

Management of lumbar spondylolisthesis: A retrospective analysis of posterior lumbar interbody fusion versus transforaminal lumbar interbody fusion

ABSTRACT

Background: One of the most frequent etiologies for spinal surgery is unstable lumbar spondylolisthesis (ULS). To decompress affected structures while maintaining or restoring stability through fusion, surgeons utilize a variety of procedures. When paired with interbody fusion, posterior fusion is most applied, resulting in greater fusion rates. The two most popular techniques for implementing spinal fusion are posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF). As a result, these two procedures have been assessed formally.

Methodology: A retrospective analysis of patients who underwent interbody fusion for lumbar stenosis through PLIF and minimally invasive (MI)-TLIF was performed. The patients were followed up for 24 months and fusion rates, Visual Analog Score (VAS), and Oswestry Disability Index (ODI) alongside the MacNab clinical outcome score, were assessed. The Bridwell interbody fusion grading system was used to evaluate fusion rates in computed tomography (CT).

Results: Operations were performed in 60 cases where patients suffered from ULS. PLIF was performed on 33 patients (55%) (14 males and 19 females) and 27 patients (45%) (11 males and 16 females) who underwent MI-TLIF. In 87% of our respective cohort, either the L4–5 or the L5–S1 level was operated on. Overall fusion rates were comparable between the two groups; however, the TLIF group improved more in terms of VAS, ODI, and MacNab scores. On average, MI-TLIF surgery was longer and resulted in reduced blood loss. MI-TLIF patients were more mobile than PLIF patients postoperatively.

Conclusion: With well-established adequate results in the literature, TLIF offers benefits over other methods used for interbody lumbar fusion in ULS or other diseases of the spine. However, MI-TLIF may procure more advantageous for patients if MI methods are implemented. In this instance, TLIF outperformed PLIF due to shorter operating times, less blood loss, faster ODI recovery, better MacNab scores, and a greater decline in VAS pain ratings.

Keywords: Lumbar stenosis, minimally invasive spine surgery, transforaminal lumbar interbody fusion, spondylolisthesis, transforaminal lumbar interbody fusion

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INTRODUCTION

Unstable lumbar spondylolisthesis (ULS) is one of the most common etiologies necessitating spinal surgery. There are numerous techniques employed by surgeons to decompress

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the neural structures while preserving or reinstating stability through fusion.

First method of spinal stenosis defined and categorized by a group of orthopedic surgeons in 1976 by Arnoldi *et al.*^[1] Other authors show that 3051 cases of patients admitted to the neurosurgery ward for spinal surgery were retrospectively analyzed.^[2] There are numerous techniques employed by surgeons to decompress the neural structures while preserving or reinstating stability through fusion. Posterolateral fusion is a commonly employed method with higher fusion rates when combined with interbody fusion. Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are the most used techniques for fusion. Narrowing of the central canal, lateral recess, or neural foramen in the lumbar vertebra is known as lumbar spinal stenosis (LSS). It is the most frequent indication for spinal surgery in adults over 65 despite the lack of a generally agreed diagnosis and radiological diagnostic criteria.^[3] The frequency of operation is also increasing, ranging from 1.7% to 13.1%.^[4] The registration of the frequency of pathology in Sweden reflects that, on average, spinal interventions are on the rise.^[5] Surgical interventions due to LSS have risen from 10–15/100,000 to 30–35/100,000 in a decade,^[5] and a threefold increase was observed in the previous decade.^[6]

Treatment of Lumbar stenosis (LS) varies significantly among patients. A comprehensive review was unable to put forth a recommendation for nonsurgical to conservative treatment for Grades I-II of spondylolisthesis (SL) and surgical Grades III-IV.^[7] There is a conundrum from the surgical perspective as well. Decompression alone, combined with fusion, number of levels, interbody fusion, and interspinous process spacer are known surgical modalities. The choice of surgical approach has become more complex with the introduction of minimally invasive spine surgery (MISS) techniques involving microscopes, tubular retractors, and endoscopic approaches. Interbody fusion itself presents with numerous options such as PLIF, TLIF (alongside minimally invasive-TLIF [MI-TLIF], oblique lumbar interbody fusion/anterior to psoas), lateral lumbar interbody fusion, and anterior lumbar interbody fusion.^[8]

When deciding on a course of management, other factors to consider are the etiology of the SL, the trauma sustained, and the symptoms of LSS precipitated by lumbar degenerative SL.^[3] The sliding of one vertebra over the other may result in compression of the spinal canal and/or roots and is typically precipitated by a fracture of the pars interarticularis. When grading SL, Meyerding's classification of slippage is most used (I: 25%, II: 26%–50%, III: 51%–75%, IV: 76%–100%, V:

>100% SL). While Grade I patients with Grade II SL are treated conservatively, Grade III and above are candidates for surgery. This necessity is apparent in patients with instability. There is yet again a conundrum about the treatment modality similar to LSS. However, ULS usually requires decompression and fusion. This approach has been further strengthened by combining posterior fusion with interbody fusion, which resulted in higher fusion rates, higher correction rates of deformity, stability of the correction, and improved clinical outcomes.^[9]

The most widely used techniques for lumbar interbody fusion due to its excellent clinical results and fusion rates are PLIF and TLIF.^[10] In this paper, we have retrospectively analyzed the results of patients treated for ULS through PLIF or MI-TLIF.

METHODOLOGY

A total of 60 patients between the dates of October 2018 and November 2020 were identified who underwent PLIF or MI-TLIF surgery for LS. Inclusion criteria were patients with Meyerding Grades I-III, single-level, and significant lower back and leg pain that is resistant to conservative treatment. Grades IV and V, multilevel instrumentation, concomitant spinal disorders (scoliosis, trauma, infection, and tumor), and osteoporotic patients were excluded. The Bridwell interbody fusion grading system was used to evaluate fusion rates in computed tomography (CT).

Demographic data, symptoms, radiological LS grade types, radiological fusion and instrumentation control, Visual Analogue Scale (VAS) score of lower back pain, and Oswestry Disability Index (ODI) were evaluated. The MacNab scale was used to assess the clinical outcomes and efficacy. Details of the surgical procedure are provided below.

Posterior lumbar interbody fusion

Following intubation under general anesthesia in the supine position, the patient was rolled over to the prone position on a Jackson spine frame. The iliac crest was raised with silicone rollers. A midline longitudinal incision was made after determining the correct level. The length of the incision depended on the depth of the subcutaneous fat and the thickness of the muscle plane. Paraspinal muscles were dissected off the spinous processes and lamina in the subperiosteal plane. A discectomy was performed posthemilaminectomies, where partial bilateral facetectomies were conducted when required, with complete violation avoided. The disc space was diverted on the introduction of the pedicle screws. Without harming the cortical endplates, the discectomy was continued until reaching the endplates

to create a bony surface. To remove any leftover cartilage from the endplates, curved and angled disc rongeurs were applied. Control was exerted on the matching nerve roots that exited and crossed over alongside a tester being first introduced into the disc space, after which the appropriate PLIF cages were bilaterally implanted with an autograft. Pre- and post-operative CT of a patient's spine is illustrated in Figure 1a and b.

Transforaminal lumbar interbody fusion

The MI-TLIF method employs a similar preparation and positioning of the patient to that of PLIF. The main difference is that of the exposure. An incision was made 1 cm lateral to the midpedicular line over the facet joint, where fluoroscopic guidance was useful in achieving this. A unilateral approach was employed through tubular retractors and a microscope was introduced to perform a unilateral facetectomy, laminotomy, and resection of the pars interarticularis. After achieving a clear visualization of the nerve root and thecal sac, a rigorous discectomy was performed until the endplates were free of cartilage tissue. The MI transpedicular screw was then implanted after repeating the identical PLIF trial and insertion procedures.

Radiological assessment was performed on direct anteroposterior and lateral X-rays to visualize the segment angle at the level of stabilization and adjacent segments [Figure 2]. CT was used to follow-up on the degree of fusion according to the Bridwell scale.

RESULTS

Operations were performed in 60 cases where patients suffered from LS. PLIF was performed on 33 patients (55%, of which 14 and 19 were male and female, respectively) and 27 patients (45%, of which 11 and 16 were male and female, respectively) who underwent MI-TLIF. In 87% of the patients, surgery was performed at the L4–5 or L5–S1 level [Table 1]. There were no postoperative issues and no reoperations performed.

Both methods were effective in lowering the VAS ratings, with the MI-TLIF group experiencing somewhat greater alleviation; however, this was not statistically significant. The results for ODI were comparable since MI-TLIF decreased at a faster rate [Table 2 and Figure 3]. After 24 months of follow-up, an assessment using the MacNab scale was conducted [Figure 4].

Patients who received PLIF were more likely to experience poorer outcomes than those who underwent MI-TLIF, and this difference was statistically significant. Although the lower back pain was lessened, hyperesthesia in the legs caused seven PLIF and two MI-TLIF patients to experience unsatisfactory outcomes, respectively, with discomfort while mobilizing profoundly [Table 3].

There was difference in the angle of postoperative lumbar lordosis for $29.1^\circ \pm 5.60^\circ$ and $37.3^\circ \pm 5.80^\circ$ for PLIF and TLIF, respectively. The Bridwell interbody fusion grading system was used to evaluate fusion rates in CT. No later than a year postoperatively, both surgical procedures demonstrated



Figure 1: (a) Preoperative sagittal computed tomography (CT) spine of the patient exhibiting profound unstable lumbar spondylolisthesis; (b) Postoperative sagittal CT spine of a patient displaying bilateral posterior lumbar interbody fusion cage implantation

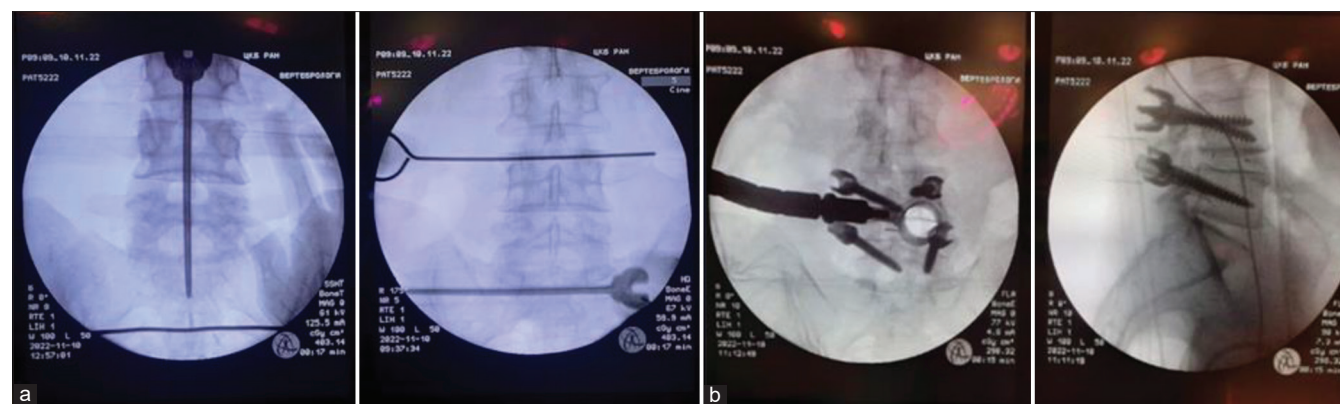


Figure 2: (a) Preoperative and (b) postoperative direct anteroposterior and lateral X-rays of a patient's spine to visualize the segment angle at the level of stabilization and adjacent segments, where (b) demonstrates bilateral minimally invasive transforaminal lumbar interbody fusion implantation

Table 1: Summary of patient demographics, grade of LS, and spinal level of intervention

Intervention	Meyerding's classification grade			Average $\pm$ SD age (years)	L1–2, L2–3	L3–4	L4–5	L5–S1
	I	II	III					
PLIF	17	11	5	53.4 $\pm$ 4.1	2	5	11	15
TLIF	18	8	1	49.7 $\pm$ 3.8	1	3	10	13

SD - Standard deviation; PLIF - Posterior lumbar interbody fusion; TLIF - Transforaminal lumbar interbody fusion; LS - Lumbar stenosis

Table 2: Summary of comparative results between transforaminal lumbar interbody fusion and posterior lumbar interbody fusion cohorts detailed in the study

Result	TLIF (%)	PLIF (%)
Good	84.6	63.8
Satisfactory	8.0	15.0
Unsatisfactory	7.4	21.2

PLIF - Posterior lumbar interbody fusion; TLIF - Transforaminal lumbar interbody fusion

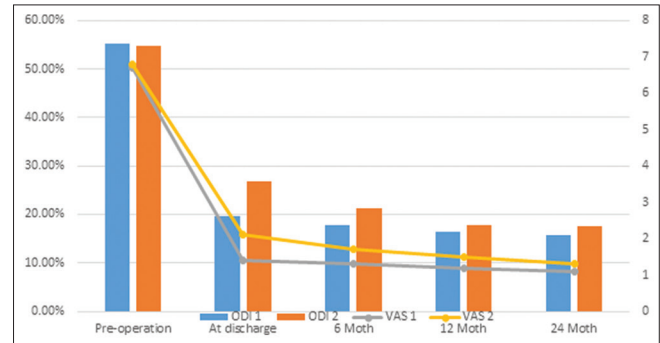
an average value of 89.3%. For PLIF, the average surgery time was 115.4 $\pm$ 16.5 min, while for MI-TLIF, it was 98.2 $\pm$ 12.5 min.

In comparison to the PLIF group, which saw an average blood loss of 315 $\pm$ 55.0 ml, the TLIF cohort experienced an average blood loss of just 75.7 $\pm$ 15.0 ml. In contrast to the TLIF cohort, which could mobilize approximately 8 h postoperatively, patients in the PLIF cohort were able to do so 1 day following surgery.

DISCUSSION

Many neurosurgeons and orthopedic surgeons still administer PLIF for spinal root decompression caused by a simple lumbar hernia or a vertebral disc displacement precipitated by aging or spinal trauma. When PLIF was first introduced by Cloward in the 1940s, the procedure revolutionized how interbody fusions were performed since it facilitated nerve root decompression while providing anterior stabilization. If not paired with posterior pedicle stabilization, substantial failure rates would ensue. The translaminal method, according to Harms and Rolinger, permitted anterior column fusion without the requirement for precise dural sac and nerve root traction, resulting in reduced blood loss than PLIF. With outstanding outcomes, these procedures remain the most popular when implementing lumbar interbody fusion.^[10] Interbody fusion also enables disc height to be maintained, allowing for the preservation of load-bearing capacity and anterior spine reconstruction postdisc removal.^[11-19]

We can determine that TLIF and MI-TLIF play a significant role in the principle of change in the techniques of spinal interventions for degenerative diseases. Role in the re-stabilization, fusion, and fixation of lumbar stenosis has proven to be more effective than conventional single-take surgery in these areas. It was

**Figure 3: Graphical representation of the VAS and Oswestry Disability Index scores exhibited in the transforaminal lumbar interbody fusion and posterior lumbar interbody fusion cohorts, denoted groups 1 and 2, respectively**

established that its development and application through the Wiltse technique would be adequate provided that the procedure is conducted in a brief period and that the blood loss is negligible in comparison to, or inferior to, PLIF. In turn, the intersomatic access is less significant for the traction of the bundle of vessels and nerves along the canal with higher levels of lumbar access, such as L2–L3, L1, and L2, which would account for minimal traction on the dural sac, minimizing paraspinal soft-tissue trauma. Patients in this study generally had satisfactory results with good fusion rates. However, MI-TLIF patients had greater improvement in VAS, ODI, and MacNab Scale scores. The Bridwell interbody fusion classification system was used to assess fusion rates in CT.

There may be a few reasons for this difference. However, this should not undermine the benefits of PLIF. It often offers the surgeon more comfort and requires fewer extra surgical apparatus alongside retractors. The increased exposure allows for easier access with clear visualization of the nerve roots and thecal sac while facilitating adequate and stable decompression. However, with an increasing trend toward MISS, the PLIF approach requires further dissection of the paravertebral muscles. As a result, patients may experience increased postoperative discomfort, which, if not effectively mitigated, might result in muscular atrophy. Retraction of the spinal level that may result in persistent postcompression radiculopathy is frequently necessary for the placement of the PLIF cage.^[20]

Our research is consistent with earlier investigations, for example, TLIF was statistically superior in terms of shorter

Table 3: Summary of Visual Analog Scale for lower back pain and Oswestry disability index for sustained disability in both posterior lumbar interbody fusion and transforaminal lumbar interbody fusion cohorts

	VAS			ODI			P
	Preoperative	Discharge	6 months	Preoperative	Discharge	6 months	
PLIF	6.8±1.7	2.1±1.4	1.3±1.0	54.7±6.8	26.7±4.4	17.6±1.4	<0.001
TLIF	6.7±1.9	1.4±1.1	1.1±0.8	55.2±6.9	19.6±4	15.7±1.3	<0.001

PLIF - Posterior lumbar interbody fusion; TLIF - Transforaminal lumbar interbody fusion; VAS - Visual analogue scale; ODI - Oswestry Disability Index.

Table 3 VAS AND ODI in patients TLIF VS PLIF REPRESENTATION PRE AND POST OPERATORY DISACHARGE

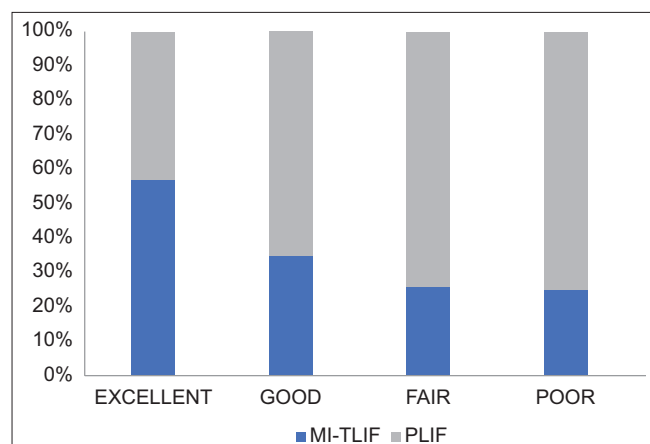


Figure 4: Graphical depiction of the MacNab Scale outcomes per the minimally invasive transforaminal lumbar interbody fusion and posterior lumbar interbody fusion cohorts. MI-TLIF - Minimally invasive transforaminal lumbar interbody fusion, PLIF - Posterior lumbar interbody fusion

operating time, reduced blood loss, and better postoperative VAS score and ODI, according to a meta-analysis of 16 trials comprising 1502 patients.^[20] There was no statistically significant difference in the fusion rates. However, the same study concluded that TLIF was superior to PLIF in the incidence of nerve root damage and dural tears. As previously noted, we necessitated a cautious approach to managing LS Grades I through II. However, after Grade III, it was decided to first assess the patients preoperatively and determine whether to perform surgery utilizing the aforementioned strategies to improve the patient's motor response to everyday activity.

CONCLUSION

A retrospective comparative observational study and the latest literature review on the topic and the data presented in this study lead to the conclusion:

1. This study has verified the advantage of TLIF versus PLIF according to previous studies in the existing literature
2. Stabilization following lumbar spinal decompression for LS is optimal in TLIF, MI-TLIF, and PLIF
3. Conservative therapies were effective in the first and second degrees of LS due to pain reduction. Grades III and IV of LS that exhibited instability were indicative of surgical intervention

4. Returning to physical activities with excellent mobility post-TLIF demonstrated superior psychomotor responses alongside a low rate of postoperative stress
5. In this study, we strongly recommend MI techniques for ULS for both the practicing surgeon and the patient.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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