

Technical pearls and surgical outcome of early transitional period experience in minimally invasive lumbar discectomy: A prospective study

ABSTRACT

Background: There is growing indications of minimally invasive spine surgery. The inherent attitude and institutive learning curve limit transition from standard open surgery to minimally invasive surgery demanding understanding of new instruments and correlative anatomy.

Materials and Methods: In this prospective study, 80 patients operated for lumbar disc prolapse were included in the study (between January 2016 and March 2018). Fifty patients (Group A) operated by various minimally invasive spine surgery (MISS) techniques for herniated disc disease were compared with randomly selected 30 patients (Group B) operated between the same time interval by standard open approach. Surgical outcome with Oswestry Disability Index (ODI) and patient satisfaction score was calculated in pre- and postoperative periods.

Results: Mean preoperative ODI score in Group A was 31.52 ± 7.5 standard deviation (SD) (range: 6–46; interquartile range [IQR]: 8; median: 32.11) and postoperative ODI score was 9.20 ± 87.8 SD (range: 0–38; IQR: 11; median: 6.67). Mean preoperative ODI score in Group B was 26.47 ± 4.9 SD (range: 18–38; IQR: 4; median: 25) and postoperative ODI score was 12.27 ± 8.4 SD (range: 3–34; IQR: 12; median: 10.0). None of the patients was unsatisfied in either group. On comparing the patient satisfaction score among two groups, no significant difference ($P = 0.27$) was found.

Discussion: On comparing the change in ODI and preoperative ODI among both groups, we found a significant difference between the groups. It is worth shifting from open to MISS accepting small learning curve. The satisfaction score of MISS in early transition period is similar to open procedure.

Conclusion: The MISS is safe and effective procedure even in transition period for the central and paracentral prolapsed lumbar intervertebral disc treatment. The results are comparable, and patient satisfaction and symptomatic relief are not compromised.

Keywords: Destandau's method, disc degenerative disease, endoscopic discectomy, minimally invasive, spondylolisthesis

INTRODUCTION

The last decade experienced accretion in armamentarium of spine surgery evolving more and more indications of minimally invasive spine surgery (MISS). The idea is to perform “target surgery” with minimal tissue handling. Adequate skin incision and preservation of biomechanical active structures such as muscle, ligaments, and bone with achievement of desired neural decompression are the key of MISS. The common indications of MISS are disc degenerative disease including lumbar disc herniation (LDH) and degenerative spondylolisthesis. Among LDH, central and paracentral herniation accounts for 80%–85%

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of limb radiculopathy, whereas foraminal and extraforaminal herniation represents 11% of all LDH.^[1,2] LDH can be surgically dealt by interlaminar or transforaminal approach [Figure 1]. Among all the MISS techniques for LDH, described in literature, standard tubular microdiscectomy (MD) and Destandau's interlaminar endoscopic discectomy dominate as most popular methods. Foraminal and extraforaminal disc herniation is better dealt with percutaneous endoscopic transforaminal discectomy (PETD). It was Hijikata who first performed PETD in 1975, but the procedure was further modified and popularized by Kambin *et al.*^[3,4]

In this article, we intend to discuss patient-related outcome (both objective and subjective) in our early experience as we shifted from open standard laminectomy to MISS mainly for disc degenerative diseases. The article highlights the postoperative outcome (Oswestry Disability Index [ODI] and patient satisfaction score) of patients with disc degenerative disease operated by various MISS techniques with the review of literature comparing them. Moreover, we have discussed the problems we faced overcoming vacillation in our transition phase.

MATERIALS AND METHODS

Individual consent from all the patients to use clinical and radiological details for publication was taken before study. Institutional ethical clearance was obtained and there was no conflict of interest.

Patient spectrum

It is worth understanding that MISS can be offered to a subset of patients only. Patients having single-level paracentral disc prolapse with unilateral radiculopathy

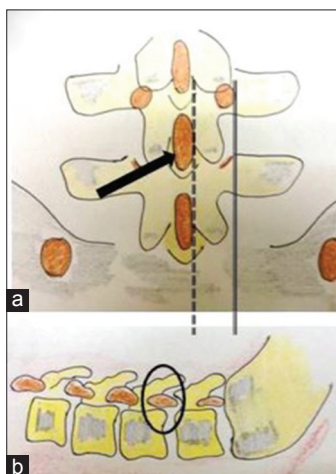


Figure 1: (a) Interlaminar window used for endoscopic discectomy by Destandau's interlaminar approach. (b) Transforaminal approach for discectomy and MI-TLIF through Kambin's triangle. The zone is formed medially by the superior facet joint, inferiorly by the transverse process, and superiorly and inferiorly by the nerve root exiting the neural foramen

predominantly unilateral and positive nerve root tension sign with or without sensory or motor neurological lesion on neurological examination were offered options for minimal invasive surgical approaches for discectomy. Multiple-level degenerative changes associated with chronic back pain and severe lumbar canal stenosis (LCS) were directly advised open lumbar discectomy. We offered MD or Destandau's endoscopic discectomy (DED) for central and paracentral LDH and PETD for foraminal and extraforaminal disc herniation. During study, choice between DED or MD was random on availability of endoscope and surgeon's preference.

Study design

In this prospective study, 80 patients operated for lumbar disc prolapse were included in the study (between January 2016 and March 2018) [Figure 2]. Total 50 patients operated by MISS (MD, DED, and PETD) for herniated disc disease were included as Group A. Thirty patients (selected randomly) underwent open lumbar discectomy for single- or two-level disc prolapse were included under Group B. All the patients were preoperatively assessed by Oswestry Disability Index (ODI) score. Patients operated through MISS approach (Group A, $n = 50$) and open standard laminectomy (Group B, $n = 30$) were re-evaluated with ODI at 6 weeks of follow up. Patient satisfaction score was also calculated at same time, a questionnaire was given, and all the patients in Group A and Group B were asked for option of choosing open versus MISS again with their own perspective (if they have to undergo discectomy).

Study parameters

The 45-point scoring (excluding questions on sexual parameters) ODI was used during preoperative and follow-up (6 weeks), and patient satisfaction score (PSS) applying North American Spine Society satisfaction scale^[5] was used at 6-week follow-up. Intraoperative complications including time of surgery (from induction to dressing) and

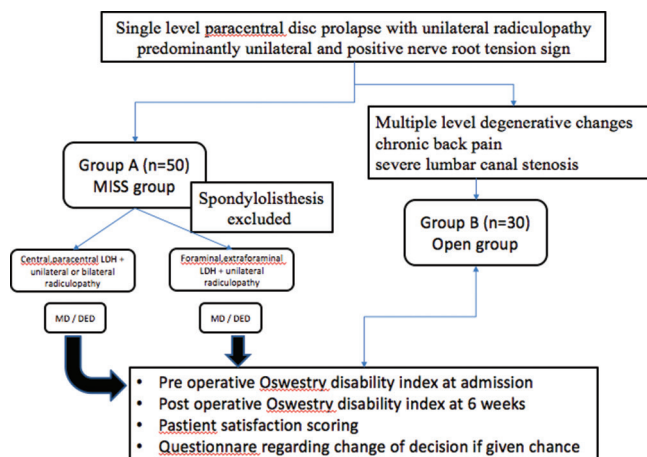


Figure 2: Our study protocol showing distribution of patients in Group A and Group B

neurological examination details were noted on individual basis. The parameters including age, sex, level of lesion, and postoperative complications were recorded from hospital case records, outpatient files, and the hospital information system.

Exclusion

Patients with radiological evidence of spondylolisthesis and those operated by senior consultant surgeon (experience more than 10 years) were excluded from the study. None of the traumatic disc herniation was included in the study.

Statistical analysis

We compared changes in ODI score, preoperative ODI, and patient satisfaction score among patients of Group A and Group B using independent test comparing distribution of median and Chi-square test. The outcome and percentage difference in ODI were compared using independent *t*-test (SPSS) version 22.00 (IBM, New York).

Surgical pearls

Destandau's endoscopic discectomy method

Among prone and knee-chest position, we prefer knee-chest position as it provides maximum reduction of lumbar lordosis, widening the interlaminar distance [Figure 3]. The position helps in seepage of blood from operative field [Figure 4a].



Figure 3: (a) Representative magnetic resonance imaging sagittal of a 46-year-male patient presented with left radiculopathy with axial sections. (b) Left paracentral lumbar disc herniation and foraminal stenosis. (c and d) Postoperative magnetic resonance imaging showing decompression of the left L5/S1 foramen with partial laminectomy defect

We use a Karl Storz localizer [Figure 4b] which can move in all three planes. Approximately 1.5–2 cm incision is made, 1 cm paramedian [Figure 4c]. After incision, lumbodorsal fascia incised and paraspinal muscle dissected till the lamina. The endospine tube (designed by Destandau) [Figure 4d and e], includes three channels: One for suction, the other for surgical instruments, and the last for root nerve retractor. The speculum with outer sheath is docked over interlaminar space under C-arm guidance. There is 12° inclination so that tip of working instrument remains in persistent vision. It is not uncommon that outer sheath with speculum enters at the wrong level, so we recommend to re-confirm the position of speculum. We drill the lower one-third of the superior lamina, and the medial part of the facet is removed by 120° 3 mm Kerrison punch followed by partial ligamentum flavum window made by 90° Kerrison punch. Preservation of fat and ligamentum flavum overlying the nerve root prevents postoperative epidural scarring and fibrosis. The thecal sac and shoulder of the nerve root retracted by dissector and then nerve root retractor. It is advised to use two cotton patties (one at the shoulder of the nerve root and another above it for retraction of the thecal sac) to prevent both dural and nerve root injuries. After annulotomy, the herniated disc is removed with the help of disc forceps.

Tubular microdiscectomy

Standard protocol for tubular discectomy is similar as described in DED. We used tubular MD retractor instead of Destandau's endospine tube and remaining procedure performed under the microscope.

Percutaneous endoscopic transforaminal discectomy [Figure 5]

We operated all cases under local anesthesia [Figure 6a] because of flexibility of intraoperative neurological examination to monitor nerve root injury. For L4/5 discectomy, the entry point is marked along the horizontal line [Figure 6b and c], and in lateral

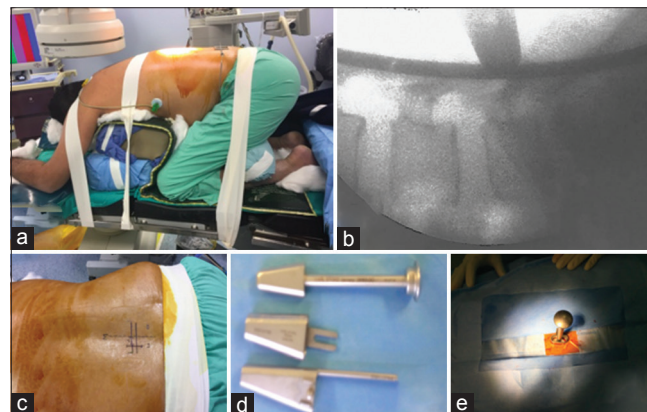


Figure 4: (a) Knee-chest position in Destandau's endoscopic discectomy, (b) disc space marked using Karl Storz localizer. (c) Two-centimeter incision is marked on 1 cm paramedian. (d and e) Speculum, outer sheath, and inner sheath with four channels which are docked under C-arm guidance



Figure 5: A 38-year-old male presented with right lower limb radiculopathy and magnetic resonance imaging lumbar spine sagittal and axial view (a and b) showing right L4-5 foraminal disc prolapse

view, the distance from anterior margin of the vertebral body to skin level is marked as vertical line [Figure 6d]. Intersecting point of above two lines is marked as entry point – approximately 10–12 cm paramedian (after confirmation of the needle tip in the foramen 1 cc bupivacaine (5%) is instilled in the foramen. The guidewire then inserted through the spinal needle through the triangular working zone into the intervertebral disc with approximately a 45° angle [Figure 6e]. The triangular working zone is basically defined by Kambin and Gellman.^[6] The guidewire location should be on the interpeduncular line. The tract is further sequentially dilated using dilators and then annulus is pierced once the tip of trocar is confirmed at the right space [Figure 6f]. Care should be taken to ensure that the smooth side of the telescopic instrument remains always oriented toward the exiting nerve root. The bevelled cannula is then inserted until reaching contact with the annular wall. The careful rotation of the bevel will protect the exiting root. We use a 0° angle optic with 15 cm length and 3 mm diameter (Yeung Endoscopic Spine System [YESS], irrigation system, and saline irrigation were used to aid visualization). After clear exposure of the extruded disc material [Figure 6h], it was removed using different size of disc forceps. We also used the radiofrequency probe to shrink the disc material and as hemostatic device. The completeness of surgery is confirmed by flapping movement of the annulus [Figure 6g].

RESULTS

Patient spectrum

The mean age in case Group A was 35.4 ± 10.9 standard deviation [SD] (range: 16–61; IQR: 17) (M:F = 35:15). The

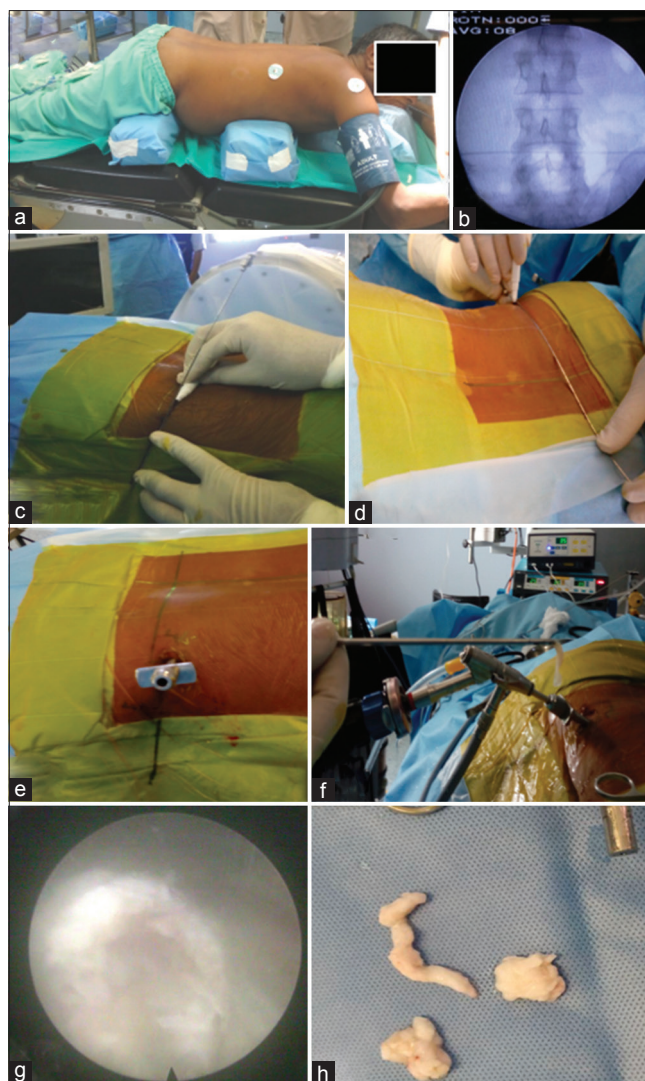


Figure 6: (a) Prone position for percutaneous endoscopic transforaminal discectomy under local anesthesia, (b) the entry point is marked along the horizontal line (c) and in lateral view, and vertical line. The guidewire then inserted through the spinal needle through the triangular working zone into the intervertebral disc with approximately a 45° angle (e). The tract is further sequentially dilated using dilators and then annulus is pierced once the tip of the trocar is confirmed at right space (f), (g) completeness of surgery is confirmed by flapping movement of the annulus (h) disc material

mean age of patients in control Group B was 41.5 ± 11.4 SD years (range: 18–68; IQR: 14) (M:F = 17:13). The age and sex distribution had no confounding effect on outcome of study. Totally 21 patients operated with MD, 23 with DED, and 6 with PETD. The mean duration of hospital stay in these groups was 4.9, 5.2, and 1.6 days, respectively.

Postoperative outcome

Surgical outcome

Thirteen patients had improvement in preoperative motor deficit ($n = 3$ MD; $n = 9$ DED; $n = 1$ PETD). The sensory numbness ($n = 14$) and bladder involvement ($n = 5$) persisted in all patients till 6 weeks of follow-up. There was significant

improvement in pain and radiculopathy (ODI score) in all patients [Figure 7].

Table 1 shows surgical complications. In Group A, 12 patients had dural tear ($n = 3$ MD; $n = 9$ DED) and 3 patients had nerve root tear (in DED). Out of 23 patients in DED group, 4 patients had new onset motor weakness and 2 of them had sensory numbness also. One patient in MD group had postoperative surgical site infection requiring increase in hospital stay and intravenous antibiotics. None of the patients had postoperative surgical site cerebrospinal fluid (CSF) leak. Out of the six patient of PETD, radiculopathy improved in all six, but mild back pain still persisted in three patients (no new onset neurological deficit seen), and all the patient were

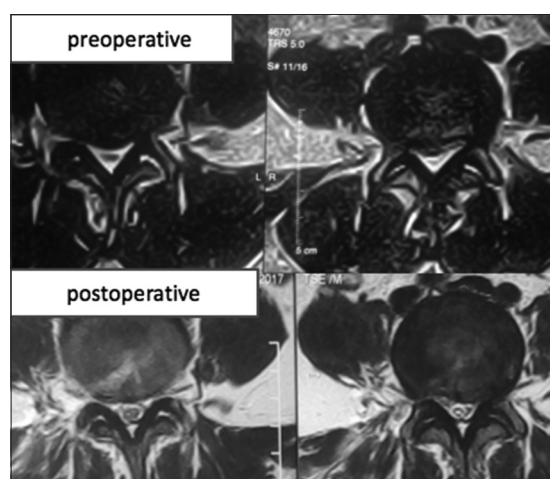


Figure 7: Representative example of patient treated via MISS approach (not included in text)

operated under local anesthesia (sutureless discectomy) and discharged on the same day of surgery.

In Group B, three patients had postoperative complications (1 urinary retention which persisted at 6-week follow-up; 2 patients were readmitted for CSF leak and needed re-suturing and antibiotics). Five patients (16.7%) had intraoperative CSF leak which was managed and were discharged without any complication or delay in hospital stay.

Oswestry Disability Index and patient satisfaction score

Mean preoperative ODI score in Group A was 31.52 ± 7.5 SD (range: 6–46; IQR: 8) and postoperative ODI score was 9.20 ± 8.8 SD (range: 0–38; IQR: 11). Thirty-four patients fully satisfied (PSS score 1), 10 patients were moderately satisfied (PSS score 2), whereas 6 patients (12%) were mildly satisfied (PSS score 3). None of the patients was unsatisfied and no patient opted for changing decision to “open” surgery.

Mean preoperative ODI score in Group B was 26.47 ± 4.9 SD (range: 18–38; IQR: 4) and postoperative ODI score was 12.27 ± 8.4 SD (range: 3–34; IQR: 12). Fifteen patients fully satisfied (PSS score 1), 10 patients were moderately satisfied (PSS score 2), whereas 5 patients (16.7%) were mildly satisfied (PSS score 3). None of the patients was unsatisfied. When asked for option of choosing again, 9 patients (30%) said that they would have preferred MISS.

On comparing the PSS among two groups, no significant difference ($P = 0.27$) was found. On comparing the change

Table 1: Clinical and postoperative details of Group A patients ($n=50$)

Procedure	Number of patients	Number of patients	Duration of stay	Dural tear (%)	Nerve injury (%)	New deficit (%)	Improvement in preoperative motor deficit (%)	Number of patients
Microscopic interlaminar discectomy (MD)								
L3-L4	0	21	4.9 ± 1.8	3 (14.3)	0	0	3 (14.3)	1 wound infection no CSF leak
L4-L5	7							
L5-S1	12							
Multiple	2							
Endoscopic interlaminar (DED)								
L3-L4	1	23	5.22 ± 2.0	9 (39)	3 (13)	Sensory=2 (8.7) Motor=4 (17.4)	9 (39)	No wound infection, postoperative CSF leak
L4-L5	9							
L5-S1	12							
Multiple	1							
Endoscopic transforaminal (PETD)								
L3-L4	0	6	1.6 ± 1.2	0	0	0	1 (16.7)	No wound infection, postoperative CSF leak
L4-L5	5							
L5-S1	1							
Multiple	0							

MD - Tubular microdiscectomy; DED - Destandau's endoscopic discectomy; PETD - Percutaneous endoscopic transforaminal discectomy; CSF - Cerebrospinal fluid

in ODI and preoperative ODI among both groups, we found significant difference [Table 2].

Subjective questionnaire about opting open or minimally invasive spine surgery

On analyzing the factors associated for changing of decision ($n = 9$) among patients in Group B, an independent *t*-test showed no significant association when median distribution of age, sex, preoperative ODI, and improvement in ODI postsurgery. On further analyzing the data, we compared the median distribution of the same factors to find any association with satisfaction score at 6 weeks of follow-up, and there was a significant association with age ($P = 0.07$) and change in ODI ($P = 0.00$), whereas preoperative ODI and gender distribution were not significant. Out of 5 patients with poor PSS, 4 had no complication and 2 had intraoperative minor leak. Out of 9 patients who wanted to change their decision (if re-option of MISS given), 8 had no complication and 4 had intraoperative minor leak.

Limitations of study

There were 4 patients in DED group which were planned for MISS but converted to open laminectomy due to technical difficulties in learning curve of surgeon. All these four patients (although crossover) were included in open Group B. We intend to eliminate any bias due to inherent expertise in standard laminectomy procedure by including only those patients who were operated by young faculty members, but still learning curve of both procedures cannot be comparable.

Then, there was relatively short duration of follow-up; hence, the long-term results of these procedures are unclear. The less number of patients in subset of PTED and DED for hypertrophic ligamentum flavum, makes it difficult to conclude a significant result.

Table 2: Comparison of patient-related outcome scores in Group A and Group B

	Group A ($n=50$)	Group B ($n=30$)	<i>P</i>
Preoperative ODI			
SD	31.52±7.5	26.47±4.9	0.00
Range	6-46	18-38	
IQR	8	4	
Median	32.11	25.00	
Percentage change in ODI			
SD	0.60±0.88	0.54±0.27	0.05
Range	-5.33-1.00	0.07-0.89	
IQR	0.32	0.55	
Median	0.76	0.58	

ODI - Oswestry Disability Index; SD - Standard deviation; IQR - Interquartile range

DISCUSSION

The biomechanical advantages and outcome yield in MISS surpass the limited literature and lack of precise guidelines. The preference trend is shifting toward MISS due to minimal tissue trauma, less blood loss, better cosmesis, less postoperative pain, shorter hospital stays with faster return to work, and thus reduced overall health-care cost.^[7-11] Our study results also supported the same facts with significant improvement in postoperative ODI score even at early learning period. The mean hospital stay of patients was rather similar to open standard procedures (discordant with quoted in literature) because of less confidence and vacillation in transition period.

The natural surgeon's instinct and familiarity with open laminectomy paved many obstacles in early journey. It takes long time to get equipped with new instruments and anatomical landmarks, working in narrow area at depth from working ports. One has to accept the long intraoperative time and radiation exposure in early learning curve.^[12] We gradually shifted using neuronavigation-guided pedicle screw fixation, thereby reducing overall radiation exposure (both to surgeon and patient) with its real-time principle and better accuracy.^[13]

Patients were satisfied in both groups; therefore, no patient in MISS group regretted their decision even when approach was converted to open intraoperatively ($n = 6$). Interestingly, these patients desired a second MISS approach. The mean duration of stay (which is proven advantage of MISS in literature) is not reduced in our study, either because few patients needed long hospital stay (re-surgery), thereby deviating the results statistically, or in early learning curve surgeons tend to be more cautious and less confident. Epstein *et al.* discussed the "learning curves" of MISS and found that number varied from zero for MIS versus open discectomy to 20–30 for a variety of cervical-thoracic-lumbar procedures.^[14] Similarly Sclafani and Kim found that durotomy is the most common complication in early learning curve of MISS.^[15]

Technical pearls for beginners

1. One has to transit in graded manner with optimal experience of open discectomy, followed by MD and then DED or PETD
2. The incision site is dynamic and tailored according to extent of migrated disc (superiorly or inferiorly). For two-level lumbar disc prolapse, we preferred single incision; due to extensive mobility of the Destandau's system, adjacent level disc can be approach easily
3. Various intraoperative obstacles encountered during surgery and how we gradually dealt them to improve our MISS outcome

(a) Frequent muscle poke out in the endoscopic view: We used three small gauge pieces, one over superior lamina, one over inferior lamina, and another lateral to facet joints, (b) bleeders from paraspinal muscle: 10 cc lignocaine with adrenaline diluted with saline instilled in depth till interlaminar level before incision, (c) bleeders from epidural venous plexus over the annulus: prevented by knee-chest position with head part of the table, (d) frequent lens fogging: prevented by continuous saline irrigation during whole surgery, (e) wrong level entry at wrong disc space: prevented by confirmation of the desired level by C-arm before to start bone work, (f) excessive drilling of lamina pars to expose nerve root: prevented by knee-chest position instead of prone, significantly increased interlaminar distance, and widened the foramen, and (g) frequent dural tear while excision of ligamentum flavum by rongeur was prevented by continuous saline irrigation system and use of nerve hook to break adhesions between central part of ligamentum flavum and dura

4. In the early part of learning curve, left-side paracentral disc prolapse is the ideal case to start with
5. Relative contraindication for endoscopic discectomy: In obese patients or with severe LCS due to facet joint, hypertrophy and HLF prefer open surgery in early learning curve.

Which technique is better?

MD requires sequential tubular retractor to approach the disc space and thereby increases radiation exposure compared to DED, which requires only two X-ray shoots, one in the beginning and another at the time of confirmation for endospine tube. One of the disadvantages of MED is the limited visual field and long duration surgery. In PTED, the retraction over the thecal sac and nerve roots is minimal with a cosmetic sutureless scar. However, it is difficult to deal with a migrated herniation or to remove bony stenosis, especially at the level of the lateral recess.^[16-18] In patients who have a high iliac crest, it may also be difficult to have transforaminal or subligamentous access to the last disc space (L5-S1).

Liu *et al.* compared the 2 years' outcome of 192 patients operated for symptomatic LDH by all three different techniques and concluded that all procedures are reliable for the treatment of symptomatic LDH. With few exceptions, PETD results in rapid recovery and satisfactory clinical results after 2 years of follow-up.^[19] Another single-center prospective randomized controlled study on 193 patients compared whether PTED results in better clinical outcomes

and less surgical trauma than MED. They found that over the 1-year follow-up period, PTED did not show superior clinical outcomes and did not seem to be a safer procedure for patients with LDH compared with MED. In addition, PTED had inferior results for median disc herniation, whereas MED did not seem to be the best treatment option for far-lateral disc herniation.^[20] A systematic review of four randomized controlled trials compared MED and MD and concluded that if performed skillfully, the former is as effective as the latter. Another benefit of MED is the excellent visualization provided by the microendoscope.^[21]

PTED includes two interventional approaches (percutaneous and endoscopic), and both of them demand different technical considerations. The early PTED technique, such as YESS described by various authors,^[22,23] was indicated for foraminal or extraforaminal disc herniation as well as for intracanal herniation. Nevertheless, large central and extraligamentous herniation was contraindicated for this procedure. The TESSYS technique advocated by Hoogland and others made it possible to operate inside the spinal canal by enlarging the intervertebral foramen through foraminoplasty.^[24] According to our early experience, patients with unilateral paracentral, foraminal, or extraforaminal disc prolapse with limb radiculopathy without LCS or foraminal stenosis would be more suitable candidates for PTED under local anesthesia. Caudally migrated disc prolapse excision by this technique demands more surgical experience.

CONCLUSION

MISS is a safe and effective procedure even in transition period for the central and paracentral prolapsed lumbar intervertebral disc treatment. The results are comparable to standard open discectomy. Patient satisfaction and pain relief are not compromised once the surgeon is versed with anatomical landmarks and surgical nuances. We believe that it is worth to follow the learning curve and shift to minimally invasive surgery. Patient satisfaction depends on percentage change in ODI and age of the patient. The more is change in ODI, more will be patient satisfaction ($P = 0.00$), and elderly age patients have lesser PSS ($P = 0.07$). The decision of changing procedure from open to MISS is random and does not depend on age, gender, preoperative ODI, or change in ODI.

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Conflicts of interest

There are no conflicts of interest.

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