

ORIGINAL STUDY

Microscopic Assisted MIS-TLIF Through Wiltse Paraspinal Approach Using a Novel Plastic Tube in Treatment of Adult Lumbar Disc Diseases

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Abstract

Background data: Minimal invasive surgery transforaminal lumbar interbody fusion (MIS-TLIF) is less invasive with less blood loss, postoperative pain, comorbidities, and shorter hospital stay than traditional open surgery.

Purpose: The aim is to assess the feasibility of microscopic MIS-TLIF using 50 ml plastic tubular syringe instead of expensive expandable or tubular retractors in the treatment of adult lumbar disc diseases; analyze the clinical, radiological, and functional outcomes and comparing our data with the recent studies discussing the same issue.

Study design: Retrospective clinical study.

Patients and methods: From 2018 to 2020, 35 patients with symptomatic lumbar disc diseases were treated by microscopic-assisted MIS-TLIF surgery through Wiltse approach using a fashioned 50 ml plastic syringe. Back or leg pain were evaluated clinically by applying the visual analog scale (VAS), Oswestry disability index (ODI), and modified Prolo scales. Radiological workup included plain radiographs and Magnetic Resonance Imaging (MRI). Perioperative data, incision length and radiation time were documented. All patients were serially followed up as regards clinical, functional, and radiological outcome. Interbody fusion was evaluated using Brantigan Steffe Fraser (BSF) criteria.

Results: A significant postoperative improvement in VAS for LBP and LL pain, ODI, and modified Prolo scores with statistically significant difference between preoperative, during and at the final follow-up. The mean fusion time was 8.72 ± 2.18 months and according to BSF criteria, twenty-seven patients (90%) showed definitive fusion (grade 5). One patient had a temporary neurological deficit, one experienced a misplaced pedicular screw, and one had a surgical site infection.

Conclusion: Microscopic MIS-TLIF surgery using a novel plastic syringe is an effective, cheap procedure in the treatment of symptomatic degenerative lumbar disc diseases with adequate canal decompression, radiological correction and functional improvement without financial burden.

Keywords: Lumbar disc diseases, Minimal invasive surgery, Techniques, Transforaminal lumbar interbody fusion

Introduction

Harms and Rolinger were the first to describe open transforaminal lumbar interbody fusion (TLIF) [1], which is an effective procedure for lumbar spondylodesis, despite its high invasiveness

with complication rates up to 25% [2]. With the incoming of minimally invasive spine surgery (MISS), Foley and Lefkowitz [3] introduced the MIS-TLIF with the advent of fewer complications; less intraoperative blood loss and postoperative narcotic use; shorter hospitalization and recovery time; with similar clinical outcomes and fusion rates compared

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with conventional open TLIF [4]. The superiority of MIS-TLIF is due to less muscle disruption and destabilization of the spinal segment, in addition, achieving bilateral decompression via a unilateral approach if needed and indirect neural decompression [2]. However, using microscopes and access to microsurgical facilities is challenging and limited in middle-income countries because of lack of equipment and high purchasing costs [5].

The objective of this study is introducing simple technique to overcome weak facilities during MIS-TLIF surgery in treatment of lumbar disc diseases using a novel plastic syringe instead of minimal invasive distractible or tubular retractor and evaluating the postoperative clinical, radiological, functional, and perioperative outcomes.

Patients and methods

Thirty-five adult patients with degenerative lumbar disc diseases were managed at our hospital between January 2018 and August 2020 after obtaining an informed consent from all patients in accordance with the guidelines of our medical ethical committee (No.394:2022).

The inclusion criteria were cases with single or double level degenerative disc diseases, unilateral or bilateral radiculopathy, grade 1–2 degenerative spondylolisthesis, extra-foraminal disc prolapse, facet joint cysts or arthritis and, revision spine surgery. Patients with serious systemic diseases (such as; severe osteoporosis, metabolic or vascular diseases, infection), medically unfit patients, non-compliant patients, psychological disorder and patients with deformity were excluded from this study.

Pain was assessed by the visual analog scale (VAS) for low back pain (LBP) and lower limb (LL) pain. Validated Arabic Oswestery disability index (ODI) [6,7] and modified Prolo score [8] were used for functional assessment. Plain radiological evaluation was done pre, postoperatively and at final follow-up visits using anteroposterior, lateral, and lateral views in flexion and extension to calculate segmental lumbar lordosis (SLL) [The angle between the superior endplate of cephalad vertebrae and the inferior endplate of the caudal vertebrae in the affected motion segment], disc space height (DSH) [the median of measurement of three lines each have two points at the posterior, middle and anterior part of adjacent end plates of vertebra above and vertebra below], percentage of slippage according to Meyerding grading [9], foraminal height [the length between the highest point in the caudal pedicle and the lowest point in the rostral

pedicle]. Magnetic resonance imaging (MRI) used to determine the level and percentage of spinal canal compromise (SCC) in axial cuts either pre and postoperatively, disc varieties, degree of facet osteoarthritis and foraminal morphology. Multidetector computerized tomography (MDCT) was used in selected cases with suspected pars defect.

Operative procedure

Under hypotensive general anesthesia the patient was situated over the orthopedic surgery table in the prone position on a couple of firm pillows. Möller-Wedel Hi-R 1000 microscope is used (FS: 4–20, built in xenon, light source 300 w, power zoom 1:6). Proportional integral derivative (PID) distance was set preoperatively for both the surgeon and the assistant for binocular vision. Skin was accurately marked for the level to be operated upon utilizing fluoroscopy. Small paraspinous incision after disinfection and sterile draping was done selectively on the predominant side of complaint, then splitting of multifidus and longissimus coli muscles by the tip of the index finger. Two small retractors were used between 2 previously mentioned muscles to create a space for insertion of plastic tubular syringe over the working zone. Then, a preadjusted 50 ml plastic sterile tubular syringe (inner diameter:29 mm) is introduced over the working field. The length of plastic tube is preadjusted and measured depending on the depth of paraspinous muscle in each case from the skin towards the targeting facet joint deeply and the remaining unnecessary length of plastic tube was cut by a surgical scissor/scalpel and removed. After press fit insertion of the preadjusted plastic tube between multifidus and longissimus coli muscles, it was firmly fixed over the working area (the facet joint) by its tight suturing to the skin then the microscope was positioned and tilted 30–45° towards the working area to allow good visualization and exposure. Then, microscopically assisted decompression was done via the same three main osteotomies for unilateral facetectomy. Following adequate decompression and control of bleeding, disc space was identified. Then a cruciate-shaped incision is made in the annulus fibrosus of the disc. Gradual removal of the disc material with different sized rongeurs while angulating the rongeurs in different directions to make sure there is no remaining disc material left in the disc space to prevent contralateral bulging of the disc material after insertion of the cage.

The end plates are prepared via variable sized shavers, then variable sized trials are used to measure the exact size of the cage, and any remnants of

disc material were removed to widen the space. Local morselized bone graft obtained from decompression side was impacted in the anterior ^{1\3} portion of empty disc space. A tricortical iliac bone autograft or a cage filled with local bone graft is inserted. In order to prevent contralateral foraminal stenosis the cage is inserted in a diagonal manner just to cross the midline of the disc space.

Pedicular screws were put in the dominant side of the offending level after cage insertion through the plastic syringe using the free hand technique and compression is applied over the pedicular screws to hold the cage in place and prevent its subsidence or posterior dislodgement.

The contralateral side was fixed percutaneously by long crown pedicular screws through small paraspinal incision using the K wireless technique previously reported by Spitz et al. [10] under C-Arm guidance. A 1-cm-long longitudinal incision is planned for each screw lateral to the lateral border of the pedicle. This lateral starting point ensures proper docking of the awl onto the junction of the lateral superior facet and transverse process (lateral pedicle border on AP fluoroscopy) away from the facet joint to avoid its injury and maintain a triangulating screw trajectory. Using the long crown pedicular screws (instead of the cannulated percutaneous pedicular screws that is still deficient in our hospital) allowed the rod placement through the small incision. After contouring the rod in lordosis, it was placed in position on the screws and the screw nuts were tightened. Wound irrigation and intra-wound vancomycin antibiotic were applied over the operative field to minimize the chance of surgical site infection (Figs. 1–4).

In cases of degenerative spondylolisthesis (10 cases), primary one side percutaneous screw fixation was performed to facilitate slippage reduction, disc space preparation and cage insertion from contralateral side. Also in double level disc disease, plastic syringe was inserted in one side to operate the offending level and another syringe was used on the contralateral side to operate the other affected level. Sometimes two neighbors syringe were applied from one side to operate on two adjacent dominant levels.

Postoperative regimen and follow-up

All patients had postoperative plain X-rays taken in two views to evaluate alignment, slippage reduction and implant or graft insertion. For the first five days following surgery, both antibiotics and analgesics were administered. Patients were allowed to sit on the bed or walk on the first postoperative day.

Patients did not require support by lumbosacral orthosis. Perioperative outcomes and complications were documented. Patients were followed up every 3 months in the first year then every 6 months till the end of the follow-up. The patients were evaluated clinically (VAS for LBP and LL pain), radiologically (SLL, DSH, foraminal height, slippage reduction, SCC and fusion using BSF criteria [11]) and functionally (ODI and modified Prolo score) at follow-up visits. MDCT scan was needed for 5 patients (20%) to confirm fusion and 1 patient (3.3%) with misplaced screw during follow-up period.

Statistical analysis

The acquired data were coded, tabulated, and statistically analyzed via SPSS (version 26, IBM Corporation, Armonk, New York, USA). Descriptive statistics were calculated for numerical data by mean, standard deviation, and minimum and maximum of the range. Categorical data were calculated by number and percentage. McNemar test was applied when nonparametric and parametric variables were analyzed using the paired sample t-test was for comparison of quantitative data. *P* value < 0.05 was significant, *P* value < 0.001 was considered highly significant, and *P* value > 0.05 was insignificant.

Results

Thirty patients [11 males and 19 females with mean age 42.5 years] with their complete medical records were accessible for this retrospective analysis while the remaining 5 cases were dropped during follow-up and excluded from the study due to incomplete medical data. Reported comorbid diseases were smoking in 25 (83.3%), Diabetes Mellitus in 9 (30%), hypertension in 6 (20%), compensated liver disease in 5 (16.7%), and bronchial asthma in 4 (13.3%). Indications for surgery were, posterolateral degenerative disc herniation in 12 (40%), far lateral disc was observed in 3 (10%), spondylolisthesis in 10 (33.3%), and revision surgery due to previous inadequate decompression in 5 (16.7%) cases. LBP was reported in all cases while radicular lower limb (LL) pain was reported in 20 (66.7%) including right side in 13 cases and left side 7 cases.

Operated single level surgery was L5-S1, L4-5 and L3-4 levels in 14 (46.7%), 9 (30%) and 4 (13.3%) patients respectively while double levels were performed in 3 (10%) patients. Fibro-carbon reinforced Polyetheretherketone (PEEK) cage augmented by morselized bone graft in 24 (80%) cases and

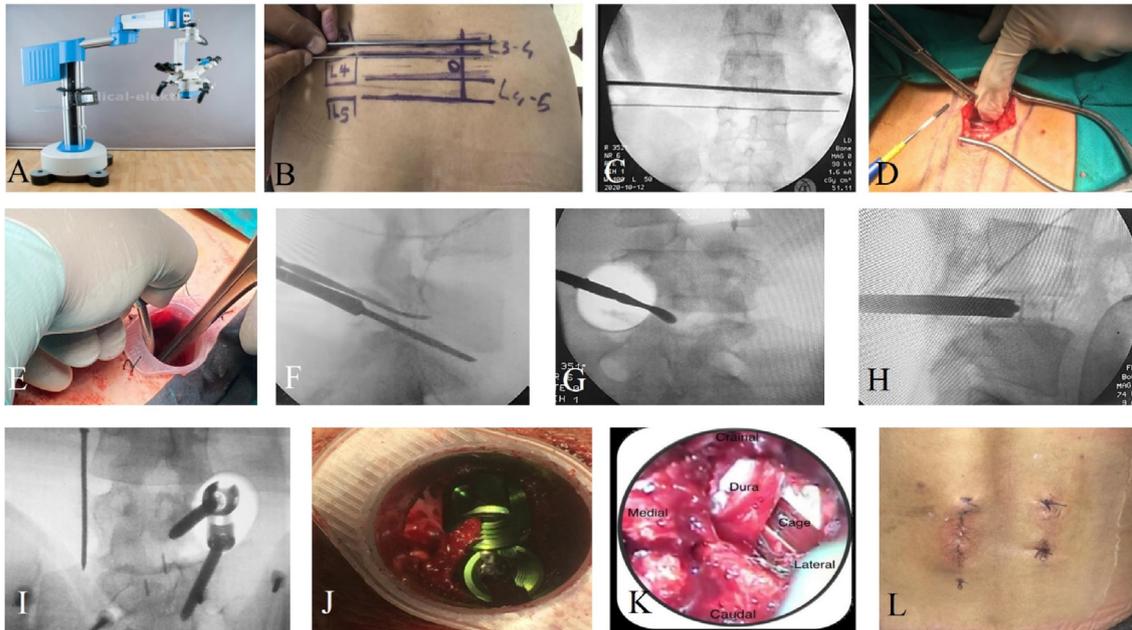


Fig. 1. Showing steps of microscopic MIS-TLIF surgery using a novel plastic 50 ml tubular syringe.)A(Möller-Wedel Hi-R 1000 microscope,)B(skin marking,)C(disc leveling by fluoroscopy,)D(muscular splitting by index finger as described by Wiltse approach to reach over facet joint,)E(insertion and tight suturing of plastic tube to the skin over the working zone (facet joint),)F(disc space identification,)G(disc preparation and curettage,)H(cage insertion,)I(pedicular screw insertion through plastic tubular syringe,)K(microscopic intraoperative photo showing dura and nerve root after cage insertion,)L(contralateral percutaneous K wireless screw insertion and skin closure.

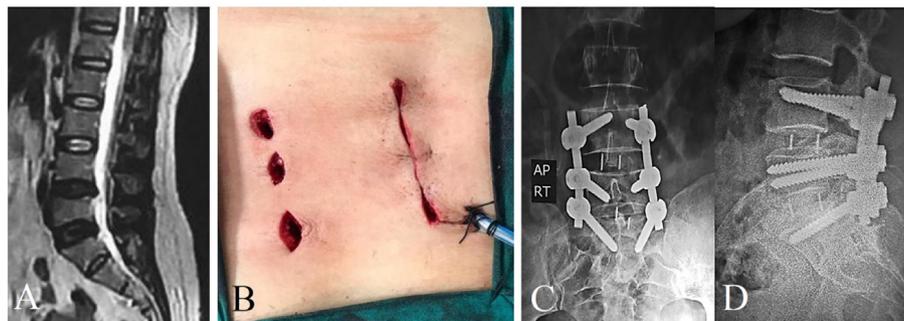


Fig. 2. (A) showing preoperative sagittal T2 weighted MRI of double levels L4-5 and L5-S1 degenerative disc diseases with spinal canal compromise, (B) showing operative photo, (C,D) postoperative radiograph after double level MIS-TLIF surgery through right Wiltse paraspinal approach and contralateral percutaneous K wireless spine fixation.



Fig. 3. (A) showing preoperative sagittal T2 MRI cut of previous inadequate discectomy at L4-5 level, (B) postoperative clinical photo of previous scar and incision length after MIS-TLIF at L4-5 through left Wiltse approach, (C) Lateral postoperative radiograph after MIS-TLIF surgery through Wiltse paraspinal approach and contralateral percutaneous K wireless spine fixation.



Fig. 4. (A) showing T2 sagittal MRI film, (B) lateral plain radiograph of degenerative spondylolisthesis grade I at L5- S1 with spinal canal compromise, (C) postoperative lateral imaging after MIS-TLIF surgery through right Wiltse paraspinous approach and contralateral percutaneous K wireless spine fixation with adequate slippage reduction, (D) clinical photo of incision length during follow-up period.

tricortical iliac bone graft in 6 (20%) cases as inter-body graft.

Mean operative blood loss was 200 ± 20 (150–250) ml, mean operative time was 170 ± 25 (120–240) minutes, the mean operative radiation exposure time was 2.27 ± 0.6 (1.5–4) minutes, and the mean incision length was 4.5 ± 1.5 (3–6) cm. Mean hospital stay was 1.5 ± 0.7 (1–2) days.

Clinically, patients reported an improvement of their back and leg pain with significant difference between preoperative and immediate postoperative VAS ($P < 0.001$). Regarding VAS for LBP and LL pain, ODI & modified Prolo scores, there was an

improvement with statistically significant difference between preoperative, during and at the final follow-up ($P < 0.001$) (Chart 1).

Radiographically, mean immediate postoperative DSH and foraminal height were significantly increased 2.6 mm and 4.1 mm respectively from preoperative state ($P < 0.01$) with slight decline of DSH 0.35 from immediate postoperative DSH without affection of foraminal height at the final follow-up state. Mean immediate postoperative SLL angle was significantly corrected 3.4° from preoperative state ($P < 0.01$) with slight loss at the end of follow-up. Percentage of spinal canal decompression

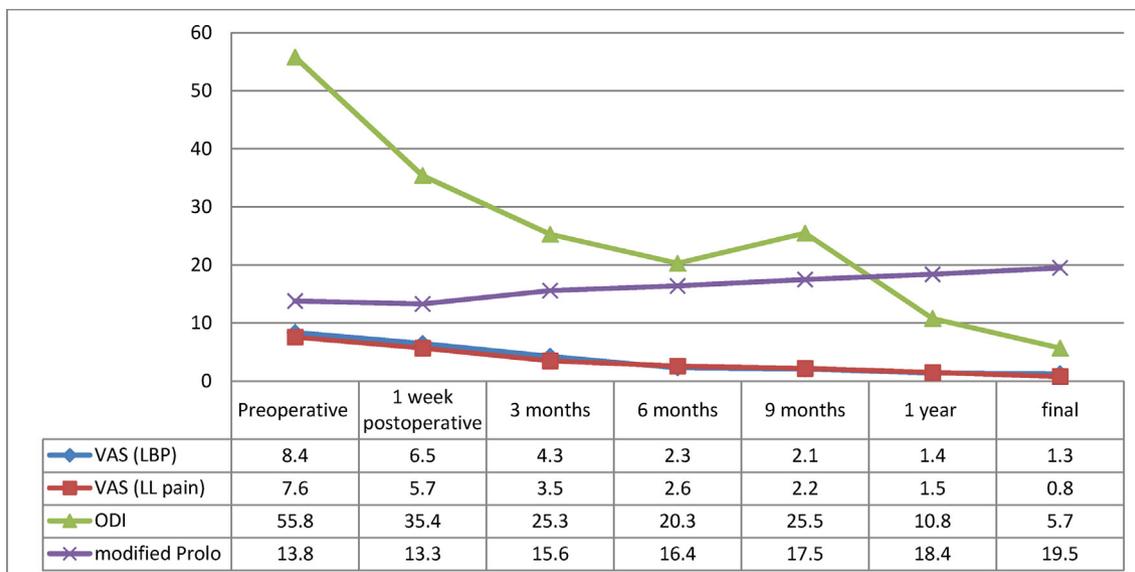


Chart 1. A line chart showing different means of VAS for LBP and LL pain, ODI, and modified Prolo scores during follow-up period.

(the difference between pre- and postoperative SCC in axial MRI cuts \(\preoperative SCC \times 100\)) and slippage reduction (the difference between pre and postoperative slippage degree according to Meyerding grading [9] in lateral radiograph \(\preoperative slippage degree \times 100\)) were 51.9% and 69.78% respectively (Table 1).

The mean follow-up period was 36 ± 3.2 (24–48) months. Mean fusion time was 8.72 ± 2.18 months. According to BSF criteria [11], twenty-seven patients (90%) showed definitive fusion (grade 5) while 3 cases (12%) had probable fusion (grade 4) at final follow-up.

Reported complications included postoperative temporary foot drop in 1 case likely caused by nerve root manipulation and resolved within 2 months by physiotherapy; misplaced pedicular screw in 1 case which required reinsertion in the correct trajectory, and surgical site infection in 1 case that was treated by wound debridement with vancomycin antibiotic powder spread over the infected site.

Discussion

Outcomes of health-related quality of life (HRQOL) are of paramount importance when assessing the effectiveness of any technique. In the current study, the percentage of VAS for (LBP and LL pain), ODI [6,7] and modified Prolo score [8] improvement was 87.5%, 90.9% and 63.2%, respectively between preoperative and final status. Foraminal height, DSH, angle of SLL and percentage of slippage reduction in spondylolisthesis cases were corrected for 4.1 mm, 2.6 mm, 3.4° and 69.78%, respectively.

Despite the proven efficacy of the conventional posterior techniques, they are accompanied by extensive muscle morbidity, significant blood loss and higher risk for injury of neural structures. Hence, the anterior techniques and the minimally invasive techniques found their way up as an alternative for the conventional techniques [12].

The concept of MISS procedure is still a matter of controversy. Some surgeons may classify a technique as minimally invasive, while others may label it as open. Procedures utilizing tubular retraction, expandable working tubes, and percutaneous screws along with miniopen techniques, unilateral

and bilateral Wiltse procedures, and combinations of these techniques have been determined as MISS procedures [13].

In 2005, technical feasibility and initial results of MIS-TLIF was published by Holly as a potential alternative to decrease morbidity associated with open techniques including blood loss and extensive soft-tissue dissection. Preserving the natural posterior tension band and the use of a muscle-splitting approaches or tubular retraction system minimize the damage to paraspinous musculature, with subsequent minimal postoperative pain and muscular necrosis [14].

However, many spine surgeons could not use MIS-TLIF due to its learning curve, high cost of equipment, long operative time and high radiation exposure rather than conventional lumbar fusion and difficulty to manage bilateral symptoms using unilateral approach [15].

MIS-TLIF surgery through Wiltse paraspinal approach allowed a direct exposure over the working zone with minimal muscle disruption, sparing of multifidus muscle and posterior tension surface of the vertebra including posterior ligamentous complex (PLC). So, it is an ideal choice for revision cases to avoid injury of the neural structures during decompression and neurolysis.

It should be mentioned that minimally invasive tubular or distractible retractors are unavailable in our hospital until now, before this study we had an exhausting experience using hand held retractors to replace the distractible or tubular retractors, which was a huge burden on both; the surgeon who had to operate in an inadequate visualization of the operative field and the assistant who had to hold the retractors for a long time. This obstacle was avoided using 50 ml plastic syringe [its core diameter 29 mm which is almost equivalent to the largest sequential tubular retraction system (28 mm)], this is a point of novelty in our study.

On comparing our results with previous literatures discussing MIS-TLIF surgery, mean intraoperative estimated blood loss, operative time and radiation exposure time in the current manuscript were relatively higher than other studies as Lv et al. [16]; Monk et al. [17]; Song et al. [18] and Wang et al.

Table 1. Radiological outcomes in our group of patients ($n = 30$).

Parameters	Preoperative	Postoperative	Final	Correction%	Correction loss
DSH/mm	8.74 ± 1.35	11.34 ± 1.5	10.99 ± 0.9	29.7%	0.35 ± 0.6
Foraminal height/mm	9.7 ± 1.2	13.8 ± 1.3	13.4 ± 0.5	42.2%	0.4 ± 0.8
Slippage/%	35.54 ± 4.35	10.74 ± 3.32	12.6 ± 2.45	69.78%	$1.86 \pm (-0.87)$
SLL/ $^\circ$	7.5 ± 1.2	10.9 ± 0.5	9.9 ± 0.9	45.3%	1 ± 0.4
SCC/%	65.56 ± 7.07	31.55 ± 3.5	–	51.9%	–

DSH, disc space height; SCC, spinal canal compromise; SLL, segmental lumbar lordosis.

[19]. This may be attributed to lack of tubular retractor and percutaneous screw system in our institute. Mean hospital stay in the current manuscript is shorter than both Lv et al. [16] and Monk et al. studies [17]. Patient's functional outcomes go in line with Wang et al. [19], and Jacob et al. [20] studies whom reported significant improvement in VAS and ODI after MIS-TLIF surgery. The follow-up period in the current study is longer in our study than others (Table 2).

The reported complications in this study were transient foot drop, surgical site infection and misplaced screw in 3 patients consequently, this was much less than Zhu et al. [21] who in a meta-analysis including 927 cases reported incidence of complication of 10.78%. Complications in their study included dural tear (11 cases), screw malposition (10), neurological deficit (11 cases), Wound infection (17 cases), hematoma (1case), urinary retention (17 cases), urinary tract infection (3 cases), atelectasis (8 cases), pneumonia (1 case), deep venous thrombosis (1case), pulmonary embolism (1case), cage subsidence/migration (4 cases), Pseudarthrosis (2 cases), bone nonunion (1case), adjacent segment disease (12 cases) and reoperation in 27 cases.

The variability of results concerning estimated blood loss, surgical time and complication rate with MIS-TLIF among different studies may be related to the learning curve of surgeons. The learning curve is greatly expressed in our study, the huge difference in the operative time between the first cases (240 minutes) compared to the last case (120 minutes) sums it all.

Limitations of our study included retrospective study design, relatively small data size and absence of control group. Moreover, body mass index and pelvic parameters like pelvic incidence and tilt were not evaluated in this cohort. Follow-up, although not short, is not long to allow evaluation for adjacent segment disease. A well-designed prospective study with larger patient's sample size, control group and proper randomization is required for confirmation of our results. Future prospective comparative studies (with other similar surgeries using expandable/tubular retractor or other different MISS procedures like endoscopic trans-Kamban triangle lumbar interbody fusion (EndoLIF), lateral lumbar interbody fusion (LLIF), oblique lumbar interbody fusion (OLIF) and extra-foraminal lumbar interbody fusion (ELIF).

Conclusion

Considering these findings, it is concluded that MIS-TLIF through Wiltse paraspinous approach is effective in management of adult lumbar disc

Table 2. Comparison between results of the current study versus other studies.

Studies	No of cases	Procedure	Follow-up/months	Perioperative outcomes					Fusion rate
				Operative Time/min	Blood Loss/ml	Hospital Stay/day	Incision Length/cm	Radiation Time/sec	
This study	30	MIS-TLIF – Wiltse approach	24–48	170 ± 25	200 ± 20	1.5 ± 0.7	4.5 ± 1.5	136.2 ± 36	90%
Lv et al. [16]	48	MIS-TLIF		104.1 ± 17.2	146.2 ± 41	7.2 ± 2.7	NA	NA	90.7%
Monk et al. [17]		MIS-TLIF	3	106.2 ± 27.7	NE	13.5 ± 6.3	NA	NA	
Song et al. [18]	24	MIS-TLIF	12	145.67 ± 24.82	140.25 ± 12.6	NA	NA	NA	
Wang et al. [19]	38	MIS-TLIF/tubular retractor	12	92.31 ± 45.32	184.60 ± 68.36	NA	NA	42.68 ± 10.28 s	89.5%
Jacob et al. [20]	740	MIS-TLIF	48	127.6 ± 44.6	68.1 ± 78.1	2.05 ± 1.5	NA	NA	NA

NA, not applicable.

diseases with many advantages like less incision length, blood loss, short hospital stays. We also introduce a beneficial low-cost substitute method to the expensive unavailable tubular retractor.

Author declaration of funding statement

No funds were received in support of this work.

Ethics Information

The article does not contain information about medical device(s)/drug(s).

Conflicts of interest

There is no conflict of interest.

Abbreviations

BSF	Brantigan steffe fraser criteria
DSH	Disc space height
MISS	Minimally invasive spine surgery
ODI	Oswestry disability index
PID	Proportional integral derivative
PLC	Posterior ligamentous complex
RT	Radiation time
SLL	Segmental lumbar lordosis
TLIF	Transforaminal lumbar interbody fusion
VAS	Visual analog scale

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