

Does Transforaminal Lumbar Interbody Fusion Have Advantages over Posterolateral Lumbar Fusion for Degenerative Spondylolisthesis?

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Abstract

Study Design Retrospective cohort study.

Objective To compare the clinical and radiographic outcomes of transforaminal lumbar interbody fusion (TLIF) and posterolateral lumbar fusion (PLF) in the treatment of degenerative spondylolisthesis.

Methods This study compared 24 patients undergoing TLIF and 32 patients undergoing PLF with instrumentation. The clinical outcomes were assessed by visual analog scale (VAS) for low back pain and leg pain, physical component summary (PCS) of the 12-item Short-Form Health Survey, and the Oswestry Disability Index (ODI). Radiographic parameters included slippage of the vertebra, local disk lordosis, the anterior and posterior disk height, lumbar lordosis, and pelvic parameters.

Results The improvement of VAS of leg pain was significantly greater in TLIF than in PLF unilaterally (3.4 versus 1.0; $p = 0.02$). The improvement of VAS of low back pain was significantly greater in TLIF than in PLF (3.8 versus 2.2; $p = 0.02$). However, there was no significant difference in improvement of ODI or PCS between TLIF and PLF. Reduction of slippage and the postoperative disk height was significantly greater in TLIF than in PLF. There was no significant difference in local disk lordosis, lumbar lordosis, or pelvic parameters. The fusion rate was 96% in TLIF and 84% in PLF ($p = 0.3$). There was no significant difference in fusion rate, estimated blood loss, adjacent segmental degeneration, or complication rate.

Conclusions TLIF was superior to PLF in reduction of slippage and restoring disk height and might provide better improvement of leg pain. However, the health-related outcomes were not significantly different between the two procedures.

Keywords

- ▶ TLIF
- ▶ PLF
- ▶ outcome
- ▶ disk height
- ▶ lordosis
- ▶ pelvic parameters

Introduction

Spinal fusion is an effective treatment for degenerative spondylolisthesis.¹ Two of the most common surgical procedures to address this condition are posterolateral lumbar fusion (PLF) with instrumentation and transforaminal lumbar

interbody fusion (TLIF) with instrumentation.² Several prior studies have compared these two procedures.^{2–5} Although some studies reported that interbody fusion was superior to PLF in the improvement of back pain,^{6,7} many other studies demonstrated that both procedures provided nearly equivalent outcomes.^{2,4,5}

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An advantage of PLF would be a simpler procedure with fewer complications. On the other hand, TLIF may provide anterior support and restore the disk height, which would lead to indirect decompression of the foraminal stenosis. There is increasing recognition of the importance of lumbar lordosis and pelvic parameters (and their restoration) in restoring the global spine balance.⁸ Although TLIF is believed to restore lumbar lordosis, there have been conflicting results about the effect of TLIF on the restoration of lordosis.^{9,10} The influence of TLIF and PLF on the pelvic parameters has rarely been compared. The purpose of this study was to compare TLIF with PLF in the treatment of degenerative spondylolisthesis using clinical and radiographic outcomes.

Methods

Objective

This was a retrospective study of patients with degenerative spondylolisthesis treated by three spine surgeons in a single spine center during the years from 2006 to 2011. The choice of surgical technique (TLIF or PLF) was based on the surgeon's preference. The inclusion criteria were: (1) diagnosis of degenerative spondylolisthesis refractory to conservative management; (2) planned one- or two-level instrumented fusion; (3) pre- and postoperative visual analog scale; (4) radiographs; (5) pre- and postoperative 12-item Short Form Health Survey (SF-12); and (6) a minimum follow-up period of 1 year. All the outcomes were measured at the final follow-up period. The visual analog scale of leg pain was measured on the right and left side, regardless of the surgical side. We excluded patients who had had prior fusion surgery. Our institutional review board approved this study.

Operative Techniques

Patients were positioned prone on a Jackson table. The posterior spinal elements were exposed using a standard subperiosteal dissection. A laminectomy was performed bilaterally for PLF. Bone grafts were harvested from iliac crest and/or local bone and supplemented with fresh frozen allograft. The pedicle screw fixation was performed with bone grafting. In cases of TLIF, only a unilateral facetectomy for the symptomatic side was generally performed. A discectomy was then performed using a curette and rongeurs, and an interbody cage with bone graft was inserted. The pedicle screw fixation was performed with bone grafting to the residual posterior elements. Bone grafts were harvested from iliac crest and/or local bone and supplemented with fresh frozen allograft.

Radiographic Parameters

Radiographic parameters of interest included (1) slippage of the vertebra; (2) local disk lordosis; (3) anterior and posterior disk height; (4) lumbar lordosis: T12–S1 angle; (5) pelvic parameters: sacral slope, pelvic tilt, and pelvic incidence (► Fig. 1).

Local disk lordosis and the disk height were measured at L4/L5 level if two levels were included in the fusion area. Adjacent segmental degeneration (ASD) was evaluated at the proximal segment next to the upper instrumented vertebra.

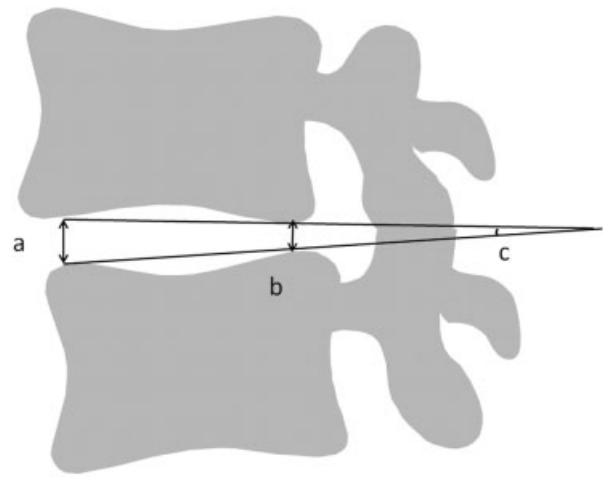


Fig. 1 Radiographic parameters: (a) anterior disk height, (b) posterior disk height, (c) local disk lordosis.

ASD was graded into four categories based on the University of California, Los Angeles grading scale for intervertebral space degeneration (► Table 1).¹¹

Radiographic fusion was determined by the posteroanterior and lateral radiographs (► Fig. 2). PLF fusion was defined as a solid, large fusion mass, at least unilaterally, with a smaller fusion mass on the contralateral side on the posteroanterior radiograph without loosening of the pedicle screws on the lateral radiograph.¹² TLIF fusion was defined as cases that met the PLF fusion criteria and had osseous continuity between the graft bone and the vertebra on the posteroanterior radiograph without loosening of the pedicle screws on the lateral radiograph.¹³ Pseudarthrosis was defined as those cases that did not meet the fusion criteria. Assessment was performed at the final visit using radiographs.

All radiographic parameters were assessed by a digital viewer, Surgimap Spine (Nemaris, Inc., New York, New York, United States; <http://www.surgimapspine.com/>).

Statistical Analysis

The *t* test was used to compare clinical and radiographic parameters between the two groups. The chi-square test was used to compare the categorical data. A *p* value less than 0.05 with the two-tailed test was considered statistically significant. A logistic regression analysis was performed defining fusion status as the dependent variable. The independent

Table 1 Grading scale for intervertebral disk degeneration¹¹

	Disk space narrowing	Osteophytes	End plate sclerosis
1	–	–	–
2	+	–	–
3	+/-	+/-	–
4	+/-	+/-	+

Note: Grade is based on the most severe radiographic finding. Patients were graded based on the worst category satisfied.



Fig. 2 (Left) Posterolateral fusion. (Right) Transforaminal lumbar interbody fusion.

variables included type of bone graft, number of fusion levels, type of surgery, radiographic loosening of pedicle screws, and age. The statistical analysis was performed with SPSS Statistics (version 20; IBM, Armonk, New York, United States).

Results

Patient Demographics

The patient demographics are shown in **Table 2**. The TLIF group was comprised of 6 men and 18 women with a mean age of 59 ± 14 years. The mean follow-up period was 1.8 ± 1.3 years, and there were 29 total fusion levels. In the PLF group, there were 11 men and 21 women with a mean age of 61 ± 11 years. The mean follow-up period was 2.0 ± 1.0 years, and there were 51 total fusion levels. There were no significant differences in age, gender, follow-up period, body mass index, diabetes, or smoking status between the PLF and TLIF groups.

Clinical Outcomes

Visual Analog Scale

There were no significant differences in preoperative leg pain or low back pain between the TLIF and PLF groups (**Table 3**). The improvement in the low back pain was significantly greater in the TLIF group compared with the PLF group (TLIF 38 ± 27 versus PLF 22 ± 31 ; $p = 0.03$). The improvement in the left leg pain was significantly greater in the TLIF group than in the PLF group (TLIF 34 ± 42 versus PLF 10 ± 35 ; $p = 0.03$). There was no significant difference in the improvement in the right leg pain between the TLIF group and the PLF group (TLIF 31 ± 48 versus PLF 22 ± 42 ; $p = 0.4$). The leg pain was improved on the decompression side.

Health-Related Outcomes

The preoperative Oswestry Disability Index (ODI) was 49 ± 15 in the TLIF group and 48 ± 13 in the PLF group ($p = 0.9$). The postoperative ODI was 34 ± 22 in the TLIF group and 34 ± 18 in the PLF group ($p = 0.7$). There was no significant difference in the ODI improvement between the groups (TLIF: 15 ± 19 versus PLF: 14 ± 15 ; $p = 0.8$).

The preoperative physical component summary (PCS) of the SF-12 was 33 ± 6 in the TLIF group and 28 ± 9 in the PLF group ($p = 0.03$). The postoperative PCS was 39 ± 10 in TLIF group and 34 ± 10 in PLF group ($p = 0.06$). There was no significant difference in PCS improvement between the groups (TLIF: 6 ± 9 versus PLF: 7 ± 9 ; $p = 0.7$).

Radiographic Parameters

Local Measurement

The radiographic parameters are shown in **Table 4**. The preoperative slippage was 5.3 ± 2.9 mm in the TLIF group and 5.2 ± 3.5 mm in the PLF group ($p = 0.9$). The postoperative slippage was 1.7 ± 2.3 mm in the TLIF group and 4.1 ± 3.1 mm in the PLF group ($p = 0.003$). The reduction in slippage was significantly greater in the TLIF group (-3.6 ± 3.0 mm) compared with the PLF group (-1.1 ± 2.9 mm; $p = 0.006$).

The preoperative local disk lordosis was 6.0 ± 4.3 degrees in the TLIF group and 4.2 ± 3.5 degrees in the PLF group ($p = 0.2$). The postoperative local disk lordosis was 6.0 ± 3.9 degrees in the TLIF group and 4.5 ± 2.6 degrees in the PLF group ($p = 0.2$). There was no significant difference in the change of local disk lordosis between the groups (TLIF: 0.1 ± 3.3 degrees versus PLF: 0.3 ± 2.9 degrees; $p = 0.9$). The change in anterior and posterior disk height was significantly greater in the TLIF group

Table 2 Demographics and operative data

Demographic data	TLIF (n = 24)	PLF (n = 32)	p Value
Age (y)	59 ± 14	61 ± 11	0.5
Gender (male/female)	6/18	11/21	0.6
Follow-up (y)	1.8 ± 1.3	2.0 ± 1.0	0.5
BMI (kg/m ²)	26.3 ± 5.8	25.8 ± 6.3	0.6
Diabetes mellitus (%)	8.3	9.4	0.9
Smoking (%)	12.5	9.4	0.7
1 level/2 levels	19/5	13/19	
Fusion level			
L3/L4	4	8	
L4/L5	19	30	
L5/S1	6	13	
Bone graft (iliac/local)	7/17	16/16	0.2
Estimated blood loss (mL)	368 ± 225	368 ± 156	>0.99
Surgical time (min)	165 ± 62	151 ± 57	0.8

Abbreviations: BMI, body mass index; PLF, posterolateral lumbar fusion; TLIF, transforaminal lumbar interbody fusion.

Note: Values are expressed as mean ± standard deviation.

Table 3 Comparison of clinical outcomes

	TLIF (n = 24)	PLF (n = 32)	p Value
VAS low back pain			
Pre	69 ± 28	63 ± 25	0.4
Post	31 ± 23	41 ± 27	0.2
Change	-38 ± 27	-22 ± 31	0.03 ^a
VAS left leg pain			
Pre	45 ± 40	31 ± 32	0.2
Post	12 ± 25	21 ± 28	0.1
Change	-34 ± 42	-10 ± 35	0.03 ^a
VAS right leg pain			
Pre	58 ± 35	43 ± 33	0.1
Post	27 ± 35	22 ± 29	0.8
Change	-31 ± 48	-22 ± 42	0.4
ODI			
Pre	49 ± 15	48 ± 13	0.9
Post	34 ± 22	34 ± 18	0.7
Change	-15 ± 19	-14 ± 15	0.8
SF-12 PCS			
Pre	33 ± 6	28 ± 9	0.03 ^a
Post	39 ± 10	34 ± 10	0.06
Change	6 ± 9	7 ± 9	0.7
SF-12 MCS			
Pre	41 ± 17	40 ± 14	0.8
Post	46 ± 14	47 ± 14	0.9
Change	6 ± 18	5 ± 16	0.6

Abbreviations: ODI, Oswestry Disability Index; MCS, mental component summary; PCS, physical component summary; PLF, posterolateral lumbar fusion; Pre, preoperative; Post, postoperative; SF-12, Short Form-12; TLIF, transforaminal lumbar interbody fusion; VAS, visual analog scale.

^ap < 0.05.

Table 4 Comparison of radiographic parameters

	TLIF (n = 24)	PLF (n = 32)	p Value
Slippage (mm)			
Pre	5.3 ± 2.9	5.2 ± 3.5	0.9
Post	1.7 ± 2.3	4.1 ± 3.1	0.003 ^a
Change	-3.6 ± 3.0	-1.1 ± 2.9	0.006 ^a
Local disk lordosis (degrees)			
Pre	6.0 ± 4.3	4.2 ± 3.5	0.2
Post	6.0 ± 3.9	4.5 ± 2.6	0.2
Change	0.1 ± 3.3	0.3 ± 2.9	0.9
Anterior disk height (mm)			
Pre	10 ± 2.9	8.7 ± 2.5	0.1
Post	11 ± 2.2	8.6 ± 2.7	0.001 ^a
Change	1.4 ± 1.8	0.0 ± 1.7	0.008 ^a
Posterior disk height (mm)			
Pre	6.0 ± 1.6	5.8 ± 1.5	0.7
Post	7.3 ± 1.3	5.7 ± 1.4	0.001 ^a
Change	1.2 ± 1.5	0 ± 1.5	0.01 ^a
Lumbar lordosis (degrees)			
Pre	50 ± 14	51 ± 13	0.6
Post	52 ± 12	52 ± 12	0.9
Change	1 ± 10	1 ± 8	0.7
Sacral slope (degrees)			
Pre	33 ± 10	36 ± 7	0.2
Post	35 ± 8	35 ± 7	0.9
Change	2 ± 6	-1 ± 6	0.2
Pelvic tilt (degrees)			
Pre	20 ± 9	19 ± 6	0.6
Post	19 ± 10	18 ± 7	0.9
Change	-1 ± 8	0 ± 5	0.3
Pelvic incidence (degrees)			
Pre	53 ± 9	54 ± 8	0.4

Abbreviations: PLF, posterolateral lumbar fusion; Pre, preoperative; Post, postoperative; TLIF, transforaminal lumbar interbody fusion.

Note: Values are expressed as mean ± standard deviation.

^a $p < 0.05$.

(anterior: 1.4 ± 1.8 mm and posterior: 1.2 ± 1.5 mm) compared with the PLF group (anterior: 0 ± 1.7 mm and posterior: 0 ± 1.5 mm; $p < 0.01$).

Lumbar Lordosis and Pelvic Parameters

The preoperative lumbar lordosis was 50 ± 14 degrees in the TLIF group and 51 ± 13 degrees in the PLF group ($p = 0.6$). The postoperative lumbar lordosis was 52 ± 12 degrees in both groups ($p = 0.9$). There was no significant difference in the change in lumbar lordosis (TLIF: 1 ± 10 degrees versus PLF: 1 ± 8 degrees; $p = 0.9$).

The preoperative sacral slope was 33 ± 10 degrees in the TLIF group and 36 ± 7 degrees in the PLF group ($p = 0.2$). The postoperative sacral slope was 35 ± 8 degrees in the TLIF

group and 35 ± 7 degrees in the PLF group ($p = 0.9$). There was no significant difference in the change in sacral slope between the groups (TLIF: 2 ± 6 degrees versus PLF: -1 ± 6 degrees; $p = 0.9$).

The preoperative pelvic tilt was 20 ± 9 degrees in the TLIF group and 19 ± 6 degrees in the PLF group ($p = 0.6$). The postoperative pelvic tilt was 19 ± 10 degrees in the TLIF group and 18 ± 7 degrees in the PLF group ($p = 0.9$). There was no significant differences in the change in pelvic tilt between the groups (TLIF: -1 ± 8 degrees versus PLF: 0 ± 5 degrees; $p = 0.3$).

There was no significant difference in pelvic incidence between the groups (TLIF: 53 ± 9 degrees versus PLF: 54 ± 8 degrees; $p = 0.4$).

Table 5 Complications

	TLIF (n = 24)	PLF (n = 32)	p Value
Fusion rate (%)	96	84	0.2
Adjacent segmental degeneration	1.1 ± 0.4	1.3 ± 0.8	0.3
Dural tear (case/%)	1/4	4/12.5	0.3
Infection	0	0	>0.99

Abbreviations: PLF, posterolateral lumbar fusion; TLIF, transforaminal lumbar interbody fusion.

Union Rate and Adjacent Segmental Degeneration

There were 5 patients with pseudarthrosis in the PLF group and 1 patient with pseudarthrosis in the TLIF group (►Table 5). Thus, the fusion rate was 84% in the PLF group and 96% in the TLIF group ($p = 0.3$).

The adjacent segmental degeneration grading score was 1.3 in the PLF group and 1.1 in the TLIF group ($p = 0.3$). The logistic regression analysis demonstrated that loosening of the pedicle screw was significantly associated with the fusion status ($p < 0.01$). However, the other parameters were not significantly associated with the fusion status.

Complications

The estimated blood loss was nearly equivalent for both procedures (TLIF: 368 ± 194 mL versus PLF: 368 ± 131 mL; $p > 0.99$). There were 1 case (4%) with dural tear in the TLIF group and 4 cases (12.5%) with dural tear in the PLF group ($p = 0.3$). One case in the PLF group underwent revision surgery due to contralateral leg pain.

Discussion

In the present study, the TLIF group had significantly greater improvement in the left leg pain and in low back pain compared with the PLF group. However, the other health-related outcomes demonstrated nearly equivalent improvement, and the right leg pain scale was not significantly different. The radiographic parameters of reduction of slip-

page, postoperative disk height, and change in the disk height were significantly greater in the TLIF group. Other radiographic parameters, including local disk lordosis, lumbar lordosis, and pelvic parameters, showed similar results between the study groups.

Only one randomized study has reported that the use of additional interbody fusion (circumferential fusion) in the treatment of various lumbar degenerative diseases showed significantly greater improvement in the health-related outcomes (►Table 6).⁶ Although this interbody fusion was combined with PLF and anterior lumbar interbody fusion (ALIF), Videbaek et al reported that circumstantial fusion had significantly greater improvement in ODI, PCS, and low back pain scale.⁶

Other studies reported nearly equivalent outcomes between TLIF and PLF. The Spine Patient Outcomes Research Trial reported that surgical treatment for degenerative spondylolisthesis provided substantially greater improvement in pain and function than conservative therapy alone.¹ However, the choice of fusion procedure (which included PLF with or without pedicle screws and PLF with interbody fusion) did not change the outcome.² A randomized study from the Swedish Lumbar Spine Group concerning degenerative low back pain compared PLF, PLF with pedicle screws, and PLF with interbody fusion.⁴ In their study, the clinical outcomes were similar between the three groups. More recently, Høy et al performed a randomized controlled study comparing TLIF with instrumented PLF for various degenerative lumbar

Table 6 Review of previous studies

Author	Design	Diagnosis	Comparison	Leg pain	Low back pain	ODI
Fritzell et al ⁴	RCT	Chronic LBP	PLF versus circumferential fusion (PLF + ALIF or TLIF)	NS	NS	NS
Videbaek et al ⁶	RCT	Heterogeneous population with chronic LBP	PLF versus circumferential fusion (PLF + ALIF)	NS	Significantly better in circumferential fusion	Significantly better in circumferential fusion
Abdu et al ²	Retrospective	Degenerative spondylolisthesis	PLF versus circumferential fusion (PLF + ALIF or TLIF)	NA	NA	NS
Høy et al ⁵	RCT	Heterogeneous population with chronic LBP	PLF versus TLIF	NS	NS	NS
Present study	Retrospective	Degenerative spondylolisthesis	PLF versus TLIF	Significantly better in TLIF	Significantly better in TLIF	NS

Abbreviations: ALIF, anterior lumbar interbody fusion; LBP, low back pain; NA, not available; NS, no significant difference; ODI, Oswestry Disability Index; PLF, posterolateral fusion, RCT, randomized control study; TLIF, transforaminal lumbar interbody fusion.

disorders.⁵ They found no difference in improvement of low back pain, leg pain, ODI, or Short Form-36 score between TLIF and instrumented PLF. However, Høy et al mentioned that their patients were a heterogeneous population and this may have blurred their results. Kim et al randomly compared PLF, PLIF, and PLIF with PLF for various degenerative lumbar diseases.¹⁴ They found no significant differences in the clinical results and union rates between the three fusion methods. However, they did report that PLIF without iliac bone graft had the advantage of elimination of the donor site pain.

Slippage reduction and postoperative local disk height were significantly greater in the TLIF group. The necessity of reducing slippage for spondylolisthesis has been a controversial issue.^{15,16} However, many studies have reported that a reduction in slippage was not associated with a better outcome, especially for degenerative spondylolisthesis.^{17,18}

Several groups have reported on the effect of interbody fusion on the lumbar lordosis.^{9,19-21} Hsieh et al reported a limited increase in lumbar lordosis treated by TLIF compared with ALIF.⁹ They reported that TLIF decreased local disk lordosis by 0.1 degrees and lumbar lordosis by 2.1 degrees. Dorward et al compared TLIF with ALIF for the treatment of long deformity constructs.²¹ They reported that TLIF decreased local disk lordosis by 1.7 degrees at L4/L5 and by 1.4 degrees at L5/S1. However, both studies mentioned that facetectomy was performed only unilaterally for TLIF. On the other hand, Yson et al reported that TLIF with bilateral facetectomy increased local disk lordosis by 7.2 degrees.²² Jagannathan et al reported that TLIF with bilateral facetectomy increased local disk lordosis by 20 degrees.¹⁰

Biomechanically, the anterior placement of the interbody cage away from the instant axis of rotation has the advantage of maximizing local disk lordosis if it acts as a fulcrum.²² However, the anterior placement of the interbody cage to maximize lordosis requires the compression of the posterior elements. Faundez et al reported that the anterior placement of the cage alone could not increase local disk lordosis.²³ Compression across the posterior elements potentially decreases the posterior disk height at the fusion site and may lead to foraminal stenosis. Actually, no study has demonstrated a simultaneous increase in both local disk lordosis as well as posterior disk height. If posterior compression is performed to maximize local disk lordosis, surgeons need to prevent the caudal nerve root impingement from the residual superior articular process. Jagannathan et al reported that they performed pedicle-to-pedicle decompression with complete bilateral facetectomies to achieve the maximum lordosis.¹⁰ In the present study, we generally used box-shaped cages and performed unilateral facetectomy. Thus, the disk height increased anteriorly and posteriorly, but the increases in local disk lordosis and lumbar lordosis were limited. However, it is technically demanding to insert a wedged high cage into a narrowed disk space. A newly invented expandable TLIF cage might be a future option to simultaneously gain lordosis and disk height.²⁴

Few studies have reported the influence of TLIF and PLF on pelvic parameters. Ould-Slimane et al reported that single-level TLIF increased lumbar lordosis by 9.3 degrees and

decreased pelvic tilt by 5.8 degrees.²⁵ In the present study, the pelvic parameters showed little change due to a limited increase in lumbar lordosis.

Our study had several limitations including its retrospective, nonrandomized design. In addition, there was a possibility of selection bias as the surgeons tended to choose TLIF for patients who were likely to have foraminal stenosis.

Our results correlated with many previous studies in that postoperative health-related outcomes did not differ significantly between TLIF and PLF groups. However, the visual analog scale in the left leg was significantly improved in the PLF group compared with the TLIF group. This might be due to the indirect decompression effect of the caudal nerve root by restoration of the disk height at the surgical site.²⁶

The proposed advantages of TLIF over PLF, including the reduction in slippage, restoration of disk height, greater lumbar lordosis, and higher union rate, might be expected to result in the improved pain scores. However, such improvement failed to demonstrate significant differences in health-related outcomes.

Conclusion

The TLIF group demonstrated significantly greater improvement in low back pain and unilateral leg pain compared with the PLF group. However, no differences in improvement in either ODI or PCS were noted between the groups. The postoperative slippage and disk height were significantly greater in the TLIF group, but local disk lordosis, lumbar lordosis, and pelvic parameters were similar between the groups.

Disclosures

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