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Original Article

Clinical outcomes of posterior lumbar interbody fusion followed by sight-guided translaminar facet screw in the treatment of intervertebral disc herniation combined with vertebrae fracture: a preliminary study

Hongjian Yu[1], Baoke Li[2], Hui Shi[3], Cuimei Qin[4], Caixia Zhang[5], Wenqiang Zhang[6]

Departments of [1]Bone and Joint Surgery, [2]Traumatic Orthopaedics, Binzhou People's Hospital, Binzhou 256610, Shandong Province, China; Departments of [3]Bone and Joint Surgery, [5]Geriatric Medicine, Binzhou Medical University Hospital, Binzhou 256610, Shandong Province, China; [4]Department of Gynaecology, Traditional Chinese Medicine Hospital of Binzhou, Binzhou 256610, Shandong Province, China; [6]Department of Bone and Joint Surgery, Shandong Qianfoshan Hospital, Jinan 250014, Shandong Province, China

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Abstract: Our study aimed to investigate the clinical efficacy of sight-guided translaminar facet screw fixation (TLFSF) with posterior lumbar interbody fusion (PLIF) in treating intervertebral disc herniation and lumbar vertebrae fracture. Between April 2012 and April 2014, 68 elderly patients with intervertebral disc herniation and vertebrae fracture who had undergone PLIF with sight-guided TLFSF were enrolled, as experimental group. Between April 2010 and April 2012, the control group comprised 53 subjects with the same disorders who had undergone PLIF with pedicle screw fixation. Visual analog scale (VAS) scores, disc height, facet screw position, bony fusion, complications and Japanese Orthopaedic Association (JOA) scores were collected and analyzed. No significant differences were observed in operative time, incision lengths, blood loss, drainage volume, and hospital stays between two groups. The height conducted postoperatively ($P = 0.033$) and at the last follow-up ($P = 0.021$) were significantly higher than those in control group. Comparing to controls, there was a significantly higher proportion of type I screw position which meant the screw was located in the laminar bone in experimental group ($P = 0.025$). Moreover, significant benefits of less pain and complications were observed in experimental, relative to control (pain: 2.1 vs. 2.8, $P = 0.037$; complication: 7.4% vs, 11.3%, $P = 0.014$). Importantly, there were higher fusion rate, higher JOA recovery rate, and more vertebral stabilization in experimental than that of controls ($P < 0.05$). Based on this preliminary data, TLFSF plus PLIF is an effective and minimally invasive option for treating intervertebral disc herniation combined with lumbar vertebrae fracture, with good efficacy and screw accuracy.

Keywords: Sight-guided translaminar facet screw fixation, posterior lumbar interbody fusion, intervertebral disc herniation, lumbar vertebrae fracture

Introduction

Degenerative lumbar spine disease, for example, spinal stenosis and lumber disc herniation, is characterized by chronic back pain as well as neurological symptoms. Presently, this is still a serious clinical problem which can result in disabilities in varying degrees. Various etiologic factors, including aging as well as exposure to loading forces, contribute to the development of lumbar intervertebral disc herniation [1], although trauma, straining, or lifting injuries have also been implicated. Nowadays, lumbar discectomy, decompression, and spinal fusion surgeries are solutions for treating the pain and spinal instability.

As we all know, posterior lumbar interbody fusion (PLIF) is widely accepted and the most satisfying technique for managing degenerative lumbar spine diseases due to the advantages of restoring disc height, nerve root decompression, disc stabilisation, and reinforcement of the anterior spinal column since the first introduced in 1953 [2]. However, this strategy has been found to be related with a high rate of

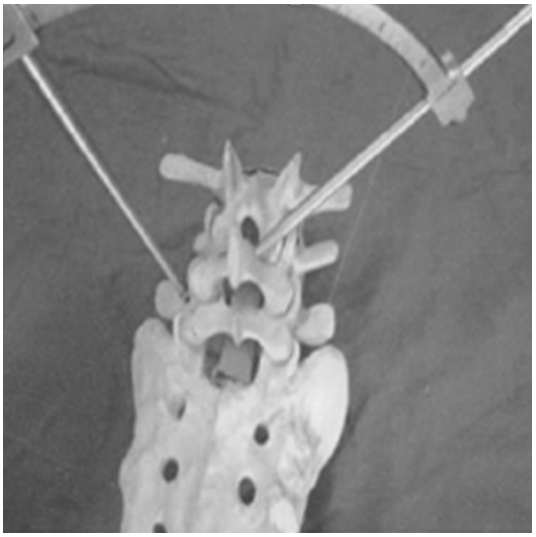

Figure 1. Schematic drawings exhibiting aiming device on a spinal column specimen.

non-union. Fortunately, application of pedicle screws has been added to this fusion technique to provide direct stability and to improve the union rates [3, 4]. Nevertheless, pedicle screw fixation can lead to unnecessary trauma to the lumbar musculo-ligamentous complex, and increase infection rates and injury, eventually cause poor clinical outcomes [5]. Thus, a more minimally invasive way was expected. Excitedly, translaminar facet screw fixation (TLFSF), as an important lumbar fixation means, has gained popularity because of the advantages of reduced invasiveness, good stability, elastic fixation, procedure simplicity as well as excellent efficacy [6, 7]. Taking into consideration of nerve root symptoms in many cases, decompression was necessary. Image-guided percutaneous surgery was mainly applied in the translaminar facet screw placement [8, 9]. Frequently, sight-guided screw fixation has been reported to enhance the accuracy and safety of screw placement, thus avoiding nerve as well as vascular damage induced by inaccurate puncture [10]. Moreover, previous studies have mainly focused on involving the interbody fusion of intervertebral disc herniation, little on the treatment of herniation combined with vertebrae fracture [11, 12].

Herein, this study proposed to compare the clinical efficacy of sight-guided percutaneous TLFSF with interbody fusion and pedicle screw fixation plus interbody fusion. These surgical technologies were utilized to treat the elderly patients with intervertebral disc herniation combined with lumbar vertebrae fracture.

Materials and methods

Physical data

This was a retrospective study of patients who were diagnosed with herniation of an intervertebral disc combined with lumbar vertebrae fracture and undergone surgical treatment at our institute. Approval for this study was required from the Institutional Reviewing Board (IRB). In addition, prior to operation, all participants signed written informed consent.

Between April 2012 and April 2014, PLIF using bone graft with translaminar facet screw (custom-made by Shanghai Pu Wei Medical Devices, Shanghai, China) under gunsight guiding by percutaneous were performed at our hospital for the elderly patients who were diagnosed with herniation of an intervertebral disc combined with lumbar vertebrae fracture, which was named as experimental group. During the period of April 2010 and April 2012, the control group comprised subjects with the same disorders of experimental group who had undergone PLIF with pedicle screw fixation. The pedicle screws used in our study were XIA (Stryker, Kalamazoo, Michigan). Clinical, radiological as well as magnetic resonance imaging (MRI) examination were applied in the diagnosis of all patients.

The patients with infection, tumor, unilateral instrumentation, multi-level surgery, and revision surgeries were excluded.

Surgical technique

In experimental group, the patients underwent PLIF with TLFSF under gunsight guiding (aiming device on a spinal column specimen exhibited in **Figure 1**). The subjects were placed in the prone position, and the procedure was performed under general anesthesia. The operation comprised of the following three steps:

Discectomy: An incision center adjacent to the spine on the symptomatic or more severe segment was made along the spinous process lengthways to the waist. Then, the erector spinae was stripped on the side of the most serious lesion or nerve root symptoms, thereby expanding the laminar space as well as the stenotic lateral recess were visible. Laminectomy

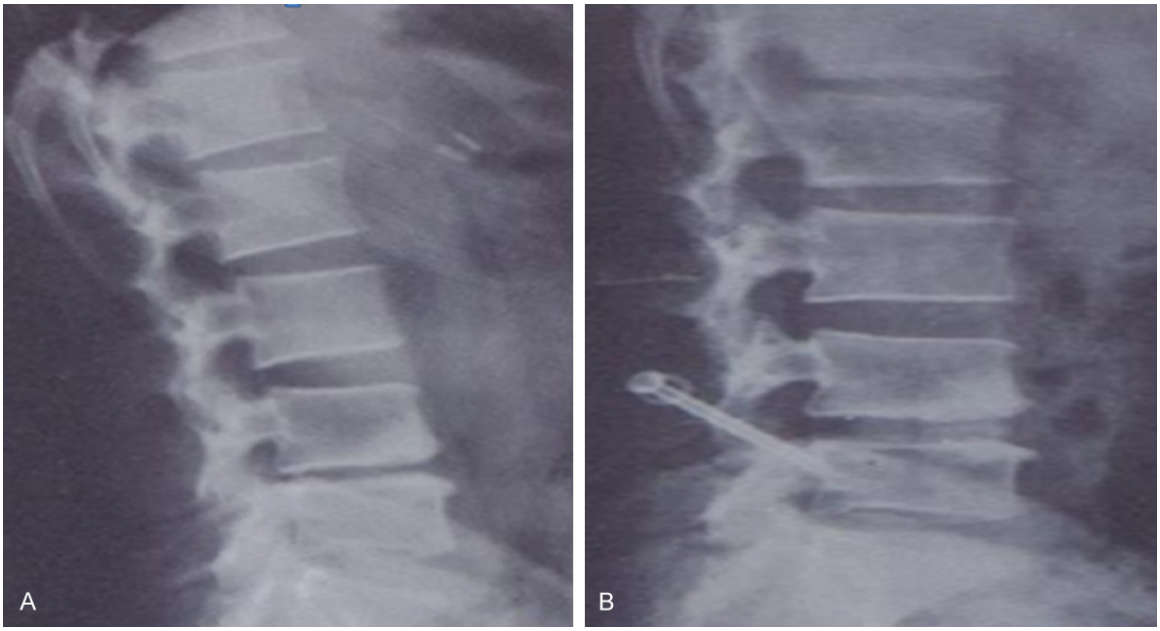

Figure 2. A: MR indicated that the intervertebral disc space for L4/L5 was narrowed. B: The patient was treated with posterior lumbar interbody fusion using bone graft supplemented with translaminar facet screw fixation under gunsight guiding.

or complete excision of the inferior articular process and discectomy were implemented under microscopic visualization.

Decompression and fusion: Nerve root detection and decompression were achieved successfully. After that, an incision of 2.0 cm in length was made to remove bone samples from the osterior iliac crest. Moreover, the interbody fusion cage (DePuy Orthopedics, Warsaw, IN, USA) was trimmed to a size of 2-3 mm. Bone samples during decompression were morselized in a bone mill, and then packed into the cage. Before the insertion of the cage, the local morselized bone was grafted as much as possible into the intervertebral space. Either a rectangular (anatomical shape) or banana-shaped cages were chosen and employed based on the intervertebral height. Following, a single cage filled with morselised bone graft material was inserted into the side with symptoms or more severe symptoms or the more severe stenotic foramen seen on magnetic resonance imaging (MRI).

*Sight-guided TLFSF (**Figure 2A** and **2B**):* After fusion procedure, percutaneous TLFSF was conducted. In brief, the entry point of the positioning rod was determined as the intersection between the midline of the transverse process and the outer edge of the contralateral superior facet under C-arm X-ray guidance. The lateral angle of the lamina plane was determined preoperation using MRI, and the insertion angle of the guide sleeve was decided according to this lateral angle. The line of this angle was extended to the skin. The distance from the midline to the point that the line meets the skin was measured. In the operative field, a paravertebral, vertical line was drawn at this distance from the midline. Then the caudal angle of the screw trajectory was determined using the fluoroscope. The guide sleeve, as the entry point of the guide pin, was inserted percutaneously at the upper one-third of the base of the spinous process. The insertion depth was identified dependent on the measurement of the length of the screw channel pre-operatively. The needle was introduced along the lateral angle and caudal angle until the tip of needle anchored at the cranial one-third of the base of the spinous process via lamina, inferior facet, and superior facet of the lower vertebra on the contralateral side, to the transverse process. A lumbar anteroposterior view was done to verify that the position and depth of the guide pin was suitable. Once proper placement had been verified, the sight was withdrawn, and a titanium hollow screw of corresponding length as well as diameter was implanted.

Table 1. Patient characteristics

Characteristic	Experimental group	Control group
No. of patients	68	53
Male/female	47/21	36/17
Mean age at the time of surgery	69.5	68.9
Level of surgery		
L3-4	11	8
L4-5	22	17
L5-S1	18	14
L4-5 and L5-S1	17	14
Mean VAS score	3.2 ± 0.1	3.3 ± 0.5

Notes: VAS, Visual Analogue Scale.

In control group, the patients were subjected to PLIF with pedicle screw fixation. The same steps of PLIF were mentioned above. A transpedicular screw system was placed on the symptomatic side under the guide of the X-ray. After inserting the cage, pedicle screw fixation was performed to secure the stability and to improve the bony union immediately after fusion. Standard wound closure was performed following hemostasis.

Following operation, routine managements including hemostasis, washing with sterile saline, placement of drain, as well as layered wound closure were implemented serially.

Postoperative management

Conventional anti-infection therapy, fixation of waist, alleviating pain, and prevention of the vein thrombus of low limbs were carried out. Two days after operation, the drainage tubes were removed. Patients wore functional waist brace and were allowed to get out of bed and walk 4 weeks postoperatively. Eight weeks post-operatively, exercise training for abdominal and back muscles was initiated.

Clinical assessments

The incision lengths, duration of surgery, the hemorrhage volume, drainage volume, and hospital stays were recorded in these two groups. In addition, Visual analog scale (VAS) scores for back pain were evaluated taken preoperatively and at twelve months post-operation. Furthermore, we evaluated the height of the intervertebral disc space according to the radiography measurements conducted preoperatively, immediate-postoperatively and at the last follow-up. Additionally, the proper screw location and complications were evaluated. Facet screw position was divided into the following three categories: type I which meant the screw is located in the laminar bone; type II meant the screw partially penetrates the lamina; type III meant the screw completely penetrates the lamina, that is to say the screw is located on the laminar surface or completely enters the spinal canal. Moreover, we carefully evaluated the bone bridging formation and the absence of radiolucency around the screws as well as cage, and looked for any evidence of instability on the flexion-extension lateral radiographs to assess the boney union, although the radiopaque titanium cage made it difficult to assess whether boney union was achieved. The solid bony union was believed to be obtained when the bony trabecular continuity and bone bridging were observed in the intervertebral space, and endplates became invisible on the radiographs during the period of follow-up. Fusion failure was assessed based on the following criteria: the presence on anteroposterior and lateral radiographs of a definite radiolucent line around a cage or screw or more than 5° motion on lateral radiographs.

Japanese Orthopaedic Association (JOA) scores (range-6 to 15) were also obtained to assess the symptoms, sighs, bladder function and daily activities for all patients taken pre-operation and at the latest follow-up. The JOA recovery rates were computed the formula as follows: recovery rate = (postoperative JOA score - preoperative JOA score)/(29- preoperative JOA score) × 100%.

Estimation of sample size

Enough samples are crucial to guarantee the conclusion reliability. Therefore, in our study, we utilized G*Power 3.1.9.2 software to make power analysis to calculate the sample size using $\alpha = 0.05$ and power$(1-\beta) = 0.80$ based on JOA score of post-operation, JOA recovery rate (%), and hight of intervertebral disc of post-operation as well as the period of follow-up.

Statistical analysis

SPSS 17.0 (SPSS Inc., Chicago, IL, USA) was utilized for the statistical analysis. The statistics data were presented as mean ± standard devi-

Table 2. The comparison of clinical outcomes between these two groups

	Incision lengths (cm)	Duration of surgery (min)	Hemorrhage volume (mL)	Drainage volume (mL)	Hospital stays (d)
Experimental group	4.3 ± 0.5	80.7 ± 10.6	280.8 ± 30.4	230.4 ± 56.7	8.5 ± 1. 3
Control group	4.2 ± 0.8	78.2 ± 11.4	273.6 ± 25.7	215.3 ± 44.2	8.3 ± 1.1
P	0.353	0.925	0.426	0.458	0.984

Table 3. The comparison of Visual Analogue Scale (VAS) scores, height of intervertebral disc, and screws position between these two groups

	Number	VAS scores		Hight of intervertebral disc (mm)			Type I screw position (%)
		Pre-operation	Post-operation	Pre-operation	Post-operation	Follow-up	
Experimental group	68	3.2 ± 0.1	2.1 ± 0.3*	6.7 ± 0.4	12.3 ± 1.2	11.5 ± 2.2	61 (89.7)
Control group	53	3.3 ± 0.5	2.8 ± 0.2	6.8 ± 0.5	10.5 ± 1.3	9.2 ± 1.6	40 (75.5)
P		0.351	0.037	0.328	0.033	0.021	0.025

Note: *P < 0.05 vs. pre-operation.

ation (SD) or n (%) of patients. Differences in parameters variables were analyzed by t test. Statistical difference was determined based on a *P* value < 0.05.

Results

Baseline characteristics

A total of 121 patients who were followed up for 1 year were included in this study. The specific characteristics were exhibited in **Table 1**. Among the 68 patients of experimental group, the mean age at the time of surgery was 69.5 years (range from 66 to 78 years old). There were 47 males and 21 females. Clinical course ranged from 5 days to 16 years. L4/L5 compression fracture was present in 22 patients, L5/S1 flexion distraction fracture in 18, and L4/L5 as well as L5/S1 burst fracture in 17, and L3/L4 fracture-dislocation in 11.

Similarly, the control group comprised 53 older subjects with of intervertebral disc herniation combined with lumbar vertebrae fracture. The pre-operative demographic characteristics of patients were as follows. The mean age at the time of surgery was 68.9 years (range from 65 to 76 years old). There were 36 males and 17 females. L4/L5 compression fracture was present in 17 patients, L5/S1 flexion distraction fracture in 14, and L4/L5 as well as L5/S1 burst fracture in 14, and L3/L4 fracture-dislocation in 8.

Of note, no significant differences were observed among the indexes of gender, mean age, back pain, disease region and disease type in these two treatment groups (P > 0.05).

Comparison of surgery outcomes between these two groups

As shown in **Table 2**, patients in the experimental group had longer operative time (80.7 versus 78.2 mins), a little longer incision lengths (4.3 versus 4.2 cm) and hospital stays (8.5 versus 8.3 d), more blood loss (280.8 versus 273.6 mL), as well as greater drainage volume (230.4 versus 215.3 mL) as compared with the control group. However, no significant differences were obtained for these indexes (P > 0.05).

Comparison of VAS scores, height of intervertebral disc, and the position of screws

VAS pain scores were assessed pre-operatively and at the last follow-up. Pre-operatively, the main VAS score was 3.2 in experimental group and 3.3 in control group, but there was no significant difference (P > 0.05). Twelve months postoperatively, the mean pain score was 2.1 in experimental group and 2.8 in control group, and the significant difference was observed (P = 0.037). Significantly, in the experimental group, VAS was remarkably decreased postoperatively, relative to that of pre-operation (P < 0.05). However, there was no difference in the VAS pre-operatively and post-operatively in the control group (P > 0.05). No statistical significance was obtained in the height of intervertebral disc of the affected segments prior to surgery between these groups (P = 0.328).

Table 4. The comparison of complications, bony union and stability, and Japanese Orthopaedic Association (JOA) scores as well as JOA recovery rates

	Number	Bony union and stability (%)		Complications (%)	JOA scores		
		6 months followed up	12months followed up		Pre-operation	Post-operation	JOA recovery rate (%)
Experimental group	68	61 (89.7)	57 (83.8)	5 (7.4)	12.4 ± 2.3	26.5 ± 2.8	81.3 ± 10.2
Control group	53	41 (77.4)	36 (67.9)	6 (11.3)	12.8 ± 1.6	20.3 ± 2.1	73.6 ± 14.3
P		< 0.001	< 0.001	0.014	0.854	0.021	0.012

After operation, the heights of intervertebral disc were significantly increased, and 12 months postoperatively, the height was reduced relative to that of post-operation in both two groups. Remarkably, the height conducted postoperatively (P = 0.033) and at the last follow-up (P = 0.021) were significantly higher than those in control groups. Screw positions were evaluated as follows: type I, 61 patients (89.7%) in experimental group and 40 cases (75.5%) in control group. Comparing to control group, there was a significantly higher proportion of type I screw position in experimental group (P = 0.025, **Table 3**).

Comparison of complications, bony union, bony stability, and JOA scores as well as JOA recovery rates

As depicted in **Table 4**, during the 12-month follow-up, fewer patients in the experimental group experienced significant complications relative to control group (5 out of 68: 7.4% vs. 6 out of 53:11.3%, P = 0.014). Similarly, relative to control group, the outcomes of bony union and stability was better in experimental group at 6-month and 12-month follow-up (P < 0.001). In regard to JOA score, the pre-operation score of experimental group was a litter smaller than that in control, but no significant difference was observed (P = 0.854). The scores were significantly elevated during the period of follow-up in both two groups. Importantly, in the period of follow-up, the JOA score was significantly increased in experimental group, relative to control group (P = 0.021). In addition, the JOA recovery rate of experimental group was remarkably higher than that of control group (P = 0.012).

The calculation of sample size

We assumed that the ratio of sample size in the experimental and control group was 1:1. Statistical power values suggested that the total samples were respective 8 and 84 based on JOA score of post-operation and JOA recovery rate. Moreover, statistical power values indicated that the total samples were respective 18 and 26 based on intervertebral disc of post-operation as well as the period of follow-up. Significantly, in our study, the patients in experimental and control groups were 68 and 53, respectively. According to these results, we thought the overall power value was relatively good, and the sample size was sufficient for our study.

Discussion

Surgical technique PLIF has been demonstrated to be suitable for treating degenerative lumbar spine disorders to resolve the pain and spinal unstability [13]. In an attempt to improve the early stability and a high fusion rate, pedicle screw fixation was traditionally used when in addition to interbody fusion [14]. However, the complications related with pedical screw insertion are well reported [15]. Except pedicle screw fixation, translaminar facet screw technology under sight-guided has gained favor due to the adjustable property of depth of positioning rod and guide sleeve angle, decreased infection rates and injury, minimal invasiveness, good stability, elastic fixation, and excellent efficacy [16-18].

In the current study, the baseline characteristics were not significantly different between the patients in the two groups. The operative time, incision lengths, blood loss, drainage volume, and hospital stays were also not statistically significant in these two groups. On the contrary, considerable improvement in clinical results was obtained in experimental group. During the 12-month follow-up, fewer patients in the experimental group experienced significant complications relative to control group. Mo-

reover, the efficiency of bony union and stability was better in experimental group at 6-month and 12-month follow-up relative to control group. Our study was in line with the study offered by Zeng and the colleagues [19], who suggested that PLIF plus TLFSF decreased the range of motion of the fixed segments compared to the other three fixation methods. Similarly, Jacobs et al. [20] have demonstrated that fusion plus TLFSF greatly improve the clinical results without significant increased risk. As reported, TLFSF has a feature of elastic fixation, which decreases stress shielding, and accelerates fusion quality as well as speed but reducing the disturbance with the mechanical environment of neighboring segments [21]. In keeping with the literature, during the period of follow-up in our study, disc height augmented immediately after the operation, and then reduced as time progressed in experimental and control groups. Remarkably, the heights conducted postoperatively and at the last follow-up were significantly higher in experimental group than those in control groups. Importantly, the ratio of screw location in the laminar bone in experimental group was higher than that of control. The JOA score was also significantly increased in experimental group, relative to control group. Based on these result, PLIF plus TLFSF under sight-guided is more optimal for the treatment of older patients with intervertebral disc herniation combined with lumbar vertebrae fracture, when relative to PLIF combined with pedical screw fixation. Nevertheless, the axial load capacity and anti-rotation torque of TLFSF with interbody fusion is weaker than that of pedicle screw fixation with fusion [22]. This weaker axial load can greatly decrease the intercertebral height during follow-up period. In the current work, the endplate was removed by the cage. Thereby, it is essential to strictly control the indications and contraindications for the application of this operational technology to get better outcomes [23, 24].

The present study has several drawbacks. First of all, our work did not consider loosening. However, Ferrara *et al.* [25] have suggested that 6-Nm load does not affect the stiffness of pedicular or transfacet fixation after 180,000 cycles eccentrically applied. Thus, we supposed that the results of our study might use to multilevel procedures, yet further work is needed to verify this hypothesis. Additionally, our study compared the clinical outcomes of two kind of fixation method during different periods, possibly causing the deviation of the results. Last but not least, sample size was little, and the patients in control group and experimental group were in different years, which might result in the selection bias. Thus, our results need to be verified in larger cohort of patients enrolled in the same period. In spite of these shortcomings, sight-guided TLFSF plus PLIF is an acceptable and suitable treatment for some patients with lower lumbar disease.

Based on this preliminary non-randomized clinical data, TLFSF plus PLIF is an effective and minimally invasive option for treating intervertebral disc herniation combined with lumbar vertebrae fracture, and when compared to PLIF combined with pedical screw fixation, has similar operative duration, incision lengths, blood loss, hospital stay, good clinical and radiological outcomes, with additional significant benefits of less pain and complications, higher fusion rates and JOA recovery rates, as well as much more vertebral stabilization.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Wenqiang Zhang, Department of Bone and Joint Surgery, Shandong Qianfoshan Hospital, No. 16766 Jingshi Road, Jinan 250014, Shandong Province, China. E-mail: zhangwenqiangmed@sina.com

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