Section: Orthopaedics

Original Research Article

COMPARING CLINICO-FUNCTIONAL OUTCOMES BETWEEN OPEN TRANSFORAMINAL LUMBAR INTERBODY FUSION (O-TLIF) AND MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION (MIS-TLIF) IN SURGICAL MANAGEMENT OF DEGENERATIVE SPINAL STENOSIS AND SPONDYLOLISTHESIS

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Received : 07/08/2025
Received in revised form : 19/09/2025
Accepted : 04/10/2025

Keywords:
Lumbar spinal stenosis, Degenerative spondylolisthesis, Open TLIF, MIS-TLIF, Functional outcomes.

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DOI: 10.47009/jamp.2025.7.5.155

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (5); 811-815

ABSTRACT

Background: Low back pain (LBP) is a leading cause of disability worldwide, often linked to degenerative lumbar spinal stenosis (DLSS) and degenerative lumbar spondylolisthesis (DLS). Transforaminal lumbar interbody fusion (TLIF) remains the standard surgical intervention when conservative measures fail. However, controversy persists between open TLIF (O-TLIF) and minimally invasive TLIF (MIS-TLIF) regarding optimal clinical outcomes. **Materials and Methods:** This prospective randomized controlled study included 60 patients (30 O-TLIF, 30 MIS-TLIF). Functional outcomes were measured using the Visual Analogue Scale (VAS), Oswestry Disability Index (ODI), and Roland-Morris Disability Questionnaire at baseline, 6 weeks, 3 months, and 6 months. Operative duration, radiation exposure, intraoperative blood loss, hospital stay, and complications were analyzed. **Result:** The mean operative time was significantly longer in MIS-TLIF (214.8 ± 17.6 mins) compared to O-TLIF (156.9 ± 18.0 mins). MIS-TLIF required significantly more fluoroscopic shots (55.0 ± 5.1 vs. 12.2 ± 3.1). Blood loss was substantially lower in MIS-TLIF (103.4 ± 19.4 ml) compared to O-TLIF (273.3 ± 37.6 ml). Hospital stay was shorter in MIS-TLIF (3.6 ± 1.0 days) than O-TLIF (5.2 ± 1.1 days). Both groups demonstrated statistically significant improvements in pain and disability scores ($p<0.0001$). **Conclusion:** MIS-TLIF offers advantages of reduced blood loss, shorter hospital stay, and faster functional recovery, though at the expense of longer operative time and higher radiation exposure. O-TLIF remains a valid and efficient option in selected cases.

INTRODUCTION

Low back discomfort is the second most common reason for individuals to seek medical assistance. Low back pain (LBP) is the most prevalent cause of disability among individuals under the age of 45. With the ongoing increase in life expectancy, there will be a corresponding rise in the occurrence of symptomatic spinal disease secondary to degenerative disc disorders, spinal stenosis and spondylolisthesis.[1] While lumbar stenosis may not pose a direct threat to one's life, it can result in persistent and debilitating pain, as well as significant limitations in physical activity. Prompt and precise diagnosis and treatment of lumbar stenosis at an early stage is crucial in maintaining the ability to engage in physical activities among the senior population.[2] Lumbar spinal stenosis is a gradual and deteriorating condition that results in the narrowing of the spinal canal, lateral recess, or neural foramina. It is categorized into two groups: congenital and acquired. The narrowing causes the compression of lumbosacral roots by either the bone canal or soft tissues such as the inter-vertebral disc, facet joints, and ligamentum flavum. The narrowing of the spinal canal leads to axial lumbar discomfort, radicular pain, and cauda-equina syndrome when the thecal sac and

nerve roots get significantly compressed.[2] Degenerative Lumbar Spondylolisthesis (DLS) represents a prevalent spinal disorder characterized by the anterior displacement of the vertebra above the vertebra below, leading to compression of the thecal sac as well as spinal nerves in the involved spinal segment. These symptoms may include discomfort, loss of sensation, and reduced strength in the lower limbs.[3] Newman originally described degenerative spondylolisthesis in 1955.[4] Previous explanations distinguished this disorder from those induced by a pars interarticularis defect. In 1930, Junghanns coined the term "Pseudospondylolisthesis". In his analysis of anatomical specimens from Schmorl's collection, he identified the presence of an undamaged posterior element. Nevertheless, this phrase caused some ambiguity, as there is definitely a genuine spondylolisthesis present in this disease. Therefore, MacNab, in 1950, employed the term "spondylolisthesis with an intact neural arch". Wiltse et al. developed a widely acknowledged categorization of spondylolisthesis, which is based on its causes. Degenerative spondylolisthesis is one of the five components of this system.[5] Management of lumbar spinal stenosis and spondylolisthesis includes activity modifications, analgesics, physiotherapy, nerve root block, epidural steroid and surgery. Surgical management ranges from decompression surgeries to fusion surgeries. A range of interbody fusion procedures have been utilized in the lumbar spine to enhance fusion rates, preserve vertebral alignment, regain stability, and restore disk space height. The surgical treatment of degenerative spondylolisthesis has been a subject of debate and disagreement. Historical authors advocated for decompression as the sole treatment, deeming stabilizing operations following laminectomy as superfluous.[6] The Open Transforaminal Lumbar Interbody Fusion (Open-TLIF) procedure was initially described by Harms and Rolinger in 1982. The Open Transforaminal Lumbar Interbody Fusion procedure enables a complete fusion with a single approach from the back and has been successfully performed for several years. Nevertheless, some recent investigations have documented the detrimental consequences of the substantial muscle dissection and retraction that are necessary for typical Open-TLIF treatments.[7] In addition, standard open exposures for lumbar fusion have been associated with extended hospital stays and substantial expenses. Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS-TLIF) is a recently developed procedure that aims to minimize tissue damage to the muscles in the back, particularly the multifidus, and preserve the structures in the middle of the spine. Furthermore, it provides the added benefits of reduced incision size, decreased blood loss, shorter hospitalization, quicker recuperation after surgery, earlier resumption of work, and consequently improved functional outcomes.[8]

Aim & Objectives of the Study

To compare the Clinico-Functional outcome between Open TLIF and MIS - TLIF in the surgical management of Degenerative Lumbar Spinal Stenosis (DLSS) and Degenerative Lumbar Spondylolisthesis (DLS).

1. To compare certain parameters including surgical duration, quantity of C-arm exposure, blood loss, hospital stay between the two procedures.
2. To compare the incidence of complications, compare the functional outcome between the two procedures.

MATERIALS AND METHODS

Study Design and Duration: Prospective randomized controlled trial conducted from January 2023 to August 2024 at the Department of Orthopaedics, Trichy SRM Medical College Hospital & Research Centre.

Study Population: Sixty patients presenting with chronic low back pain with/without radiculopathy, refractory to at least 6 weeks of conservative therapy, were enrolled.

Inclusion Criteria

- Age 31–70 years
- DLSS with/without disc prolapse
- Grade I or II DLS with chronic pain and/or radiculopathy
- Failure of conservative management

Exclusion Criteria

- Severe comorbidities precluding anesthesia
- Spinal tumors or metastasis
- Spinal tuberculosis under active treatment
- Non-degenerative causes of stenosis or listhesis

Randomization: Patients were randomized equally into two groups: O-TLIF (n=30) and MIS-TLIF (n=30).

Evaluation Criteria: Functional and clinical outcomes were assessed using:

- VAS (Visual Analogue Scale) for pain
- ODI (Oswestry Disability Index)
- Roland-Morris Disability Questionnaire

Assessments were performed preoperatively, and at 6 weeks, 3 months, and 6 months postoperatively.

Operative and Post-operative Parameters

- Duration of surgery (minutes)
- Intraoperative blood loss (ml)
- Radiation exposure (C-arm shots)
- Length of hospital stay (days)
- Complications

Statistical Analysis: Data were analyzed using SPSS v26. Continuous variables were compared using independent t-tests, categorical variables with Chi-square/Fisher's exact test. Kaplan–Meier survival analysis estimated functional improvement timelines. Significance was set at $p<0.05$.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

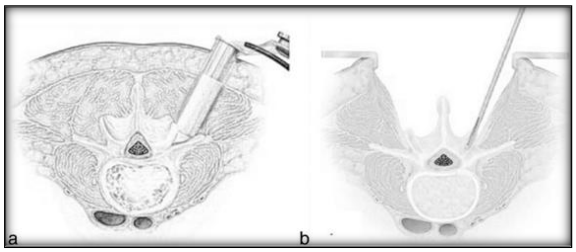

Figure 1: A. MIS-TLIF. B. Open-TLIF.20

Positioning and Preparation

Figure 2: (a) Positioning of the patient (left) & (b) Parts painted and draped(right)

Instruments

Figure 3: Pedicle screws for (a) Open-TLIF and (b) MIS-TLIF

Figure 4: (a) Sleeves used in MIS-TLIF (b) Bone Graft Funnel

Intra Op Images

Figure 5: Dissection and pedicle screw and rod fixation in Open-TLIF

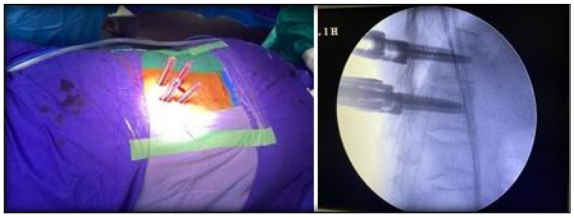

Figure 6: Pedicle screw fixation in MIS-TLIF and C-arm images

RESULTS

Patient Demographics

Baseline demographic characteristics were comparable between the two groups [Table 1].

Table 1: Demographic Profile of Patients

Parameter	O-TLIF (n=30)	MIS-TLIF (n=30)
Mean Age (years)	55 ± 13.1	51 ± 13.7
Male: Female	18:12	17:13
Duration of Symptoms (months)	12.3 ± 3.5	11.9 ± 3.8

Operative Parameters

Table 2: Comparison of Operative Parameters

Parameter	O-TLIF (Mean ± SD)	MIS-TLIF (Mean ± SD)
Duration of Surgery (mins)	156.9 ± 18.0	214.8 ± 17.6
Radiation Exposure (shots)	12.2 ± 3.1	55.0 ± 5.1
Blood Loss (ml)	273.3 ± 37.6	103.4 ± 19.4
Hospital Stay (days)	5.2 ± 1.1	3.6 ± 1.0

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Figure 7: L4-L5 Degenerative spondylolisthesis with Left radiculopathy, Procedure done : L4-L5Open TLIF a)Pre op X-ray (left) , b)Pre-OP MRI (mid saggital), c)Post op X-ray AP/LAT view, d)post op follow up at 3 months e) post op follow up at 6 months.

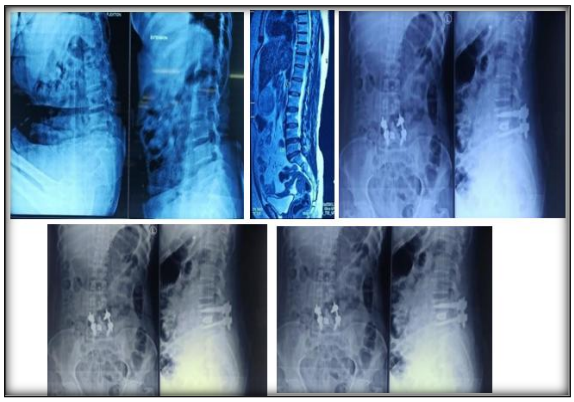

Figure 8: L4-L5 Degenerative lumbar spinal stenosis, Procedure done: L4-L5 MIS TLIF a) Pre op X-ray (left), b) Pre-OP MRI (mid saggital), c) Post op X-ray AP/LAT view, d) post op follow up at 3 months e) post op follow up at 6months

DISCUSSION

Individuals suffering from symptomatic Degenerative Spinal Stenosis as well as low grade spondylolisthesis are commonly managed with the combination of nerve root decompression or spinal fusion. The traditional approach for decompression and fusion is the gold standard, however, there is an increasing trend towards using minimally invasive methods. Nevertheless, there is a dearth of rigorous studies directly comparing these two procedures to determine their respective benefits and specific circumstances in which one method should be employed. The present investigation incorporates clinical, safety, and radiological measures to assess the efficacy of minimally invasive decompression and fusion (MIS-TLIF) compared to the conventional open approach (Open-TLIF).[9-15]

Age Distribution: In our study, mean (SD) age of MIS-TLIF group was 51(13.72) and Open-TLIF group was 55(13.16). Previous study by Roclawski et al,[19] showed mean (range) age of 61.1 (46-78) in O-TLIF group and 63.4 (39-79) in MIS-TLIF group. Another study by David et al. showed a mean (SD) age of 56.5 (15.7) in Open-TLIF group and 54.4 (13.8) in MIS-TLIF group.

Gender Distribution: In our study, there were 26.67% males and 73.33% females. This was similar to previous study by Roclawski et al which showed 33.33% males and 66.67% females in Open TLIF group and 27.27% males and 72.72% females in MIS-TLIF group.[16-19] Another study by David et al,[15] showed 53% females in Open-TLIF group and 50% females in MIS-TLIF group.

Diagnosis: In our study, among MIS-TLIF group, 20(66.67%) had Degenerative Lumbar Spinal Stenosis and 10 (33.33%) had Degenerative Spondylolisthesis. Among Open-TLIF group, 19 (63.34%) had Degenerative Lumbar Spinal Stenosis and 11 (36.66%) had Degenerative Spondylolisthesis. Previous study by Roclawski et al,[19] showed primary Degenerative Spondylosis in 67% and DS revision after previous decompression in 33% patients in Open TLIF group and primary Degenerative Spondylosis in 73% and DS revision after previous decompression in 27% patients in MIS-TLIF group. Another study by David et al,[11] showed spondylolisthesis in 33%, Lumbar Spinal Stenosis in 45%, degenerative disc disease in 2%, facet arthropathy in 1% and pars defect in 2% patients in Open-TLIF group and spondylolisthesis in 41%, lumbar spinal stenosis in 27%, degenerative disc disease in 30% and facet arthropathy in 1% patients in MIS-TLIF group.

Duration of Surgery: In our study, mean (SD) duration of surgery was 214.77 mins (17.58) in MIS-TLIF group and 156.93 mins (17.97) in Open-TLIF group. Open-TLIF duration of surgery was significantly ($p < 0.0001$) lower than MIS-TLIF. Previous study by Roclawski et al,[19] showed mean procedure time of 110 mins in Open-TLIF group and 117 mins in MIS-TLIF group. Another study by David et al showed a mean (SD) 247 (93) mins in Open-TLIF group and 240 (75) mins in MIS-TLIF group.

Fluoroscopic shots: In our study, mean (SD) number of fluoroscopic shots were 55 (5.10) in MIS-TLIF group and 12.17 (3.06) in Open-TLIF group. Open-TLIF number of fluoroscopic shots were significantly ($p<0.0001$) lower than MIS-TLIF. In a study by Kulkarni et al.10, the mean (range) fluoroscopic shots required were 8.2 (5-18) in Open-TLIF group and 57.77 (44-96) in MIS TLIF group.

Amount of blood loss: In our study, mean (SD) amount of blood loss was 103.40 ml (19.35) in MIS-TLIF group and 273.30 ml (37.55) in Open-TLIF group. Open-TLIF amount of blood loss was significantly ($p<0.0001$) higher than MIS-TLIF. Previous study by Roclawski et al,[19] showed mean blood loss of 450 ml in Open-TLIF group and 170 ml in MIS-TLIF group. Another study by David et al.72 showed a mean (SD) blood loss of 499 (431) ml in Open-TLIF group and 197 (223) ml in MIS-TLIF group.

Duration of hospital stay: In our study, mean (SD) duration of hospital stay was 3.60 days (1.04) in MIS-

ISSN (O): 2687-5365; ISSN (P): 2753-6556

TLIF group and 5.20 days (1.10) in Open-TLIF group. Open-TLIF duration of hospital stay was significantly ($p<0.0001$) higher than MIS-TLIF. Previous study by Roclawski et al,[19] showed mean hospital stay of 3.7 days in Open-TLIF group and 2.1 days in MIS-TLIF group. Another study by David et al showed a mean (SD) hospital stay of 3.6 (1.4) days in Open-TLIF group and 2.7 (1.5) days in MIS-TLIF group.

Complications: In our study, among MIS-TLIF group, radiculopathy was seen in 3(10%) patients and transient sciatica was seen in 1 (3.33%) patient. Among Open-TLIF group, dural tear was seen in 2 (6.67%) patients, radiculopathy was seen in 1 (3.33%) patients and superficial wound infection was seen in 3 (10%) patients. Previous study by Roclawski et al,[19] showed incidental durotomy in 4%, transient sciatica in 4%, hematoma in 4% and superficial wound infection in 12.5% in Open-TLIF group and transient sciatica in 9%, improper implant position in 4.5% and cage subsidence in 9% in MIS-TLIF group.[20]

CONCLUSION

Overall, MIS (Minimally Invasive Surgery) offers several benefits compared to the Open-TLIF (Open Transforaminal Lumbar Interbody Fusion) procedure. These advantages include decreased blood loss, shorter hospital stays, reduced complications, improved pain relief, and better outcomes in terms of Rolland-Morris score and Oswestry low back disability questionnaire (ODI score). However duration of surgery and number of fluoroscopic shots required were significantly lower in Open-TLIF group. The use of O-arm navigation could have a significant reduction in radiation exposure and duration of surgery compared to conventional C-arm in performing of MIS-TLIF.

When deciding between MIS-TLIF and Open-TLIF for treating Degenerative Lumbar Spinal Stenosis and Degenerative Spondylolisthesis, clinicians should take into account patient considerations and the expertise of the surgeon. Further research is required to include a bigger sample size of patients and extend the duration of the follow-up period, in order to enhance the credibility and validity of the study.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556