Comparison of clinical and radiological results of posterolateral fusion, posterior lumbar interbody fusion and transforaminal lumbar interbody fusion techniques in the treatment of degenerative lumbar spine

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INTRODUCTION Lower back pain due to degenerative disc disease is a common problem that requires surgical treatment, such as posterolateral fusion and posterior instrumentation (PLF), posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF). This retrospective study aimed to compare the clinical and radiological outcomes of these techniques.

METHODS 81 patients were treated between 2003 and 2006. The patients were divided into three groups: Group I (PLF n = 17 [43 levels]); Group II (PLIF n = 27 [52 levels]); and Group III (TLIF n = 37 [70 levels]). All patients underwent the same pre- and postoperative clinical and radiological evaluations (using Oswestry Disability Index [ODI], Stanford score and local criteria). Follow-ups were performed at three months and yearly for three years.

RESULTS There was no significant difference in the rates of intra-operative complications (Group I: 17.6%; Group II: 11.1%; Group III: 18.9%; p = 0.688) and postoperative complications (Group I: 11.8%; Group II: 25.9%; Group III: 13.5%; p = 0.343) among the groups. There was a significant decrease in the ODI scores over time (p < 0.005) but no significant difference among the groups at different follow-up times. Radiographic fusion rates for Groups I, II and III were 88%, 88.9% and 91.9%, respectively.

CONCLUSION Surgical techniques such as PLF, PLIF and TLIF are equally suitable for treating degenerative disc disease, with no differences observed in complications and clinical outcomes. However, in our study, the best radiological outcome was found in patients treated with TLIF.

Keywords: degenerative, fusion, lumbar interbody, posterolateral, transforaminal
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INTRODUCTION

Degenerative disc disease of the lumber spine is a serious problem that causes varying degrees of disability. Lower back pain, sciatica, paraesthesia, weakness and intermittent claudication are the main symptoms caused by degeneration. Many surgical techniques are used in treating this problem, including posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), and posterolateral fusion and posterior instrumentation (PLF). The simplest procedure is arthrodesis without instrumentation, but this has been found to be associated with a high rate of non-union. Addition of pedicle screw fixation provides direct stability to the spine and improves the fusion rate.[1-6] PLIF was firstly described by Cloward in 1940 and modified by Lin,[7,8] after which it became a common operation. PLIF affords the opportunity to achieve a stable three-column fixation with anterior support and 360° fusion, and is done only posteriorly.[9-11] It also protects the posterior instruments from strain and failure, and may result in superior maintenance of spondylolisthetic reduction.[9,10,12-14] Moreover, it decreases morbidity and has a lower cost compared to the anterior approach.[1,2,15] PLIF is limited to fusions of L3–S1 so as to avoid the risk of damage to the conus medullaris and cauda equina due to traction.[16]

In 1998, Harms and Rolinger reported the results of 191 patients treated with TLIF between 1993 and 1996.[17] This technique has the advantages of PLIF with less perioperative complications.[16,18] It also offers more surfaces for bone graft application and preserves the posterior tension band, which results in more stability.[1] Furthermore, it produces a greater increase in segmental lordosis compared to PLIF and makes it easier to perform revision surgery due to the undisturbed contralateral foramen.[13,16,19,20]

This study aimed to compare the clinical and radiological outcomes of PLF, PLIF and TLIF, the surgical techniques used in treating degenerative disc disease and spinal stenosis.

METHODS

A total of 81 patients (165 levels) with degenerative disc disease of the lumbar spine were treated in our hospital between 2003 and 2006 with three different surgical methods. The patients were divided into three groups based on the method of surgery. The different types of instrumentation used included multiaxial

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Table I. Pre-operative demographic and clinical characteristics of patients according to the method of surgery.

Characteristic	No. of patients (%)			p-value
	Group I (n = 17)	Group II (n = 27)	Group III (n = 37)	
Gender				0.315
Male	7 (41.2)	6 (22.2)	14 (37.8)	
Female	10 (58.8)	21 (77.8)	23 (62.2)	
Mean age ± SD; range (yrs)	54.2 ± 13.6; 36.0–66.0	50.6 ± 13.1; 29.0–70.0	45.8 ± 12.3; 29.0–74.0	0.076
Mean duration of symptoms; range (yrs)	7.8; 2.0–24.0	6.8; 0.025–29.0	4.6; 0.083–18.0	0.041
Back pain	17 (100.0)	27 (100.0)	37 (100.0)	*
Radiating pain				0.006
Unilateral	10 (58.8)	10 (37)	27 (73)	
Bilateral	7 (41.2)	17 (63)	10 (27)	
Sensory disturbance				0.618
Yes	15 (88.2)	22 (81.5)	30 (78.9)	
Unilateral	7 (41.2)	8 (29.7)	5 (13.5)	
Bilateral	8 (47.0)	7 (25.9)	24 (64.9)	
No	2 (11.8)	12 (44.4)	8 (21.6)	
Muscle weakness				0.946
Yes	9 (52.9)	13 (48.1)	19 (51.4)	
No	8 (47.1)	14 (51.9)	18 (48.6)	
Claudication				*
Yes	17 (100.0)	27 (100.0)	37 (100.0)	
No	0	0	0	
Sphincter disturbance				0.381
Normal	16 (94.1)	26 (96.3)	37 (100.0)	
Abnormal	1 (5.9)	1 (3.7)	0	

* p-value was not calculated, as the assumption of chi-square test is violated.

Group I: posterolateral fusion and posterior instrumentation; Group II: posterior lumbar interbody fusion; Group III: transforaminal lumbar interbody fusion

screws and polyether-etherketone interbody cage. Clinical, radiological and magnetic resonance imaging evaluation were used in the diagnosis of all patients. The patients received physiotherapy and non-steroidal anti-inflammatory drugs for 6–12 weeks before surgery. They were operated on by a single surgeon and evaluated before and after surgery by four independent surgeons.

Group I comprised 17 patients (with 43 levels) aged 36–66 (mean age 54.2) years who were treated with PLF. The male to female ratio was 7:10. All the patients had back pain, sciatica and neurogenic claudication. Sensory disturbance was present in all except two patients, and motor weakness was observed in nine patients. Only one patient had urinary retention. The duration period of symptoms ranged 2–24 (mean 7.8) years (Table I). Group II included 27 patients (with 52 levels) aged 29–70 (mean 50.6) years. The male to female ratio in this group was 6:21. The patients were treated with PLIF technique. All patients had back pain, sciatica and neurogenic claudication. Sensory disturbance was found in 15 patients, muscle weakness in 13 patients and only one patient had urinary incontinence. The duration period of symptoms ranged from three weeks to 29 years (mean 6.78 years) (Table I). Group III included 37 patients (with 70 levels) aged 29–74 (mean 44.8) years who were treated with TLIF technique. The male to female ratio was 14:23. All patients had back pain, sciatica, neurogenic intermittent claudication. 29 patients had sensory disturbances, 19 had muscle weakness and none had sphincter dysfunction. The duration of symptoms ranged from one month to 18 years (mean 4.6 years) (Table I).

We evaluated the patients clinically before surgery and at three months, one year, two years and three years post surgery. The Oswestry Disability Index (ODI), Stanford score and our local clinical criteria were used for clinical evaluation. Local criteria were used to assess the clinical outcomes using four categories. The outcome was considered 'poor' if the patient reported no change or more severe pain and sciatica postoperatively, pain that did not respond to analgesia, increased numbness, paraesthesia, same or increased weakness, accompanied by general dissatisfaction and inability to do daily activities. The outcome was considered 'fair' if the patient reported improvement in back pain and sciatica by up to 50% with irregular analgesia, and mild improvement in numbness, paraesthesia and weakness. Such patients had mild difficulty with daily activities and their satisfaction level increased to 50%–70% in comparison with the preoperative status.

The outcome was considered 'good' if the patient experienced significant improvement in back pain and sciatica (70%) that required only occasional analgesia, significant improvement in numbness and paraesthesia, marked improvement in muscle weakness and no limitation in daily activities. In such cases, patient satisfaction was noted to be 70%–80%. The outcome was considered 'excellent' when the patient had no or rare pain, no neurological deficits and no limitation in daily activities, with > 80% improvement in patient satisfaction.

Table II. Intra- and postoperative complications among patients according to the method of surgery.

Complication	No. of patients (%)			p-value
	Group I (n = 17)	Group II (n = 27)	Group III (n = 37)	
Intraoperative				0.688
Male	14 (82.4)	24 (88.9)	30 (81.1)	
Female	3 (17.6)	3 (11.1)	7 (18.9)	
Postoperative				0.343
No	15 (88.2)	20 (74.1)	32 (86.5)	
Yes	2 (11.8)	7 (25.9)	5 (13.5)	
Death	0 (0.0)	1 (3.7)	1 (2.7)	
Infection	1 (5.9)	1 (3.7)	0 (0.0)	
Sciatcia	1 (5.9)	2 (7.4)	2 (5.4)	
DVT and PE	0 (0.0)	1 (3.7)	0 (0.0)	
Pleural effusion	0 (0.0)	1 (3.7)	0 (0.0)	
Epidural seroma	0 (0.0)	1 (3.7)	0 (0.0)	
Muscle weakness	0 (0.0)	0 (0.0)	2 (5.4)	

Group I: Posterolateral fusion and posterior instrumentation; Group II: Posterior lumbar interbody fusion; Group III: Transforaminal lumbar interbody fusion; DVT: deep venous thrombosis; PE: pulmonary embolism

Radiological assessment included plain radiographs at three months, one year, two years and three years after surgery, in addition to dynamic lateral views at the last follow-up. Radiographic fusion was considered to be present based on obliteration of the disc space with continuous bony mass between the two vertebral bodies (PLIF and TLIF), continuous trabecular bone throughout the inter-transverse fusion mass, no motion on flexion and extension radiographs, and absence of instrument loosening or failure (all groups).

The Statistical Package for the Social Sciences version 15 (SPSS, Chicago, IL, USA) was used for data processing and analysis. The subjects' variables were described using frequency distribution for categorical variables, and mean and standard deviation for continuous variables. Chi-square test was used to compare the percentages, and one-way ANOVA was used to compare the means among the three groups. The changes in scores over time were tested using repeated measures analysis. A p-value < 0.05 was considered to be statistically significant.

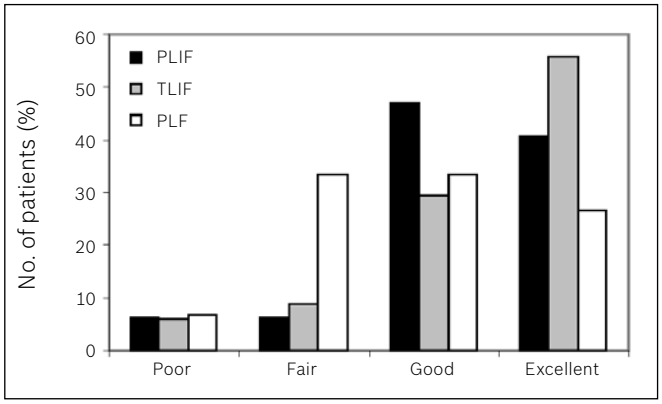

Fig. 1 Graph shows the clinical outcome after three months of follow-up. PLIF: posterior lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion; PLF: posterolateral fusion and posterior instrumentation

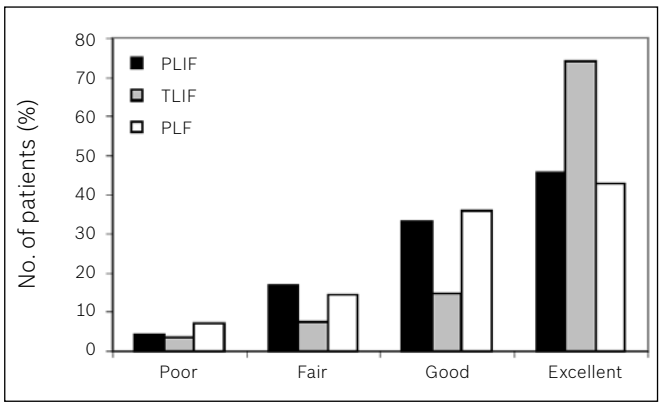

Fig. 2 Graph shows the clinical outcome after one year of follow-up. PLIF: posterior lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion; PLF: posterolateral fusion and posterior instrumentation

RESULTS

Table I shows the pre-operative demographic and clinical characteristics of patients according to the method of surgery. Pre-operatively, the three groups differed significantly (p = 0.006) in terms of the radiating pain. Patients treated with TLIF were more likely to have a pre-operatively unilateral radiating pain compared to patients treated with PLF and PLIF. There were no significant differences among the three treatment groups in terms of gender (p = 0.315), average age (p = 0.076), back pain (p = 0.190), sensory disturbance (p = 0.618), muscle weakness (p = 0.946) and sphincter disturbance (p = 0.381).

The rates of intra- and postoperative complications among the patients according to the method of surgery are shown in Table II. The rates of intra-operative complications were not significantly different (p = 0.688) among the three groups (17.6% in Group I, 11.1% in Group II and 18.9% in Group III). They included a small dural tear, nerve root injury and minor vascular injury. Intra-operative complications of Group I were mainly small (about 5–10 mm) dural tears that appeared during laminectomy and nerve root decompression. In Group II, a small dural tear was noticed in two patients and pedicle fracture in one patient, while in the third group, one patient had nerve root injury with foot drop and a small vascular injury.

Overall, the rates of postoperative complications were not significantly different (p = 0.343) among the three groups

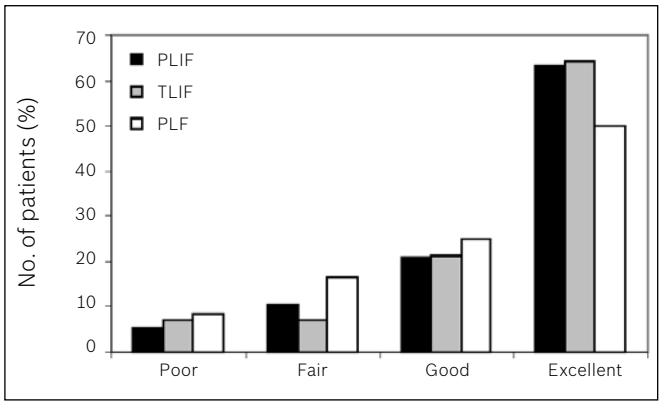

Fig. 3 Graph shows the clinical outcome after two years of follow-up. PLIF: posterior lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion; PLF: posterolateral fusion and posterior instrumentation

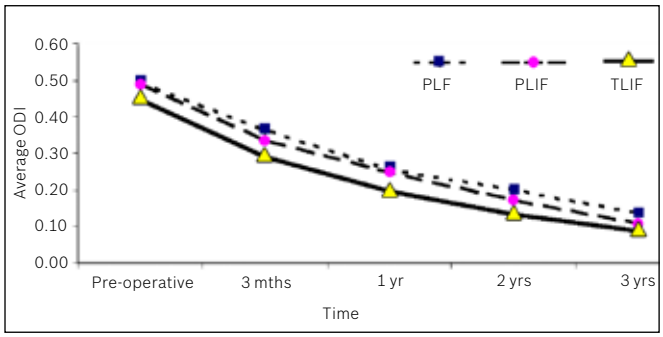

Fig. 4 Graph shows the change in Owestry Disability Index score over time. ODI: Owetry Disability Index; PLIF: posterior lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion; PLF: posterolateral fusion and posterior instrumentation

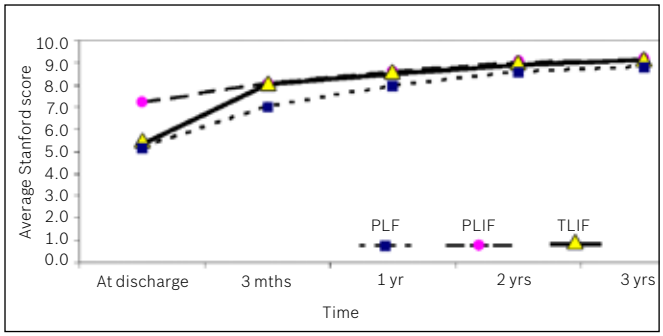

Fig. 5 Graph shows the change in Stanford score over time. PLIF: posterior lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion; PLF: posterolateral fusion and posterior instrumentation

(11.8% in Group I, 25.9% in Group II and 13.5% in Group III). During follow-up, one patient in Group II died due to massive pulmonary embolism. In addition, one patient in Group III died due to septicaemia and septic shock. Other postoperative complications included wound infection in two patients from Group I, one patient from Group II and two patients from Group III (one of whom died due to septic shock). Weakness in ankle dorsiflexion was noticed in one patient from each group. Deep venous thrombosis and pulmonary embolism occurred in two patients from Group II (one of patient died and the other was treated), and sciatica was found in two patients from Group I, two from Group II and five from Group III. Most of these complications were resolved with proper management, except for foot drop, which persisted and did not improve.

The distribution of patients in each group based on the local criteria at different follow-up times is shown in Figs. 1–3. Fig. 4 shows the change in ODI scores over time in the three treatment groups. Pre-operatively, there was no significant difference ($p = 0.547$) in the average ODI score among the three groups. There was significant decrease in the ODI score over time in the three treatment groups with significant p-value (p-value for trend < 0.005), with no significant difference in the change in the mean ODI among them at different follow-up times.

At the last follow-up, radiological studies, including plain and lateral dynamic radiographs, were obtained to evaluate fusion. Radiographic fusion was present in 15 out of the 17 (88%) patients in Group I, 24 out of the 27 (88.9%) patients in Group II and 34 out of the 37 (91.9%) patients in Group III.

DISCUSSION

This retrospective study included 81 patients with degeneration of the intervertebral disc (165 levels) who were treated surgically by three different techniques: PLF, PLIF and TLIF. PLF is a widely used procedure to decompress the spinal canal in order to relieve pain and nerve compression. If PLF is combined with rigid stabilisation, it gives a very high chance for fusion despite the possibility of graft resorption and stress shielding of the intervening bone.[1,3,12,21-23] Compared with PLF, combined posterolateral and interbody fusion produces a more rigid construct that is immediately stable after surgery, provides 360° fusion mass and protects the posterior instruments.[1,9,10,12] PLF had limited indications in our study, as we tried to preserve the sagittal plane as much as possible by using interbody fusion, which explains the small number of patients (n = 17) in this group. Most of the patients were operated on using interbody fusion with pedicle screw instrumentation with either the PLIF or TLIF technique. PLIF has been widely used to treat degenerative spinal column diseases with canal stenosis.

The results of TLIF operations were first published in 1998 by Harms and Jeszenszky, the pioneers of this technique,[23] who operated on 191 patients between 1993 and 1996. The indications for the operation were spondylolisthesis, post-discectomy syndrome, de novo scoliosis and spinal canal stenosis. Their results were excellent for treatment of spondylolisthesis and moderate for de novo scoliosis and post-discectomy syndrome. The complications seen were mainly dural tears, nerve root injuries and pseudoarthrosis.[23] Lowe and Tahernia reported excellent results in two patient, good results in six and poor results in two out of the 29 patients who underwent this surgical procedure.[18] We used TLIF in patients who had back pain with or without unilateral symptoms and mild to moderate canal stenosis. Many previous studies have reported satisfactory outcome in two-thirds of patients.[18,23] Hackenberg et al recommended careful patient selection so as to get better results.[24] The technique of interbody fusion is very important biomechanically, as it preserves the sagittal plane and gives the normal mechanical status of the whole spine, pelvis and lower limbs.[1,13,16,18,19]

In our study, most of the studied baseline demographic and clinical characteristics were not significantly different among the patients in the three groups. The rates of intraoperative complications were also not significantly different ($p = 0.688$) among the three groups. ODI showed significant linear improvement in all three treatment groups ($p < 0.005$), with the greatest improvement observed in the first three months post operation. There was no significant difference in the mean ODI among the three treatment groups at different follow-up times (Fig. 4). There was considerable improvement in the Stanford scores in Groups I and III during the first three months post operation, but no further improvement was seen subsequently (Fig. 5).

According to our local criteria, poor results in all three groups did not help to improve the irreversible complications (nerve root injury with foot drop or epidural adhesions). We observed improvement from 'fair' to 'good' and from 'good' to 'excellent' at different follow-up times, with less improvement in Group I (Figs. 1–3). In Group III, less of the epidural space was dissected, and the lamina and facet joint were also preserved, which may account for the slightly higher number of 'excellent' outcomes and less late complications in Group III patients compared to the other two groups, but this was not statistically significant. In addition, Group III had the highest fusion rates among the three groups, as the wide interbody area, the preserved lamina and facet on one side and the intertransverse processes provided a wide area for fusion.

As we did not find any significant differences among the three treatment groups, we postulate that PLF could be used for patients who require only limited surgery (without interbody) in order to save time, especially when the patients' condition is bad. To our knowledge, few studies have compared these three surgical techniques in the same study. Our results are comparable to those of previous studies despite some limitations, in particular, the small number of patients in Group I.

In conclusion, this study shows no difference in intra- or postoperative complications among the three treatment groups, despite one mortality in Group II and Group III each. In addition, there was no statistical difference in ODI, Stanford score and local clinical criteria among the three groups, although the fusion rate was found to be higher with TLIF (91.9%). There was also no incidence of pseudoarthrosis in any of the groups.

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