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Transforaminal lumbar interbody fusion (TLIF) versus posterior lumbar interbody fusion (PLIF) in the treatment of single-level lumbar spondylolisthesis

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Abstract

Background: Various surgical procedures have been recommended for the treatment of lumbar spondylolisthesis, but controversy still exists regarding the optimal surgical technique. In this study, we compared the clinical and radiologic outcomes of posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) with pedicle screw fixation in the treatment of single-level lumbar spondylolisthesis.

Methods: Ninety-four patients underwent lumbar interbody fusion with pedicle screw fixation for the treatment of adult lumbar spondylolisthesis. Forty-six had PLIF with two cages and pedicle fixation (group 1), and 48 had TLIF with one cage and pedicle fixation (group 2). The follow-up was performed clinically using the visual analog scale (VAS) and Oswestry Disability Index (ODI) Questionnaires. Outcome scores were assessed 3, 6, and 12 months after surgery. Radiographs were obtained postoperatively and at regular intervals for 6 months. Perioperative outcomes such as surgery time, blood loss, length of hospital stay, and incidence of surgical complications were also recorded.

Results: Estimated blood loss and operative time in the TLIF group were significantly lower than those in the PLIF group. VAS for back pain and ODI were significantly better in the TLIF group than the PLIF group. However, at the time of the last follow-up, both groups had similar slip reduction and spinal fusion rates. More complication rate was encountered in the PLIF group compared to the TLIF group.

Conclusions: Our study showed that TLIF is superior to PLIF with respect to functional outcome and complication rate in grade I/II single-level lumbar spondylolisthesis.

Keywords: Lumbar spondylolisthesis, Posterior lumbar interbody fusion (PLIF), Transforaminal lumbar interbody fusion (TLIF)

Introduction

Spondylolisthesis (spondylos = vertebrae; listhesis = slip-page) is defined as the forward slippage of one vertebra on another [1]. Of its 5 subtypes, degenerative and isthmic spondylolisthesis are the most common in adults [2]. Both can lead to compression and instability, which result in radicular and low back pain [3].

Surgical fusion is a crucial method for stabilizing the spine in cases of lumbar spondylolisthesis; it is used to

reduce the pain in patients with chronic low back pain [4]. Different surgical fusion techniques are currently available including anterior interbody fusion, posterior interbody fusion, posterolateral fusion, and repair of the pars interarticularis [5–9].

PLIF or TLIF can achieve a circumferential spinal stabilization by the placement of pedicle screws and an interbody spacer through a single posterior approach [10–12]. There is no definitive evidence for one approach being superior to the other in terms of fusion or clinical outcomes [13].

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The current study is a retrospective clinical case series aiming to compare the surgical results of PLIF and TLIF in the treatment of low-grade spondylolisthesis.

Patients and methods

Patient population and selection criteria

Between March 2015 and May 2018, 94 patients underwent lumbar interbody fusion with pedicle screw fixation for the treatment of adult lumbar spondylolisthesis at the Department of Neurosurgery, Tanta University Hospital. Forty-six had PLIF with two cages and pedicle fixation (group 1), and 48 had TLIF with one cage and pedicle fixation (group 2). Inclusion criteria were as follows: single-level, low-grade (Meyerding grades I or II), isthmic or degenerative spondylolisthesis, and significant back and leg pain that failed conservative management.

Exclusion criteria were spondylolisthesis grades III and IV, instrumentation of more than two levels, a history of a previous fusion surgery to the lumbar spine, concomitant deformities of the spine (scoliosis, tumor, or trauma), and osteoporosis diagnosed by means of radiography and bone mineral density examination (T-score ≤ 2.5). Body mass index (BMI) [14] was calculated in all cases before surgery, and patients with BMI ≥ 40 (morbid obesity) were excluded from our study.

Informed consent was obtained from all participants. The choice of a lumbar fusion technique was individualized based on clinical needs of each patient, surgeon preferences, and patients' request according to the informed consent and explanation of various surgical procedures. A summary of demographic and pre-operative data is presented in Table 1.

Surgical technique

All patients were operated under general anesthesia and in prone position. All patients had single-level fusion performed. Brace support was recommended for up to 6–8 weeks after surgery.

PLIF

A midline skin incision was used. The fascia was incised and then the paravertebral muscles were dissected from the spine. Radiographs were used to confirm the appropriate vertebral level. Bilateral pedicle screw-rod constructs were then inserted, and a laminectomy was performed at that level. This was followed by bilateral foraminotomy and discectomy, and interbody graft placement. Cartilaginous material was removed from the endplates using an endplate scraper. Interbody fusion was performed with a polyetheretherketone (PEEK) cage filled with autologous bone graft on each side. A final fluoroscopy was performed as necessary to confirm

Table 1 Patients' characteristics

Parameters	PLIF group (N = 46)	TLIF group (N = 48)
Age (years)		
Range	20–56	23–52
Mean \pm SD	37.59 \pm 8.84	38.75 \pm 7.23
Gender		
Male	15 (32.6%)	19 (39.6%)
Female	31 (67.4%)	29 (60.4%)
Follow-up, months		
Range	6–30	6–32
Mean \pm SD	20.24 \pm 7.39	19.02 \pm 5.03
VAS back (preoperative)		
Range	5–9	5–9
Mean \pm SD	7.00 \pm 1.26	7.25 \pm 1.28
VAS leg (preoperative)		
Range	4–9	4–9
Mean \pm SD	7.39 \pm 1.24	6.75 \pm 1.28
ODI (preoperative)		
Range	34–79	32–77
Mean \pm SD	55.37 \pm 13.05	51.42 \pm 12.45
Grade of spondylolisthesis		
Grade I	25 cases (54.3%)	32 cases (66.7%)
Grade II	21 cases (45.7%)	16 cases (33.3%)
Type of spondylolisthesis, n (%)		
Degenerative	27 cases (58.7%)	25 cases (50%)
Isthmic	19 cases (41.3%)	23 cases (50%)
Affected level		
L3–L4	4 (8.7%)	3 (6.2%)
L4–L5	25 (54.3%)	31 (64.6%)
L5–S1	17 (37%)	14 (29.2%)

pedicle screw fixation and cage placement. The wound was profusely irrigated and closed in layers.

TLIF

A midline skin incision was performed. The muscles and soft tissues were retracted to expose the lateral aspect of the spinous process, the lamina, and the facet joint. Based on the clinical presentation, a unilateral laminectomy and partial facetectomy were performed on the side consistent with the patient's symptoms. A bilateral laminectomy was done only for clinically significant bilateral neural element compression. After adequate decompression of the neural elements has been performed, bilateral pedicle screws were placed in the standard fashion. Distraction of the disc space was performed using the four pedicle screws, and complete discectomy was done from one side using rongeurs and disc shavers.

The bone chips obtained from laminectomy were inserted to fill the anterior third of the disc space, then a kidney-shaped cage filled with iliac bone graft was placed into the disc space. After insertion of bone grafts in both groups, the screws were tightened to the lordotic rod. Distraction or compression was added to achieve a good reduction in a proper lordotic curve. A closed drainage system was inserted in all cases, and wound closure was performed in layers.

Perioperative, clinical, and radiological assessments

The study assessed perioperative results related to the operative procedure such as blood loss, operation time, hospital stay, and complications within 1 month postoperatively. Oswestry Disability Index (ODI) Questionnaires [15] were administered for functional evaluation, and the visual analog scale (VAS) [16] was used to assess pain preoperatively and postoperatively. Moreover, the same clinical parameters together with neurologic examination were evaluated at follow-up visits, which were scheduled 3, 6, and 12 months after the operation.

Radiographic evaluation included preoperative X-rays (standard lumbar anteroposterior/lateral, flexion/extension views), computed tomography (CT), and magnetic resonance imaging (MRI).

Lumbosacral spine plain X-ray, including anteroposterior and lateral views, was obtained in all cases within 72 h after surgery to evaluate the position of screws and the cage. Static and dynamic radiographs were obtained 3 and 6 months postoperatively. All patients underwent repeat X-ray and CT scan 1 year postoperatively. We compared pre- and postoperative radiographs. For the analysis, the postoperative radiographs included only the final radiograph at a minimum of 6 months after surgery.

The focus was to evaluate three radiographic characteristics at follow-up: (1) percentage of slip and percentage of reduction, (2) cage and screws position, and (3) fusion rate.

The degree of spondylolisthesis was measured as a percentage of the distance from the posterior border of the caudal vertebra to the posterior border of the rostral vertebra, normalized to the superior end plate diameter of the former (Fig. 1). Slip reduction was defined as the difference between the pre- and postoperative spondylolisthesis. The reduction rate was calculated as follows:

$$\frac{\text{Preoperative slippage distance} - \text{postoperative slippage distance}}{\text{Preoperative slippage distance}} \times 100\%.$$

Fusion rates were assessed with the Bridwell grading system by the final radiograph at a minimum of 6

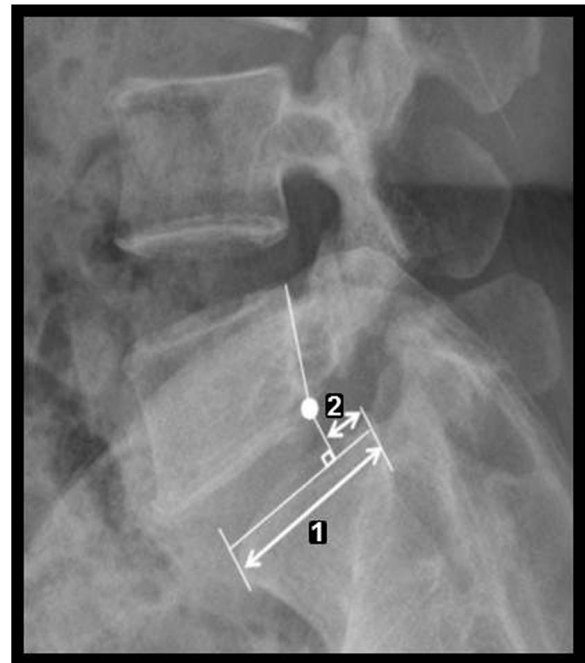


Fig. 1 Degree of spondylolisthesis (%) = distance (2)/distance (1) × 100%. The spondylolisthesis degree was measured as a percentage of the distance from the posterior border of the caudal vertebra to the posterior border of the rostral vertebra, normalized to the superior end plate diameter of the former

months after surgery. The Bridwell system is composed of the following categories and grades [17]: *Grade I*: fused with remodeling and trabeculae present, *grade II*: graft intact but not fully remodeled and incorporated, with no lucencies above or below, *grade III*: graft intact but with a definite lucency at the top or bottom of the graft, and *grade IV*: definitely not fused, with resorption of bone graft and collapse. Both grades I and II were considered radiographic signs of solid fusion, and the fusion condition at the last follow-up was collected for analysis.

The criteria used to prove solid fusion inpatients were Trabeculae seen bridging the interbody gap with iso-dense bone in the cage and the adjacent vertebral bodies, anteriorand/or posterior sentinel signs, no lucencies around the pedicle screws, no lucencies around the cages, Integration of the cage with the endplates and silhouetting of the cage, and no evidence of motion on dynamic flexion and extension X-rays.

Statistical analysis

Data were expressed as mean ± standard deviation. Statistical analysis was done using Student *T* test with IBM SPSS Statistics for Windows, Version 21 (IBM Corp., Armonk, NY).

Results

Clinical outcome

There were significant differences between the groups in relation to VAS for back pain and ODI. These variables were significantly higher in the TLIF group compared to the PLIF group. There was no significant difference between the two groups with respect to VAS for leg pain at final follow-up (Table 2).

Surgical time and blood loss

Estimated blood loss and operative time in the TLIF group were significantly lower than those in the PLIF group ($P < 0.05$) (Table 2).

Reduction and fusion results

At the time of the last follow-up, both groups had similar slip reduction, and spinal fusion rates ($P > .05$). Spondylolisthesis slip reduction rate was 51.7913.59% in the TLIF group and 64.6810.87% in the PLIF group ($P = 0.116$). Solid fusion (Bridwell fusion grades I or II) was achieved in all patients (Figs. 2 and 3). In total, 32 out of 46 patients (66.7%) in the TLIF group and 31 out of 48 (67.4%) patients in the PLIF group achieved grade I fusion, and all others achieved grade II fusion (Table 3).

Operative and postoperative complications

In the PLIF group, there were five complications: two dural tears (repaired primarily), two neurologic deficit (postoperative weakness of great toe dorsiflexion, which was relieved spontaneously), and one deep wound infection (managed with debridement, drains, and intravenous antibiotics).

A superficial infection was diagnosed in two patients in the TLIF group, which was treated conservatively. In the TLIF group, one patient experienced a dural tear without neurologic symptoms (repaired primarily).

All these complications did not lead to irreversible sequelae. No perioperative complications in either group required revision surgery (Table 2).

Discussion

Spondylolisthesis, either degenerative or isthmic type, is usually associated with radicular symptoms and back pain due to instability and compression [18, 19], but surgical treatment of spondylolisthesis not only depends on decompression of neural tissue and stabilization of motion segment but also reconstitution of disc space height and restoration of sagittal plane translational and rotational alignment are essential [20].

Interbody fusion is commonly used in surgical treatment of low-grade spondylolisthesis as it achieves solid fusion, preserves the disc height, maintains the load-bearing capacity, and reconstructs the anterior column after disc evacuation [21–23].

PLIF or TLIF can achieve circumferential spinal stabilization by a single posterior approach [24], but TLIF usually requires unilateral exposure with less operative time and blood loss [25]. In the current study, both the operative time and blood loss in PLIF was significantly higher compared to TLIF ($p = 0.0004$ and 0.0001 , respectively). Liu et al. [26] have similarly reported that both the intraoperative time and blood loss volume were higher in the PLIF group than those of the TLIF group. This might be attributed to the necessity if

Table 2 Comparison of surgical outcomes between PLIF and TLIF

Parameters	PLIF group (n = 46)	TLIF group (n = 48)	P value
Operation time (minutes)	127.39 ± 21.62	114.48 ± 13.26	0.0004
Blood loss (cm ³)	456.96 ± 120.74	366.15 ± 78.49	0.0001
VAS back pre	7.00 ± 1.26	7.25 ± 1.28	0.1717
VAS back post	2.26 ± 1.00	1.77 ± 0.75	0.0044
VAS back change	4.74 ± 1.14	5.40 ± 1.18	0.0037
VAS leg pre	7.39 ± 1.24	7.17 ± 1.36	0.1752
VAS leg post	3.24 ± 1.18	2.98 ± 0.91	0.0824
VAS leg change	4.15 ± 1.44	4.19 ± 1.41	0.4245
ODI pre	51.42 ± 12.45	55.37 ± 13.05	0.0684
ODI post	16.85 ± 4.44	17.67 ± 7.33	0.2581
ODI change	33.98 ± 10.40	37.70 ± 10.61	0.0449
Postoperative complications (number of cases)	5	3	
Dural tear	2	1	
Nerve root injury (neurologic deficit)	2	0	
Wound infection	1	2	



Fig. 2 TLIF procedure for the patient with isthmic L5/S1 spondylolisthesis. a Preoperative X-ray lateral view. b, c Posteroanterior and lateral X-ray films 6 months after surgery. Note the reduction in the anterolisthesis, restoration of disk height, and the visible bone fusion

the bilateral exposure in PLIF compared to the unilateral exposure required in TLIF.

In the present work, the improvement of the VAS for back pain was significantly higher in the TLIF group compared to the PLIF group ($p = 0.0037$). This came in agreement with the work of El-Sayed et al. [27] who reported that the postoperative VAS for back pain was significantly improved in the TLIF group compared to the PLIF group. Nevertheless,

Lars et al. [28] reported that the improvement in VAS was related to the pre-operative pathology, where the isthmic spondylolisthesis showed more improvement in VAS compared to the degenerative type. This might explain the significant VAS for back pain improvement in the current study, as isthmic spondylolisthesis represented 50% of the TLIF group cases compared to only 41.3% of the PLIF group. On the other hand, the study of Han et al. [29] showed no

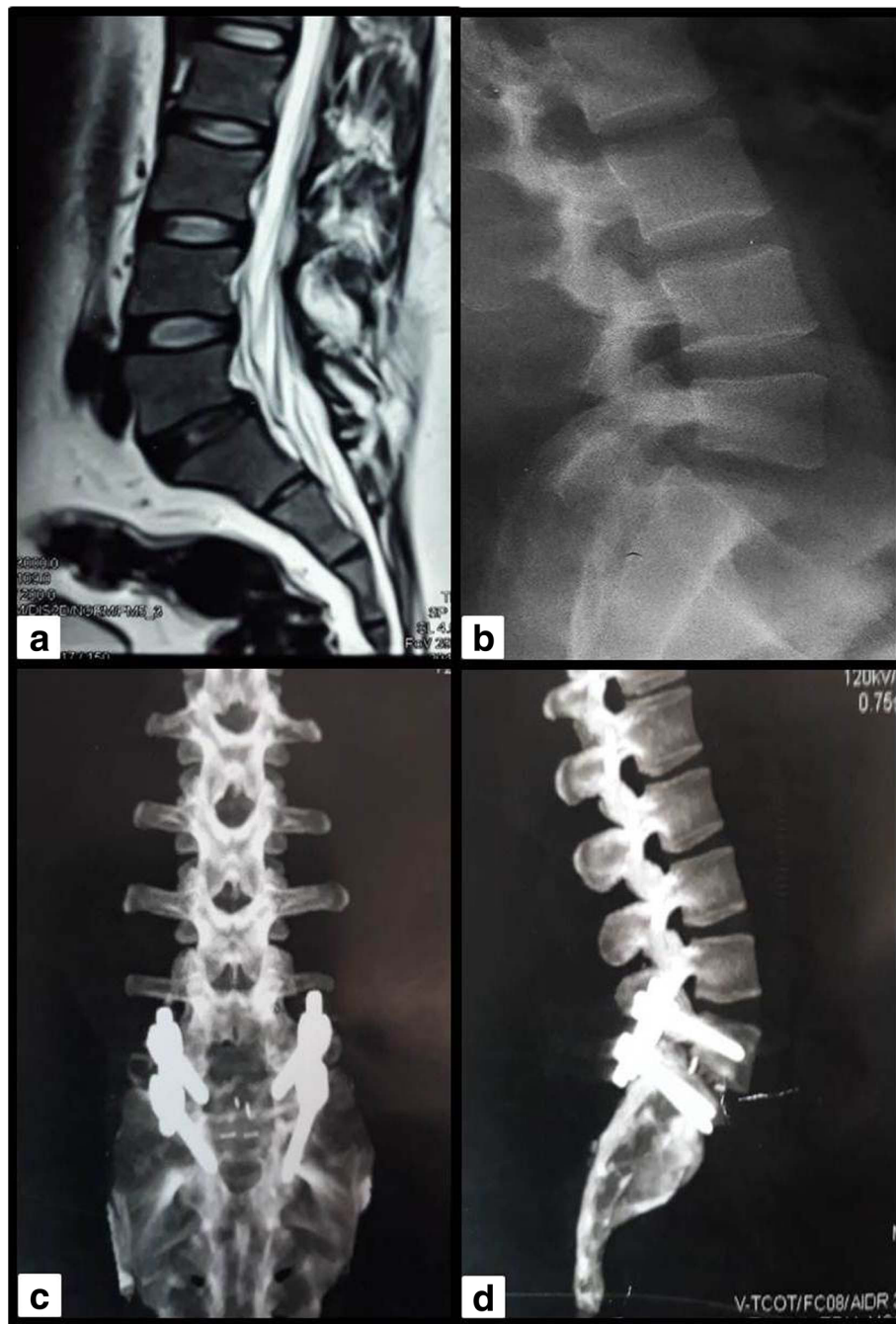


Fig. 3 PLIF procedure for the patient with degenerative L5/S1 spondylolisthesis. a Preoperative MRI. b Preoperative X-ray lateral view. c, d Posteroanterior and lateral X-ray films 6 months postoperatively. Note the reduction in the anterolisthesis and restoration of disk height

statistically significant difference in VAS for pain at any time between the PLIF group and TLIF group.

In the current study, we could report a complication rate of 10.9% occurring in the PLIF group including a dural tear in 4.4% of cases, nerve root injury in another 4.4% of cases, and a deep wound infection in only 2.2% of them, but in TLIF group, there was a complication rate of only 6.3% including 4.2% of cases with a

superficial wound infection and 2.1% of them with a dural injury. Humphreys et al. [30] and Yehya [31] both evaluated the results of PLIF versus TLIF in their studies and reported that the complication rate in PLIF was higher than in TLIF. This might be attributed to the necessity of bilateral exposure and excessive medial retraction of the dura when placing the cage in the PLIF technique, which increases the incidence of neural

Table 3 Slip reduction and fusion rate of spondylolisthesis

Parameters	PLIF group (n = 46)	TLIF group (n = 48)	P value
Degree of spondylolisthesis			
Preoperative (%)	22.37 ± 10.20	18.08 ± 6.42	0.4968
Postoperative (%)	8.24 ± 5.32	8.71 ± 3.98	0.4511
Slip reduction (%)	64.68 ± 10.87	51.79 ± 13.59	0.1160
Fusion rate			
Grade I			
Number	31	32	
Rate %	67.4	66.7	
Grade II			
Number	15	16	
Rate %	32.6	33.3	

complications such as nerve injury, dural tear, and epidural scarring [32–34].

In our study, by the time of the last follow-up, both groups showed no significant difference in slip reduction and spinal fusion rate. Solid fusion was achieved in all cases including grade I fusion in 66.7% of cases in the TLIF group and 67.4% of cases in the PLIF group. Similarly, Yan et al. [35] in a comparative study between PLIF and TLIF, found that there was no significant difference between both groups in slip reduction rate and that all patients have achieved spinal fusion with no case of cage extrusion. Nevertheless, in the study of Lee et al. [36], after 1 year of follow-up, fusion grade I was achieved in 61.9% of cases in TLIF group and in 63.3% in PLIF group without a statistically significant difference between both groups.

Conclusion

The current study could show that TLIF is superior to PLIF with respect to the functional outcome and the complication rate in grade I/II single-level lumbar spondylolisthesis.

Abbreviations

BMI: body mass index; ODI: Oswestry Disability Index Questionnaires; PLIF: posterior lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion; VAS: visual analog scale

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Authors' contributions

All authors have equally participated in designing the work and operating the patients. AE and IS have equally performed the data acquisition and analysis. ER has done the data interpretation and the scientific writing. All authors have thoroughly read, revised, and approved the final submitted manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethics approval was provided by the local Ethical Committee of the Faculty of Medicine, Tanta University. Reference number 32769 was obtained on the 26th of December 2018. Consent for participation was not applicable as this is a retrospective study, so the ethical committee waived the consent to participate.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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