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ORIGINAL ARTICLE

Clinical and Radiological Evaluation of Percutaneous Trans-Pedicular Screw Fixation in Management of Low Grade Spondylolisthesis

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ABSTRACT

Background: When treating low-grade spondylolisthesis, transforaminal interbody fusion (TLIF) can offer a safe procedure with high fusion and few problems. The aim of this work was to improve clinical and radiological outcomes of patients with low grade spondylolisthesis by performing percutaneous transpedicular screw fixation.

Methods: Eighteen patients 13 males (72%) and 5 females (28%) with low-grade isthmic spondylolisthesis operated with TLIF. Clinical and functional outcome was assessed on Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI). The follow up period of the series was 6 months. 6 patients were L5-S1 and 11 were L4-L5.

Results: All the patients underwent interbody fusion using the MIS-TLIF technique augmented with posterior percutaneous pedicle screws placement. Mean operative time for all cases was (70.72 ± 13.77 min) and the mean blood loss was (50.64 ± 11.35). By grading the patients according to the patient satisfaction index (PSI); it was found that in 15 patients (83.33%) surgery met their expectations (grade I), 3 patients (16.7%) were grade II. There were no major systemic complications. Two cases were complicated by subcutaneous hematoma, and one patient was complicated with superficial wound infection. But None of them had any neurological deficit till the final follow up.

Conclusions: MIS-TLIF is a safe method of managing low grade isthmic spondylolisthesis with obvious improvement in clinical and radiological outcome of these patients.

Keywords: Transforaminal lumbar interbody fusion**;** Percutaneous trans-pedicular screw; Spondylolisthesis.

INTRODUCTION

The slippage of one vertebral body over the other is known as spondylolisthesis (DS). Lower back pain (LBP) and leg discomfort are common symptoms of this illness, which may be linked to spinal canal stenosis. [1].

It is a prevalent pathology with a prevalence of 2.7% in males and 8.1% in females [2].

Frequently, patients have low back pain that gets worse as they extend at the afflicted area. This movement may result in decreased spinal range of motion and mechanical pain. When the patient adopts a flexed posture, the impinged nerve experiences less stress, which lessens the discomfort. The constriction of the nerve foramina might compress the exiting nerve roots, causing radicular pain as well. When one vertebra slips on the next vertebrae, the traveling nerve root may impinge and cause this compression. Central canal stenosis, disc protrusion, and related lateral recess narrowing might also result in pain. While some positions, such lying supine, can relieve the pain, direct probing of the afflicted region may make it worse. The reason for this improvement is that a supine position lessens the instability of spondylolisthesis, which releases pressure on

the bony components and opens the neural foramen or spinal canal [5].

Anteroposterior, lateral and dynamic plain films are the standard diagnostic tools for spondylolisthesis. These films help to identify abnormal alignment between adjacent vertebral bodies and detect any motion during flexion and extension, indicating instability. In cases of isthmic spondylolisthesis, a pars defect may be present, often referred to as the "Scotty dog collar." This lesion, which represents a fracture in the pars interarticularis, manifests as a hyperdensity where the collar would go on a cartoon dog. When diagnosing spondylolisthesis, computed tomography (CT) of the spine is advised for the maximum sensitivity and specificity. Compared to axial CT imaging, sagittal reconstructions using CT scans offer a better image of spondylolisthesis and more bony definitions. While soft tissue and disc abnormalities linked to spondylolisthesis can be seen on magnetic resonance imaging (MRI) of the spine, it may be more difficult to spot bony features and possible pars deficiencies on MRI [3, 4].

Conservative treatment should be considered for most cases of degenerative spondylolisthesis. Pain control can be attempted through medical treatment, such as NSAIDs and other analgesics. Physical methods, including bracing and flexion strengthening exercises, can also be effective in managing pain for many individuals. In selected cases where medical treatment is not successful, epidural steroid injections may be considered [1].

If medical treatment fails to relieve symptoms, surgical treatment may be necessary. It is indicated in cases of severe intractable pain and neurological deficit. However, traditional procedures for posterior lumbar spine fusion often involve extensive stripping, large incisions, and retraction of the paraspinal muscles, resulting in severe postoperative pain, muscle atrophy and a slow recovery [6]. On the other hand, posterior interbody fusion and percutaneous pedicle screw fixation offer more stable structures that allow for early mobilization and appropriate correction of deformities. Percutaneous fixation, being a minimally invasive technique, reduces surgical dissection and muscle damage compared to open techniques (muscle preserving technique). Follow-up MR imaging has shown atrophy in the paraspinal muscles after such exposures, leading to poorer clinical outcomes. [6]

Posterior lumbar interbody fusion and percutaneous fixation utilize a more eloquent muscle splitting technique to accurately position screws and cages under C- arm images. This approach minimizes the risk of severe trauma typically associated with an open approach, enabling successful implantation of hardware at different levels. Our main focus is on the percutaneous insertion of pedicle screws, and we provide detailed instructions for setting up images, employing a surgical approach, and effectively inserting these screws [7].

Aim of the Work: This study aimed to improving clinical and radiological outcomes of patients with low grade spondylolisthesis by performing percutaneous transpedicular screw fixation.

METHODS

This prospective clinical trial study conducted in spine unit Neurosurgery department, Zagazig university hospitals, in the period from April 2024 to October 2024. It included eighteen patients, 13 males (72%) and 5 females (28%) of low-grade isthmic spondylolisthesis. The follow up period of the series was 6 months.

An informed consent was taken before the surgery from all patients, and the study was authorized by the research ethical council (IRB# 177/3 March-2024) at the Faculty of Medicine at Zagazig University. The investigation was conducted in accordance with the Declaration of Helsinki, the World Medical Association's Code of Ethics for human studies.

Inclusion criteria were age ranging from 18 to 60 years old, low grade spondylolisthesis (GI and GII) and multiple or single level disc prolapse. Exclusion criteria were malignancy, infection, psychological insult and medical history of muscle disease.

Preoperative:

Every patient had their demographic information gathered, including their age, sex,

occupation, smoking status, and body mass index (BMI). Broad evaluation to determine the patient's overall suitability for surgery was done. Every patient had a local examination of their lumbar spine to assess any deformities, scars from prior surgeries, painful spots, and range of motion. Neurological examination of motor, sensory and reflexes of both upper and lower limbs was done to all the patients. Assessment in terms of Oswestry disability index (ODI) and visual analogue scale scores (VAS) for back and leg pain were evaluated before surgery.

All patients underwent laboratory evaluation including complete blood picture, blood sugar, LFT & KFT, bleeding profile, hepatitis markers, ABO & RH grouping.

Plain lumbar spine standing radiographs, both static (lateral and anterior-posterior) and dynamic (flexion and extension), were evaluated for each patient. Long standing film from occiput till coccyx anterior-posterior and lateral was taken before the operation. Computed tomography when needed to confirm the pars defect and any dysplastic changes, MRI sagittal, coronal and axial view for all the patients, DEXA scan to exclude patients with osteoporosis were done.

Operative procedure:

All patients received general anesthesia with endotracheal intubation. Foleys catheter was applied before operation to ensure that bladder distention not increasing intra-abdominal pressure during the procedure. Single dose of broad-spectrum antibiotic was given before the induction of anesthesia.

Operative technique:

The patients were placed prone on radiolucent table on firm rolls to support the iliac crest, rib cage and the clavicle, keeping the hip extended. The helping surgeon, the radiologist technologist, the image intensifier, and the operating surgeon stood on the patient's problematic side, were stationed at the non-symptomatic side of the patient with easy turn of the C-Arm from Antero-Posterior to Lateral images by passing under the operating. Two paramedian incisions were done centered on the facet complex to facilitate bilateral facetectomy. The skin incision was made along the cephalocaudal line between the upper and lower inter-pedicular line. For the L3–S1 levels, a single incision was usually needed as the lumbar lordosis helped us to approach those levels through the same incision. The fascia was incised in line with the skin incision, or a more medial fascial incision is preferred to help the bony docking of the retractor system. Blunt dissection with a finger was used to divide the paraspinous muscle down to the base of the transverse process. Docking the Jamshidi needle without numerous fluoroscopic pictures was made easier by the ease with which the optimal beginning position for pedicle cannulation could be palpated at the intersection of the transverse process and the facet.

Under the direction of the C-Arm, the lateral side of the pedicle was delineated on the skin. In order for the Jamshidi needle to be angled correctly when targeting the pedicle, the skin incision should be made laterally to the fascial incision, depending on the depth of the soft tissue between the skin and the pedicle. After making the skin incision, "dock" the Jamshidi needle onto the pedicle's lateral surface. The ideal places to dock are over the pedicle's lateral wall at three o'clock and nine o'clock on the right-left side, respectively. The needle was advanced to traverse the pedicle from lateral to medial with no more than 75% of the pedicle on the PA view, with the needle tip slightly embedded (5 mm) in bone and the shaft properly aligned with the pedicle's axis. The tip should be at the junction of the pedicle and vertebral body on a lateral view, which is regarded as "safe" and poses no risk of medial pedicle penetration. Fluoroscopic pictures should be obtained periodically to track the needle's progress. It should be observed that the needle's shaft and endplate are parallel. A pedicle tap was employed down the guidewire's trajectory after it was positioned down the Jamshidi needle (figure 1A). In order to allow rod passage, cannulated pedicle screws were introduced with their screw extensions attached, being careful not to extend the K-wire past the anterior portion of the vertebral body (figure 1B). To protect the soft tissue around each guidewire, soft-tissue dilators were placed over them. The rod can then be passed utilizing the method unique to the

pedicle screw system after this alignment is satisfactory. Before the last tightening, the build can be compressed or distracted, and screw extensions can be taken out.

Doing MIS-TLIF: We used the quadrant system of Medtronic, we began with the non-symptomatic side with insertion of two percutaneous guide wire into the pedicles and then performing facetectomy, then insertion of pedicular screws rod insertion and doing distraction on that side. On the symptomatic side, we do not place the screws until preparing of the disc space and the TLIF cage is inserted; otherwise, the screw heads might hinder our access to the disk space, so we insert the guide wires in the pedicles, doing facetectomy of the facet, preparing the disc space and cage insertion. After that, insertion of the screws and doing compression on the screws bilaterally. (figure 1C).

A lateral fluoroscopy was performed to check the level and specify the facet joint site using a guide wire. The last expandable retractor was positioned with the flexible retractor arm between the K-wires after a series of tubular dilators. The soft tissue inside the retractor's margins was coagulated using either monopolar or bipolar cautery. The facet's lateral border was determined, paying particular attention to the pars. Rongeurs or osteotomes were used to resect the facet joint, and Kerrison rongeurs were used to do a hemi-laminotomy.

The traveling nerve root is easily visible after the ligamentum flavum was cut away to reveal the thecal sac. As a fusion material, the graft from the bony decompression was preserved.

A knife was used to open the disc, and pituitary rongeurs and curettes are used to perform the discectomy. The traveling nerve root and thecal sac can be carefully retracted to reveal the disc by placing a nerve-root retractor medially. To maximize the surface area available for bone fusion, the cartilaginous endplates should be carefully removed. The discectomy was aided by the sequential use of disc space shavers. Blunt dilators were employed to restore intervertebral height and divert compressed disc voids.

In low-grade spondylolisthesis instances, the combination of ipsilateral disc space dilatation and contralateral screw distraction with reduction as necessary has been successful in reversing the slippage and restoring the lordosis.

Bone graft was then used to fill the disc gap and the interbody cage. To reduce the chance of sinking via the softer central cancellous endplate, the cage was inserted under AP and lateral fluoroscopic guidance, ensuring it rested directly below the anterior longitudinal ligament in the disc's center (Figure 1D).

After that, the working portal was carefully taken out to prevent the guiding wires inside the pedicles from being removed. After covering them with their sleeves, the pedicle screws were put into the vertebral bodies. Once the necessary lordosis has been performed, the rod is inserted. Before the set screws were finally locked in place, bilateral compression was applied over the screws to induce lordosis and enhance overall sagittal balance after both rods were in position. Lateral and AP radiographs are taken. The finished build was then left in place after all of the MIS pedicle screw sleeves were taken off. Layers of closure and irrigation were applied to the wounds. At this stage, all patients received a second injection of a local anesthetic (0.25% Marcaine with 1:200,000 epinephrine) to reduce post-operative pain in the skin and underlying muscle (Figure 2).

Post-operative management:

In the recovery room, the patient’s blood pressure, pulse and oxygen saturation were monitored. All patients were then admitted to the ward with no need for ICU except for one patient that was admitted for 24 hours for follow up of the blood pressure. Intravenous antibiotic was received for about 5 days after operation then oral for 10 days more. Analgesia was continued for 48 hours then as needed by the patient. Hemoglobin level was monitored the day after operation with no need for blood transfusion to any of the patients in the study. Patients were instructed to ambulate from day one after operation. Lumbosacral support was worn for two weeks for psychological support. Isometric exercise of abdominal and back muscles also started on the third day of surgery.

Follow up:

Following one month, three months, six months, and then every six months, patients were monitored. Clinically, patients were monitored using the ODI questionnaire and the VAS for leg and back pain. Radiologically, AP and lateral radiology were performed at each visit, and CT scanning was performed at the last follow-up.

RESULTS

Table1 showed that the study included 18 patients with age ranged from 22 to 46 years with mean 32.39 years. Male represented 72.2%. Nine patients were married and 55.6% came from urban residence. Out of the studied patients, 77.78% and 22.23% were engaged into stressful and less stressful work respectively. Eleven patients were non-smokers and 38.9% of patients were smokers.

Table 2; showed that operative time ranged from 117 to 144 minutes with mean 130 minutes. Blood loss ranged from 139 to 162 ml with mean 150ml.

Table 3; showed that preoperative VAS leg ranged from 7 to 10 with mean 8.72 ± 1.56 which significantly reduced to a range from 1 to 4 with mean 2.39 ± 1.24 postoperatively. Preoperative VAS back pain ranged from 7 to 10 with mean 8.61 ± 1.65, which significantly reduced to a range from 3 to 6 with mean 4.67 ± 1.46 postoperatively then it significantly reduced to a range from 2 to 3 with mean 2.61 ± 0.7.

Table 4; showed that there was a statistically significant decrease in ODI on postoperative as compared to preoperative then between follow up as compared to postoperative value.

Table 5; showed that there was a statistically significant increase in CPK from 79 preoperatively to 200 mm^2 on follow up. There was statistically significant decrease in multifidus CSA from 1341.5 preoperatively to 1250.89 mm^2 on follow up. There was a statistically significant increase in M/P intensity from 3.27 preoperatively to 3.55 on follow up.

Table 1: Distribution of the studied patients according to demographic data:

	N=18	**%**
Age (year):		
Mean ± SD	32.39 ± 9.57	
Range	22 – 46	
Gender:		
Male	13	72.2%
Female	5	27.8%
Male/Female ratio	13/5	
Marital status:		
Single	9	50%
Married	9	50%
Residence:		
Rural	8	44.4%
Urban	10	55.6%
Work:		
Housewife	3	16.6%
Mechanic	3	16.6%
Farmer	5	27.7%
Worker	4	22.2%
Employee	2	11.1%
Engineer	1	5.56%
Special habits:		
Non-smokers	11	61.1%
Smokers	7	38.9%

Table 2: Operative data the studied patients:

	Mean ± SD	Range
Operative time (min)	130.72 ± 13.77	117 – 144
Blood loss (ml)	150.64 ± 11.35	139 – 162

Table 3: Change in VAS sciatic pain findings pre and postoperatively among the studied patients:

VAS leg	Time Preoperative	Early Postop	3 m After	6 m After	Test P1	
Mean±SD	8.72 ± 1.56	2.39±1.24	0.61±0.7	0	<0.001**	
Median (Range)	7 – 10	1 – 4	0 – 2	0		
Vas Back	**Time Preoperative**	**Early Postop**	**3 m After**	**6 m After**	**Test P1**	**P2**
Mean±SD	8.61 ± 1.65	4.67±1.46	2.61±0.7	2.53±0.7	<0.001**	<0.001**
Median (Range)	7 – 10	3 – 6	2 – 3	2 – 3		

**p≤0.001 is statistically highly significant Wilcoxon signed rank test, p1 difference between postoperative and preoperative value, p2 difference between follow up and postoperative value

Table 4: Change in ODI pre and postoperatively among the studied patients.

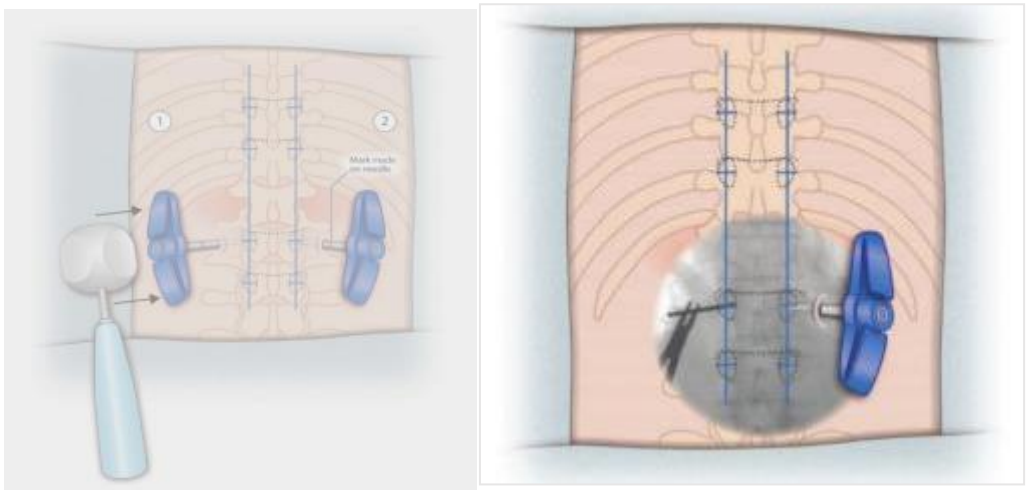
ODI	Time Preoperative	Early Postop	3 m After	6 m After	Test P1	P2
Mean±SD	80.5±10.74	34.11 ± 2.11	24.15± 5.8	6.28± 2.05	<0.001**	<0.001**
Median (Range)	70 – 91	32 – 36	18 – 30	4 – 8		

**p≤0.001 is statistically highly significant p for paired sample t test p1 difference between postoperative and preoperative value p2 difference between follow up and postoperative value

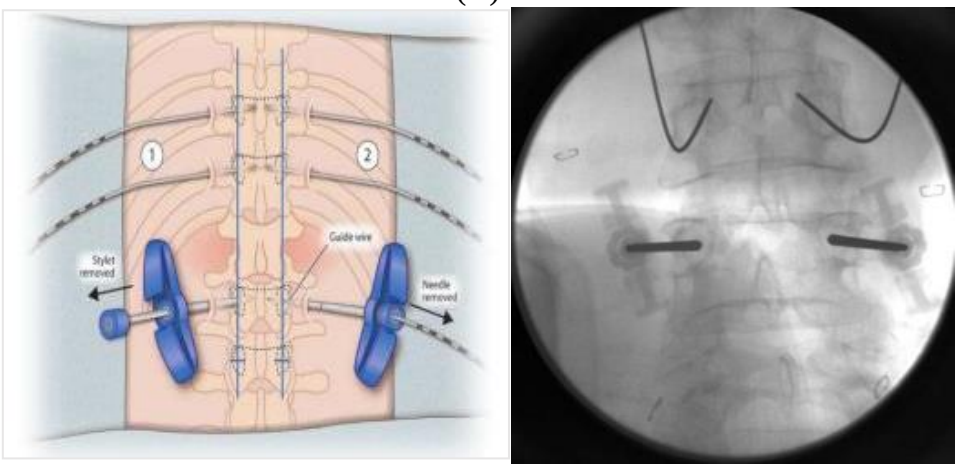
Table 5: Change in CPK, radiological evaluation pre and postoperatively among the studied patients:

CPK	Time		Test
	Preoperatively	On follow up	P
	N=18 (%)	N=18 (%)	
Mean ± SD **Median (Range)**	91.2 ± 79.82 79 (26 – 380)	222.61 ± 99.83 200 (90 – 450)	<0.001**
Radiological evaluation			
Multifidus CSA Mean ± SD (Range)	1341.5 ± 107.05 1204 – 1553	1250.89 ± 107.32 1106 – 1460	<0.001**
M/P intensity Mean ± SD (Range)	3.27 ± 0.52 2.5 – 4.2	3.55 ± 0.51 2.75 – 4.5	<0.001**

p for Wilcoxon signed rank test p for paired sample t test, **p≤0.001 is statistically highly significant



(A)



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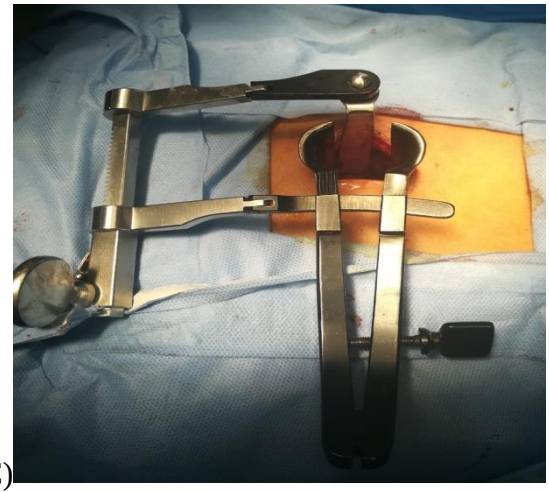

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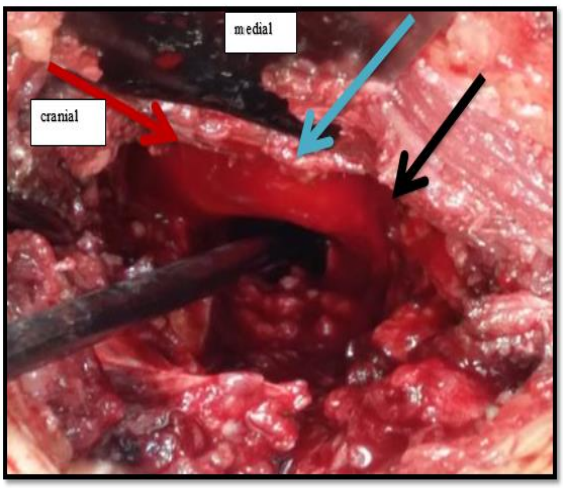

(D)

Figure 1: (**A)** Jamshidi Placement. (**B)** Guide wire placement**.** (**C)** Intra-operative photo with the quadrant in place. **(D)** Intraoperative photo with the cage handle inside the disc, the blue color points at the dura, the black arrow points at the traversing root and the black arrow points at the exiting root.

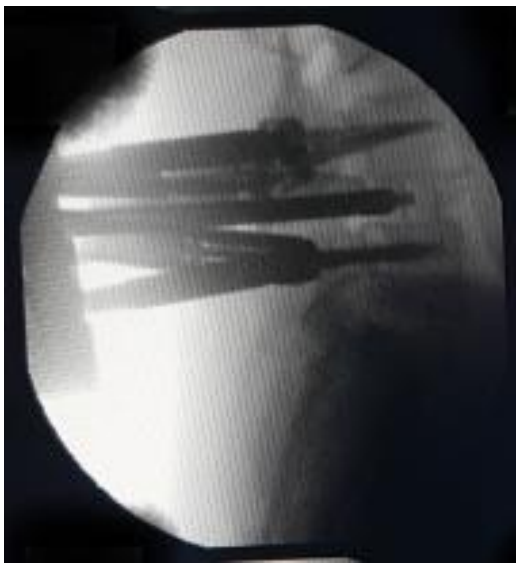

Figure 2: C-Arm photo showing disc preparation and cage entry as anterior as possible and then compression was done over the rods to increase the lordosis.

DISCUSSION

The demographic characteristics of our study population comprised 18 patients, including 5 females and 13 males. Of these, 15 patients were employed in stressful and physically demanding occupations, while the remaining 3 patients were housewives. Regarding the spinal pathology, 11 patients were diagnosed with L4-5 spondylolisthesis, 6 with L5-S1 spondylolisthesis, and 1 with L3-4 spondylolisthesis. Additionally, 11 patients were classified with grade 2 spondylolisthesis, while the remaining patients were classified with grade 1 spondylolisthesis.

Zhang et al. conducted a study involving 53 patients, of which 29 were male and 24 were female. Among the participants, 22 patients were diagnosed with L4-5 spondylolisthesis, 21 with L5-S1 spondylolisthesis, and 1 with L3-4 spondylolisthesis, while discussing the clinical efficacy of MIS-TLIF in treatment of lumbar isthmic spondylolithesis [11].

The mean blood loss reported in this study was (150.64 ± 11.35 ml) with mean operative time (130.72 ± 13.77).

the open technique's reduced skin incision, substantial muscle and periosteal dissection, retraction, longer hemostasis time, and excessive time spent identifying anatomical landmarks for the correct screw entry point. The percutaneous approach eliminates all of these factors that contribute to lengthy operating times. Using fluoroscopy during the percutaneous procedure also makes it easier to find the best locations for screw insertion. It was observed that as the surgeons' learning curve grew, the operating time progressively shrank from early to late cases. All of these elements reduce morbidity and financial costs while reducing the need for transfusions.

Zhang et al. discussed the clinical effectiveness of MIS-TLIF in treating lumbar isthmic spondylolithesis and discovered that the mean blood loss volume was 174 ml with a mean operative time of 154 minutes [11].

Jang KS et. al conducted a study comparing between paraspinal muscle sparing technique versus augmented fusion with percutaneous pedicle screw fixation, he found that the mean blood loss for percutaneous fixation group was 302 ml with mean 151 minutes of operation time, which was shorter than the 208 minutes of open surgery with an average blood loss of 448 milliliters [12].

The VAS leg improved from 8.72±1.56 preoperatively to 2.39±1.24 early postoperative up to 0.61 ± 0.7 on 3 months follow up.

The small stabbing incisions, absence of cauterization, and minimum soft tissue handling, along with the absence of iatrogenic injury to the muscles, ligaments, bone, and facet capsules, are directly responsible for the early improvement in clinical outcomes. As seen by the early ambulation, early return to work, and shorter hospital stay, this improves

functional success and lessens the need for analgesics after surgery.

Jang K Et al. states that the average leg pain scores for group of MIS-TLIF improved from 6.17 and 6.08 to 1.55 and 1.32 at 6 months [12]. Zhang Et al. found that the VAS leg score improved from 4.9 ± 0.99 to 2.02 ± 0.88 [11]. Heo DH et al. illustrated that the preoperative VAS leg changed preoperatively from 6.9 ± 1.8 to 1.6 ± 1.3 on the last follow up after 30 months [13]. Lee et al. found that the mean preoperative VAS leg improves from 6.7 preoperatively to 3.4 after 3 months follow up and to 1.6 on the final follow up [14].

The mean preoperative back visual analogue score of the studied patients was found to be 8.61 ± 1.65 with a range from 7 to 10 which improves to 2.61±0.7 with a range from 2-3 after three months postoperatively. Lee et al. found that the mean preoperative back visual analogue score improves from 5.7 preoperatively to 2.2 postoperatively [14]. Heo DH et al. states that the preoperative VAS back changed from 5.8±2.1 to 2.3 ± 1.2 postoperatively on the last follow up [13]. Zhang Et al. found that the VAS back score improved from 6.42 ± 1.19 to 2.79 ± 0.96 on the second postoperative day and to 0.91 ± 0.63 on the last follow up [11].

The patient's ODI improved from 80.5 ± 10.74 to 34.11 ± 2.11 early postoperative then to 24.15 ± 5.8 after three months and reaching 6.28 ± 2.05 on following up the patients after 6 months.

At the final follow-up, all patients' functional outcomes (ODI, VAS backpain, and VAS leg pain) improved due to the small incisions, lack of cauterization, minimum soft tissue manipulation, and absence of iatrogenic damage.

Lee et al. agrees with our study with ODI results improving from 51.8 to 21.6 upon following the patients postoperative and comparing traditional open surgery versus percutaneous pedicle screw fixation in low grade spondylolithesis [14]. Zhang Et al. found that the ODI results improved from 62 ± 7.9 preoperative to 24 ± 5.8 postoperatively which agrees with our results [11]. Heo DH et al. states that the preoperative ODI changed from 51 ± 23 to 22 ± 17.4 postoperatively [13].

By treating the lumbosacral kyphosis, spondylolisthesis reduction may assist restore proper spinal column balance. This will improve the altered biomechanics of the spine and reduce the likelihood of degenerative evolution of neighboring segments. By repositioning the bone segment in a more anatomical position, the reduction maneuver may also speed up the healing process. In fact, by transforming the shear pressures into compressive forces, lowering the slip angle and lumbosacral kyphosis may enhance the biomechanical conditions for fusion [15].

The mean CPK preoperatively was 91.2 ± 79.82 and on follow up 1 week postoperatively the mean CPK was 222.61 ± 99.83.

In the percutaneous approach, the absence of muscle splitting, dissection to reveal landmarks, and muscular retraction considerably reduces the injury to muscle fibers. Adogwa et al. The impact of intraoperative muscle dissection on long-term outcomes following minimally invasive surgery versus TLIF was examined in a prospective longitudinal cohort study. The results showed that while the mean change from baseline in the serum creatine phosphokinase level on the first postoperative day was higher for MIS-TLIF (628.07) compared to open TLF (291.42), this did not correspond with a lower two-year improvement in functional disability. Additionally, the two-year improvement in VAS-LP was comparable for both cohorts. On the first postoperative day, the total serum CPK level was significantly higher in males (1332.15±1095 U/L) than in females (284.06 ±134.85 U/L, P = 0.03), despite the fact that there was no statistically significant difference in serum CPK levels between males (188.33 ± 175.41) and females (73.46 ± 36.28) prior to surgery [16].

This was probably because the male patients, who were usually larger and more muscular, required a greater dissection of overall muscle mass. Increasing intraoperative muscle injury (as measured by the change in serum CPK level after surgery) did not correlate with decreased two-year improvement in pain and

functional disability when included in a multivariate linear regression model. Two years following MIS-TLIF versus open-TLIF surgery, patients in the top quartile (most intraoperative muscle damage; change in serum CPK levels) showed comparable improvements in pain and functional disability (ODI change score, P = 0.71) to those in the bottom quartile (least intraoperative muscle damage; change in serum CPK levels).

Regarding change in Multifidus CSA between preoperative and follow up MRI. An insignificant decrease in multifidus CSA had occurred ($P < 0.05$). Mean ± SD: 1336.17 ± 111.28 vs 1335.22 ± 111.21, p=0.07).

Regarding Change in M/P intensity between preoperative and follow up MRI. An insignificant increase in M/P intensity had occurred ($P < 0.05$). Mean ± SD: 3.32 ± 0.56 vs 3.35 ± 0.59, p=0.267).

A distinguishing feature of percutaneous pedicle screw fixation is the preservation of muscle, as opposed to the widespread muscle splitting, dissection, and retraction that characterizes conventional open pedicle screw fixation. The limited loss of the multifidus' cross-sectional area in postoperative MRI indicates that it is still maintaining the majority of its mass. When its signal is rationed to healthy psoas muscle at the multifidus/psoas index, it nevertheless maintains its signal intensity with minimal fibrous tissue. The improved functional outcome of back muscular function should be linked to this.

Hyun et al. contrasts the postoperative alterations in the multifidus muscle's cross-sectional area using the Paramedian Interfascial Approaches (PIA) and Midline Approaches (MA). With an area of 1121.3±235.7 mm2 on the preoperative CT and 889.4±241.9 mm2 on the follow-up CT, the results demonstrated a substantial decrease in the cross-sectional area of multifidus muscle on the side of the MA (-20.7%, p=0.002). The multifidus muscle's cross sectional area did not alter statistically between the preoperative (1122.9±246.0 mm2) and follow-up CT (1069.5±252.1 mm2) results on the PIA side (-4.8%, p>0.05). These findings are consistent with our PIA using Multifidus CSA (1250.89 ± 107.32), which is similar to what Hyun said [17].

Because of the coronal plane angle of the pedicle, the traditional midline method for screw fixation at the L5-S1 level requires vigorous retraction of the paraspinal muscles to establish a proper lateral-to-medial screw trajectory. The paraspinal muscles may become denervated as a result of this prolonged and forceful retraction. Furthermore, the erector spinae muscles experience a marked rise in intramuscular pressure when self-retaining retractors are used; this situation persists during the surgical operation. Furthermore, because the medial branches of the dorsal ramus are comparatively stable beneath the fibro-osseous mamilloaccessory ligament, this method may harm them at the fusion level or at nearby levels. On the other hand, new research indicates that the paraspinal sparing technique improves postoperative trunk muscle function by causing less muscular injury than the conventional midline technique. Additionally, this method enables the S1 pedicle screw to be positioned more medially, perhaps increasing the fixation's strength [12].

There is debate on the TLIF complication rate. The most frequent side effects include durotomy, nerve root damage, and wound infection. There have also been reports of implant failure, cage movement, and screw misplacement. The use of tubular retractor, which reduces the post-operative "cavity size" and aids in tamponade against the formation of a pseudo meningocele, is one of the advantageous features of MIS-TLIF. In our investigation, there were no instances of dural tears.

Parker et al. found that MIS-TLIF greatly reduced the incidence of post-TLIF surgical site infection, with 9 out of 10 published cohorts reporting a 0% incidence of infection [18].

Phan et al discovered that the MIS-TLIF had a much lower infection rate and a lower risk of neurologic deficit, hematoma, nonunion, cage malposition, screw malposition, and cerebrospinal fluid leakage [19].

In a systematic review, Sclafani and Kim According to his analysis of the MIS-TLIF

complication rate, the overall rate was 20%; however, when a surgeon's first ten surgeries were examined, the complication rate rose to 33% [20].

Wong et al. examining 513 patients who had MIS-TLIF, he reported that there was only one surgical wound infection (0.2%) and that the most frequent complication was a durotomy (5.1%). Most durotomies were performed with Kerrison rongeurs in one of three distinct steps: discectomy, ligamentum flavum excision, or bone decompression, may also happen when entering a cage [21].

Instrumentation failure leads to pseudarthrosis of the construct and post-operative neurological affection. Wong et al. Pedicle screw placement was shown to be the most frequent cause of MIS-TLIF problems resulting from instrumentation failure (0%–12.3%). In our investigation, there were no instances of pedicle violation [21].

This study showed several limitations such as being single arm study with no comparative control group. The small number of patients included together with being non-randomized study is considered another limitation. We suggest more randomized research comparing the open-TLIF and MIS-TLIF approaches for treating low-grade isthmic spondylolisthesis. Additionally, it is recommended to compare how MIS-TLIF corrects the spino-pelvic parameters when treating high-grade and low-grade spondylolisthesis.

CONCLUSIONS

Low grade isthmic spondylolisthesis can be safely managed with MIS-TLIF, which clearly improves the patients' clinical and radiological results. It is capable of maintaining and repairing appropriate spino-pelvic alignment. Long-term radiation exposure is still regarded as this technique's primary disadvantage, and lowering the learning curve can reduce the risk of complications. For obese patients, MIS-TLIF may be a suitable substitute.

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