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Research Article

Long-term Functional and Radiological Outcome of Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF) in Lumbar Degenerative Diseases: A Retrospective Study in 110 Patients

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Abstract

Materials and Methods: This retrospective study evaluated 110 patients who underwent minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) from 2014 to 2022. Inclusion criteria involved patients with chronic back and leg pain for over six weeks unresponsive to conservative treatments, including one or two-level lumbar canal stenosis or spondylolisthesis. Exclusion criteria comprised previous spinal surgeries, traumatic injuries, tumors, and poor-quality imaging. Preoperative evaluations included neurological assessments and imaging, such as static and dynamic radiographs and MRIs. Outcomes were measured based on estimated blood loss, length of hospital stay, operative time, complications, Visual Analog Scale (VAS) scores, and Oswestry Disability Index (ODI) scores. Statistical analysis utilized SPSS, with significance set at $p < 0.05$.

Results: The cohort (mean age 53.34 ± 10.6 years) included 68 patients undergoing single-level and 42 double-level MIS TLIF. The average operative time was 137 ± 22.5 minutes, estimated blood loss averaged 137 ± 39 mL, and hospital stay was 4 ± 0.8 days. Complications were reported in 12 patients (10.9%), including cage back-out (3), adjacent level disease (2), and other minor complications. Clinical outcomes revealed significant improvement, with VAS scores decreasing from 7.7 ± 0.8 preoperatively to 2.7 ± 0.7 postoperatively ($p < 0.0008$). ODI scores improved from 48 ± 6.14 to 22 ± 3.7 ($p < 0.0007$). Postoperative lumbar lordosis and pelvic incidence remained stable.

Conclusion: MIS TLIF demonstrates efficacy as a surgical intervention for lumbar degenerative diseases, delivering positive long-term functional and radiological outcomes. The technique is associated with lower perioperative morbidity, shorter hospital stays, and substantial pain relief with significant improvement in VAS and ODI scores. These results endorse MIS TLIF as a preferred alternative to traditional open surgery in suitable patient populations.

Keywords: MIS TLIF; Lumbar degenerative disease; Minimally invasive surgery; Functional outcomes; Radiological outcomes

Introduction

Degenerative lumbar spine disease is a leading cause of disability worldwide. It includes conditions such as disc degeneration, lumbar canal stenosis, and spondylolisthesis [1]. Over 266 million people suffer from degenerative disc disease worldwide and 69 million people suffer in south-east Asia with the highest in number [1]. Transforaminal lumbar interbody fusion is commonly

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done surgery in degenerative lumbar spine disease providing fusion, decompression of the normal vertebrae, and stability [2]. There are various surgical methods available for lumbar spine fusion, which include posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), minimally invasive transforaminal lumbar interbody fusion (MI-TLIF), oblique lumbar interbody fusion/anterior to psoas (OLIF/ATP), lateral lumbar interbody fusion (LLIF) and anterior lumbar interbody fusion (ALIF) [3]. A traditionally posterior approach is used for interbody fusion, however, a minimally invasive approach is becoming popular to reduce incision-related complications and cosmetically better. The minimally invasive approach has the same indication as an open approach in patients with failed medical and physical therapy in the management of degenerative spine diseases. The minimally invasive technique has an advantage over an open approach by having smaller incisions with less injury to paraspinal muscles and ligaments leading to better outcomes. In this study, we have conducted a retrospective study, showing the functional and clinical outcomes of 110 patients who underwent minimally invasive transforaminal lumbar interbody fusion.

Materials and Method

Consecutive 110 patients underwent minimally invasive transforaminal interbody fusion between a period of 2014 and 2022 in this retrospective analytical study. Inclusion criteria were back pain and leg pain for a minimum period of 6 weeks, which did not respond to the conservative treatment. All had one or two-level lumbar canal stenosis or spondylolisthesis. Exclusion criteria included more than two level involvement, previous spinal instrumentation, traumatic spine, cases of spine tumours, and lack of clear lateral lumbosacral X-ray on three different occasions, or poor-quality X-ray films. A preoperative evaluation was done in all patients with detailed neurological examination and radiological imaging. Static (anterior-posterior and lateral view) and dynamic (flexion and extension) radiographs of the lumbar spine were done. MRI was performed with T1, T2, and STIR images in all patients. Indications of the surgery were degenerate disc prolapse, spinal canal stenosis requiring decompression, recurrent prolapsed disc, and symptomatic spondylolisthesis (Grade 1 and 2). Estimated blood loss, hospital length of stay, operative time, surgical complications, revisions were observed. Visual analogue score (VAS) and Oswestry disability index (ODI) were used to observe the functional outcome of the patient.

Operative technique

Under general anaesthesia, patients were positioned in a prone (facedown) position on an X-ray-compatible table. Guided by real-time fluoroscopic imaging, the surgeon identified specific anatomical landmarks like the pedicles and spinous processes. Subsequently, two small incisions, typically measuring 2-3 centimetres in length and positioned about 4-5 centimetres away from the spine's midline, were made on the patient's back to access the spinal area. To locate the facet joints that required fusion, thin, rigid wires known as K-wires were employed. Following this, a sequential dilatation process was used to create a pathway to the surgical site. A tubular retractor was then placed over the facet joint, acting as a minimally invasive tunnel to reach the spine (Figure 1). The next step involved removing the inferior facet joint to make room for further decompression. This facet joint removal was a fundamental aspect of the procedure. Subsequently, foraminal decompression was carried out to relieve pressure on nerve roots as they exited the spinal column through small openings known as foramina. A discectomy was then performed, involving the removal of the intervertebral disc situated between the vertebrae earmarked for fusion (Figure 2). This created space for inserting a cage filled with bone graft material, which served to maintain the correct disc height and provide structural support. To secure the fused spinal segment, percutaneous pedicle screws were inserted. These screws were guided into place using fluoroscopy and were introduced through guide wires positioned over Jamshidi needles (Figure 3). Throughout the entire procedure, a standard minimally invasive technique was employed, characterized by the use of smaller incisions, minimal tissue disruption, and specialized instruments guided by real-time imaging. The ultimate goal of this procedure was to achieve spinal fusion while alleviating symptoms associated with spinal conditions such as herniated discs or spinal instability. It aimed to stabilize the affected spinal segment, decompress nerve roots, and alleviate pain and neurological symptoms. The described steps aligned with the approach commonly used in minimally invasive spine surgery (Figure 4).

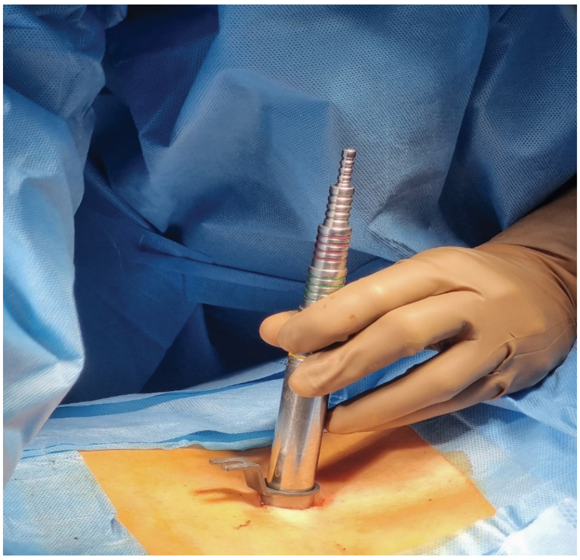

Figure 1: Tubular Retractor placed after confirming the Level.

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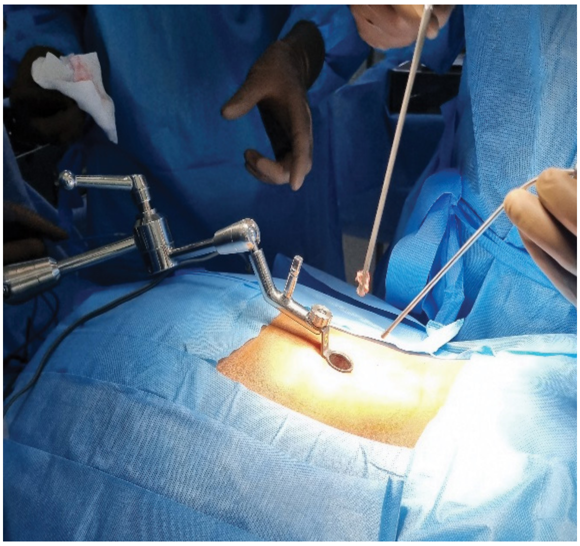

Figure 2: Facetectomy, Decompression, Discectomy.

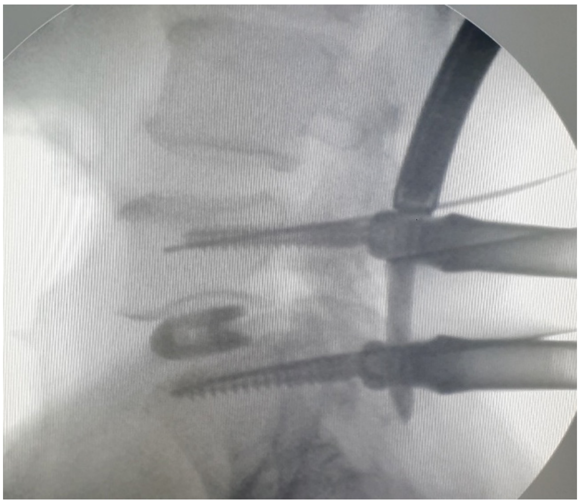

Figure 3: Fixing MIS Pedical screws over wire, Cage insertion and MIS-Rod fixation.

Figure 4: Incision site.

Radiological methods

A single observer conducted measurements of sagittal plane parameters based on lumbosacral radiographs that were acquired at three specific time points: before the surgical procedure, immediately after the surgery, and during the final follow-up. The assessment encompassed the following key parameters: Pelvic Incidence: This metric was determined by measuring the angle formed by two lines. The first line extended from the midpoint of the upper sacral endplate to the hip axis, while the second line was drawn perpendicular to the upper sacral endplate. The measurement of pelvic incidence played a critical role in evaluating pelvic alignment and spinal balance. Lumbar Lordosis: Lumbar lordosis was defined as the angle formed between the upper endplate of the L1 vertebra and the upper endplate of the sacrum. Manual measurement using the Cobb's angle method was employed for this purpose. Lumbar lordosis provided valuable insights into the curvature of the lumbar spine. For the purpose of data analysis, the research team utilized the statistical software SPSS (version 12, Chicago, Illinois). SPSS was a well-established tool for conducting statistical analyses and managing data. To assess the statistical significance of observed differences in the measured parameters, a significance threshold was set using the P-value, which was fixed at 0.05. When the P-value fell below 0.05, it indicated statistical significance, signifying meaningful variations within the data.

Outcome assessment

The patient's pain levels and their ability to function were evaluated through quantitative methods, which included a pain scale and the Oswestry Disability Index (ODI) score. The Visual Analog Scale (VAS) was used to measure the intensity of pain. Patients marked their pain level on a horizontal line ranging from 1 to 10, with 0 indicating "no pain" and 10 representing "very severe pain." This allowed for a numeric representation of the patient's pain intensity. The ODI score, on the other hand, was determined using the Oswestry Low Back Pain Disability Questionnaire. This questionnaire is designed to assess the extent of disability associated with low back pain. The ODI score is categorized as follows:0-20%: Indicating minimal disability, 20-40%: Reflecting moderate disability,40-60%: Signifying severe disability, 60-80%: Characterizing a crippled state, 80-100%: Representing being bed-bound.

Results

In this study, 110 patients were studied among which 54 were male and 56 were female. The average of the patient was 53.34±10.6 years. 68 patients underwent single level, 42 patients double level, and 2 patients three level MIS-TLIF. The average follow-up was 53.69±36.4 months (Table 1).

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Table 1: Number of patients with Age, Sex, follow-up and numbers of Single and double level MIS-TLIF.

Number of patients(n)	**110**
Average age	53.34±10.6
Male/Female	54/56
Average follow-ups (months)	53.69±36.4
Single level TLIF	
L1-l2	0
L2-l3	0
L3-l4	0
L4-l5	43
L5-S1	25
Total	**68**
Double level TLIF	
L1-L2, L2-L3	0
L2-L3, L3-L4	0
L3-L4, L4-L5	19
L4-L5, L5-S1	23
Total	**42**

The average operative time was 137±22.5 min; however, the average time for single and double levels were 126±10.6 and 156±24 respectively. The average estimated blood loss was 137±39; however, average blood loss for single level and double level were 111±19.5 ml and 180.22 ml respectively. The average length of stay in the hospital was 4±0.8; however, the average hospital stay for single level and double level were 3.6±0.5 and 4.8±0.7 respectively (Table-2) (chart-1).

In this study, we encountered, a total of 12(10.9%) patients who had intra-operative and post-operative complications. There were 2(1.8%) patients with adjacent level disc disease, 3(2.7%) patients had cage back-out, and one patient (1.1%) each had hematoma, infection, persistent numbness, and radicular symptoms. One patient (1.1%) had a Root sleeve injury intraoperatively (Figure 5). One patient (1.1%) had S1 screw breakage post-operatively which was managed with open surgery, removal, and insertion of a new screw (Figure-6). Three (2.7%) patients had back-out of the interbody cage (Figure-7), out of which one was treated conservatively without any further sequel. One out of three patients had mild weakness of the foot on the affected side, which was managed with revision surgery by removal of the cage, had recovered at the end of three months. One patient had postoperative hematoma, developed severe radicular pain, and decreased power on the ipsilateral ankle post-operatively. It was diagnosed on MRI and was treated with drainage of hematoma. Radicular pain and ankle weakness were improved on a month's follow-up. In this series 5 (4.5%) patients required revision surgery (Table-3).

Table 2: Number of average operative time, estimated blood loss and hospital stay according to single and double level involvement.

Operation time (min)	137±22.5
Single level	126±10.6
Double Level	156±24
Estimated blood loss (ml)	137±39
Single level	111±19.5
Double level	180±22
Hospital stay (days)	4±0.8
Single level	3.6±0.5
Double level	4.8±0.7

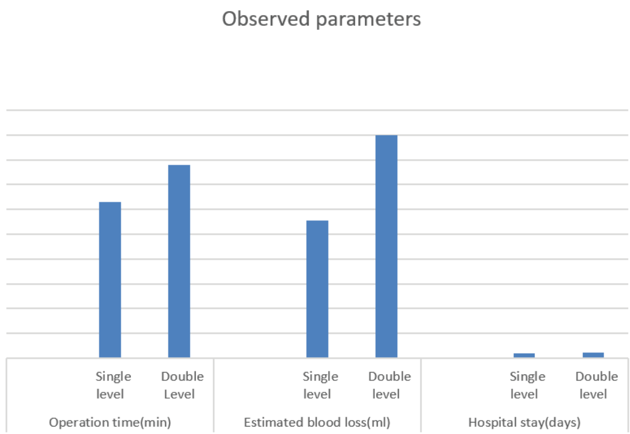

Chart 1: Observed Parameters

Table 3: Complications of MIS-TLIF

		Percentages
Total no	12	10.9%
Cage back-out	3	2.7%
Adjacent level disease	2	1.8%
Hematoma	1	1.1%
Infection	1	1.1%
Persistent numbness	1	1.1%
Radicular symptoms	1	1.1%
Root sleeve injury	1	1.1%
Screw breakage	1	1.1%
Screw loosening	1	1.1%
Revision required	5	4.5%

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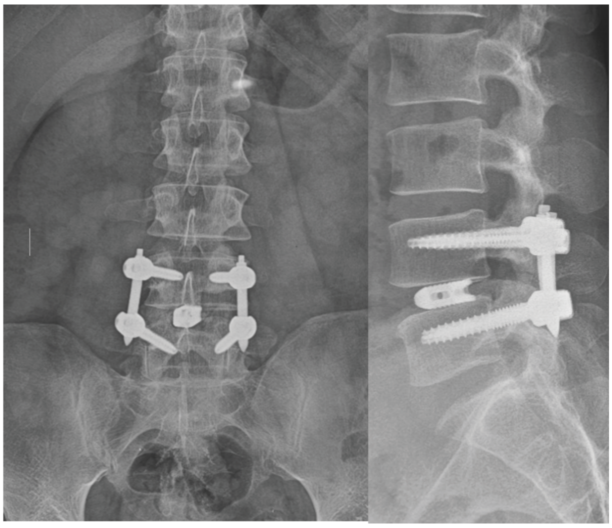

Figure 5: Post-operative Radiograph of MIS-TLIF fixation.

Regarding clinical outcome VAS score pre-operatively was 7.7±0.8 which improved significantly postoperatively to 2.7±0.7 (p value<0.0008 paired t-test). ODI score Pre-operatively was 24±5.4 which improved significantly postoperatively to 19±5.6 (p value<0.0007 paired t-test). Both VAS and ODI scores were improved on the final follow-up (p-value<0.05) (Table 4).

Regarding radiological outcomes, preoperative lordosis was 50±9.6, which was improved significantly postoperatively 52±7.4 (p value=0.01, paired t-test), which was maintained on final follow-up (p-value>0.05). The average pelvic incidence was 51±4.5 Pre-operatively, which was maintained Post-operatively, and the final follow-up was 50±5.9 (p-value 0.11, paired t-test) and 50±6 (p-value 0.08, paired t-test) respectively (Table 4).

Table 4: preoperative, postoperative, and final follow-up clinical VAS and ODI scores; and radiological parameters using lumbar lordosis, pelvic incidence, in MIS-TLIF.

		MIS TLIF	i value
VAS	Pre-op	7.7±0.8	
	Post-op	2.7±0.7	0.0001
	Final FU	1.3±0.4	0.0008
ODI	Pre-op	48±6.14	
	Post-op	22±3.7	0.0001
	Final FU	20±3	0.0007
Lumbar lordosis	Pre-op	50±9.6	
	Pot-op	52±7.4	0.01
	Final FU	51±8	>0.05
Pelvic incidence	Pre-op	51±4.5	
	Post-op	50±5.9	0.11
	Final FU	50±6	0.08

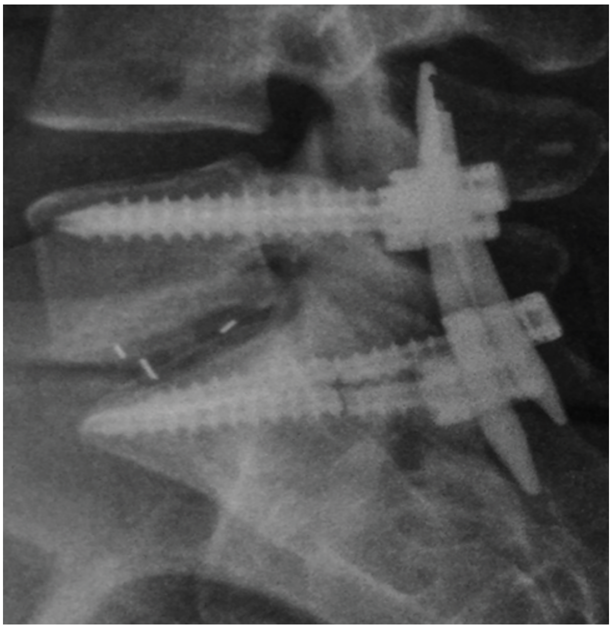

Figure 6: S1 screw breakage.

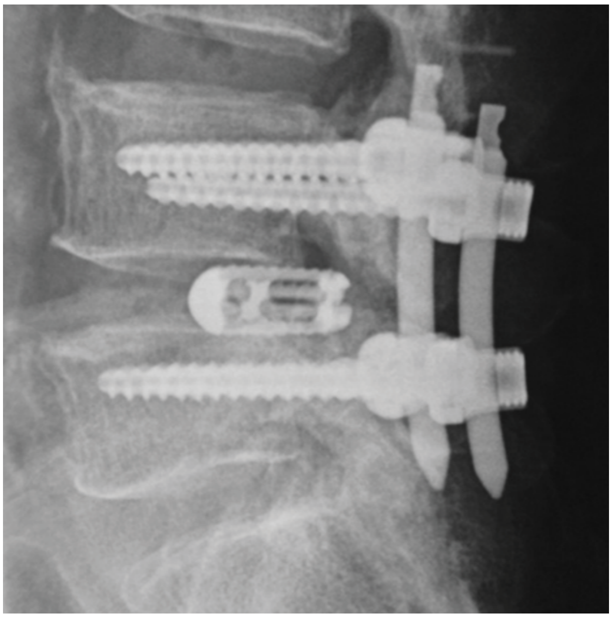

Figure 7: Cage Backout.

Discussion

Lumbar degenerative spine disease is a very commonly encountered disease in spine surgery practice affecting elderly individuals. They mainly present with lower back pain, sciatica, or in severe cases cauda equine syndrome in delayed presentation.[4] Transforaminal lumbar interbody fusion (TLIF) is a surgical approach for lumbar degenerative disease. Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) was first introduced by Floey et al. [5]. MIS-TLIF is advantageous compared to Open TLIF by decreasing blood loss and injury to paraspinal muscles and

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soft tissues leading to faster recovery [5]. Conventional open TLIF which causes atrophy of multifidus muscle leads to disability and increased biomechanical strain on adjacent levels. It also increases fibrosis, which can cause postoperative radiculopathy. However, in this present study, we did not observe any residual pain, weakness in back muscles, or post-operative radiculopathy [6].

Spinopelvic parameters are important in terms of maintaining the pelvis balanced. Pelvic incidence (PI) is the mathematical summation of pelvic tilt and sacral slope. One of the major goals while performing MIS-TLIF surgery is to maintain these spinopelvic parameters to keep the pelvis balanced while stranding from sitting and also during walking [7]. In this study, we were able to maintain the pelvic incidence post-operatively (p value-0.11) and on follow-up (0.08). Kepler et al. [8] showed that failure to achieve appropriate lumbar lordosis leads to greater local stress and eventual aggravation of lower back discomfort and lower back pain leading to poor clinical outcomes [8]. In this study, we were able to restore the normal lumbar lordosis and it was maintained on postoperative follow-up (p value>0.05).

The major disadvantages of open TLIF are soft tissue and extensive muscle damage due to retraction, increased blood loss, and increased post-operative pain and hospital stay [9]. Hammad et al. [10] in their meta-analysis of 194 articles of MIS-TLIF showed significantly less blood loss, hospital stay, and improvement in VAS and ODI scores, which are comparable with our findings (p-value <0.05) [9,10]. Due to the minimally invasive approach there was minimal soft tissue and muscle damage, and limited facetectomy and osteotomy were carried out, which prevented post-operative blood transfusion and early ambulation. All patients were mobilized on the first postoperative day with the help of a walker and independent walking with minimal support on the second postoperative day. On average, on the fourth postoperative day, patients were discharged and they were advised to regain their normal day-to-day activity as soon as possible.

The reported incidence of complications in MIS-TLIF surgery ranges from 11% to 31%, in our study it was relatable (10.9%) [11]. Operative time of more than 105 min, durotomy, more radiation, cage back out, technically demanding procedure, and steep learning curve, which are narrated in different kinds of literature. However, less blood loss, durotomy, wound infection, no drain, and less dead space are benefits of MIS-TLIF surgery compared to open TLIF surgery [12]. Literature also suggests that doing minimally invasive spine surgery decreases complications like respiratory and urinary infections. The protocol followed in our institute undergoing MIS-TLIF surgery, mobilization starts within 24 hours after surgery, which decreases the probability of urinary infection, respiratory infection, and wound-related complications [13].

Yu et al. [14], showed less anxiety, less back pain, and better functional recovery in patients undergoing MIS-TLIF than open surgery, which were correlated with VAS and ODI scores [14]. Heemskerk et al. [15], in their meta-analysis, reviewed patients for a minimum follow-up of two years and found them to have significant improvement in VAS score of both back and leg, compared to open surgery. In our study, there was a significant improvement in VAS score from 7.7±0.8 to 1.30±0.4 (p value<0.05) and ODI score from 48±6.14 to 20±3(<0.05) on final follow-up. Similar findings were shown by Peng et al and Schiaz et al on long-term follow-up [16,17].

The limitations of this study were due to the retrospective nature of the study, there was a lack of randomization, the single-center study, and less number of patients.

Conclusion

Compared to standard open TLIF, MIS TLIF is effective in reducing perioperative morbidity, with less blood loss, less post-operative pain, shorter postoperative hospital stay, surgical complications, and early ambulation. It was also found to cause less anxiety and good clinical outcome improving both VAS and ODI scores. MIS-TLIF surgery on indicated and properly selected patients gives good clinical, radiological, and functional outcomes on long-term follow-up.

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