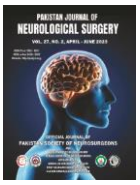

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Original Article

Comparative Study on the Effectiveness of Posterolateral Fusion vs. Interbody Fusion in Isthmic/Degenerative Spondylolisthesis

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ABSTRACT

Objective: To compare the effectiveness of posterolateral fusion versus transforaminal lumbar interbody fusion in degenerative/isthmic spondylolisthesis in terms of postoperative pain and postoperative complications.

Materials & Methods: A quasi-experimental study was conducted and 74 patients were included. Group A (n=37) patients underwent PLF, whereas Group B (n = 37) patients underwent TLIF. The pain was assessed with a visual analog scale (VAS), and for disability, the Oswestry Disability Index (ODI) was used.

Results: In Group-A, pre- and post-op back pain mean scores were 3.86 & 0.78, leg pain mean scores were 1.32 & 0.54 while ODI mean scores were 22.51 & 8.59, respectively($P \leq 0.05$). In Group B, pre- and post-op back pain mean scores were 3.41 & 0.46, leg pain mean scores were 0.84 & 0.30 and ODI mean scores were 19.89 & 6.59, respectively ($P > 0.05$). The prevalence of minimal disabilities in the TLIF (73%, 78%, 81%, 86%, & 91%) group was relatively more than in the PSF (70%, 75%, 78%, 81%, & 86%) group during pre-op, and post-op phases (2 & 6 weeks, 3 & 6 months). Relatively more patients (8.1% vs. 5.4%) with moderate disability were found in the PSF group as compared to the TLIF group. Regarding postoperative complications, in Group-A, 8.1%, 8.1%, 2.7%, 8.1%, 8.1%, 2.7%, 2.7%, 5.4%, and 5.4% patients while among Group B, 2.7%, 5.4%, 0.0%, 5.4%, 2.7%, 2.7%, 2.7%, 5.4%and 2.7% patients at 12 months had implant failure, screw pullout, screw head dislodgement, implant breakage, non-union, redo surgery, adjacent segment disease, epidural fibrosis, and sagittal imbalance, respectively.

Conclusion: The study concluded that TLIF is a safe and more effective procedure than PLF for isthmic/degenerative spondylolisthesis. It is a better surgical procedure for post-operative back pain, leg pain, complications, and disability.

Keywords: Degenerative Spondylolisthesis (DS), Isthmic Spondylolisthesis (IS), Posterolateral Fusion (PLF), Transforaminal Lumbar Interbody Fusion (TLIF).

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INTRODUCTION

Spondylolisthesis is a common condition with an incidence of 3 – 10%. Indications for surgery other than the failure of conservative treatment include progressive neurological deficits, intractable pain, and symptomatic spinal instability. Previously decompression, fusion, fusion with instrumentation, and interbody fusion were used in degenerative/isthmic spondylolisthesis. Posterolateral fusion was an improvement of these techniques. The transforaminal lumbar interbody fusion usage in addition to standard posterolateral spinal fusion for the treatment of spondylolisthesis continues to be another option. Surgical interventions for DS (degenerative spondylolisthesis) have differed with similar claims of success. The fusion-based method is the most frequently utilized surgical intervention. Posterolateral fusion has been and remains one of the largely used posterior fusion techniques. The utilization of TLIF, as well as standard PLF (posterolateral fusion) for DS treatment, continues to be another option. There is limited comparative evidence indicating that one technique is better than another regarding fusion or medical outcomes. Therefore, the present study was conducted to compare the effectiveness of posterolateral fusion versus transforaminal lumbar interbody fusion in degenerative/isthmic spondylolisthesis in terms of post-operative pain and post-operative complications at the Punjab Institute of Neurosciences (PINS), Lahore. We hypothesized that there is a difference in the outcome of posterolateral fusion versus transforaminal lumbar interbody fusion in degenerative/isthmic spondylolisthesis.

The IS (isthmic spondylolisthesis) is the most common kind of lumbar spine spondylolisthesis that manifests with the imperfection of pars interarticular/isthmus leading to vertebral body anterior slip. Normally the isthmic spondylolisthesis takes place on the L5 – S1 (90 percent), however, it is frequently on elevated levels such as L4 – 5/L3 – 4 too. The signs and indications may comprise those due to spinal malformation or neurological compression. If the IS leads to radiculopathy, this is frequently described by neural foraminal narrowing, also recognized as foraminal stenosis.[1] In the degenerative spondylolisthesis (DS)**,** one VB slips forward over the other, however, the posterior vertebral arch stays complete, that is the variation between IS and this condition. Degenerative spondylolisthesis occurs because of vertebral segment instability due to sagittal facade joint and disc degeneration; first, a decrease was found in intervertebral disc height, and later overburdening of facets because of accelerated degenerative modifications that eventually cause spondylolisthesis. In both genders, DS is related to enhanced age.[2] Aging causes skeletal muscle atrophy, which can be exchanged by the connective tissues for example fat. These modifications, which are called sarcopenia caused by a decrease in both size and number of the muscle fibers.[3] Normally the DS (degenerative spondylolisthesis) occurs at lumbar lower levels (mostly at L4 – 5) with slip level type 1 or 2 of the Meyerding classification. Frequently, DS has the Meyerding type III or additional slip. Normally the degenerative spondylolisthesis is a mixture of facet hyperplasia and ligamentum flavum thickening that causes spinal stricture.[4] The prevalence of spondylolysis in the general population is estimated at 3 – 10%, while it has been reported to be 4.4% among children aged below six years. Moreover, spondylolysis prevalence in the adult population has increased by 4 – 6%.[5] The most common site is L5 – S1 (82%), L4 – 5 (11%), L3 – 4 (0.5%), and L2 – 3 (0.5%).[6] The IS incidence is found between 6-7%, and degenerative spondylolisthesis is around 8.7%.[7]

The spondylolisthesis indications comprise leg and low back pain, reduced walkability, and neurogenic lameness. Surgical treatments are suggested once the indications may not be

alleviated through conventional treatment.[8] Conventional treatments such as medication, braces, and physical therapy are demonstrated to be useful for a few patients while surgical procedures are mostly the ultimate useful treatment.[9] The lumbar fusion incidence regarding the treatment of several degenerative lumbar vertebra diseases has significantly enhanced over more than the past 20 years.[10] Posterolateral spinal fixation is an old technique for the treatment of several lumbar spine degenerative disorders.[11] Posterolateral fusion (PLF) was an improvement of these techniques, where the side of the vertebral bodies and transverse process were decorticated and bone grafts were placed on lay to allow intertransverse process fusion, minimizing the risk of new bone formation into the neural canal. Because of the ease and good fusion rates with PLF, it has been and remains one of the largely used posterior fusion techniques.[12] According to a report the clinical success rate of posterolateral fusion is about 81 – 100%.[13]

The use of TLIF (transforaminal lumbar interbody fusion) in addition to standard posterolateral spinal fusion for the treatment of spondylolisthesis continues to be another option.[14] The principal indication of surgery in TLIF is the stabilization and fusion of the spine following the correction of adult spinal deformity. Secondary indications included the surgery for prolapsed lumbar intervertebral disc (recurrent, lateral, massive), failed surgeries by other techniques, discogenic low back pain TLIF, a much novel technique, that evades considerable retraction nerve roots, and dura. By eliminating one of the facet joints, an altered track is accepted to eliminate the disc and to insert a bone graft and a coop in the disc gap. There remains little doubt that anterior column support is required in cases of spondylolisthesis (good to excellent results in 85% of cases). Surgical treatment options are decompression, fusion, fusion with instrumentation, and interbody fusion. During the last decades, posterolateral fusion[15] and transforaminal lumbar interbody fusion[16] have turned into the most common methods which can stable the lumbar vertebra and successfully enhance performance scores after surgery.[17] Though the attractiveness of every method is arguable, therefore the present study is carried out to compare the effectiveness of posterolateral fusion vs. TLIF in isthmic/degenerative spondylolisthesis. Despite the significant amount of innovative fusion procedures that are accessible, numerous studies highlight that the most naive technique, PLF in situ, is merely as effectual as more latest techniques and causes fewer complications.[18] Several researchers suggest interbody fusion along with instrumented PLF among high-level slippage cases since the performance of PLF alone could cause progressive Kyphosis.[19] The decrease in slipped spine among high-level spondylolisthesis patients remains debatable since no clear development was demonstrated in the outcome while the complications are considerably more common.[20] Thome et al, (2005)[21] discovered improved results for lumbar spinal stenosis patients treated with less-invasive decompression vs. those treated with laminectomy in a randomized study. In a comprehensive study of lumbar stenosis decompression procedures, scientists discovered some benefits for midline-preserving decompression in reducing atrogenic instability, improving postoperative back pain, and perceived recovery following surgery. In Both TLIF and PLF the approach, positioning, and incision are similar. The dissimilarity is mainly found in exposure. TLIF engages one-sided facetectomy in addition to pars interarticular resection and laminectomy for the development of a triangular working area.[22]

MATERIAL AND METHODS

Study Design & Setting:

A quasi-experimental study was conducted at the

Department of Neurosurgery Unit III, Punjab Institute of Neurosciences (PINS), Lahore General Hospital, Lahore. The study was conducted for 12 months after the approval of the synopsis/till the final follow-up of my last patient. Formal permission was taken from the hospital's ethical committee to conduct the study. Written consent was taken from patients. Privacy and confidentiality were maintained at all costs by principles laid down in the Helsinki Declaration of Bioethics.

Sample Size & Technique

A consecutive sampling was considered. The sample size was calculated using the Open Epi calculator with a 95% confidence interval[23]. A total of 74 patients (37 + 37) were taken in this study — the formula mentioned below. Total of 74 patients enrolled.

$$n = deff \times \frac{N\hat{p}\hat{q}}{\frac{d^2}{1.96^2}(N-1) + \hat{p}\hat{q}}$$

Where
$n =$ sample size
$deff =$ design effect
$N =$ population size
$\hat{p} =$ the estimated proportion
$\hat{q} = 1 - \hat{p}$
$d =$ desired absolute precision or absolute level of precision

Patient Groups

Patients fulfilling the inclusion criteria were included and informed consent was taken. The procedure to be performed was decided randomly by the lottery method. Group, A (n = 37) patients underwent PLF, whereas Group B (n = 37) patients underwent TLIF under General Anesthesia.

Inclusion Criteria

Patients of both genders with ages above 18 years were included. Patients enrolled were diagnosed with isthmic/degenerative spondylolisthesis with no previous spine surgery or failed conservative therapy.

Exclusion Criteria

Cases of infection, obesity, and previous spine surgery were not included. Patients excluded who were found unfit for surgery, or who were not willing to participate.

Surgical Procedure

After induction of anesthesia, the patients were placed in the prone position. The posterior spinal column and the transverse processes were exposed through a posterior midline incision. In addition to medial facetectomy and foraminotomy to achieve proper thecal sac decompression as well as the roots exiting at the motion segment. The excised bone was kept for use as bone grafts after careful removal of any attached soft tissue. Pedicle screw instrumentation was carried out in all patients with care not to disrupt the upper facet joint. In TLIF cage/implant is inserted in between two vertebral bodies with a bone graft while in PLF bone graft is placed in between the transverse processes of vertebral bodies.

Data Collection and Analysis

The collected data were entered into the computer software SPSS version 25.0. Frequency and percentages were calculated for qualitative variables i.e., postoperative complications. The pain was assessed with a visual analog scale (VAS), which has a score scale of 1 – 10. To assess disability levels, the Oswestry Disability Index (ODI) scale was used as follows: 0% – 20%: Minimal disability; 21% – 40%: Moderate disability; 41% – 60%: Severe disability; 61% – 80%: Crippling back pain & 81% – 100% (these patients are either bed-bound or have an exaggeration of their symptoms). The data was recorded for postoperative complications like

implant failure, screw pullout, screw head dislodgement, and implant breakage considered. Other complications can be non-union, re-do surgery, adjacent segment disease, epidural fibrosis, and sagittal imbalance. Chi-square and independent-sample t-tests were used to compare the quantitative and qualitative variables between both groups. A p-value ≤ 0.05 was considered significant.

RESULTS

Age Distribution

Among 37 patients of Group-A (PLF), 6 (16.2%) were 18-30 years old, 10 (27.0%) were 31 – 50 years old, and 21 (56.8%) patients were above 50 years old. The patient's mean age was 48.81 ± 13.459 years (Table 1). Likewise, among 37 patients of Group-B (TLIF), 5 (13.5%) were 18 – 30 years old, 9 (24.3%) were 31 – 50 years old, and 23 (62.2%) patients were above 50 years old. The patients' mean age was 52.00 ± 12.715 **(Table 1)**.

Gender Distribution

Among 37 patients of Group-A, 29 (78.4%) were males and 8 (21.6%) were females. Among 37 patients of Group B, 31 (83.8%) were males and 6 (16.2%) were females **(Table 2)**.

Comparison of Duration of Symptoms between Groups

Among 37 patients of Group-A, 11 (29.7%) had a duration of symptoms ≤ 6 months while the majority 26 (70.3%) had > 6 months. The symptoms' mean duration was 7.84 ± 2.901 months **(Table 3)**. Among 37 patients of Group B, 13 (35.1%) had a duration of symptoms ≤ 6 months, and 24 (64.9%) patients had >6 months. The symptoms' mean duration was 7.00 ± 2.380 months **(Table 3)**. There existed an insignificant difference between the duration (≤ 6 months/ > 6 months) of symptoms in group A and group B.

Table 1: Comparison of Age between Both Groups.

Age	Group-A PLF		Group-B TLIF		P-value
	Freq.	%age	Freq.	%age	
18 – 30 years	6	16.2	5	13.5	
31 – 50 years	10	27.0	9	24.3	
> 50 years	21	56.8	23	62.2	0.873
Total	37	100.0	37	100.0	
Mean ± SD (years)	48.81 ± 13.459		52.00 ± 12.715		
t-test between mean values (years) of patients' age	P-value: 0.2981; t = 1.0480				

TABLE 2: Comparison of Sex between Both Groups.

Sex	Group-A PLF		Group-B TLIF		P-value
	Freq.	%age	Freq.	%age	
Male	29	78.4	31	83.8	
Female	8	21.6	6	16.2	0.553
Total	37	100.0	37	100.0	

Comparison of Surgery Levels between Groups

Among 37 patients of Group-A, the majority 31 (83.8%) had one level of surgery, and only 6 (16.2%) patients had two levels of surgery **(Table 4)**. Similarly, among 37 patients of Group B, mainstream 34 (91.9%) experienced one-level surgery, and 3 (8.1%) patients experienced two

levels of

Table 3: Comparison of Duration of Symptoms between Both Groups.

Duration of Symptoms	Group-A PLF		Group-B TLIF		P-value
	Freq.	%age	Freq.	%age	
≤ 6 months	11	29.7	13	35.1	
> 6 months	26	70.3	24	64.9	0.652
Total	37	100.0	37	100.0	(χ^2 test)
Mean ± SD	7.84 ± 2.901		7.00 ± 2.380		
the t-test between mean values (months) of the duration of symptoms	P-value: 0.1775; t = 1.36				

Table 4: Comparison of Surgery Levels between Both Groups.

Surgery Level	Group-A PLF		Group-B TLIF		P-value
	Freq.	%age	Freq.	%age	
One level	31	83.8	34	91.9	0.286 (χ^2 test)

surgery **(Table 4)**. There existed an insignificant difference between surgery levels (1-level/2-level) in group A and group B.

Comparison of Back Pain between Groups (at Pre-op and Post-op at 2 & 6 Weeks)

Among 37 patients of Group-A, 14 (37.8%) had **pre-operative** mild back pain and 23 (62.2%) had moderate pain **(Table 5)**. Likewise, among 37 patients of Group B, 22 (59.5%) had pre-operative mild pain and 15 (40.5%) had moderate pain **(Table 5)**.

In Group-A, 22 (59.5%), 7 (18.9%), and 8 (21.6%) while in Group B, 27 (73.0%), 6 (16.2%), and 4 (10.8%) patients had postoperative **(at 2 weeks)** no back pain, mild pain, and moderate pain, respectively **(Table 5)**.

Among Group-A patients, 21 (56.8%), 9 (24.3%), and 7 (18.9%) while among Group-B patients, 26 (70.3%), 8 (21.6%), and 3 (8.1%) patients had postoperative **(at 6 weeks)** no back pain, mild pain, and moderate pain, respectively **(Table 5)**.

Insignificant differences exist for back pain severities (no pain, mild pain, moderate pain, and severe pain) between group A and group B at the pre-op phase as well as at the post-op phases (2 and 6 weeks).

Comparison of Back Pain between Groups (at Post-op at 3, 6 & 12 Months)

The result shows that in Group-A, 23 (62.2%), 8 (21.6%), and 6 (16.2%) while in Group B, 27 (73.0%), 5 (13.5%) and 5 (13.5%) patients had postoperative **(at 3 months)** no back pain, mild pain, and moderate pain, respectively **(Table 5)**.

Among Group-A patients, 24 (64.9%), 10 (27.0%), and 3 (8.1%) while among Group-B patients, 29 (78.4%), 6 (16.2%), and 2 (5.4%) patients had postoperative **(at 6 months)** no back pain, mild pain, and moderate pain, respectively **(Table 5)**.

Among Group-A patients, 24 (64.9%), 11 (29.7%), and 2 (5.4%) while among Group-B patients, 30 (81.1%), 5 (13.5%), and 2 (5.4%) patients had postoperative **(at 12 months)** no back pain, mild pain, and moderate pain, respectively **(Table 5)**.

Insignificant differences exist for back pain severities (no pain, mild pain, moderate pain, and

severe pain) between group A and group B at the post-op phases (3, 6, and 12 months).

Table 5: Comparison of Back Pain Incidence from VAS Scores in Patient Groups.

Back Pain	Group-A PLF		Group-B TLIF		P-value (χ^2 test)
	Freq.	%age	Freq.	%age	
Pre-operative					
No pain	0	0.0	0	0.0	
Mild pain	14	37.8	22	59.5	
Moderate pain	23	62.2	15	40.5	0.063
Severe pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	
Post-operative 2 weeks					
No pain	22	59.5	27	73.0	
Mild pain	7	18.9	6	16.2	
Moderate pain	8	21.6	4	10.8	0.383
Severe pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	
Post-operative 6 weeks					
No pain	21	56.8	26	70.3	
Mild pain	9	24.3	8	21.6	
Moderate pain	7	18.9	3	8.1	0.334
Severe pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	
Post-operative 3 months					
No pain	23	62.2	27	73.0	
Mild pain	8	21.6	5	13.5	
Moderate pain	6	16.2	5	13.5	0.576
Severe pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	
Post-operative 6 months					
No pain	24	64.9	29	78.4	
Mild pain	10	27.0	6	16.2	
Moderate pain	3	8.1	2	5.4	0.434
Severe pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	
Post-operative 12 months					
No pain	24	64.9	30	81.1	
Mild pain	11	29.7	5	13.5	
Moderate pain	2	5.4	2	5.4	0.233
Severe pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	

Comparison of Leg Pain between Groups (at Pre-op and Post-op at 2 & 6 Weeks)

Table-6 elucidates that in Group-A, 26 (70.3%), 4 (10.8%), and 7 (18.9%) while in Group B, 27 (73.0%), 6 (16.2%) and 4(10.8%) patients had **pre-operative** no leg pain, mild pain and moderate pain, respectively.

In Group-A, 27 (73.0%), 6 (16.2%), and 4 (10.8%) while in Group B, 29 (78.4%), 4 (10.8%), and 4 (10.8%) patients had postoperative **(at 2 weeks)** no leg pain, mild pain, and moderate pain, respectively **(Table 6)**.

Among Group-A patients, 28 (75.7%), 6 (16.2%), and 3 (8.1%) while among Group-B patients, 28 (75.7%), 8 (21.6%) and 1 (2.7%) patients had postoperative **(at 6 weeks)** no leg pain, mild pain, and moderate pain, respectively **(Table 6)**.

Insignificant differences exist for leg pain severities (no pain, mild pain, moderate pain, and severe pain) between group A and group B at the pre-op phase as well as at the post-op phases (2 and 6 weeks).

Comparison of Leg Pain between Groups (Post-op at 3, 6 & 12 Months)

Table 6 shows that in Group-A, 28 (75.7%), 6 (16.2%), and 3 (8.1%) while in Group B, 30 (81.1%), 6 (16.2%) and 1 (2.7%) patients had postoperative **(at 3 months)** no leg pain, mild pain, and moderate pain, respectively.

Among Group-A patients, 29 (78.4%), 6 (16.2%), and 2 (5.4%) while among Group-B patients, 30 (81.1%), 7 (18.9%), and 0(0.0%) patients had postoperative **(at 6 months)** no leg pain, mild pain, and moderate pain, respectively **(Table 6)**.

Among Group-A patients, 31 (83.8%), 5 (13.5%), and 1 (2.7%) while among Group-B patients, 31 (83.8%), 5 (13.5%) and 1(2.7%)

patients had post-operative **(at 12 months)** no leg pain, mild pain, and moderate pain, respectively **(Table 6)**.

Table 6. Comparison Of Leg Pain Prevalence from VAS Scores in Patient Groups.

Leg Pain	Group-A PLF		Group-B TLIF		P-value (χ^2 test)
	Freq.	%age	Freq.	%age	
Pre-operative					
No pain	26	70.3	27	73.0	
Mild pain	4	10.8	6	16.2	
Moderate pain	7	18.9	4	10.8	0.539
Severe pain	0	0.0	0	0.0	
Total	37	100	37	100.0	
Post-operative 2 weeks					
No pain	27	73.0	29	78.4	
Mild pain	6	16.2	4	10.8	
Moderate pain	4	10.8	4	10.8	0.790
Severe pain	0	0.0	0	0.0	
Total	37	100	37	100.0	
Post-operative 6 weeks					
No pain	28	75.7	28	75.7	
Mild pain	6	16.2	8	21.6	
Moderate pain	3	8.1	1	2.7	0.526
Severe pain	0	0.0	0	0.0	
Total	37	100	37	100.0	
Post-operative 3 months					
No pain	28	75.7	30	81.1	
Mild pain	6	16.2	6	16.2	
Moderate pain	3	8.1	1	2.7	0.586
Severe pain	0	0.0	0	0.0	
Total	37	100	37	100.0	
Post-operative 6 months					
No pain	29	78.4	30	81.1	
Mild pain	6	16.2	7	18.9	
Moderate pain	2	5.4	0	0.0	0.351
Severe pain	0	0.0	0	0.0	
Total	37	100	37	100.0	
Post-operative 12 months					
No pain	31	83.8	31	83.8	
Mild pain	5	13.5	5	13.5	
Moderate pain	1	2.7	1	2.7	1.000
Severe pain	0	0.0	0	0.0	
Total	37	100	37	100.0	

Insignificant differences exist for leg pain severities (no pain, mild pain, moderate pain, and severe pain) between group A and group B at the post-op phases (3, 6, and 12 months).

Comparison of Disability as Per ODI between Groups (at Pre-op and Post-op at 2 & 6 Weeks)

Table 7 indicates that in Group-A, 26 (70.3%), 5 (13.5%), 3 (8.1%), and 3 (8.1%) while in Group B, 27 (73.0%), 6 (16.2%), 2 (5.8%) and 2 (5.4%) patients had **pre-operative** minimal disability, moderate disability, severe disability and crippling back pain, respectively.

In Group-A, 28 (75.7%), 4 (10.8%), 3 (8.1%), and 2 (5.4%) while in Group B, 29 (78.4%), 5 (13.5%), 3 (8.1%) and 0 (0.0%) patients had postoperative **(at 2 weeks)** minimal disability, moderate disability, severe disability and crippling back pain, respectively **(Table 7)**.

Among Group-A patients, 29 (78.4%), 6 (16.2%), 1 (2.7%), and 1 (2.7%) while among Group-B patients, 30 (81.1%), 2 (5.4%), 3 (8.1%) and 2 (5.4%) patients had postoperative **(at 6 weeks)** minimal disability, moderate disability, severe disability, and crippling back pain, respectively **(Table 7)**.

Insignificant differences exist for disabilities (minimal disability, moderate disability, severe disability & crippling back pain) between group A and group B at the pre-op phase as well as at the post-op phases (2 and 6 weeks).

Comparison of Disability as Per ODI between Groups (Post-op at 3, 6 & 12 Months)

Table7 describes that among Group-A patients, 30 (81.1%), 7 (18.9%), 0 (0.0%), and 0 (0.0%) while among Group-B patients, 32 (86.5%), 3 (8.1%), 1 (2.7%) and 1 (2.7%) had post-operative (at 3 months) minimal disability, moderate disability, severe disability, and crippling back pain, respectively.

The result shows that among Group-A patients, 32 (86.5%), 5 (13.5%) and 0 (0.0%) while

among Group-B patients, 34 (91.9%), 1 (2.7%) and 2 (5.4%) had post-operative **(at 6 months)**

Table 7: Comparison of Disability According to Oswestry Disability Index (ODI) between Both Groups

Disability	Group-A PLF		Group-B TLIF		P-value (χ^2 test)
	Freq.	%age	Freq.	%age	
Pre-operative					
Minimal disability	26	70.3	27	73.0	
Moderate disability	5	13.5	6	16.2	
Severe disability	3	8.1	2	5.4	0.917
Crippling back pain	3	8.1	2	5.4	
Total	37	100.0	37	100.0	
Post-operative 2 weeks					
Minimal disability	28	75.7	29	78.4	
Moderate disability	4	10.8	5	13.5	
Severe disability	3	8.1	3	8.1	0.546
Crippling back pain	2	5.4	0	0.0	
Total	37	100.0	37	100.0	
Post-operative 6 weeks					
Minimal disability	29	78.4	30	81.1	
Moderate disability	6	16.2	2	5.4	
Severe disability	1	2.7	3	8.1	0.341
Crippling back pain	1	2.7	2	5.4	
Total	37	100.0	37	100.0	
Post-operative 3 months					
Minimal disability	30	81.1	32	86.5	
Moderate disability	7	18.9	3	8.1	
Severe disability	0	0.0	1	2.7	0.300
Crippling back pain	0	0.0	1	2.7	
Total	37	100.0	37	100.0	
Post-operative 6 months					
Minimal disability	32	86.5	34	91.9	
Moderate disability	5	13.5	1	2.7	
Severe disability	0	0.0	2	5.4	0.094
Crippling back pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	
Post-operative 12 months					
Minimal disability	34	91.9	34	91.9	
Moderate disability	3	8.1	2	5.4	
Severe disability	0	0.0	1	2.7	0.549
Crippling back pain	0	0.0	0	0.0	
Total	37	100.0	37	100.0	

minimal disability, moderate disability, and severe disability, respectively **(Table 7)**. Among Group-A patients, 34 (91.9%), 3 (8.1%), and 0 (0.0%) while among Group-B patients, 34 (91.9%), 2 (5.4%), and 1 (2.7%) had post-operative **(at 12 months)** minimal disability, moderate disability, and severe disability, respectively **(Table 7)**.

Insignificant differences exist for disabilities (minimal disability, moderate disability, severe disability & crippling back pain) between group A and group B at the pre-op phase as well as at the post-op phases (3, 6, and 12 months).

Comparison of Mean VAS/ODI Scores between Both Groups

Table 8 highlights that in Group-A, pre- and post-op back pain mean scores were 3.86 ±.619&0.78 ± 1.228, leg pain mean scores were 1.32 ± 2.199 & 0.54 ± 1.346 while ODI mean scores were 22.51 ± 19.330 & 8.59 ± 8.662, respectively. The results were statistically significant (P ≤ 0.05) between pre- and post-op back pain mean scores in Group A.

In Group B, pre- and post-op back pain mean scores were 3.41 ± 1.518 & 0.46 ± 1.169, leg pain mean scores were 0.84 ± 1.573 & 0.30 ± 0.812, and ODI mean scores were 19.89 ± 16.205 & 6.59 ± 8.231, respectively. The results were statistically insignificant (P>0.05) between pre- and post-op back pain mean scores in Group B.

Moreover, from the t-test, insignificant differences exist for pre-op/post-op (back/leg pain) VAS & ODI scores between groups A & B.

Comparison of Postoperative Complications Between Both Groups

Table 9 depicts that among Group-A patients, 3 (8.1%), 4 (10.8%), 2 (5.4%), 3 (8.1%), 2 (5.4%), 0

Table 8: Comparison of Mean between Both Groups.

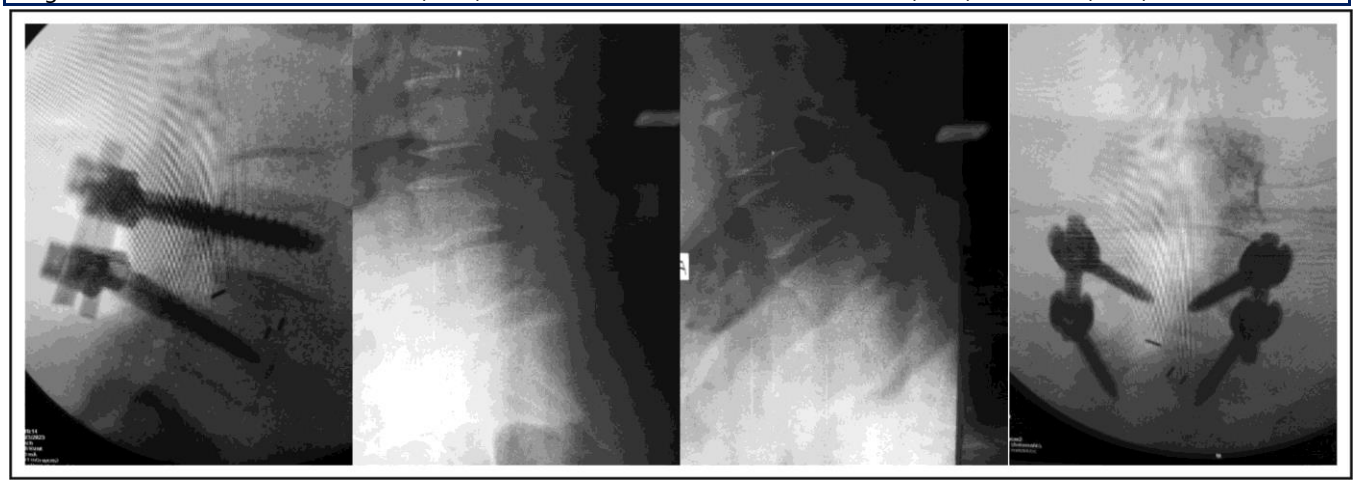
	Groups	Pre-op Score	Post-op Score	**P-values** from the t-test (between pre-op & post-op of Group A/Group B
Back pain (VAS Scores)	Group-A (PLF)	3.86 ± .619	0.78 ± 1.228	0.002*
	Group-B (TLIF)	3.41 ± 1.518	0.46 ± 1.169	0.882
	P values from t-test (for pre-op/post-op back-pain scores between groups A & B)	P value: 0.221	P value: 0.254	
Leg pain (VAS Scores)	Group-A (PLF)	1.32 ± 2.199	0.54 ± 1.346	0.000*
	Group-B (TLIF)	0.84 ± 1.573	0.30 ± 0.812	0.067
	P values from t-test (for pre-op/post-op leg-pain scores between groups A & B)	P value: 0.283	P value: 0.3562	
ODI (for disabilities)	Group-A (PLF)	22.51 ± 19.330	8.59 ± 8.662	0.000*
	Group-B (TLIF)	19.89 ± 16.205	6.59 ± 8.231	0.107
	P values from t-test (for pre-op/post-op ODI scores between groups A & B)	P value: 0.5295	P value: 0.3120	

*significant result

Table 9: Comparison of Postoperative Complications between Both Groups.

Complications	6 months			12 months		
	PLF n=37	TLIF n=37	P-value	PLF n=37	TLIF n=37	P-value
Implant failure	3 (8.1%)	1 (2.7%)	0.304	3 (8.1%)	1 (2.7%)	0.304
Screw pull-out	4 (10.8%)	2 (5.4%)	0.394	3 (8.1%)	2 (5.4%)	0.643
Screw head dislodgement	2 (5.4%)	1 (2.7%)	0.556	1 (2.7%)	–	0.314
Implant breakage	3 (8.1%)	2 (5.4%)	0.643	3 (8.1%)	2 (5.4%)	0.643
Non union	2 (5.4%)	1 (2.7%)	0.556	3 (8.1%)	1 (2.7%)	0.304
Redo surgery	–	–	–	1 (2.7%)	1 (2.7%)	1.000
Adjacent segment disease	2 (5.4%)	2 (5.4%)	1.000	1 (2.7%)	1 (2.7%)	1.000

Epidural fibrosis	–	–	–	2 (5.4%)	2 (5.4%)	1.000
Sagittal imbalance	1 (2.7%)	–	0.314	2 (5.4%)	1 (2.7%)	0.556



(a) (b) (c) (d)

Figure 1(a): Example of TLIF; **1(b):** Pre-op (TLIF); **1(c):** Pre-op Lateral Flexion (TLIF); **1(d):** Post-op AP view (TLIF).

(0.0%), 2 (504%), 0 (0.0%), and 1 (2.7%) while among Group-B patients, 1 (2.7%), 2 (5.4%), 1 (2.7%), 2 (5.4%), 1 (2.7%), 0 (0.0%), 2 (5.4%), 0 (0.0%) and 0(0.0%) at 6 months had implant failure, screw pullout, screw head dislodgement, implant breakage, non-union, redo surgery, adjacent segment disease, epidural fibrosis, and sagittal imbalance, respectively.

Likewise among Group-A patients, 3 (8.1%), 3 (8.1%), 1 (2.7%), 3 (8.1%), 3 (8.1%), 1 (2.7%), 1 (2.7%), 2 (5.4%) and 2 (5.4%) while among Group-B patients, 1 (2.7%), 2(5.4%), 0 (0.0%), 2 (5.4%), 1 (2.7%), 1 (2.7%), 1 (2.7%), 2 (5.4%) and 1 (2.7%) at 12 months had implant failure, screw pullout, screw head dislodgement, implant breakage, non-union, redo surgery, adjacent segment disease, epidural fibrosis, and sagittal imbalance, respectively.

DISCUSSION

During past decades, PLF and TLIF are considered the most popular surgical methods for lumbar spine stabilization and can improve the patient's life quality. Keeping in mind the effectiveness of both techniques, this current study was carried out to compare the effectiveness of PLF versus TLIF in isthmic/degenerative spondylolisthesis. To acquire appropriate outcomes, 74 patients were included in the study and divided into two equal groups. In Group-A (PLF), 37 patients underwent Posterolateral Fusion whereas in Group B (TLIF), 37 patients were treated with TLIF under general anesthesia. The study revealed that in both groups majority of the patients were 31-50 years old. The mean age of the patients in the PLF group was 48 years while the mean age in the TLIF group was 52 years. Elghany et al,[24] reported that patients in both groups were younger than our study groups. They confirmed that the mean age of the patients in the PLF group was 38 years while the mean age of the patients in the TLIF group was 36 years. Farid and Elkholy[25] also observed that the mean age of the patients in the PLF group was 38 years while in the TLIF group was 39 years. However, Yadav et al,[26] reported that in the PLF group, the mean age of the patients was 47 years while in the TLIF group was 48 years. Farrokhi et al,[17] highlighted that in the PLF group, the mean age of the patients was 55 years while in the TLIF group, the mean age of patients was 52 years.

Burton et al,[27] reported that isthmic spondylolisthesis prevalence is generally between 4 – 8 percent but the disease is three times more common among males than females. The results

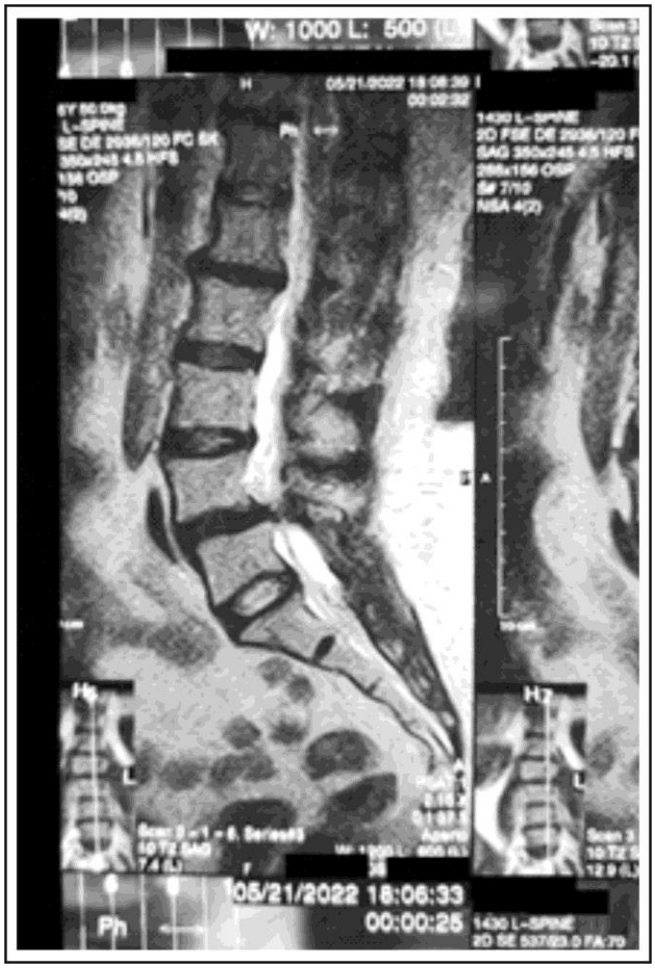
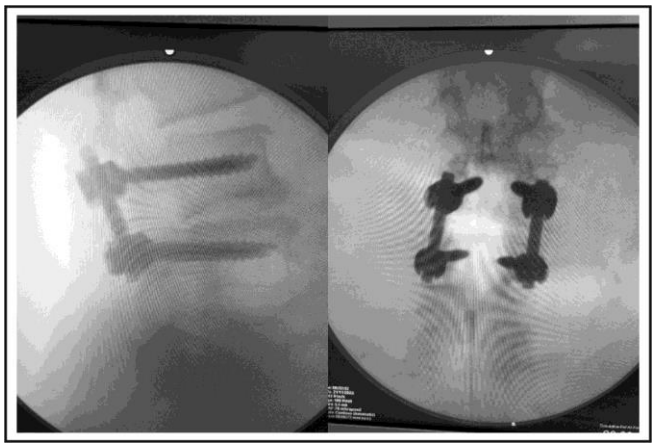


Figure 2: Pre-op MRI (TLIF).



(a) (b)

Figure 3(a): PSF lateral view (post-op); **3(b):** PSF AP view (post-op).

of our study also highlighted that the disease was more prevalent among male patients. In our

study, 78.4% of patients were in the PLF group while 83.8% of patients in the TLIF group were males and the remaining proportion in both groups was females. Farrokhi et al, (2021) reported a significant majority (91.7%) of patients in the PLF group and 61.0% of patients in the TLIF group were females. Yadav et al, (2020) stated that 38.0% of patients in the PLF group and 25.0% of patients in the TLIF group were males while the remaining significant majority of the patients were females. A study done by Farid and Elkholy [25] reported that only 25.0% of patients in the PLF group while 30.0% of patients in the TLIF group were males. It was found during the study that the mainstream of patients in the PLF group had a duration of symptoms ≤ 6 months while in the TLIF group, the majority had a duration of symptoms > 6 months and most of the patients in both groups had one level surgery. When the comparison between both groups was made about back pain, the study disclosed that the TLIF technique was found better than the PLF in terms of pre-operative pain, and post-operative (2& 6 weeks; 3, 6 & 12 months) back pain. Likewise, the relief of leg pain was found better among patients treated with the TLIF technique regarding pre-operative pain, and post-operative (2 & 6 weeks; 3, 6, & 12 months) leg pain.

For isthmic/degenerative spondylolisthesis treatment, TLIF is considered a safe and effective technique. The finding of our study also demonstrated that TLIF surgical procedure was found better than PLF regarding back pain and leg pain. The patients treated with TLIF had less post-operative mean visual analog scale (VAS) score than PLF. However, the results were found statistically insignificant (P>0.05). Yadav et al. (2020) showed comparable results that TLIF surgical procedure was found better than PLF regarding back pain and the results were found statistically significant (P<0.001). A similar scenario was also reported in a study carried out by Farrokhi et al,[17] who confirmed that the TLIF technique was found better than PLF regarding pain with statistically significant results (P = 0.0001). Farid and Elkholy[25] exhibited similar outcomes according to the VAS score, patients treated with the TLIF technique had more relief in pain than the PLF group and the results were statistically significant.

In our study, when disability was assessed among patients according to Oswestry Disability Index, the study revealed that TLIF was found more effective technique than PLF (post-op mean score: 6.59 ± 8.231 vs. 8.59 ± 8.662), although the results were found insignificant. There were more patients in the category of mind & moderate back pain (59%, & 40%) during the pre-op phase in group B (TLIF) as compared to group A (PSF). During post-op (2 & 6 weeks), there were more patients with no pain (73%, & 70%) in patients treated with TLIF as compared to PSF. Similarly, during post-op (3, 6 & 12 months), there were more patients with no pain (73%, 78%, & 81%) in patients treated with TLIF as compared to PSF. There were an almost equal number of patients (70%, & 73%) who did not experience leg pain during the pre-op and post-op (2 & 6 weeks) phases. During post-op (6 & 12 months) there were slightly more patients with no pain (81%, & 81%) in group B (TLIF) as compared to group A (PSF). However, at 12 months post-op, there were an equal number of patients (83.8%) who were having no pain in both groups. Good surgical outcomes were observed with both PSF and TLIF procedures, however, the prevalence of minimal disabilities in the TLIF (73%, 78%, 81%, 86%, & 91%) group was relatively more than in the PSF (70%, 75%, 78%, 81%, & 86%) group during pre-op, and post-op phases (2 & 6 weeks, 3 & 6 months). This indicates that a smaller number of patients were having more severe disabilities (i.e., moderate to crippling). At the 12-month post-op phase, equal prevalence (91.9%) of minimal disabilities was reported with both procedures, however, relatively more patients (8.1% vs. 5.4%) with moderate disability were found in patients who were treated with the PSF procedure as

compared to TLIF.

The results of Kelly et al,[28] are comparable with our study results also asserted that according to ODI, TLIF was found more effective technique than PLF (post-op mean score: 26.8 ± 19.2 vs. 28.9 ± 21.2), however, the results were found insignificant. Another study conducted by Farid and Elkholy[25] also verified that as per ODI, TLIF was a more effective procedure than PLF (post-op mean score: 16.5 ± 6.68 vs. 19.5 ± 9.31), however, the results were found in significant (P value: 0.4). A similar study performed by Elghany et al, also reported that according to the Oswestry Disability Index score, TLIF was found better technique than PLF (post-op mean score: 17.6 ± 5.4 vs. 20.6 ± 6.2) while the results were also found statistically significant (P value: 0.026). Farrokhi et al,[17] found TLIF is a better procedure than PLF (post-op mean score: 24.58 ± 6.66 vs. 27.36 ± 7.10) while the results were also found statistically significant (P value: 0.026). The results of another study undertaken by Yadav et al,[26] also confirmed that according to the ODI score, TLIF was proven better technique than the PLF (post-op mean score: 10.9 ± 4.17 versus 12.3 ± 5.44) and the results were statistically significant. When post-operative complications between both groups were compared, our study disclosed that the TLIF technique was found better than the PLF technique at 12 months regarding implant failure, screw pullout, screw head dislodgement, implant breakage, non-union, and sagittal imbalance while comparable results were found only for redo surgery, adjacent segment disease, epidural fibrosis. The findings of a study done by Elghany et al,[24] showed that TLIF surgical procedure was better than PLF regarding superficial infection, deep infection, and residual radiculopathy. But the findings of a study carried out by Farid and Elkholy[25] indicated that the PLF technique was better than TLIF regarding dural tear, wound infection, CSF leakage, and transient foot drop. Farrokhi et al,[17] reported in their study that complications were observed in only two patients. One patient was from the TLIF group who demonstrated paraparesis and back pain after 24 hours of surgery while the other patients from PLF developed ipsilateral weakness of the extensor hallucis longus which completely recovered after 3 months of conservative care and physiotherapy.

A study was carried out by Ghasemi[29] to compare the radiological and clinical outcomes of the TLIF technique versus IPF among 145 consecutive patients with DS. During the study, 80 patients experienced the TLIF technique while 65 patients experienced instrumented PLF. Insignificant differences were found between both groups for age, BMI, gender, comorbid conditions, and smoking (P > 0.05). Insignificant differences were found in before-surgery VAS for backache and leg pain in both cohorts (P > 0.05). Insignificant cohort differences were found in surgery level, hospitalization duration, and surgical treatment complications (P > 0.05). Duration of surgery, blood loss, and success rates of fusion were found significantly better in TLIF than in the PLF cohort (P < 0.05). The Study concluded that TLIF is better than PLF regarding fusion rate and functional outcome. A study was performed by Levin and Comrades[30] to compare the clinical outcomes, frequency of fusion, surgery time, and blood loss between open PLF alone and open TLIF + PLF for spondylolisthesis. Results showed that 84.7% were the success rates of fusion in the PLF cohort and 94.3% in the TLIF cohort. When compared with patients in the TLIF cohort, patients in the PLF cohort had a considerably lower chance of attaining solid arthrodesis. Regarding improvement in the backache, the point assessment regarding effect size was in the favor of TLIF cohort. For ODI, the assessment regarding effect size was considerably in the favor of TLIF cohort. The time of surgery was considerably less in the PLF cohort. The insignificant difference was noticed in the leg pain, health-related quality of life improvement, infectivity rate, and blood loss. The results of this

meta-analysis were found consistent with randomized controlled trials, in favor of TLIF regarding attaining radiographic fusion as well as better enhancement in the ODI and backache. The study concluded that for patients who experienced fusion for the spondylolisthesis, TLIF was found better than PLF regarding radiographic fusion attainment.

Irianto et al,[31] ascertained the superior surgical treatments regarding degenerative spondylolisthesis that are yet arguable. During the study, fifty related pieces of literature were investigated about DS, investigative techniques, as well as treatment during the period from 2007 to 2017. The results indicated that an insignificant difference was found regarding backache utilizing VAS during the preoperative procedure, treatment duration, operating level, and complications after surgery between both cohorts. Also, an insignificant difference was found regarding leg pain between both cohorts. In contrast, the blood loss amount, successful fusion, and surgery duration were considerably found elevated in TLIF than PLF cohort. The study concluded that TLIF is comparatively better than PLF for fusion success, despite the surgical extended duration and blood loss higher amount. Christensen et al,[32] performed research to know the cost-utility and cost-effectiveness of TLIF when compared with PLF from a societal viewpoint. The study found that TLIF is not an appropriate option for PLF from societal and socioeconomic perspectives. Audat et al,[33] carried out a study to make the comparison between radiological and clinical outcomes for techniques namely TLIP, PLIF, and PLF. A significant reduction was found in ODI scores ($P < 0.005$) however, the insignificant difference in cohorts at several follow-up times. The study concluded that surgical procedures such as TLIF, PLF, and PLIF are equally appropriate for degenerative disc disorder treatment, without differences noticed in the clinical outcomes and complications. Though, a better radiological outcome was observed among TTLIF patients.

A study was undertaken by Ali et al,[34] to compare TLIF early outcomes for lytic vs. DS. During the study, 14 females and 8 males with a mean age of 36 years experienced TLIF for lytic (15 patients) or DS (7 patients). The study demonstrated that VAS mean score regarding low backache significantly improved preoperatively from 7.4 – 2.1 at one year ($P = < 0.001$), as did VAS mean score regarding leg pain from 6.7 – 1.4 ($P = 0.001$) while the mean ODI from 67.8 percent to 11.8 percent ($P = < 0.001$). None of the patients showed any remaining neurological deficiency and all attained radiological synthesis. The complete outcome was found excellent among sixteen patients and good among 5 patients while fair in 1 patient. Sixteen patients resumed their normal daily activities. The study concluded that TLIF is an effective and safe operation regarding lytic and DS treatment. Khan et al,[35] undertook a study to assess the clinical & radiological outcomes of subjects who experienced TLIF with an interbody cage for spondylolisthesis. In 28 cases, the major pathology was lytic listhesis, whereas 17 had degenerative listhesis. There was no focus on several levels. The study showed no intra-operative complications. Two patients developed neurological deficits in the form of partial foot drop. There were statistically significant improvements from preoperative VAS to post-operative VAS. Fusion could be assessed in all patients. Anterior interbody fusion was attained among 78.3% of patients and posterior lateral fusion was achieved in 69.6%. After 6 months of surgery, 4 patients showed no fusion. The study concluded that TLIF is a useful and safe technique to attain circumferential fusion.

CONCLUSION AND RECOMMENDATIONS

The study concluded that TLIF is a safe and more effective procedure than PLF for isthmic/

degenerative spondylolisthesis. It is a better surgical procedure regarding post-operative back pain, leg pain, complications, and disability. Further studies are required to be carried out on a large scale to assess the safety and efficacy of both techniques. The present study was conducted to compare the effectiveness of posterolateral fusion versus transforaminal lumbar interbody fusion in degenerative/isthmic spondylolisthesis in terms of post-operative pain and post-operative complication like implant failure. It is anticipated that the results of the study will be helpful for healthcare providers and health planners for better planning and to provide better treatment to patients.

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Additional Information

Disclosures: Authors report no conflict of interest.

Ethical Review Board Approval: The research was a retrospective study.

Human Subjects: Consent was obtained by all patients/participants in this study.

Conflicts of Interest:

In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

AUTHOR CONTRIBUTIONS

Sr. No.	Author's Full Name	Intellectual Contribution to Paper in Terms of
1.	Syed Ahmad Faizan	Study Design, Methodology, and Paper Writing.
2.	Mudassir Masaud	Data Calculation and Data Analysis.
3.	Zubair Mustafa Khan	Interpretation of Results.
4.	Tariq Imran	Statistical Analysis.
5.	Asif Bashir	Literature Review Quality Insurer.