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Comparative Analysis of Functional Outcomes in L4-L5 Instability Treated with Bilateral Trans-Pedicular Fixation vs. Bilateral Trans-Pedicular Fixation with Posterior Lumbar Interbody Fusion

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ABSTRACT

Background: Low back pain (LBP) is a leading cause of work-related disability, with the L4-L5 segment being the most affected in the lower lumber spine. Instability due to trauma, degeneration, or congenital factors causes severe pain and numbness. While conservative treatments exist, severe cases require Bilateral Trans-Pedicular Fixation or its advanced form, PLIF, for enhanced stability. Post-operative care is crucial to prevent complications. This study compares functional outcomes of Bilateral Trans-Pedicular Fixation versus Bilateral Trans-Pedicular Fixation with Posterior Lumbar Interbody Fusion for L4-L5 instability.

Methods: This comparative experimental study involved 60 patients diagnosed with L4-L5 instability, randomly allocated into two groups. This study at MGM Medical College, Aurangabad, compared fixation with and without posterior lumbar interbody fusion in 60 patients with L4-L5 instability. Conducted from 1st November 2014 to 31st October 2016, it assessed clinical and radiological outcomes over six months using X-rays, MRIs, and statistical analysis.

Results: This study was conducted among both groups with similar demographics, with no significant differences in comorbidities, trauma history, or neurological deficits. Group II (fixation with PLIF) had longer surgery duration, higher intraoperative blood loss, and superior functional recovery at 24 weeks. Radiological fusion was significantly higher in Group II (80% vs. 53.3%). Complication rates were similar in both groups (13.3%).

Conclusion: This study concluded that PLIF showed superior fusion and functional recovery despite longer surgery time and higher blood loss. Both procedures had similar complication rates, making PLIF preferable for enhanced stability in L4-L5 instability cases.

Key-words: L4-L5 Instability, Bilateral Trans-Pedicular Fixation, Posterior Lumbar Interbody Fusion (PLIF), Spinal Stability and Functional Recovery

INTRODUCTION

L4-L5 instability is a physical condition where the lower lumbar spine, i.e. the fourth and fifth vertebrae, becomes unstable due to reasons like trauma, degeneration, or even congenital causes.

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This instability of the L4-L5 region may produce severe pain that might spread into the legs and can cause burning, shooting pain, or numbness [1]. In most cases, the problem of instability is not identified due to other conditions like muscle injuries. Its treatment is mainly focused on non-surgical methods like physical therapy to strengthen the core and back muscles and algorithm drugs to reduce pain and inflammation. Lifestyle changes, e.g. correct posture, normal weight, and good nutrition, are also major factors that can improve the instability. But in cases not managed and recovered with conservative methods the treatment is done by surgical

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methods like Bilateral Trans-Pedicular Fixation and its advanced version with PLIF [2]. Bilateral Trans-Pedicular Fixation is a surgical intervention in which both sides of the vertebrae pedicles are fixed to stabilize the spine.

This surgical intervention aims to stabilize the spine and thereby relieve pain. At first, the patient's complete medical history, as well as imaging studies like X-rays, CT scans, and MRI, are performed [3,4]. During the surgical procedure, the region was located using those imaging techniques and an incision was made in that location. Muscles and soft tissues were retracted, and screws were inserted into both sides of the pedicles. After fixing the screws, the rods were inserted to maintain alignment and stability. Minimal invasive techniques are used for shorter and painless recovery [3]. Bilateral trans-pedicular fixation also causes several problems, including infection, bleeding, nerve injury, and possible failure of the rod or screws.

To overcome these problems, a bilateral trans-pedicular fixation with the PLIF technique is used [4]. It is a more advanced approach, and the procedure is like bilateral trans-pedicular fixation. Still, after screwing both sides of the pedicle, we remove the intervertebral disc from the affected region, which creates a space where we put our interbody cage. This interbody cage is filled with bone graft material that provides support and stability to that region. Once the screw and cage were fixed, the rod was inserted and placed to maintain the alignment [5]. This procedure is helpful in patients with significant spinal instability where stabilization and fusion of vertebrae are essential. Posterior lumbar interbody fusion provides better stability than the conventional Bilateral Trans-Pedicular Fixation. Although they are sophisticated techniques, they might also cause issues. Thus, post-operative care and regular follow-ups are needed [4,5].

MATERIALS AND METHODS

Research Design- This comparative experimental study included 60 patients diagnosed with L4-L5 instability, randomly assigned to two groups using a lottery system. Group I (n=30) underwent fixation without posterior lumbar interbody fusion, while Group II (n=30) underwent fixation with posterior lumbar interbody fusion. All patients were followed for six months, with evaluations conducted at 4, 12, and 24 weeks, including clinical and radiological assessments to compare outcomes. The study was approved by the Department of Orthopaedics at MGM Medical College, Aurangabad, India and conducted from November 1, 2014 to October 31, 2016. Patients were enrolled through simple random sampling based on inclusion and exclusion criteria and then allocated to one of the two groups using a lottery system. Preoperative assessments included X-rays of the lumbosacral spine in anteroposterior and lateral views, lateral views during flexion & extension, positions, and MRI of the lumbosacral spine with whole spine screening. These evaluations ensured accurate diagnosis and helped determine the severity of instability, guiding appropriate surgical intervention for each patient.

Inclusion Criteria

- Patients aged 18-60 years of both genders
- With degenerative disc disease between L4 & L5 with instability
- Spondylolisthesis L4 & L5 with instability
- Pain, functional deficit, or neurologic deficit for 6 months preceding enrolment
- No response to non-operative treatment modalities for 6 months preceding enrollment
- Available for long-term follow-up and interval visits

Exclusion Criteria

- >60 years of both gender
- >2 levels to be instrumented
- Previous fusion attempt at the involved level (S)
- Previous open, posterior, lumbar spine surgical procedures at involved Level L4-L5
- Previously documented osteopenia or osteomalacia
- Active localised or systemic infection
- Disease entity or condition precluding the possibility of bony fusion
- Had immunosuppressive disorder
- Known sensitivity to device materials
- Traumatic instability

Statistical Analysis- Data were collected in Excel and analyzed using SPSS 20. Results were presented through charts and tables. Qualitative data were analyzed using frequencies, percentages, and the chi-square test for associations. Quantitative data were summarized with mean and standard deviation, and an unpaired t-test ($p<0.05$) was used for group comparisons. The study assessed the efficacy and challenges of fixation with and without posterior lumbar interbody fusion over six months using clinical and radiological evaluations.

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RESULTS

Both groups had identical gender distribution (63.3% females, 36.7% males). The most common age group was 51-60 years (Group I: 43.3%, Group II: 50.0%), with mean ages of 49.57±8.58 (Group I) and 49.13±12.27 (Group II). Hypertension was the most common comorbidity (Group I: 13.3%, Group II: 10.0%), followed by diabetes mellitus. Trauma history was comparable (p=0.488). No significant differences were found between the groups (Table 1).

Table 1: Clinical Characteristics of Study Participants

	Group I		**Group II**	
	(without Cage)		**(with Cage)**	
	No	**Percentage**	**No**	**Percentage**
Gender				
Male	11	36.7	11	36.7
Female	19	63.3	19	63.3
Total	30	100%	30	100%
Age- Group				
20-30	0	0	3	10%
31-40	5	16.60%	5	16.60%
41-50	12	40.00%	7	23.30%
51-60	13	43.30%	15	50%
Total	30	100%	30	100%
Mean±SD	49.57±8.58		49.13±12.27	
Comorbidities				
COPD	1	3.30%	1	3.30%
DM	1	3.30%	3	10%
HTN	4	13.30%	3	10%
DM+HTN	1	3.30%	1	3.30%
History of trauma				
YES	4	13.30%	6	20.00%
NO	26	86.70%	24	80.00%
Total	30	100%	30	100%
Chi-square value	0.48			
p-value	p=0.488 NS			

Neurological deficits were observed in 23.3% of Group I and 30.0% of Group II, with no significant difference (p=0.559). Grade I listhesis was more common in Group I (70.0%) than in Group II (53.3%), while Grade II was more frequent in Group II (46.6%) than in Group I (30.0%), with no significant difference (p=0.534). However, the mean radiological grade was significantly higher in Group I (60.67±27.90) than in Group II (49.67±16.71) (p=0.043), indicating a notable difference (Table 2).

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Table 2: Comparison of Neurological Deficits and Radiological Grade of Listhesis Between Groups

	Group I (without Cage)		Group II (with Cage)		Chi-square value	p-value
	No	Percentage	No	Percentage		
Neurological deficits						
YES	7	23.30%	9	30%	0.341	p=0.55 NS
NO	23	76.70%	21	70%		
Total	30	100%	30	100%		
Radiological Grade of Listhesis						
Grade I	21	70.00%	16	53.30%	0.438	p=0.53 NS
Grade II	9	30.00%	14	46.60%		
Total	30	100%	30	100%		
Mean±SD	60.67±27.90		49.67±16.71		1.97	p=0.043 S

Group II had a significantly longer surgery duration (183.33±30.66 min) than Group I (129.33±43.70 min) ($p<0.0001$). Intraoperative blood loss was also higher in Group II (262.67±67.25 mL) than in Group I (206.67±35.26 mL) ($p<0.001$). However, postoperative blood loss, immobilization, and hospital stay were comparable between groups ($p>0.05$). Functionally, Group II showed superior recovery over time, with significantly higher mean scores at 4, 12, and 24 weeks ($p<0.05$). Radiological fusion was more frequent in Group II (80%) than in Group I (53.3%), with a higher absence of fusion in Group I (46.6%). Overall improvement was significantly greater in Group II (93.92±8.85) than in Group I (85.72±16.86) ($p=0.022$), indicating better outcomes with cage fixation (Table 3).

Table 3: Comparison of Intraoperative, Postoperative, and Functional Outcomes Between Groups

	Group I without Cage	Group II with Cage	Chi-square value	p-value
Mean Duration of Surgery				
Mean±SD	129.33±43.70	183.33±30.66	5.54	p<0.0001 S
Intraoperative				
Mean±SD	206.67±35.26	262.67±67.25	4.04	p<0.001 S
Post-operative				
Mean±SD	36.00±10.37	38.00±15.18	0.59	p=0.554 NS
Mean Post-Operative Immobilization				
Mean±SD	1.57±0.63	1.63±0.67	0.12	p=0.934 NS
Mean Post-Operative Stay in Hospital in Days				
Mean±SD	4.87±1.40	4.93±1.41	0.18	p=0.853 NS
Pre-Operative				
Mean±SD	5.66±0.92	5.89±1.02	0.39	p=0.582 NS
4 weeks				
Mean±SD	11.90±1.84	12.83±1.44	2.18	p=0.033 S
12 weeks				

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Mean±SD	13.03±1.88		13.90±0.66		2.38	p=0.021 S
24 weeks						
Mean±SD	13.70±1.53		14.66±0.48		3.29	p=0.002 S
Radiological Fusion						
Present	16	53.30%	24	80%		-
Absent	14	46.6	6	20%	3.98	
Total	30	100%	30	100%		
Mean Improvement Rate						
Mean ±SD	85.72±16.86		93.92±8.85		2.35	p=0.022 S

Group I, only 04(13.3%) patients were found complications like Dura Rupture 1(3.3%), Neuroprexia 1(3.3%), Pseudoarthrosis 1(3.3%) and Suture Line Infection 1(3.3%) in patients. Where as in Group II, 04(13.3%) patients were found complications like Foot Drop 1(3.3%), Bladder Incontinence 1(3.3%), Suture Line Infection 1(3.3%) and Unilateral Mydriasis 1(3.3%) in patients (Fig. 1).

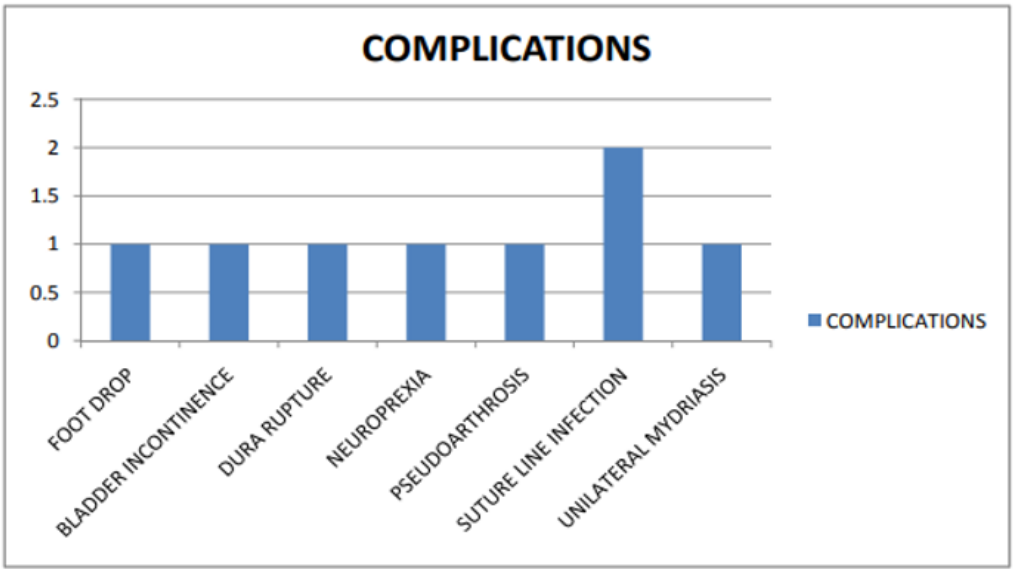

Fig. 1: Complications of the patients

DISCUSSION

Our study mainly focuses on the outcomes of these two interventions [6]. It discussed the differences in several crucial outcome parameters, including fusion rate, restoration of intervertebral disc height, reestablishment of midline sagittal alignment, clinical pain, functional disability improvements, operative time, and volume of blood loss indicative of operative efficiency, and the total number of complications. Fusion is one of the major parameters for surgical intervention in spinal surgery [7]. It is important because the higher fused rates of long-term stability provide better clinical outcomes. Bilateral Trans-Pedicular Fixation alone relies on posterolateral fusion, which brings small outcomes due to restored stability in cases where the direct fusion of the degenerated disc is impossible.

However, the addition of PLIF to the operative procedure creates a 360° bone fusion, which consists of disc excision, clean preparation using endplates, and insertion of the interbody bone graft-loaded cage. The inter-body adds not just to fusion rates but because biomechanical data and clinical series would deliver a much stronger biological and mechanical construct [6-8].

Another key outcome measure was found to be the restoration of disc height coupled with improvement in segmental lordosis. When Bilateral Trans-Pedicular Fixation is executed in isolation, the technique does not restore the disc space because it primarily focuses on stabilizing the posterior elements. On the other hand, PLIF directly targets the anterior column by providing structure to the intervertebral space through disc removal and the placement of a cage [6,7]. This procedure

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not only reinstates disc height but also can enhance segmental lordosis and thus improve the overall sagittal balance of the lumbar spine. This kind of surgical intervention is especially important in cases of degenerative conditions, where restoring and providing proper spinal alignment can reduce the risk of adjacent segment degeneration and chronic lower back pain [6,8].

Several studies focus on the outcomes of pain alleviation and functional disability. Both surgical techniques are well known for reducing pain and providing function and stability; however, while bilateral Trans-Pedicular Fixation alone can stabilize the motion in the vertebral column and reduce pain by limiting abnormal movement, it may be unable to provide more stability and outcome than a combined procedure with PLIF. Incorporation of PLIF tends to show more significant improvements in clinical outcomes, particularly over the long term thus promoting superior restoration of disc height and alignment. This indicates that although patients undergoing either procedure are likely to experience considerable relief from pain and disability, the patients receiving the interbody fusion, i.e. PLIF, may benefit further through improved spinal mobility and might also reduce the recurrence of symptoms, as found in several clinical studies [8-10]. Studies also show that operative time and blood loss vary significantly between the two approaches in surgical efficiency. BTPF alone is generally less invasive and involves fewer procedures and technical steps, which results in less operative time and reduced blood loss [9,10]. This is primarily a consequence of the lack of additional dissection, disc removal, and cage insertion required in PLIF. The combined method, by improving fusion rates and achieving better correction of vertebral stability, requires a more extensive surgical procedure. This leads to longer operative time and increased blood loss. These considerations during surgical intervention become particularly important in-patient populations for which stress reduction is vital [11-13].

The complication stands as a critical component in surgical decision-making. As BTPF alone provides no risk with manipulating disk space and cage migration, or it might even cause no neural injury during disk preparation. It is generally less complicated and riskier as compared to PLIF. Insertion of the interbody cage by removing the intervertebral disk increases risk and complexity during surgery. Thus, the following is a conventional BPTF that can be considered where disc space restoration is not required. Although the PLIF technique can cause risk, its overall outcome makes it a better choice for intervention [14-16].

Table 4: Comparison of Bilateral Transpedicular Fixation (BTPF) Alone vs. BTPF with PLIF for L4–L5 Instability [13-16]

Outcome Measure	BTPF Alone	BTPF with PLIF
Fusion Rate	Relies on posterolateral fusion; may be adequate but sometimes lower	360° fusion via interbody bone grafting yields a higher, more robust rate
Disc Height Restoration	Limited improvement (disc space not directly addressed)	Direct restoration of disc height with cage insertion
Sagittal Alignment	Minimal change in segmental lordosis	Better restoration of segmental and overall lumbar lordosis
Clinical Outcomes (Pain/Disability)	Provides effective stabilization and pain relief	Comparable pain relief; potential for improved long-term alignment benefits
Operative Time and Blood Loss	Generally shorter time and less blood loss	Increased time and blood loss due to disc removal and cage placement
Complication Rate	Lower risk related to disc space manipulation	Slightly higher risk (e.g. cage migration, subsidence) though overall rates are similar

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CONCLUSIONS

This study compared Bilateral Trans-Pedicular Fixation with and without PLIF in patients with L4-L5 instability. This randomised study conducted among 60 patients showed that while both procedures were effective, PLIF provided superior stability, better functional recovery, and higher radiological fusion rates (80% vs. 53.3%). However, it required longer surgery time and led to greater intraoperative blood loss. Postoperative complications were similar in both groups (13.3%). These findings suggest that PLIF is a more effective technique for patients with significant spinal instability, offering enhanced recovery and fusion, despite its increased surgical demands. Regular postoperative care and monitoring remain crucial for both procedures to minimize complications and ensure optimal recovery.

CONTRIBUTION OF AUTHORS

Research concept- Dr. Suman Dhar
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Data collection- Dr. Suman Dhar
Data analysis and interpretation- Dr. Suman Dhar
Literature search- Dr. Suman Dhar
Writing article- Dr. Suman Dhar
Critical review- Dr. Mangesh Panat, Dr. Muqtadeer Ansari
Article editing- Dr. Suman Dhar
Final approval- Dr. Mangesh Panat

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