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RESEARCH ARTICLE
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EXPERIENCE OF ENDOSCOPIC LUMBAR DISCECTOMY

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ABSTRACT

Background: Lumbar intervertebral disc prolapse has been treated using a variety of techniques, including normal, micro, percutaneous, and transforminal endoscopic discectomy. By using a posterior interlinear endoscopic technique, the access to the spine is maintained to a minimum without stripping the paraspinal muscles and limiting muscular injury.

Objective this study's objective was to assess the technical issues, side effects, and overall preliminary outcomes of micro endoscopic discectomy.

Materials and Methods: This study was retrospective, carried out at the department of neurosurgery Qazi Hussain Ahmad Medical Complex, MTI Kpk Pakistan for a duration of two years from January 2021 to January 2022. Overall 100 consecutive cases of microendoscopic dissectomy performed on patients between the ages of 19 and 65 are documented. The criteria for inclusion were every individual with single nerve root injuries, as well as migratory discs at L4-L5 and L5-S1. Bilateral radiculopathy patients were excluded. To assess the effectiveness of the decompression, all individuals had preoperative MRI, and the first 11 patients experienced postoperative MRI. When an MRI was equivocal (n=7), diagnostic chosen nerve root slabs were performed in some instances to localize the particular root cut. Using the Medtronics Metrx system, a single surgeon performed all of the surgeries on the patients. Only three patients had operations using 16-mm ports, whereas 97 received operations using 18-mm ports. Following surgery, all persons were organized as soon as the pain reduced and were released 24 to 48 hours later. According to modified Macnab criteria, patients were assessed for technical issues, problems, and inclusive outcomes. Patients were monitored after two, six, and twelve weeks**.**

Results: The average continuation time was 12 months (with a range of 3 months - 4 years). One individual with suspected root wound needed open transformation. In five initial instances, single facet excision was performed intraoperatively. In seven instances, there were minor dural punctures, and one case had root injury. The average surgery was 70 minutes; the range was 25 to 210 minutes. 20 to 30 ml of blood were lost on average. In the first 25 instances, technical challenges included guide pin insertion, picture orientation, peroperative dissection, bleeding issues, and attaining incorrect levels, all of which are indicative of a clear learning curve. An MRI performed after surgery (n=11) revealed total decompression. Overall, 91% of patients had satisfactory to outstanding outcomes, and three of the four patients who had recurrence underwent further surgery. Postoperative discitis affected four individuals. One of the patients had discitis and needed to be fused, while the others were treated conservatively. Even after four years of continuation, one patient with root injury to the L5 root still had numbness in the L5 area.

Conclusion: Micro endoscopic discectomy is a less invasive discectomy technique with promising preliminary outcomes. The outcomes of this treatment are acceptable, safe, and successful after a certain learning curve has been overcome and skill has been attained.

Key words Endoscopic lumbar discectomy, Lumbar discectomy, microendo system,

Introduction

Despite Mixter and Bar's original publication, Oppenheim and Fedre Krause performed the first discectomy in 1906.(1,2) Since then, fenestration, hemilaminectomy, and laminectomy have all been developed and are still commonly used across the globe. Injections of intradiscal chymopapain led to the development of the lateral method in 1964.(3) Following this, Hijikata (4) introduced manual percutaneous discectomy, followed by Onik (5) introducing automated percutaneous discectomy, laser nucleolysis (6), and transdiscoscopy discectomy.(7) Because lumbar radiculopathies caused by large, free-fragment (noncontained) disc pathology that result in any kind of bony compression of the nerve root are still particular adverse reactions to percutaneous lumbar discectomy, the indications for these techniques have typically been restricted to restricted lumbar disc herniations. The thought of a percutaneous, even less intrusive technique for treating lumbar disc degeneration persisted, nevertheless.

Asargil (8), Casper (9), and Williams (10) pioneered the use of microscopes during posterior discectomy, resulting in a smaller skin cut and reduced epidural and muscular damaging. Patients had reduced postoperative discomfort and made an early recovery and return to work. This method may be used to treat bone lateral stenosis as well as any disc disease. Microdiscectomy has subsequently evolved into the industry standard treatment. The improvements in instrument design and optics have enabled the effective implementation of less hostile medical principles to the abdomen, chest cavity, and numerous joints (knees, shoulder area, and wrist), where surgical efficacy is at minimum analogous to traditional, more invasive methodologies, less time in the hospital and recovery times. It was first developed to utilize an endoscope for posterior disc excision.

A genuine discectomy may be carried out using the Microendo method, which enables the usage of micro-apparatus via a tube in endoscopic supervision. Without severing or separating the paraspinal muscles from their insertion, the incision size is further minimized, and the muscles are instead dilated by virtue of their suppleness. This has further decreased muscle scarring and invasive to the paraspinal muscle. Microendoscopic discectomy (MED) is the term used to describe this technique.

A conic "freehand" functioning channel (the Endospine by J. Destandeau) or a cylindrical retractor (the Metrx system, Medtronics), developed by Foley and Smith, are the two innovative technologies for endoscopic posterior discectomy.(11) This study was conducted to evaluate the Endoscopic lumbar discectomy experiences

Materials and methods

This study was retrospective, carried out at the department of neurosurgery Qazi Hussain Ahmad Medical Complex, MTI Kpk Pakistan for a duration of two years from January 2021 to January 2022. Retrospective evaluation was done on 100 consecutive instances of L4-5 or L5-S1 PIVD treated by the MED technique from August 2002 to December 2005 in patients aged 19 to 65. One surgeon performed surgery on each patient. Patients with unilateral radiculopathy, lumbar disc prolapse, a positive strait leg raising investigation, and the diagnosis of a single nerve root lesion met the inclusion criteria. Patients with cauda equina syndrome, binary root involvement, or bilateral symptoms were not included. All poster lateral discs, including those that were sequestered (n = 18), drifted, and chosen central discs (n = 8) with unilateral signs were operated on based on imaging. To assess the effectiveness of the decompression, every individual had MRI preoperative and the first 11 samples underwent postoperative MRI. When an MRI was unclear, diagnostic selective nerve root blocks were performed in certain instances (n=7) to pinpoint the single root lesion. All patients were only given surgery after receiving adequate conservative care for at least

six weeks, which included rest, activity reduction, and physiotherapy and painkillers medicines. The symptoms lasted anywhere from six weeks to eight years. The Medtronic Metrx system was used during the procedure.

Operative technique

All the techniques were done under general anesthesia .The patient was positioned prone, with her stomach free and the spine extended to expose the interlaminar space, on either bolsters or a spinal frame. The Television screen was at the skull's end, the IITV was on the former side, and the surgeon was standing on the disc prolapse side. The tubular retractor containing an endoscope was held in a steady site by an adjustable arm assembly that was linked to an operating table rail, releasing the neurosurgeon's hands in the process. The cut was highlighted in AP and IITV's lateral projection. The key to the port is where the guide wire enters, and we examined the cable in IITV. In lateral projecting, it ought to run parallel to the space between the discs and in AP projecting, it would be at the second-rate margin of the superior lamina. **(Fig 1).** An eighteen -mm skin slit was created after entrance site was identified approximately 1-1.5 cm laterally to the midline.

The fascia and subcutaneous tissue were severed. The guide wire was withdrawn after the first dilator had been inserted over it. The muscles were separated subperiosteally while the dilator was docked over the lamina and the medial, lateral, superior, and inferior borders of the lamina were felt. Over the initial dilator, the subsequent dilators were added in turn. The paraspinal muscles dilated as a result.

Over the last dilator, the 18-mm tubular retractor was inserted, and the final position was confirmed by IITV The coupler, the camera, and light source were all attached to the endoscope. The connector was attached to the tubular retractor's outer edge before the entire system was inserted through it. The orientation of the picture came first after the endoscope had been implanted. The underlying anatomy must display the medial component at 12 o'clock on the screen and the lateral section at 6 o'clock for the picture to be properly oriented. A surgical tool could be positioned in a horizontal location, and then the route circle on the camera/coupler could be turned until the apparatus seemed to be at the lowest on the videotape display. After coagulation and rongeur were used to eliminate the soft tissues, the inferior margin of the nerve lamina was identified. It was possible to separate the ligamentum flavum from the lamina by locating it below the inferior margin of the lamina and using penfield to do so. With the use of a Kerrison rongeur, the overhang lamina was removed till the flavum's edge was reached. Punches are used to remove the flavectomy after shielding it from the dura below. The flexible arm might be loosened if necessary for this motion in order to raise and lower the tubular retractor. Retractor "wanding" was the term used for this action. The dural border and nerve root were located after the flavectomy. Nerve root was then mildly withdrawn. If there The laminoforaminotomy may have been enlarged to provide for appropriate root decompression, regardless of whether there was a big disc, stiff root, appropriated disc, or adjacent retreat stenosis. Epidural dissection was done after the root was retracted. Bipolar coagulation could be used to coagulate the veins. The sequestered bits may be removed once the limit of disc space was reached, or a micro-knife might be used to perform annulotomy if necessary**.(Fig 2).** Using disc forceps, any loose objects in the disc area were taken out. Following discectomy, the root mobility underwent one last inspection. It is necessary to arrange the entry port appropriately. Reaching the location of sequestration or the central disc region sometimes required wanding or angulation of the scope.

After a thorough cleaning, the material was sealed up and coated with gelfoam. The lumbodorsal fascia was stitched when the scope was withdrawn. Sutures were placed in the subcuticular skin, and dressing was used.

An 18-mm tubular retractor was used to operate on all but three of the patients. The final three patients were treated with a 16 mm tube-shaped retractor after gaining sufficient expertise with an 18 millimeter port. As soon as the individual was at peace and the discomfort from the procedure ended, the patients were permitted to walk. Patients were released between 24 and 48 hours. For three weeks, patients were urged to walk till they could tolerate the pain. All activities were

permitted, with the exception of leaning forward, lifting weights, and resting for longer than thirty minutes. Lifting heavy objects and bending forward were prohibited until three months after surgery. After three weeks, they could go back to work. Following up with the patients occurred at 2, 6, and twelve weeks. The average continuation period was twelve months, with a 3 to 4 year range and examined for neurological deficiency, leg discomfort, and back pain complaints. Additionally assessed were any new symptoms, postoperative problems, or the essential for change to open surgical procedure. Depending on the degree of back pain reduction, the outcomes were rated as outstanding, good, fair, or bad. As well as any problems, analgesic usage, and leg discomfort. To grade the outcomes, we employed modified Macnab criteria. Excellent - no discomfort, no activity restrictions, and full participation in all activities; positive: intermittent pain with symptom alleviation, return to work with modest modification; Poor outcomes - having impartial indications of root injury or reprise surgical procedure at the catalog level; fair - some increased functional ability but remains impaired or jobless;

Results

All patients had good surgical outcomes. One patient needed to have open surgery because of a nerve root damage. The average procedure was 70 minutes, with ranges from 25 to 210 minutes. Inadvertent excision of the surface joints (n=5), small Dural perforations (n=7) that did not need healed or conversion to open surgery, and injury to the nerve root (patient=1) that required conversion to open surgery were postoperative consequences. None of these individuals had any postoperative clinical issues. After 24-48 hours following surgery, all patients were released. Individual had certain lingering leg discomfort for up to 3 weeks. The first 11 patients' post-operative MRIs revealed full decompression**.(Fig 3)**

Additionally, postoperative X-rays were acquired to determine the amount of the necessary laminotomy. **(Fig 4)** In our earliest instances, we did have challenges and difficulties. Postoperative discitis affected four individuals. Out of these four Three patients had conservative care and were free of their symptoms at the most recent check-up, while one needed surgery that included debridement and underbody fusion. One individual needed an open surgical conversion due to nerve root injury that occurred during surgery, however that victim still had residual anesthesia in the L5 distribution at the time of the final follow-up. Return of the disc at the same level took place in four cases. A recurrence happened two months after the first operation. After surgery, all of the patients initially had a symptom-free time before experiencing a return of symptoms.

Recurrent/residual disc was seen at the same level on a second MRI. Three of these individuals required further surgery.

One patient got acceptable outcomes at the most recent follow-up but declined to have a second operation. About seventy eight patients had satisfied results, 13 had usual results, 5 had medium results, and 4 had poor results that necessitated recurrence surgery. 91% had outstanding to good outcomes overall. Initial instances had technical issues with scope vision, picture angle, guide wires piercing the dura, incorrect levels on either one the superior or even opposed side, particularly in cases of obese individuals, and lateral an entrance across the joints. The first 25 instances included all of these issues.

DISCUSSION

The overall success rate of a routine discectomy varies across series from 68% to 95%. (12-16) although normal discectomy produces similarly acceptable outcomes, Yasargel and Caspar's micro discectomy is regarded as the industry standard. he results of micro discectomy also range between 88 and 98.5%. 17-19)

Both treatments are tried-and-true methods that provide successful surgical outcomes for individuals with disc prolapse. By comparing the outcomes of macro and microdiscectomy, Katayama et al. They came to the conclusion that neither patient's surgical result differed from the others, but the microdiscectomy provided superior illumination and magnification, which reduced the size of the incision and tissue invasion. Additionally, they discovered that microdiscectomy

permitted patients to resume work earlier and with reduced postoperative narcotic painkiller usage. The method with less nerve invasion, a littler incision, less postoperative analgesic usage, and an earlier return to work is the preferred option if the overall results of the two surgeries are the same. By combining conventional lumbar microsurgical methods with an endoscope, the MED procedure developed by Foley et al. enables surgeons to effectively treat lateral recess stenosis and free-fragment disc pathologic causes. Comparing the endoscopic procedure to a traditional open microdiscectomy, the endoscopic approach allows for even smaller incisions and less tissue stress. In comparison to more invasive open operations, the MED method considerably reduces iatrogenic harm to the paraspinal musculature, which might possibly result in extra long-term advantages. The purely thing that has to be determined is if the lasting outcome will be equivalent to that of a regular microdiscectomy and whether it will involve less tissue invasiveness than a microdiscectomy.There are several publications that demonstrate the effectiveness of MED and show generally equivalent outcomes.21-25Our study's total score was 91%. We compared our findings to those of Periz-Cruit et al. 21 (N=150), whose series had an average surgery duration of 66 minutes, an average blood loss of 22 ml, an average hospital stay of 7.7 hours, and an average complication rate of 12%. 5%, a second procedure rate was 4 percent, ordinary time back to work was seventeen days, and the whole outcome was 94 percent. Compared to 7.7 hours in their trial, we were in the hospital for 24-48 hours. Other Similar outcomes were obtained in both series for variables including operating duration (66 vs. 70 min), hurdle rate (5 percent equally succession), reoperation r (4 vs. 3%), return to work (17 vs. twenty one days), and general consequences (94 vs. 91%). In their collection of 107 instances, Ranjan et al. 24 found similar outcomes. They had an average of 120 minutes of surgery, a 24- to 48-hour hospital stay, a 6.5% complication rate, one patient who had exposed surgical procedure conversion, and two patients who experienced recurrence. One open surgery conversion and four patients (4%), in our study, suffered recurrence discs. These findings indicate that MED is both safe and efficient. There isn't a strong prospective randomized trial available yet to compare the outcomes of MED, microdiscectomy, and regular discectomy. Although Schizas 26 conducted a nonrandomized research comparing the outcomes of MED with conventional microoperating discectomy and came to the conclusion that MED is at least as successful as microsurgical discectomy for the treatment of uncontained or large contained disc herniations.

With a smaller skin incision, less analgesic usage, and an earlier return to work than microdiscectomy, microendoscopic discectomy (MED) claims to have even less tissue invasion than microdiscectomy. The slightest soft tissue incursion is demonstrated by numerous studies comparing the paraspinal muscles' post-operative MRI signal, the nerve roots' intraoperative EMG findings, and serum points of biological factors indicative of a post-operative stirring response and destruction to the vertebral muscles.(29)

Despite the fact that these parameters were not examined in our series, our personal judgment is the same since all patients had just an 18-mm cut in their skin and first postoperative MRI results indicated very little signal alterations in the paraspinal muscles.

In addition to paracentral discectomies, lateral disc herniations, recurrent disc herniations, decompressions of lumbar canal stenosis, 32 and transforaminal interbody fusion have all been treated using less invasive microendoscopic decompression techniques.(33) The complication rate in our series is 5 percentage , and the relapse rate is 4%, both of which are consistent with the outcomes of macro- and micro discectomy. The difficulties we encountered were brought on by our early learning curve. Due to the two-dimensional views, alignment with the scope, manipulation of the scope, the limited amount of room for dissection, and the management of epidural hemorrhage, MED has a distinct learning curve.(34,35) Nevertheless from our primary understanding, it looks MED is a skill which gives quick rehabilitation and a reduced amount of bleeding

Lack of comparable controls made it difficult to evaluate and quantify how much less bleeding and earlier recuperation occur after MED than after normal or microdiscectomy. To demonstrate these claims, a well-executed double-blind prospective randomized control experiment contrasting MED with microdiscectomy and regular discectomy is required.

Conclusion A less invasive discectomy technique called microendoscopic discectomy has shown excellent first results. Although there is a learning curve at first, the procedure's outcomes are acceptable and safe after proficiency with the method is attained.

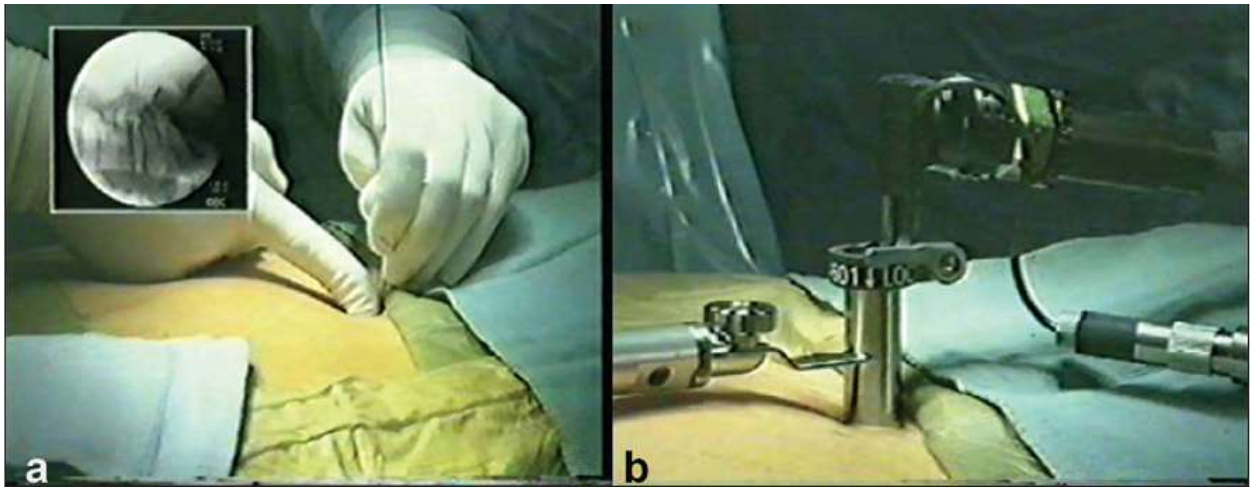

Figure 1: Intra-operative picture displays (a) monitor wire insertion (b) insertion of the tube-shaped retractor and endoscope

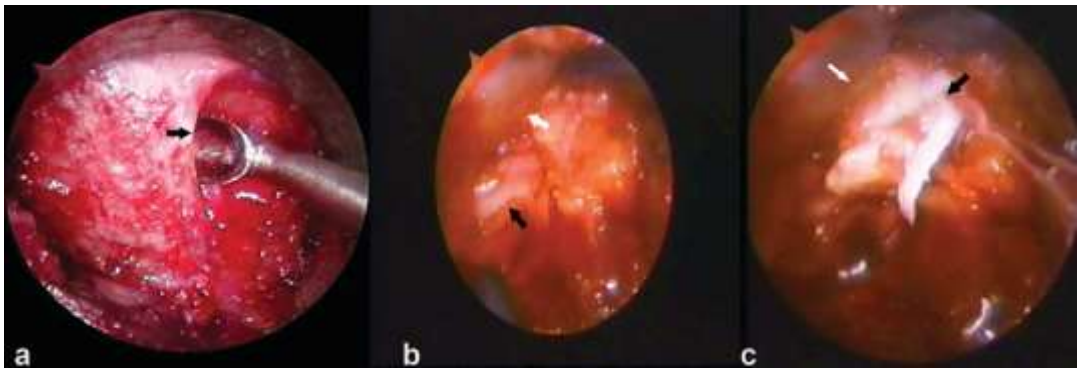

Figure 2: Intra-operative picture demonstrates (a) space outlook of the laminar edge. The arrow displays the inferior edge of the lamina. (b) Scope view of the dural cover (white arrow) and nerve root (black arrow) (c) Scope outlook of the disc (black arrow)

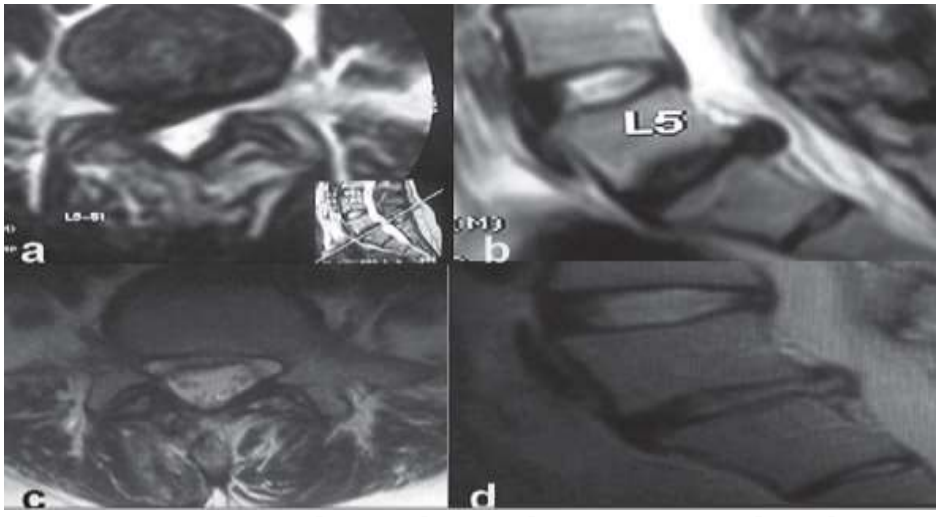

Figure 3: Pre-operative T2WI axial (a) and sagittal interpretation (b) indicates prolapse disc at L5-S1. Post-operative T2WI axial (c) and sagittal (d) displays acceptability of decompression

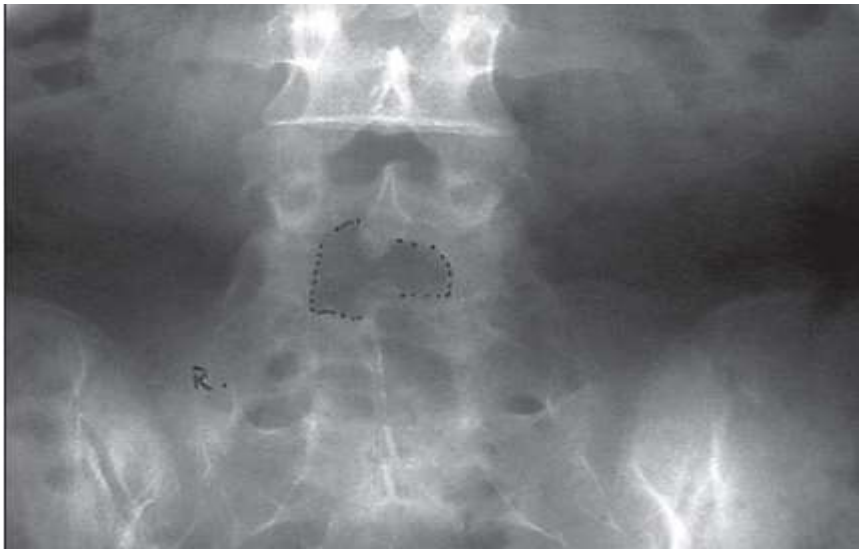

Figure 4: Post-operative x-ray lumbosacral spine anteroposterior view display size of laminectomy

REFERENCES

1. Mixter WJ, Barr JS. Rupture of the intervertebral disc with involvement of the spinal canal. N Engl J Med 1934; 211:210-5.
2. Chedid KJ, Chedid MK. The tract of history in the treatment of lumbar degenerative disc disease. Neurosurg Focus 2004; 16:E7.
3. Smith L, Brown JE. Treatment of lumbar intervertebral disc lesion by direct injection of chymopapain. J Bone Joint Surg Br 1967;49:502-19.
4. Hijikata S. Percutaneous nucleotomy: A new concept technique and 12 years' experience. Clin Orthop Relat Res 1989; 238:9-23.
5. Onik G, Helms CA, Ginsberg L, Hoaglund FT, Morris J. Percutaneous lumbar diskectomy using a new aspiration probe. AJR Am J Roentgenol 1985;144:1137-40.
6. Choy DS, Ascher PW, Ranu HS, Saddekni S, Alkaitis D, Leibler W, et al. Percutaneous laser disc decompressions: A new therapeutic modality. Spine 1992;17:949-56.
7. Schreiber A, Suezawa Y. Transdiscoscopic percutaneous nucleotomy in disc hemiation. Orthop Rev 1986;15:75.
8. Yasargil MG. Microsurgical operation for herniated lumbar disc. In: Wullenweber R, Brock M, Hamer J, Klinger M, Spoerri O, editors. Advances in neurosurgery. Springer-Verlag: Berlin; 1977. p. 81.
9. Caspar W. A new surgical procedure for lumbar disc herniation causing less tissue damage through microsurgical approach. In: Wullenweber R, Brock M, Hamer J, Klinger M, Spoerri O, editors. Advances in neurosurgery. Springer-Verlag: Berlin; 1977. p. 74-7.
10. Williams RW. Microlumbar discectomy: A conservative surgical approach to the virgin herniated lumbar disc. Spine 1978;3:175-82.
11. Foley KT, Smith MM. Microendoscopic discectomy. Tech Neurosurg 1997;3:301-7.
12. Yorimitsu E, Chiba K, Toyama Y, Hirabayashi K. Long-term outcomes of standard discectomy for lumbar disc herniation: A follow-up study of more than 10 years. Spine 2001;26:652-7.
13. Loupasis GA, Stamos K, Katonis PG, Sapkas G, Korres DS, Hartofilakidis G. Seven-to 20 year outcome of lumbar discectomy. Spine 2000; 24:2313.
14. Gibson JN, Waddell G. Surgical interventions for lumbar disc prolapse updated cochrane review. Spine 2007; 32:1735-47.
15. Mariconda M, Galasso, Beneduce T, Volpicelli R, Della Rotonda G, Secondulfo V, et al. Minimum 25 yr. outcome of standard discectomy for lumbar disc herniation. J Bone Joint Surg Br 2006;88:SuppI.152-3

16. Toyone T, Tanaka T, Kato D, Kaneyama R. Low-back pain following surgery for lumbar disc herniation: A prospective study. J Bone Joint Surg Am 2004;86:893-6.
17. Findlay GF, Hall BI, Musa BS, Oliveira MD, Fear SC. A 10-year follow-up of the outcome of lumbar microdiscectomy. Spine 2004;23:1168-71.
18. Koebbe CJ, Maroon JC, Abla A, El-Kadi H, Bost J. Lumbar microdiscectomy: A historical perspective and current technical considerations. Neurosurg Focus 2002;13:E3.
19. Maroon JC. Current concepts in minimally invasive discectomy. Neurosurgery 2002;51:S13745.
20. Katayama Y, Matsuyama Y, Yoshihara H, Sakai Y, Nakamura H, Nakashima S, et al. Comparison of surgical outcomes between macro discectomyand micro discectomyfor lumbar disc herniation: A prospective randomized study with surgery performed by the same spine surgeon. J Spinal Disord Tech 2006;19:344-7.
21. Perez-Cruet MJ, Foley KT, Isaacs RE, Rice-Wyllie L, Wellington R, Smith MM, et al. Microendoscopic lumbar discectomy: Technical note. Neurosurgery 2002;51:S129-36.
22. Palmer S. Use of a tubular retractor system in microscopic lumbar discectomy: 1 year prospective results in 135 patients. Neurosurg Focus 2002;13:E5.
23. Brayda-Bruno M, Cinnella P. Posterior endoscopic discectomy (and other procedures). Eur Spine J 2000; 9:S24-9.
24. Ranjan A, Lath R. Microendoscopic discectomy for prolapsed lumbar intervertebral disc. Neurol India 2006;54:190-4.
25. Wu X, Zhuang S, Mao Z, Chen H. Microendoscopic discectomy for lumbar disc herniation: Surgical technique and outcome in 873 consecutive cases. Spine 2006;31:2689-94 .
26. Schizas C, Tsiridis E, Saksena J. Microendoscopic discectomy compared with standard microsurgical discectomy for treatment of uncontained or large contained disc herniations. Neurosurgery 2005; 57:357-60.
27. Muramatsu K, Hachiya Y, Morita C. Postoperative magnetic resonance imaging of lumbar disc herniation: Comparison of microendoscopic discectomy and Love's method. Spine 2001;26:1599-605.
28. Schick U, Dohnert J, Richter A, Konig A, Vitzthum HE. Microendoscopic lumbar discectomy versus open surgery: An intraoperative EMG study. Eur Spine J 2002;11:20-6.
29. Sasaoka R, Nakamura H, Konishi S, Nagayama R, Suzuki E, Terai H, et al. Objective assessment of reduced invasiveness in MED: Compared with conventional one-level laminotomy. Eur Spine J 2006;15:577-82 .
30. Foley KT, Smith MM, Rampersaud YR. Microendoscopic approach to far lateral lumbar disc herniation. Neurosurg Focus 1999;7:5.
31. Isaacs RE, Podichetty V, Fessler RG. Microendoscopic discectomy for recurrent disc herniations. Neurosurg Focus 2003;15:11.
32. Khoo LT, Fessler RG. Microendoscopic decompressive laminotomy for the treatment of lumbar stenosis. Neurosurgery 2002;51:S146-54.
33. Isaacs RE, Podichetty VK, Santiago P, Sandhu FA, Spears J, Kelly K, et al. Minimally invasive microendoscopy-assisted transforaminal lumbar interbody fusion with instrumentation. J Neurosurg Spine 2005;3:98-105.
34. Ikuta K, Tono O, Tanaka T, Arima J, Nakano S, Sasaki K, et al. Surgical complications of microendoscopic procedures for lumbar spinal stenosis. Minim Invasive Neurosurg 2007;50: 145-9.
35. Nowitzke, Adrian M. Assessment of the learning curve for lumbar microendoscopic discectomy. Neurosurgery 2005; 56:755-6