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Clinical and Radiological Outcome of Minimally Invasive-Transforaminal Lumbar Interbody Fusion in Patients with Single or Double-Level Involvement with Minimum 2-Year Follow-up

Hitesh N. Modi[1], Utsab Shrestha[1], Udit D. Patel[1]

Abstract

Purpose: The objective of this study is to analyze the clinical and radiological outcome of Minimally Invasive-Transforaminal Lumbar Interbody Fusion (MIS-TLIF) in terms of estimated blood loss (EBL), operative time, length of stay (LOS) in the hospital, complication, Oswestry disability index (ODI) score, visual analog scale (VAS) score, and parameters of sagittal spinal balance before and after surgery. The parameters of sagittal spinal balance included in this study were pelvic Incidence (PI), lumbar lordosis, focal lordosis at the index level.

Materials and Methods: All cases were retrospectively followed up. Single-level and double-level MIS-TLIF procedures for back pain and leg pain operated between 2015 and 2018 were included in the study. PI, Lumbar lordosis, Focal lordosis at index level was measured on preoperative, post-operative, and final follow-up lateral lumbosacral X-ray in the supine position. Demographic data, intraoperative blood loss, operative time, LOS, ODI score, and VAS score at different times were reviewed and analyzed.

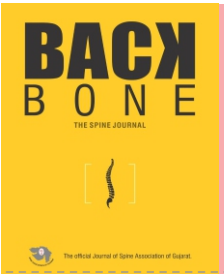
Results: Fifty-four patients were included among them 24 were male and 30 were female. The average age of the patients was 51.6 ± 12.1 years. Sixteen double-level surgery and 38 single-level surgeries. The average value of follow-up was found to be 39.6 ± 12.4 months. The average value of operative time, the EBL and the LOS were 170.8 ± 19.8 min, 132.1 ± 34.8 mL, and 4.8 ± 0.8 days, respectively. The average PI was 54.9 ± 11.2° preoperatively, 55.0 ± 10.7° postoperatively and 54.8 ± 10.9° at the final follow-up. Pre-operative lumbar lordosis and focal lordosis were 44.55 ± 12.9° and 7.76 ± 5.2°, respectively with postoperatively and final follow-up to 48.88 ± 13.1° and 10.62 ± 5.1°, respectively. VAS score and ODI scales were improved significantly from preoperative 8.4 ± 0.9 and 56.3 ± 4.9, respectively, to postoperatively and final follow-up 2.0 ± 0.8 and 21.6 ± 5.4, respectively. The postoperative complications and revision occurred in 8 (14.8%) and 4 (7.4%) patients, respectively.

Conclusion: MIS-TLIF is a novel technique with the good radiological and clinical outcome with decreased perioperative morbidity. It is also superior to open TLIF in terms of EBL, hospital LOS, operative time, perioperative morbidity, and surgical complications.

Keywords: Minimally invasive-transforaminal lumbar interbody fusion, clinical improvement, pelvic incidence, lumbar lordosis, focal lordosis.

Introduction

Minimally invasive surgery-transforaminal lumbar interbody fusion (MIS-TLIF) was introduced by Foley et al. as an alternative to open-TLIF to reduce extensive paraspinal muscle stripping and to avoid excessive pressure on muscles due to retractors [1]. Several published reports have highlighted the major advantages of MIS-TLIF over open-TLIF such as less blood loss, minimize iatrogenic soft tissue and muscle injury, less post-operative pain, shorter hospitalization, and faster recovery [2, 3, 4]. The correction of sagittal spinal balance is directly related to the improvement of pain and function after spine surgery in various disease states; and the pelvic incidence (PI) with other spinopelvic parameters plays an important role in sagittal balance in a variety of spinal diseases [5]. Recent review articles suggest that clinical outcomes of MIS-TLIF are comparable with that of open-



[1]Department of Spine Surgery, Zydus Hospitals and Healthcare Research Private Limited, Zydus hospital road, Thaltej, Ahmedabad, Gujarat, India 380054.

Address of correspondence :
Dr. Hitesh N. Modi,
Department of Spine Surgery, Zydus hospitals and healthcare Research Private Limited, Zydus hospital road, Thaltej, Ahmedabad, India.
E-mail: drmodihitesh@gmail.com

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TLIF in terms of fusion and recovery from symptoms [6, 7, 8]. In contrast, exposure to ionizing radiation is one of the main arguments against MIS-TLIF [9]. In addition, longer surgical times have also been reported for MIS-TLIF at least during the first few cases, which could reflect technical differences; however, some authors associate this with a significant learning curve [10, 11, 12, 13, 14]. Although there are several studies on the outcome of MIS-TLIF, the evaluation of the effect of MIS-TLIF on sagittal balance has been less emphasized. As the study of sagittal balance has become important due to the devastating consequences to the patient in case of imbalance in the sagittal balance.

We have considered the importance of pelvic and lumbar sagittal balance into account for comparison on the preoperative, the postoperative, and the follow-up X-rays. Similarly estimated blood losses (EBL), length of surgery, length of stay (LOS) in the hospital, visual analog scale (VAS), and Oswestry disability index (ODI) scores taken at different times have also been evaluated. The objective of this study was to present, analyze and report clinical and radiological outcome of the MIS-TLIF procedure.

Materials and Methods

This retrospective analytical study included 54 patients who were operated for MIS-TLIF between 2015 and 2018. Inclusion criteria were back pain and leg pain for a minimum period of 6 months, 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, traumatic spine, cases of spine tumors, revision surgeries, lack of clear lateral lumbosacral X-ray at three different occasions, or poor-quality X-ray films.

EBL, hospital LOS, operative time, perioperative morbidity, and surgical complications were collected prospectively in all surgeries were reviewed and analyzed.

Operative technique

Under general anesthesia, patients were positioned in the prone position on radiolucent table, and using fluoroscopic images, the pedicles and spinous process were marked. Two paramedian incisions of 2–3 cm in length were made 4–5 cm off midline. K-wire is used to identify the facet joint of relative levels to be fused. Sequential dilatation done and tubular retractor was docked over the facet joint. Inferior facet was removed, and foraminal decompression was performed. After that discectomy done and correct size cage with bone graft was inserted. Percutaneous pedicle screws were placed through the guide wires which were inserted over Jamshidi needles under the fluoroscopic guidance using standard minimally invasive technique for the pedicle screw insertion (Fig. 1).

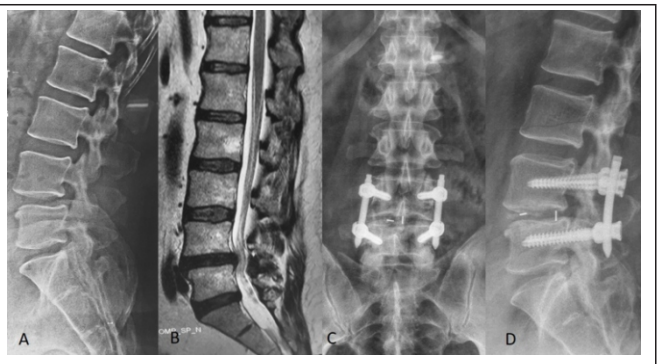

Figure 1: (A) preoperative X-ray, (B) MRI suggesting grade 1 spondylolisthesis with disc bulging in a 48-year-old male who was treated in form of MIS TLIF at L4-5 shown in postoperative (C) AP and (D) lateral X-ray of lumbar spine.

Radiological methods

Measurement of parameters of sagittal balance was done by a single observer from the lumbosacral radiographs taken preoperatively, post-operatively, and at final follow-up. PI was measured between two lines; one from the mid-point of the upper sacral endplate to the hip axis, another line was perpendicular to the upper sacral endplate. Lumbar lordosis is defined as the angle between the upper endplate of the L1 vertebra and the upper endplate of the sacrum and measured manually by Cobb's angle method. Focal Lordosis at the index level is the angle between the upper and lower endplate composing the disc space. Focal lordosis of the disc space was measured where the cage was placed.

Analysis of the above data was done using SPSS software for the statistical analysis (SPSS version 12, Chicago, Illinois). P value was taken 0.05 to find out any significant difference.

Results

In our study total of 54 patients were included among them 24 were male and 30 were female. The average age of the patients was 51.6 ± 12.1 years. There were 38 and 16 patients with single-level and double-level involvement, respectively. The average follow-up was 39.6 ± 12.4 months (Table 1).

The average operative time, EBL and LOS were 170.8 ± 19.8 min, 132.1 ± 34.8mL, and 4.8 ± 0.8 days, respectively (Table 2). The average PI was 54.9 ± 11.2° preoperatively, which was maintained at 55.0 ± 10.7° postoperatively (P = 0.148, paired t-test) and 54.8 ± 10.9° at the final follow-up (P = 0.305, paired t-test). Preoperative lumbar lordosis and focal lordosis were 44.55 ± 12.9° and 7.76 ± 5.2°, respectively, that improved significantly postoperatively to 48.88 ± 13.1° (P = 0.042, paired t-test) and 10.62 ± 5.1° (P = 0.003, paired t-test), respectively. Both were maintained at the final follow-up (P > 0.05) (Table 3).

Regarding the clinical outcome VAS score and ODI scales were improved significantly from preoperative 8.4 ± 0.9 and 56.3 ± 4.9, respectively, to postoperatively 2.0 ± 0.8 (P < 0.0001, paired t-test) and 21.6 ± 5.4 (P < 0.0001, paired t-test), respectively. Improvement in both the scores was maintained

Table 1: Suggests number of patients with single or double level MIS-TLIF.

No. of patients	54
Average age (years)	51.6±12.1
Male/Female	24/30
Average follow-up (months)	39.6±12.4
Single level TLIF	38
L1-L2	0
L2-L3	0
L3-L4	4
L4-L5	24
L5-S1	10
Double level TLIF	16
L1-L2, L2-L3	0
L2-L3, L3-L4	0
L3-L4, L4-L5	6
L4-L5, L5-S1	10

Table 2: Shows average operation time, blood loss and hospital stay in both groups and according to single or double level involvement

	MIS-TLIF
Operation time (min)	170.8±19.8
Single level	166±15.7
Double level	182.2±24.1
Estimated blood loss (mL)	132.1±34.8
Single level	120.4±25.0
Double level	160±39.4
Hospital stay (days)	4.8±0.8
Single level	4.7±0.8
Double level	5.1±0.8

Table 3: Shows preoperative, postoperative, and final follow-up clinical VAS and ODI scores; and radiological parameters using lumbar lordosis, pelvic incidence, and focal lordosis at index level in MIS-TLIF.

		MIS-TLIF	i value
VAS	Pre-operative	8.4±0.9	
	Post-operative	2.0±0.8	$P<0.0001$
	Final FU	2.0±0.8	$P>0.05$
ODI	Pre-operative	56.3±4.9	
	Post-operative	21.6±5.4	$P<0.0001$
	Final FU	21.6±5.4	$P>0.05$
LL	Pre-operative	44.55±12.9	
	Post-operative	48.88±13.1	$P=0.042$
	Final FU	48.88±13.1	$P>0.05$
PI	Pre-operative	54.9±11.2	
	Post-operative	55.0±10.7	$P=0.148$
	Final FU	54.8±10.9	$P=0.305$
FL	Pre-operative	7.76±5.2	
	Post-operative	10.62±5.1	$P=0.003$
	Final FU	10.62±5.1	$P>0.05$

Table 4: Complications in MIS-TLIF.

Complications	MIS-TLIF
Total no (n=8)	14.80%
Persistent Numbness	1
Radicular Symptoms	1
Cage Backout	3
Hematoma	1
Dural Tear	1
Screw Breakage	1
Revision required (n=4)	7.40%

at the final follow-up (P > 0.05, paired t-test) (Table 3).

Regarding post-operative complications, there were eight (14.8%) intraoperative and postoperative complications seen (Table 4). There were three patients with postoperative cage back out; and one patient each had persistent numbness, radicular symptoms, hematoma, dural tear, and screw breakage. One patient had intra-operative complications in form of minor dural leak, which was managed with packing without any postoperative sequel. One patient had S1 screw breakage after the surgery that was revised in form of removal of broken screw with insertion of new screw with open surgery. Three patients had back out of interbody cages; out of which one was treated conservatively without further sequel (Fig. 2). Patient did not have any complaints and was diagnosed on

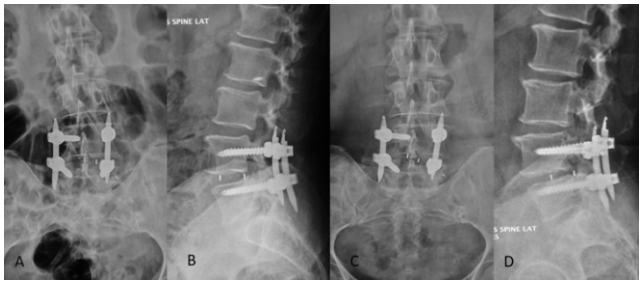

Figure 2: Postoperative (A) AP and (B) lateral X-ray of lumbar spine after MIS-TLIF at L4-5 in a 62-year-old lady who developed mild back out of cage on 3-month postoperative X-ray in (C) AP and (D) lateral X-ray without any symptoms. Patient was treated conservatively without any further sequel.

Figure 3: Postoperative (A) AP and (B) lateral X-ray of lumbar spine after MIS-TLIF at L4-5 in a 22-year-old male who developed back out of cage on 6-month postoperative X-ray in (C) AP and (D) lateral X-ray with severe radicular symptoms and mild weakness of ankle. Patient was treated with removal of cage.

routine postoperative follow-up at 3 months. No further backout happened and fusion was seen on regular follow-up at 9 months. Two patients had cage back out causing radicular symptoms and mild weakness of the foot on affected side in one patient (Fig. 3). Both were revised in form of removal of interbody cage and symptoms resolved in both patients including recovery of foot weakness within 3 months of revision surgery. One patient who developed postoperative hematoma developed severe radicular pain in both lower extremities with slight decrease in power in the ankles. Magnetic resonance imaging (MRI) suggested the development of hematoma which was reopened and drained. Symptoms improved and power recovered after revision. There were four patients (7.4%) who required revision surgery in the series. All patients went back to their previous activity level after the surgery.

Discussion

In conventional open-TLIF surgery, posterior midline incision with the splitting of posterior tension band muscles and unilateral retraction of nerve roots are usually performed [15]. However, this is associated with significant morbidity postoperatively due to extensive dissection resulting into iatrogenic damage with denervation of the paraspinal muscles. Damage done to the paraspinal muscles during the dissection and pressure caused by the retractors leads to several short terms and long-term effects [16]. MIS-TLIF achieves the same goals as open-TLIF through a less traumatic approach. Because of the unilateral paraspinal approach used in MIS-TLIF, posterior tension band is spared. As the dissection of soft tissue is minimal just to allow docking tubular retractors, muscle stripping is minimal. Similarly, the only facetectomy on more symptomatic side is performed avoiding complete laminectomy. These steps are different from open-TLIF and decrease the blood loss reduces postoperative surgical site pain and make the recovery from surgical stress speedy. In the present study, although we did not focus on the effect on musculature with MIS-TLIF, good clinical results and outcome suggested its efficacy in treating such patients using MIS-TLIF. Most of the patients did not complaint of any residual back pain or weakness of back muscles postoperatively, thus proves the efficacy of MIS-TLIF in preserving posterior structures.

PI is an important pelvic parameter of sagittal spinopelvic balance as it is the only anatomical parameter and sacral slope, pelvic tilt being the positional parameter. Thus, PI affects the sagittal balance at a lumbar, thoracic and cervical level as the spine in the sagittal plane is like an open linear chain linking the head to the pelvis where the shape and orientation of each anatomic segment are closely related and influence the adjacent segment [17, 18, 19]. This is the reason; more emphasis is given to the preservation and restoration of the normal spinal contour during the spinal surgeries. In our study group, overall PI remained unchanged postoperatively, which helped us in surgical planning. In addition, lumbar lordosis and focal lordosis at the operative side improved significantly helped us to achieve desired angle post-operatively with MIS-TLIF.

In contemporary research about surgical techniques, a study on sagittal balance has become a strong necessity. In this study, we have used parameters such as PI, lumbar lordosis, and focal lordosis angle at the index level to quantify the sagittal balance of the patients. In our study, values of pre-operative, post-operative, and final follow-up PI are similar which further validates the statement that PI is constant in an adult [20]. Regarding sagittal balance parameters, post-operative PI and final lumbar lordosis (LL) were found to be 55° and 48.9°. Singh et al. and Sudhir et al. found PI to be 48.52° and 55.48°, respectively, in their studies. Lumbar lordosis angle was found to be 48.84° and 58.78° in those studies done in asymptomatic Indian volunteers [21, 22]. Thus, MIS-TLIF technique is found to be efficient to maintain lumbar lordosis in the normal range.

In our study, duration of surgery, EBL, and length stay of the patient was found to be 170.8 ± 19.8 min, 132.1 ± 34.8 mL and 4.8 ± 0.8 days, respectively, which is comparable to the finding of studies performed by others [4, 23, 24, 25]. Because the tissue dissection was minimal and limited osteotomy was carried out with facetectomy of the affected side, average EBL was less than in traditional open-TLIF. The drain tube was avoided during closure and blood transfusion was not required in all of the patients. Post-operatively, all our patients were mobilized with the help of physiotherapist the next day. All patients were encouraged to regain their activities as soon as possible post-operatively after the discharge, which proved the efficacy of the technique.

Wang et al. in their study found improvement in VAS score and ODI score as 6.3 and 30.4, respectively [26]. Mean post- pre difference of VAS score and ODI score were 6.4 and 34.7, respectively, in our study. Better VAS and ODI outcomes result from shorter durations of intramuscular pressures and less tissue injury caused by a more experienced surgeon, however, longer operation time is often associated with poor VAS and ODI scores when surgery is performed by surgeons in the early stage of the learning curve with MIS-TLIF [27, 28, 29, 30]. A multicenter randomized study conducted by Alamin et al. to evaluate the effect of MIS-TLIF versus open-TLIF on paraspinal musculature using MRI showed that both quantitative and qualitative measures of edema in the multifidus were significantly less in the MIS-TLIF group, which is consistent with less muscle injury [31]. Although we did not perform post-operative MRI in our patients, significant improvement in postoperative VAS and ODI scores indirectly

proved its efficacy in preserving paraspinal muscles in MIS-TLIF.

Hammad et al. found that the complication rate in MISS TLIF was 11.3%. Wound infection, nerve root injury, durotomy, cardiopulmonary, and hardware failure were the noted complications. However, numbness and pain were not included in complication [32]. In our study, the complication rate was found to be 14.8% in 8 patients where cage backout, dural tear, screw failure, postoperative hematoma, persistent numbness, and radicular symptoms were seen as complications. We feel that our complication rate is similar to the published literature. The only revision surgery in our patients was performed for screw failure, cage back out, and postoperative hematoma. In our study, we had no case of wound infection. Jhala et al. also had no incidence of postoperative infection [33]. Wong et al. found a significantly lower rate of systemic respiratory and urinary infections, which was attributed to patient's overall earlier mobilization and ambulation and a significantly lower overall wound infection rate with MIS-TLIF [7]. Less tissue trauma, less blood loss volumes, and smaller potential dead space are the possible cause of lower incidence of wound infection. In our center, mobilization is started within 24 h of surgery in compliant patients which decreased the probability of respiratory infection and urinary tract infection; subsequently decreased the incidence of wound infection. Similarly, drain is not kept in MIS-TLIF which decreases the chance of retrograde infection. This can be attributed to the reduction of wound infection in our cases.

There are some limitations of this study which include retrospective nature of the study, lack of randomization while selecting the patient, relatively shorter minimum follow-up duration. Because of the shorter minimum follow-up duration, it is not possible to conclude on the possibility of adjacent segment disease after MIS-TLIF surgery.

Conclusion

This study results have shown that MIS-TLIF is a novel technique with the good radiological and clinical outcome with decreased perioperative morbidity. It is also superior in terms of EBL, hospital LOS, operative time, perioperative morbidity, and surgical complications.

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Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

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