

# Transforaminal lumbar interbody fusion versus posterolateral fusion in degenerative lumbar spondylosis

## A meta-analysis

Bin-Fei Zhang, MD, Chao-Yuan Ge, MD, Bo-Long Zheng, MD, Ding-Jun Hao, MD, PhD\*

### Abstract

**Objective:** The aim of the study was to evaluate the efficacy and safety of transforaminal lumbar interbody fusion (TLIF) versus posterolateral fusion (PLF) in degenerative lumbar spondylosis.

**Methods:** A systematic literature review was performed to obtain randomized controlled trials (RCTs) and observational studies (OSs) of TLIF and PLF for degenerative lumbar spondylosis. Trials performed before November 2015 were retrieved from the Medline, EMBASE, Cochrane library, and Chinese databases. Data extraction and quality evaluation of the trials were performed independently by 2 investigators. A meta-analysis was performed using STATA version 12.0.

**Results:** Two RCTs and 5 OSs of 630 patients were included. Of these subjects, 325 were in the TLIF and 305 were in the PLF group. Results showed that TLIF did not increase the fusion rate based on RCTs (relative risk [RR] = 1.06; 95% confidence interval [CI]: 0.95–1.18;  $P=0.321$ ), but increased it based on OSs (RR = 1.14; 95% CI: 1.07–1.23;  $P=0.000$ ) and overall (RR = 1.11; 95% CI: 1.05–1.18;  $P=0.001$ ) as compared with PLF. TLIF was able to improve the clinical outcomes based on 1 RCT (RR = 1.33; 95% CI: 1.11–1.59,  $P=0.002$ ) and overall (RR = 1.19; 95% CI: 1.07–1.33;  $P=0.001$ ), but not based on OSs (RR = 1.11; 95% CI: 0.97–1.27;  $P=0.129$ ) as compared with PLF. There were no differences between TLIF and PLF in terms of visual analogue scale, Oswestry Disability Index, reoperation, complications, duration of surgical procedure, blood loss, and hospitalization.

**Conclusions:** In conclusion, evidence is not sufficient to support that TLIF provides higher fusion rate than PLF, and this poor evidence indicates that TLIF might improve only clinical outcomes. Higher quality, multicenter RCTs are needed to better define the role of TLIF and PLF.

**Abbreviations:** CI = confidence interval, DDD = degenerative disc disease, NOS = Newcastle-Ottawa Scale, ODI = Oswestry Disability Index, OSs = observational studies, PLF = posterolateral fusion, RCTs = randomized controlled trials, RR = relative risk, SMD = standard mean difference, TLIF = transforaminal lumbar interbody fusion, VAS = visual analogue scale.

**Keywords:** degenerative lumbar spondylosis, meta-analysis, posterolateral fusion, transforaminal lumbar interbody fusion

### 1. Introduction

For many years, spinal fusion has been the standard choice to treat low back pain generated from degenerative lumbar spondylosis, such as degenerative disc disease (DDD), failed disc surgery, spondylosis, spondylolisthesis, and spinal stenosis. Even though various management approaches have evolved over

the past many years, a high-level evidence of the best surgical strategy lacks so far.<sup>[1,2]</sup> One of the important reasons for this might be the numerous types of fusions, which contribute to various efficacies.<sup>[3–5]</sup>

At present, transforaminal lumbar interbody fusion (TLIF) is an advanced surgical intervention for fusion in degenerative lumbar spondylosis, which was first reported in 1998 by Harms and Jeszenszky.<sup>[6]</sup> Theoretically, TLIF should offer the same benefits of circumferential fusion,<sup>[7]</sup> with higher safety than other interbody fusion methods because it avoids the direct traction to spine. In terms of the spinal stability, TLIF technology retains supraspinal ligament and interspinal ligament. On the basis of these theories, TLIF could achieve a good and reliable efficacy. However, Høy et al<sup>[8]</sup> reported that TLIF did not improve functional outcome in patients, when compared with instrumented posterolateral fusion (PLF), the simplest fusion. Conversely, another study demonstrated that the TLIF group was significantly superior to uninstrumented PLF group in terms of pain index and global assessment.<sup>[9]</sup> So far, the evidence to support an improved outcome with TLIF as compared with PLF is scarce. Thus, to evaluate the efficacy and safety of TLIF for degenerative lumbar spondylosis comprehensively, we performed a global search of published studies on this topic. We then performed a quantitative analysis for clinical decision making.

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B-FZ and C-YG equally contributed to this work.

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Department of Spine Surgery, Hong-Hui Hospital, Xi'an Jiaotong University College of Medicine, Beilin District, Xi'an, Shaanxi Province, China.

\* Correspondence: Ding-Jun Hao, Department of Spine Surgery, Hong-Hui Hospital, Xi'an Jiaotong University College of Medicine, Beilin District, Xi'an, Shaanxi Province, China (e-mail: haodingjunspine@126.com).

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## 2. Methods

### 2.1. Literature search

We searched Medline (1966 to 2015.11), EMBASE (1974 to 2015.11), and the Cochrane library (Issue 11 of 12, November 2015) using a search strategy that combined medical subject headings (MeSH)/Embase tree (Emtree) terms and free text words: transforaminal lumbar interbody fusion, posterolateral fusion, degenerative lumbar disorders, degenerative lumbar spondylosis, “Osteoarthritis, Spine”, degenerative spondylolisthesis, degenerative disc disease. We also searched the following databases in Chinese: CNKI, CBM, WanFang, and VIP. Retrieval dates came from time of database creation to November 2015. In addition, we manually checked the references listed, including studies, to filter potential eligible research studies.

### 2.2. Inclusion criteria

Honghui Hospital ethics committee approved the study. All analyses in this meta-analysis were based on previous published studies; thus, no ethical approval or patient consent was required. The studies that met the following criteria were included: study design—randomized controlled trials (RCTs) or observational studies (OSs); the participants—patients with degenerative lumbar spondylosis, which included degenerative spondylolisthesis, DDD, spinal stenosis, etc, but degenerative lumbar scoliosis; the interventions—patients were assigned to TLIF or PLF, irrespective of open or minimally invasive approaches in TLIF, and instrumented or uninstrumented in PLF; the outcomes—primary endpoints were fusion rate (defined as radiographic fusion) and clinical outcomes (the outcome was assessed by the patient, based on local criteria and classified as much better, better, unchanged, or worse. The level of much better and better was defined as good outcome). The secondary endpoints were visual analogue scale (VAS), Oswestry Disability Index (ODI), reoperation, complications (dural lesion, nerve root cutoff, superficial wound infection, hematoma, pneumothorax, sciatica, etc), duration of surgical procedure, blood loss, hospitalization, and the publication was available either in English or Chinese. Patients with sequestration of disk hernia, psychosocial instability, isthmic spondylolisthesis, drug abuse, and previous spine surgery other than discectomy were excluded.

### 2.3. Data extraction and quality evaluation

Chao-Yuan Ge and Bo-Long Zheng included the studies according to the criteria independently: identifying the possible studies, screening the potentially relevant studies, assessing for eligibility, and lastly including the final studies. When the full-text studies were gotten, they extracted design methods and baseline information of studies. When the needed continuous variables were described as median, we translated them into mean and standard deviation.<sup>[10]</sup> The methodological quality of RCT was assessed by the above investigators. The criteria were referred to the Cochrane Reviewers’ Handbook 5.1.0. The methodological quality of OSs was evaluated by Newcastle-Ottawa Scale (NOS). Three major components were as follows: selection of study groups (0–4 points), ascertainment for exposure of interest in the studies (0–3 points), and quality of adjustment for confounding factors (0–2 points). A higher score represented better methodological quality. The quality of each study was graded either low (0–4) or high (5–9) level.<sup>[11]</sup> Disagreements were resolved by discussing with a third investigator (Bin-Fei Zhang).

### 2.4. Statistical methods

We chose relative risk (RR) and standard mean difference (SMD) as effective sizes, with 95% confidence interval (95% CI). Statistics of  $I^2$  was calculated to assess the heterogeneity in the analysis.<sup>[12]</sup> In the process of quantitative synthesis, fixed-effects model was adopted when heterogeneity was low ( $I^2 < 50\%$ ,  $P > 0.1$ ). When heterogeneity was high ( $I^2 > 50\%$ ,  $P < 0.1$ ), subgroup analysis underwent to explore the possible sources of heterogeneity, or random-effects model was adopted.<sup>[13]</sup> We also added our substantive knowledge of endpoints as a factor to choose models. Because of the methodological heterogeneity from study design, the fixed- and random-effects models were chosen to assess consistency in primary endpoints, and models of secondary endpoints were based on value of  $I^2$ . The statistically significant difference was  $P < 0.05$ . STATA 12.0 version (STATA Corporation, College Station, TX) was used to perform the statistic.

## 3. Results

### 3.1. Process for selecting trials

We searched 655 possible studies at first, but most of them were excluded because of irrelevant studies. After screening and assessing the potentially relevant studies, we finally included 7 studies.<sup>[8,9,14–18]</sup> The detailed flowchart of studies included was shown in Figure 1.

### 3.2. Characteristics of included trials and quality evaluation

As shown in Table 1, 630 patients with degenerative lumbar spondylosis were included totally, of them 325 and 305 were in the TLIF and PLF group, respectively. In PLF, 6 studies used instrumented PLF<sup>[8,14–18]</sup> and 1 study used uninstrumented PLF.<sup>[9]</sup> All patients suffered from degenerative lumbar spondylosis, containing DDD, spondylolisthesis, spinal stenosis, and postdiscectomy syndrome. In these studies, the number of surgery levels differed among the studies; there were 448 and 417 levels in TLIF and PLF group, respectively. Four

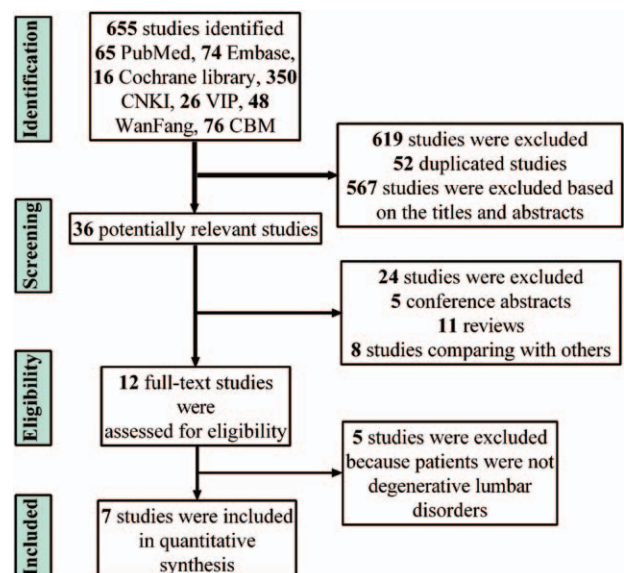


Figure 1. Flowchart of studies included in the meta-analysis.

**Table 1**  
Summary of included studies.

Study	Design	No. of patients (TLIF/PLF)	Mean age (y, TLIF/PLF)	Female (TLIF/PLF)	Diagnosis	No. of levels	Outcomes	Follow-up, mo
Jalalpour et al (2015) <sup>[9]</sup>	RCT	68/67	44/45	20/19	DDD or postdiscectomy syndrome	96 levels/84 levels	Fusion rate, VAS, ODI, reoperation, complications, clinical assessment	24
Høy et al (2013) <sup>[8]</sup>	RCT	51/49	50.3/49.3	27/32	DDD, spondylolisthesis, spinal stenosis, failed back surgery	67 levels/70 levels	Fusion rate, VAS, ODI, operation time, blood loss, hospitalization, reoperation, complications	24
Barbarawi et al (2015) <sup>[18]</sup>	OS	50/30	45.9/36–69	31/18	DDD	90 levels/59 levels	Fusion rate, ODI, complications, clinical assessment	60
Fujimori et al (2015) <sup>[16]</sup>	OS	24/32	59/61	18/21	Degenerative spondylolisthesis	29 levels/51 levels	Fusion rate, VAS, ODI, operation time, blood loss, reoperation	23
Audat et al (2012) <sup>[17]</sup>	OS	37/17	45.8/54.2	23/10	DDD	70 levels/43 levels	Fusion rate, ODI, complications, clinical assessment	36
Xie et al (2012) <sup>[14]</sup>	OS	35/45	57.35/58.45	20/28	Degenerative spondylolisthesis	36 levels/45 levels	Fusion rate, VAS, ODI, operation time, blood loss, hospitalization, reoperation, complications	24
Wu (2015) <sup>[15]</sup>	OS	60/65	45.38/47.01	27/29	Degenerative lumbar disorders	60 levels/65 levels	Fusion rate, VAS, ODI, complications	—

DDD = degenerative disc disease, ODI = Oswestry Disability Index, OS = observational study, PLF = posterolateral fusion, RCT = randomized controlled trial, TLIF = transforaminal lumbar interbody fusion, VAS = visual analogue scale.

studies<sup>[8,9,14,16–18]</sup> followed patients for 23 to 24 months; 2 studies<sup>[17,18]</sup> reported follow-up for 36 to 60 months, and Wu<sup>[15]</sup> did not report the follow-up.

The qualities of 2 RCTs were evaluated. Jalalpour et al<sup>[9]</sup> reported that randomization was performed by the nurse attending the outpatient clinic after inclusion. Høy et al<sup>[8]</sup> used block randomization. Allocation concealment was detailed in the study by Høy et al,<sup>[8]</sup> which was done using sealed envelopes, and Høy et al<sup>[8]</sup> also reported the blinding in patients. Intention-to-treat analysis was adopted in Høy et al.<sup>[8]</sup> Selective reporting and other biases were low risk in the study by Høy et al<sup>[8]</sup> and unclear in that by Jalalpour et al.<sup>[9]</sup> Thus, we determined that the study by Høy et al<sup>[8]</sup> was of high quality and that by Jalalpour et al<sup>[9]</sup> was of low quality. The NOS score was used to assess the qualities of OSs. According to the criterion, the quality of each study was scored from 6 to 8, representing the high level of OSs, shown in Table 2.

**3.3. Primary endpoint**

**3.3.1. Fusion rate.** Seven studies compared the fusion rate of TLIF and PLF. As shown in Figure 2, the aggregated results of these studies were divided into 2 subgroups according to the study design. Heterogeneities in RCTs and OSs subgroups were  $I^2=0.0\%$  ( $P=0.444$ ) and  $I^2=7.9\%$  ( $P=0.362$ ), respectively. We adopted a fixed-effects model, which suggested that TLIF did not

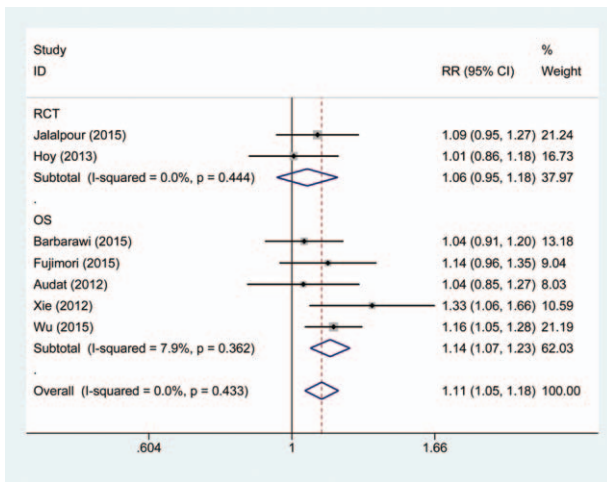
increase the fusion rate based on RCTs (RR=1.06; 95% CI: 0.95–1.18;  $P=0.321$ ), but increased the fusion rate based on OSs (RR=1.14; 95% CI: 1.07–1.23;  $P=0.000$ ) and overall (RR=1.11; 95% CI: 1.05–1.18;  $P=0.001$ ) as compared with PLF. Also, results under random-effects model demonstrated same outcome: TLIF did not increase the fusion rate based on RCTs (RR=1.05; 95% CI: 0.95–1.17;  $P=0.343$ ), but increased the fusion rate based on OSs (RR=1.13; 95% CI: 1.05–1.21;  $P=0.001$ ) and overall (RR=1.11; 95% CI: 1.05–1.17;  $P=0.000$ ) as compared with PLF.

We further performed sensitivity analyses to explore stability. As shown in Figure 3, results changed to varying degrees after removing any one study. The studies with the greatest influence on overall results were those by Xie et al<sup>[14]</sup> and Wu.<sup>[15]</sup> Fusion rate was 1.08 RR (95% CI: 1.02–1.15;  $P=0.008$ ) after removing the study by Xie et al,<sup>[14]</sup> and 1.10 RR (95% CI: 1.02–1.18;  $P=0.009$ ) after removing that by Wu,<sup>[15]</sup> which illustrated that the results were rather stable.

**3.3.2. Clinical outcomes.** Four studies reported clinical outcomes in the TLIF and PLF group. As shown in Figure 4, heterogeneity in OSs subgroups was  $I^2=0.0\%$  ( $P=0.958$ ). Thus, we adopted the fixed-effects model for aggregating results. The results demonstrated that TLIF was able to improve the clinical outcomes based on 1 RCT (RR=1.33; 95% CI: 1.11–1.59,  $P=0.002$ ) and overall (RR=1.19; 95% CI: 1.07–1.33;  $P=0.001$ ),

**Table 2**  
The qualities of observational studies.

Studies	Is the case definition adequate?	Representativeness of the cases	Selection of controls	Definition of controls	Comparability of cases and controls on the basis of the design or analysis	Ascertainment of exposure	Same method of ascertainment for cases and controls	Nonresponse rate	Total score
Barbarawi et al (2015) <sup>[18]</sup>	★	★	★	★	★★	★	★	☆	8
Fujimori et al (2015) <sup>[16]</sup>	★	☆	★	★	★★☆	★	★	☆	6
Audat et al (2012) <sup>[17]</sup>	★	★	★	★	★★☆	★	★	☆	7
Xie et al (2012) <sup>[14]</sup>	★	☆	★	★	★★☆	★	★	☆	6
Wu (2015) <sup>[15]</sup>	★	☆	★	★	★★	★	★	☆	7



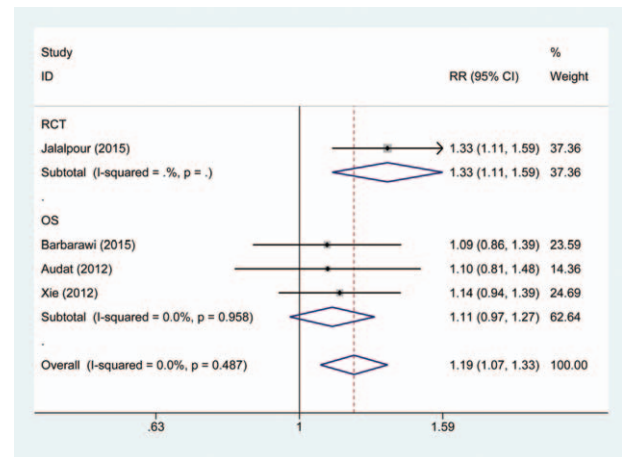
**Figure 2.** Forest plot comparing fusion rate between TLIF and PLF under study design. The statistical method used was the Mantel-Haenszel (M-H) method, the effect measure was RR, and the analysis method was the fixed-effects model.

but not based on OSs (RR=1.11; 95% CI: 0.97–1.27;  $P=0.129$ ) as compared with PLF. Under random-effects model, results show same outcomes, TLIF could improve the clinical outcomes based on RCT (RR=1.33; 95% CI: 1.11–1.59,  $P=0.002$ ) and overall (RR=1.19; 95% CI: 1.07–1.32;  $P=0.002$ ), but not in OSs (RR=1.12; 95% CI: 0.97–1.28;  $P=0.114$ ) as compared with PLF.

We hypothesized the quality of study will influence the results, and we performed sensitivity analyses to explore stability. As shown in Figure 5, results changed after removing any one study. The study with the greatest influence on overall results was that by Jalalpour et al.<sup>[9]</sup> Excellent and good clinical assessment was 1.11 RR (95% CI: 0.97–1.27;  $P=0.230$ ) after removing the study by Jalalpour et al.<sup>[9]</sup>

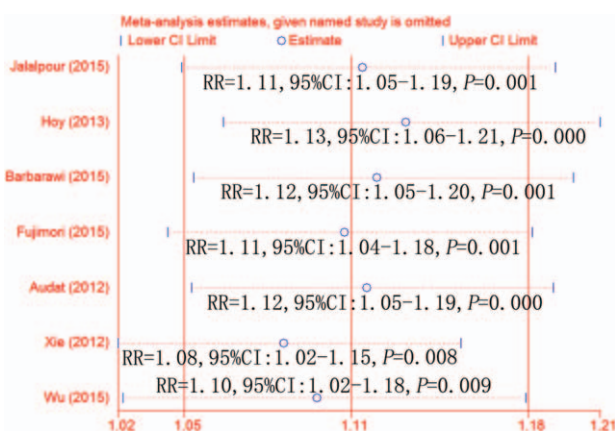
**3.4. Secondary endpoints**

We also compared the VAS, ODI, reoperation, complications, duration of surgical procedure, estimated amount of blood loss, and hospitalization of both groups, shown in Table 3. After we adopted the random- or fixed-effects model, we found that TLIF

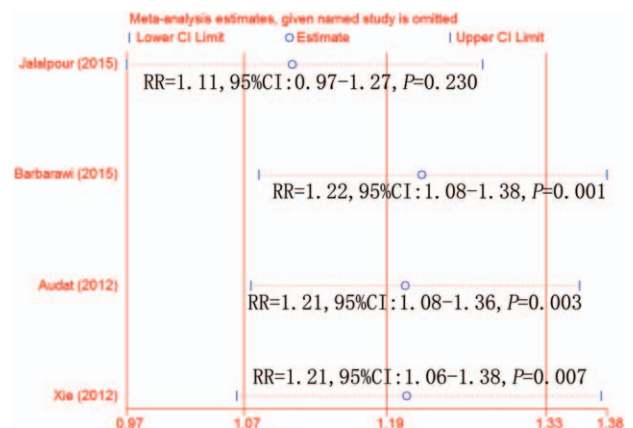


**Figure 4.** Forest plot comparing clinical outcomes between the TLIF group and PLF group under study design. The statistical method used was the Mantel-Haenszel (M-H) method, the effect measure was RR, and the analysis method was the fixed-effects model.

did not decrease the back pain level (SMD=-0.98; 95% CI: -2.20 to 0.24;  $P=0.115$ ) or leg (SMD=-0.17; 95% CI: -0.63 to 0.28;  $P=0.456$ ), and did not decrease the score of ODI (SMD=-0.93; 95% CI: -2.23 to 0.37;  $P=0.159$ ) compared with PLF group. In addition, we compared the reoperation of both groups. Results under random-effects model suggested that TLIF did not increase the reoperation rate based on RCTs (RR=0.83; 95% CI: 0.18–3.75;  $P=0.809$ ) or OSs (RR=0.21; 95% CI: 0.03–1.77;  $P=0.151$ ), or overall (RR=0.60; 95% CI: 0.20–1.80;  $P=0.361$ ) compared with PLF. The complications under fixed-effects model indicated that TLIF did not increase the complications rate based on RCTs (RR=1.72; 95% CI: 0.80–3.72;  $P=0.166$ ) or OSs (RR=0.79; 95% CI: 0.45–1.39;  $P=0.419$ ) or overall (RR=1.05; 95% CI: 0.67–1.65;  $P=0.823$ ) as compared with PLF. We also compared the duration of surgical procedure, estimated amount of blood loss, and length of hospitalization of both groups, which reported that TLIF did not increase the duration of surgical procedure (SMD=0.57; 95% CI: -0.04 to 1.18;  $P=0.066$ ) or blood loss (SMD=0.23; 95% CI: -0.12 to 0.58;  $P=0.202$ ) or hospitalization (SMD=0.14; 95% CI: -0.25 to 0.54;  $P=0.476$ ) compared with PLF group.



**Figure 3.** Sensitivity analyses of fusion rate between TLIF and PLF.



**Figure 5.** Sensitivity analyses comparing clinical outcomes between the TLIF group and PLF group.

**Table 3**  
**Summary of secondary endpoints.**

Items	Study	Heterogeneity		Analysis model	Statistical method	RR/SMD	P
		I <sup>2</sup> , %	P				
VAS							
Back	[8,9,15,16]	96.80	0.000	Random effects	Cohen d	SMD=-0.98; 95% CI: -2.20 to 0.24	0.115
Leg	[8,15,16]	71.60	0.030	Random effects	Cohen d	SMD=-0.17; 95% CI: -0.63 to 0.28	0.456
ODI	[8,9,15,16]	97.20	0.000	Random effects	Cohen d	SMD=-0.93; 95% CI: -2.23 to 0.37	0.159
Reoperation							
RCTs	[8,9]	70.00	0.068	Random effects	Mantel-Haenszel	RR=0.83; 95% CI: 0.18-3.75	0.809
OSs	[14,16]	0.00	0.532	Random effects	Mantel-Haenszel	RR=0.21; 95% CI: 0.03-1.77	0.151
Overall	[8,9,14,16]	38.30	0.182	Random effects	Mantel-Haenszel	RR=0.60; 95% CI: 0.20-1.80	0.361
Complications							
RCTs	[8,9]	1.30	0.314	Fixed effects	Mantel-Haenszel	RR=1.72; 95% CI: 0.80-3.72	0.166
OSs	[14-18]	24.40	0.259	Fixed effects	Mantel-Haenszel	RR=0.79; 95% CI: 0.45-1.39	0.419
Overall	[8,9,14-18]	19.50	0.281	Fixed effects	Mantel-Haenszel	RR=1.05; 95% CI: 0.67-1.65	0.823
Duration of surgical procedure	[8,16]	69.90	0.068	Random effects	Cohen d	SMD=0.57; 95% CI: -0.04 to 1.18	0.066
Blood loss	[8,16]	16.00	0.275	Random effects	Cohen d	SMD=0.23; 95% CI: -0.12 to 0.58	0.202
Hospitalization	[8]	—	—	Random effects	Cohen d	SMD=0.14; 95% CI: -0.25 to 0.54	0.476

CI=confidence interval, ODI=Oswestry Disability Index, OS=observational study, RCT=randomized controlled trial, RR=relative risk, SMD=standard mean difference, VAS=visual analogue scale.

### 3.5. Publication bias

Publication bias was assessed, even though only 7 studies were included in this analysis. We chose the fusion rate to analysis because there were 7 studies. The results illustrated that there was no publication bias; Begg test ( $z=0.30$ ,  $P=0.764$ ; Fig. 6) and Egger test ( $t=0.79$ ,  $P=0.466$ ) did not indicate the bias.

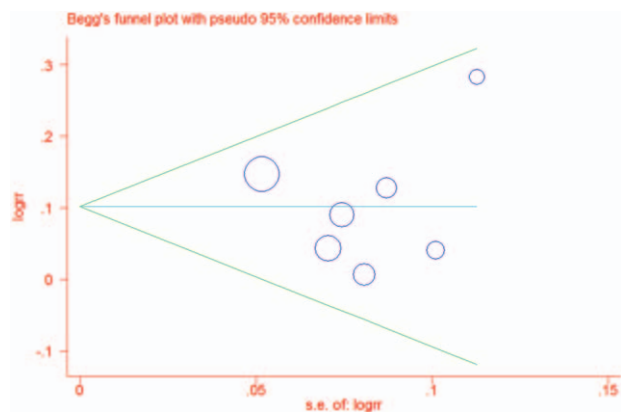
## 4. Discussion

PLF can reach promising outcomes with relatively low surgical risks and technical demands, and many surgeons have accepted this technique as a therapy for spondylolisthesis.<sup>[19,20]</sup> In addition, TLIF, minimally invasive or open TLIF,<sup>[21]</sup> is now widely used in lumbar spinal fusion because of minimal invasiveness to the spinal canal, shorter duration, and low morbidity compared with other fusion methods. It is considered by many authors to be the treatment of choice to achieve interbody fusion.<sup>[22,23]</sup> Even though different fusion methods have been compared, there was no real difference in clinical

satisfaction, complication rate, and fusion rate.<sup>[24,25]</sup> However, the comparison between pure PLF and TLIF is uncertain. Do they have similar outcomes in degenerative lumbar spondylosis? To our knowledge, this study is the first meta-analysis to analyze a TLIF procedure with instrumented or uninstrumented spinal PLF procedure.

The results show that TLIF might increase the fusion rate in OSs. However, synthetic results from 2 RCTs<sup>[8,9]</sup> do not show significant differences. Thus, evidence supporting that TLIF provides higher fusion rate than PLF is scarce. Meanwhile, when PLF is divided into instrumented<sup>[8,14-18]</sup> and uninstrumented PLF,<sup>[9]</sup> the results demonstrate that TLIF could not increase fusion rate compared with uninstrumented PLF (RR=1.09; 95% CI: 0.95-1.27;  $P=0.224$ ) or instrumented PLF (RR=1.05; 95% CI: 0.96-1.14;  $P=0.267$ ). These results are consistent with those from a Swedish Lumbar Spine Study that failed to show any difference between the instrumented or uninstrumented PLF.<sup>[26]</sup> When we analyzed the clinical outcomes, TLIF was able to improve the level in overall population and RCT.<sup>[9]</sup> When excluding Chinese OS,<sup>[14]</sup> the data also indicated that TLIF might improve the clinical outcomes (RR=1.21; 95% CI: 1.06-1.38;  $P=0.004$ ). In the sensitivity analysis, after removing RCT by Jalalpour et al,<sup>[9]</sup> clinical assessment changed, the quality of study does influence the results. We analyzed that OSs might exaggerate the efficacy,<sup>[27]</sup> especially PLF, which contributes to the instability after removing the study by Jalalpour et al.<sup>[9]</sup> Thus, based on the above analysis, the current evidence illustrates that TLIF might improve the clinical outcomes compared with PLF.

It is important to note 2 possible rationales for explaining TLIF does not demonstrate advantages in fusion, despite a better trend in clinical outcomes. First, different common fusion methods show that there is not much difference in the fusion rates.<sup>[24,25]</sup> Fusion can be obtained by creating suitable situation, which all of common methods can provide,<sup>[28]</sup> especially fusion rates are same in circumferential fusion and PLF.<sup>[24]</sup> Second, in TLIF, after disc is extracted, the remaining intervertebral space is filled for a better flexibility, conforming to the biomechanics of lumbar spine.<sup>[29]</sup> In PLF, we use a combination of fixation and fusion of vertebral plate/transverse process, without dealing with intervertebral space. Most of degenerative lumbar spondylosis involves a degenerative disc, thus processing disc may improve clinical



**Figure 6.** The funnel plot of fusion rate between TLIF and PLF. The y-axis represents log (RR), and the x-axis represents standard error of log (RR). Dashed line in the middle is log (RR) value calculated from fusion rate; declining lines are the boundary of 95% confidence interval. Circles indicate 7 studies.

efficacy. Therefore, we conjecture that a cage might play a vital role in improving the efficacy more than promoting fusion.

VAS and ODI are important indices to assess the quality of life. Our meta-analysis did not find any difference between these 2 fusion methods under high heterogeneity. The heterogeneity comes from the study by Jajalpour et al,<sup>[9]</sup> the possible reason maybe that it is the only study presenting uninstrumented PLF included in this meta-analysis. Our meta-analysis also demonstrated that reoperation and complications were similar between TLIF and PLF. The following could be attributable for reoperations in the PLF group: removal of the hardware due to loosening or failure,<sup>[8]</sup> symptomatic pseudarthrosis,<sup>[9]</sup> contralateral leg pain,<sup>[16]</sup> and pedicle screw breakage.<sup>[14]</sup> The main reasons for reoperation in the TLIF group were removal of the implant due to misalignment of the intervertebral space cages, nonunion, and infection.<sup>[8,9]</sup> Complications of PLF are dural lesion,<sup>[8,16]</sup> nerve root incision,<sup>[9]</sup> hematoma,<sup>[8]</sup> infection,<sup>[18]</sup> and pedicle screw breakage.<sup>[14,15]</sup> Complications of TLIF are nerve root injury, bone fragment in root canal, wound infection,<sup>[9,17,18]</sup> hematoma, and dural tear.<sup>[8,16]</sup> Thus, TLIF has similar outcomes to PLF in VAS, ODI, reoperation, and complications.

#### 4.1. Limitations

Meanwhile, our meta-analysis has several potential limitations that should be taken into consideration. First, this meta-analysis included 2 RCTs and 5 OSs with various evidence levels, especially, in fusion rate between TLIF and PLF, RCTs and OSs show different and unstable result, the reasons may be from various level of clinical qualities and study design because OSs are reported that could exaggerate the effect size.<sup>[27]</sup> Second, Jajalpour et al<sup>[9]</sup> presented patients that underwent uninstrumented PLF, which could have contributed to the clinical heterogeneity. Third, several continuous variables were described as medians, and we translated them into mean  $\pm$  standard deviation, depending on previous experience.<sup>[10]</sup> Thus, these results should be cautiously taken into consideration.

#### 5. Conclusions

In conclusion, there is not enough evidence to support that TLIF provides higher fusion rate than PLF, and this low evidence indicates that TLIF might only improve clinical outcomes. In conclusion, multicenter RCTs with higher quality are needed to testify the role of TLIF and PLF.

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