingly, in this paper, we would like providing a reference from the point of view of the evidence-based medicine. Clinicians are able to choose in accordance with the reality.

In accordance with the current clinical general, PTED offers benefits in the blood loss, incision length and bed-rest time following the operation; moreover, numerous orthopaedics physicians have gradually accepted this technique for the treatment of the lumbar diseases. Additionally, the FD surgery, being a classical surgical procedure, is extensively employed as a major cause of trauma that is easier to be accepted. The results of this study revealed the fact that the PTED is capable of lowering the intraoperative bleeding and the length of the surgical incision (MD = -40.43; 95% CI: -41.81, -39.04); in term of operation time, the results suggested that the operation time of FD was shorter as compared with that of PTED (MD = 22.96; 95% CI: 20.63-25.29); in term of the postoperative bed time, the PTED lowered significantly as compared with the FD group (MD = -6.19; 95% CI: -7.15, -5.23), which could effectively prevent or lower the risk of bedsore and postoperative deep venous thrombosis of the lower extremities. Both the VAS and ODI scores are quite important indicators for the evaluation of the quality of life. Nevertheless, no differences were observed between the two indicators in our meta-analysis. Additionally, the long-term ODI of the PTED was better than that of FD (MD = -0.19; 95% CI: -0.34, -0.04). It is suggested that the PTED offers some advantages in the final curative impact.

As regards the amount of bleeding during surgery, we observed, in the Wang SC's [19] paper, that their FD group patients make use of a small incision (3~5 cm) procedure rather than opting for the classical FD incision (5~8 cm). It highlighted the fact that the incision technology of FD is also gradually innovating, together with being close minimally invasive. As regards the postoperative bed time, Li SW's [27] paper has a PTED incision of approximately 7mm only, which is also way less than the 1.6 cm longitudinal incision in the conventional procedures. Together with the nucleus pulposus forceps and the nucleus pulposus bite of the nucleus pulposus, an electrocoagulation disc ablation decompression technique was employed for the common treatment.

In comparison with the other literatures, combined therapy further shortened the bed-rest time following the PTED. As regards the postoperative management, Li SW's [27] paper mentioned that the FD group requires staying in the bed for a period of 2 weeks following the operation and leaving the bed, subjected to the waist circumference protection following 2 weeks. Nevertheless, in principle, there is no difficulty for the FD patients to get out of the bed in 3 days subsequent to the operation [36] Whether too much bedtime impacts the results still remains to be verified. We figured out the fact that there was no significant difference in the VAS scores between the two methodologies. Consider the following reasons: 1) The VAS score standard itself houses numerous subjective factors, making it not as objective as the index. 2) Despite the fact that the PTED offers advantages in the postoperative bleeding, incision length, and bed-rest time, yet the two operations serve the same purpose.

Disclosure of conflict of interest

None.

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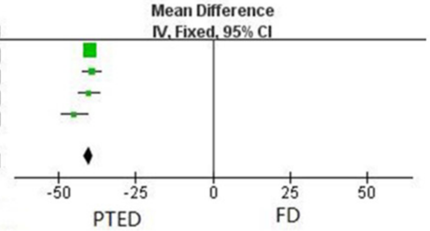
	PTED			FD				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Gong C 2015 (9)	12.2	5.1	55	52.2	3.7	30	53.6%	-40.00 [-41.89, -38.11]
Li J 2015 (18)	10.2	3.1	30	49.5	7.3	26	21.0%	-39.30 [-42.32, -36.28]
Liu JL 2014 (17)	7.2	2.1	40	47.5	11.3	40	15.1%	-40.30 [-43.86, -36.74]
Wang SC 2015(19)	20.35	6.99	48	65.5	13.55	48	10.3%	-45.15 [-49.46, -40.84]
Total (95% CI)			**173**			**144**	**100.0%**	**-40.43 [-41.81, -39.04]**

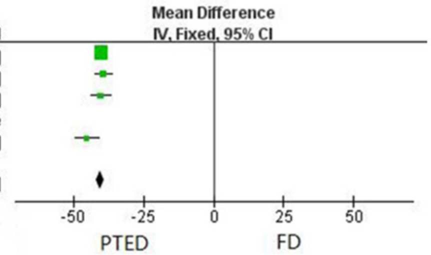
Heterogeneity: $Chi^2 = 5.34$, df = 3 (P = 0.15); $I^2 = 44\%$
Test for overall effect: Z = 57.28 (P < 0.00001)



Supplementary Figure 1. Meta-analysis for amount of bleeding of PTED versus FD.

	PTED			FD				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Gong C 2015 (9)	12.2	5.1	55	52.2	3.7	30	53.6%	-40.00 [-41.89, -38.11]
Li J 2015 (18)	10.2	3.1	30	49.5	7.3	26	21.0%	-39.30 [-42.32, -36.28]
Liu JL 2014 (17)	7.2	2.1	40	47.5	11.3	40	15.1%	-40.30 [-43.86, -36.74]
Pan ZM 2016 (11)	0.8	0	48	3.7	0.8	58		Not estimable
Wang SC 2015 (19)	20.35	6.99	48	65.5	13.55	48	10.3%	-45.15 [-49.46, -40.84]
Total (95% CI)			**221**			**202**	**100.0%**	**-40.43 [-41.81, -39.04]**

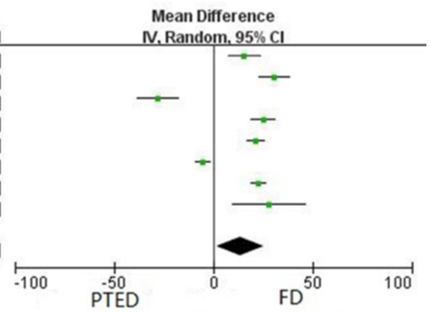
Heterogeneity: $Chi^2 = 5.34$, df = 3 (P = 0.15); $I^2 = 44\%$
Test for overall effect: Z = 57.28 (P < 0.00001)



Supplementary Figure 2. Meta-analysis for length of incision of PTED versus FD.

	PTED			FD				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Cui W 2014 (8)	77.5	21.3	38	61.8	13.2	40	12.6%	15.70 [7.79, 23.61]
Ding WG 2016 (22)	85.75	13.3	16	55.01	6.85	14	12.7%	30.74 [23.30, 38.18]
Dong Yeob Lee 2009 (30)	45.8	11.1	25	73.8	25.7	29	12.1%	-28.00 [-38.32, -17.68]
Li J 2015 (18)	82.7	13.2	30	57.5	9.1	26	12.9%	25.20 [19.32, 31.08]
Liu JL 2014 (17)	73.7	11.2	40	52.4	8.5	40	13.1%	21.30 [16.94, 25.66]
Sang-Soak Ahn 2016 (31)	48.66	6.45	32	53.71	8.49	34	13.2%	-5.05 [-8.67, -1.43]
Zhang Y 2016 (15)	73.9	10.3	31	51.2	4.2	31	13.2%	22.70 [18.78, 26.62]
Zhao CH 2014 (23)	88	45	36	60	34	36	10.1%	28.00 [9.58, 46.42]
Total (95% CI)			**248**			**250**	**100.0%**	**13.70 [1.83, 25.56]**

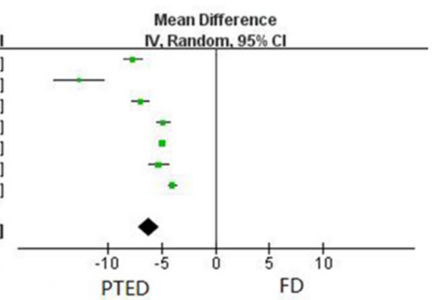
Heterogeneity: $Tau^2 = 274.36$; $Chi^2 = 234.77$, df = 7 (P < 0.00001); $I^2 = 97\%$
Test for overall effect: Z = 2.26 (P = 0.02)



Supplementary Figure 3. Meta-analysis for operation time of PTED versus FD.

	PTED			FD				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Ding WG 2016 (22)	6.19	1.28	16	13.86	1.03	14	14.6%	-7.67 [-8.50, -6.84]
Li SW 2013 (27)	5.21	1.52	14	17.9	4.08	14	8.5%	-12.69 [-14.97, -10.41]
Liu YG 2015 (28)	3.91	0.811	22	10.91	1.849	22	14.6%	-7.00 [-7.84, -6.16]
Ren JB 2015 (20)	1.12	0.43	13	6	0.88	10	15.5%	-4.88 [-5.47, -4.29]
Su JC 2016 (12)	1.3	0.4	36	6.2	0.4	40	16.3%	-4.90 [-5.08, -4.72]
Tao ZQ 2016 (16)	1.5	0.7	28	6.8	2.3	28	14.4%	-5.30 [-6.19, -4.41]
Wang JS 2016 (21)	0.5	0.5	63	4.5	1.5	71	16.0%	-4.00 [-4.37, -3.63]
Total (95% CI)			**192**			**199**	**100.0%**	**-6.19 [-7.15, -5.23]**

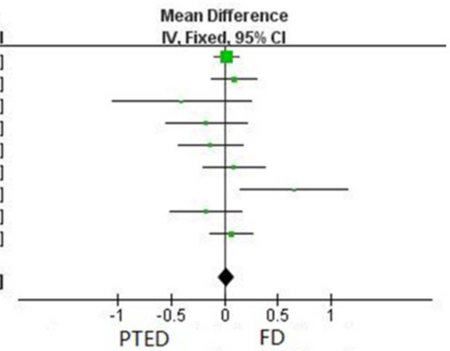
Heterogeneity: $Tau^2 = 1.47$; $Chi^2 = 134.70$, df = 6 (P < 0.00001); $I^2 = 96\%$
Test for overall effect: Z = 12.60 (P < 0.00001)



Supplementary Figure 4. Meta-analysis for postoperative bedrest time of PTED versus FD.

Study or Subgroup	PTED Mean	PTED SD	PTED Total	FD Mean	FD SD	FD Total	Weight	Mean Difference IV, Fixed, 95% CI
Zhou JS 2015 (26)	1.58	0.25	30	1.56	0.23	32	42.9%	0.02 [-0.10, 0.14]
Zhao XW 2015 (24)	3.28	0.84	118	3.19	0.66	74	13.5%	0.09 [-0.12, 0.30]
Zhao CH 2014 (23)	2.7	1.5	36	3.1	1.3	36	1.5%	-0.40 [-1.05, 0.25]
Zhang Y 2016 (15)	1.49	0.79	31	1.66	0.73	31	4.3%	-0.17 [-0.55, 0.21]
Xuan TH 2016 (14)	2.33	0.52	28	2.46	0.58	24	6.8%	-0.13 [-0.43, 0.17]
Su JC 2016 (12)	1.56	0.62	36	1.47	0.65	40	7.5%	0.09 [-0.20, 0.38]
Ren JB 2015 (20)	2.15	0.69	13	1.5	0.53	10	2.5%	0.65 [0.15, 1.15]
Liu JL 2014 (17)	1.48	0.78	40	1.65	0.74	40	5.5%	-0.17 [-0.50, 0.16]
Han K 2015 (10)	3.43	0.76	142	3.36	0.68	74	15.5%	0.07 [-0.13, 0.27]
Total (95% CI)			**474**			**361**	**100.0%**	**0.02 [-0.06, 0.10]**

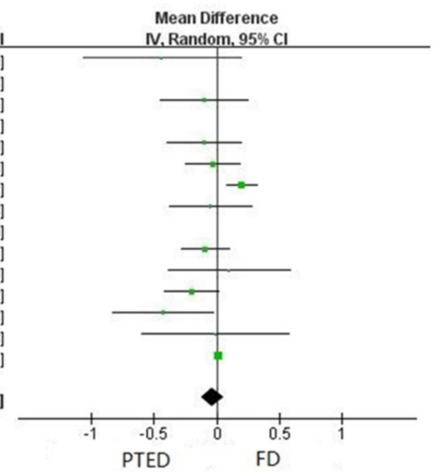
Heterogeneity: Chi² = 11.79, df = 8 (P = 0.16); I² = 32%
Test for overall effect: Z = 0.58 (P = 0.56)



Supplementary Figure 5. Meta-analysis for VAS (3 days after operation) of PTED versus FD.

Study or Subgroup	PTED Mean	PTED SD	PTED Total	FD Mean	FD SD	FD Total	Weight	Mean Difference IV, Random, 95% CI
Ding WG 2016 (22)	0.63	0.62	16	1.07	1.06	14	1.8%	-0.44 [-1.07, 0.19]
Dong Yeob Lee 2009 (30)	4	3.2	25	2.3	4.4	29	0.0%	1.70 [-0.33, 3.73]
Gong C 2015 (9)	0.5	0.5	55	0.6	0.9	30	5.2%	-0.10 [-0.45, 0.25]
Kyung-Chul Choi 2016 (29)	2	0.6	20	3.7	1	23	0.0%	-1.70 [-2.19, -1.21]
Li J 2015 (18)	0.43	0.47	30	0.53	0.64	26	6.5%	-0.10 [-0.40, 0.20]
Liu JL 2014 (17)	0.3	0.52	40	0.33	0.47	40	10.0%	-0.03 [-0.25, 0.19]
Pan ZM 2016 (11)	1.6	0.4	48	1.4	0.2	58	16.7%	0.20 [0.08, 0.32]
Ren JB 2015 (20)	1.15	0.38	13	1.2	0.42	10	5.5%	-0.05 [-0.38, 0.28]
Sang-Soak Ahn 2016 (31)	2.5	0.62	32	2.91	0.67	34	0.0%	-0.41 [-0.72, -0.10]
Su JC 2016 (12)	0.32	0.47	36	0.41	0.39	40	11.3%	-0.09 [-0.29, 0.11]
Tao ZQ 2016 (16)	1.56	1	28	1.46	0.86	28	2.9%	0.10 [-0.39, 0.59]
Wang JS 2016 (21)	1.1	0.6	63	1.3	0.7	71	9.8%	-0.20 [-0.42, 0.02]
Wang SC 2015 (19)	1.14	0.89	48	1.57	1.1	48	4.1%	-0.43 [-0.83, -0.03]
Xuan TH 2016 (14)	1.28	1.04	18	1.29	0.86	24	2.1%	-0.01 [-0.60, 0.58]
Zhou JS 2015 (26)	0.38	0.06	30	0.37	0.06	32	24.1%	0.01 [-0.02, 0.04]
Total (95% CI)			**425**			**421**	**100.0%**	**-0.03 [-0.12, 0.05]**

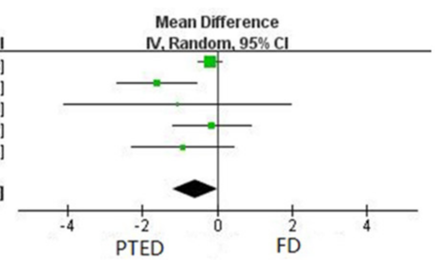
Heterogeneity: Tau² = 0.01; Chi² = 21.35, df = 11 (P = 0.03); I² = 48%
Test for overall effect: Z = 0.76 (P = 0.45)



Supplementary Figure 6. Meta-analysis for VAS (1 year after operation) of PTED versus FD.

Study or Subgroup	PTED Mean	PTED SD	PTED Total	FD Mean	FD SD	FD Total	Weight	Mean Difference IV, Random, 95% CI
Gong C 2015 (9)	4.5	0.6	55	4.7	0.8	30	42.7%	-0.20 [-0.53, 0.13]
Sang-Soak Ahn 2016 (31)	12.18	2.58	32	13.79	1.74	34	19.6%	-1.61 [-2.68, -0.54]
Wu S 2014 (25)	19.31	5.165	23	20.37	5.4	23	3.7%	-1.06 [-4.11, 1.99]
Zhang Y 2016 (15)	2.45	2.12	31	2.59	2.12	31	19.9%	-0.14 [-1.20, 0.92]
Zhou JS 2015 (26)	15.49	2.92	30	16.42	2.55	32	14.1%	-0.93 [-2.30, 0.44]
Total (95% CI)			**171**			**150**	**100.0%**	**-0.60 [-1.21, 0.01]**

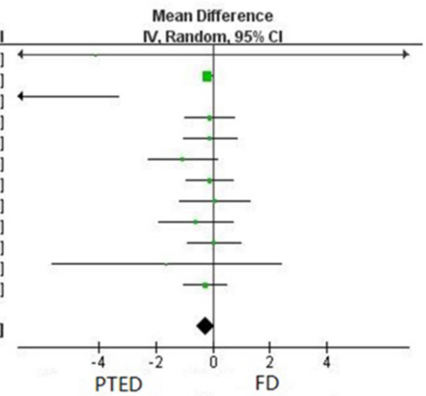
Heterogeneity: Tau² = 0.20; Chi² = 7.20, df = 4 (P = 0.13); I² = 44%
Test for overall effect: Z = 1.92 (P = 0.05)



Supplementary Figure 7. Meta-analysis for ODI (6 months after operation) of PTED versus FD.

Study or Subgroup	PTED Mean	PTED SD	PTED Total	FD Mean	FD SD	FD Total	Weight	Mean Difference IV, Random, 95% CI
Dong Yeob Lee 2009 (30)	40.9	25.5	25	45	26.1	29	0.0%	-4.10 [-17.89, 9.69]
Gong C 2015 (9)	2.2	0.3	55	2.4	0.4	30	35.3%	-0.20 [-0.36, -0.04]
Kyung-Chul Choi 2016 (29)	12.5	7.5	20	20.2	7.2	23	0.5%	-7.70 [-12.11, -3.29]
Li J 2015 (18)	2.1	1.1	30	2.2	2	26	9.4%	-0.10 [-0.96, 0.76]
Liu JL 2014 (17)	2.48	2.15	40	2.59	2.13	40	8.3%	-0.11 [-1.05, 0.83]
Sang-Soak Ahn 2016 (31)	9.63	2.31	32	10.68	2.67	34	5.5%	-1.05 [-2.25, 0.15]
Su JC 2016 (12)	2.54	1.84	36	2.64	1.79	40	10.2%	-0.10 [-0.92, 0.72]
Tao ZQ 2016 (16)	8.97	2.34	28	8.9	2.3	28	5.4%	0.07 [-1.15, 1.29]
Wang JS 2016 (21)	10.1	3.5	63	10.7	4.2	71	4.8%	-0.60 [-1.90, 0.70]
Wang SC 2015 (19)	8.91	2.3	48	8.87	2.32	48	8.5%	0.04 [-0.88, 0.96]
Wu S 2014 (25)	11.18	7.046	23	12.8	6.776	23	0.6%	-1.62 [-5.62, 2.38]
Zhou JS 2015 (26)	4.33	1.43	30	4.59	1.59	32	11.5%	-0.26 [-1.01, 0.49]
Total (95% CI)			**430**			**424**	**100.0%**	**-0.26 [-0.56, 0.05]**

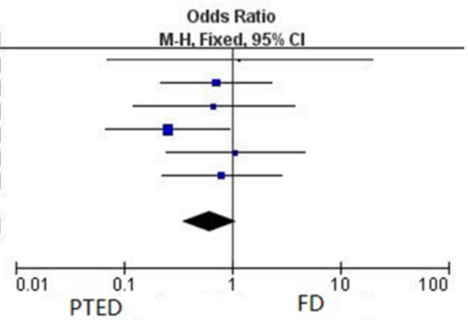
Heterogeneity: Tau² = 0.06; Chi² = 14.77, df = 11 (P = 0.19); I² = 26%
Test for overall effect: Z = 1.65 (P = 0.10)



Supplementary Figure 8. Meta-analysis for ODI (final follow-up) of PTED versus FD.

Study or Subgroup	PTED Events	PTED Total	FD Events	FD Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Dong Yeob Lee 2009 (30)	1	25	1	29	3.1%	1.17 [0.07, 19.67]
Han K 2015 (10)	7	142	5	74	21.5%	0.72 [0.22, 2.34]
Li SW 2013 (27)	3	14	4	14	10.8%	0.68 [0.12, 3.83]
Pan ZM 2016 (11)	3	48	12	58	35.1%	0.26 [0.07, 0.97]
Sang-Soak Ahn 2016 (31)	4	32	4	34	11.7%	1.07 [0.24, 4.70]
Wu S 2014 (25)	6	23	7	23	17.8%	0.81 [0.22, 2.92]
Total (95% CI)		**284**		**232**	**100.0%**	**0.62 [0.35, 1.11]**
Total events	24		33			

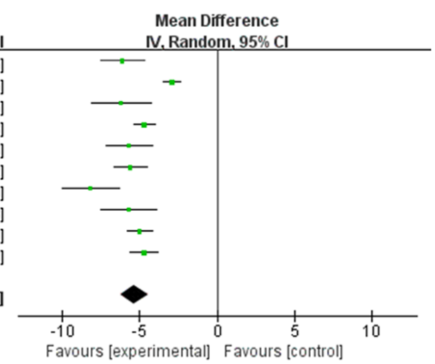
Heterogeneity: Chi² = 2.65, df = 5 (P = 0.75); I² = 0%
Test for overall effect: Z = 1.60 (P = 0.11)



Supplementary Figure 9. Meta-analysis for complications of PTED versus FD.

Study or Subgroup	PTED Mean	PTED SD	PTED Total	FD Mean	FD SD	FD Total	Weight	Mean Difference IV, Random, 95% CI
Cui W 2014 (8)	7.7	2.6	38	13.8	3.8	40	9.5%	-6.10 [-7.54, -4.66]
Dong Yeob Lee 2009 (30)	0.9	0.5	25	3.8	1.4	29	12.0%	-2.90 [-3.45, -2.35]
Gong C 2015 (9)	4	0.4	55	10.2	5.4	30	7.9%	-6.20 [-8.14, -4.26]
Han K 2015 (10)	5.9	1.6	142	10.6	2.7	74	11.8%	-4.70 [-5.37, -4.03]
Kyung-Chul Choi 2016 (29)	1.5	1.1	20	7.2	3.5	23	9.3%	-5.70 [-7.21, -4.19]
Pan ZM 2016 (11)	7.2	1.6	48	12.8	3.8	58	10.6%	-5.60 [-6.68, -4.52]
Sang-Soak Ahn 2016 (31)	7.5	2.63	32	15.65	4.8	34	8.2%	-8.15 [-10.00, -6.30]
Shi YM 2016 (13)	5.5	1.7	10	11.2	2.4	10	8.3%	-5.70 [-7.52, -3.88]
Su JC 2016 (12)	4.5	1.2	36	9.5	2.3	40	11.4%	-5.00 [-5.81, -4.19]
Xuan TH 2016 (14)	4.95	1.06	18	9.67	1.96	24	11.1%	-4.72 [-5.64, -3.80]
Total (95% CI)			**424**			**362**	**100.0%**	**-5.32 [-6.22, -4.43]**

Heterogeneity: Tau² = 1.65; Chi² = 65.71, df = 9 (P < 0.00001); I² = 86%
Test for overall effect: Z = 11.69 (P < 0.00001)



Supplementary Figure 10. Meta-analysis for hospitalization days of PTED versus FD.