Full Endoscopic Interlaminar Lumbar Disc Surgery: Is it the Gold Standard Yet?

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INTRODUCTION

Lower back pain with pseudoradicular or sciatic pain is one of the oldest maladies faced by mankind since early ages. It is one of the most common neurological complaints for outpatient visits second only to headache in the United States. Even Hippocrates, popularly considered the father of medicine, advised a rest of 40 days to relieve the symptoms of sciatica, a protocol still practiced effectively by many.

Vesalius described the anatomy of the spine with a description of intervertebral discs in 1555. In 1909, F. Krause probably made the first successful resection of a lumbar ruptured disc (1) while A. Taylor performed the first unilateral laminectomy in the same year (2). Typical surgical findings, associated clinical symptoms and surgical treatment were published by Mixter and Barr in the New England Journal of Medicine in 1934 (3). In 1938, Barr surgically confirmed the relationship between disc herniation and sciatica by following 83 patients. Subsequently, lumbar discectomy became one of the most frequent operations performed by spine surgeons.

About 40 years later, in the year 1977, M. G. Yasargil and W. Caspar independently published their results about patients with a herniated lumbar disc treated by using the microscope for microdiscectomy (4) and microdiscectomy with a medial facetectomy (5). Both used the microscope to improve the intraoperative exposure of the surgical field. The microscopic approach further enables the surgeons to make smaller incisions resulting in decreased post-operative pain, decreased fibrosis and earlier return to work. Also in the 1970s, R. Williams highlighted his results about this surgical technique by using specialized instruments for a very small incision (6). Until today, the microsurgical lumbar discectomy represents the "gold standard" of care; and a patient satisfaction rate of up to 97% can be achieved (7).

ABSTRACT

BACKGROUND: Minimally invasive lumbar surgeries are becoming more popular and a routine in most neurosurgery departments around the world. We reviewed the literature and technique on fully endoscopic interlaminar lumbar discectomy.

AIM: To review latest literature and the technique and provide experience from two centers.

MATERIAL AND METHODS: Literature review and give our experience.

RESULT: Fully endoscopic interlaminar microdiscectomy is a viable alternate to microscopic procedure and results in decreased morbidity.

CONCLUSION: Microendoscopic interlaminar fenestration is possible with full endoscopic technique and is a safe and effective treatment of degenerative lumbar spine diseases.

KEY WORDS: Endoscopic spine, endoscopic technique, interlaminar approach, lumbar discectomy, minimally invasive
In 1977, S. Hijikata developed an instrumentation system to remove a lumbar disc herniation percutaneously (8). In the 1990s, lumbar spine surgery reached another level by the development of endoscopic optics and digital cameras. In 1999, K.T. Foley emphasized the advantages of the so-called “micro endoscopic discectomy” as potentially less denervating and less destabilizing procedure (9). Other authors in the past also highlighted that micro endoscopic discectomy has the advantage of smaller skin incision, and less irritation to the nerve root compared to standard open surgery, less scar, better aesthetics, and less financial burden in terms of early discharge and early return to work (10-12). Subsequent studies showed decreased inflammatory markers like interleukin-6 with use of endoscopic versus microsurgical techniques due to reduced trauma and less muscular damage (10, 13). Today many other endoscopic techniques are available on the market (14-16).

The initial euphoria was somewhat dampened by studies that failed to show a significant advantage of endoscopic techniques compared with the so-called “gold standard” for microdiscectomy (17, 18). These and other studies furthermore pointed out an additional need of surgical time (18), a higher complication rate (19, 20), as well as a higher failure rate (21) with the tubular technique. Another criticism is the learning curve for this technique. Microsurgical experience and attending workshops are required and can help to shorten the learning curve and help to implement the microendoscopic technique in the daily routine (22). At present, there is strong demand by the patients for minimally invasive and particularly endoscopic procedures in spine surgery (23). Despite the steep learning curve with the earlier techniques (24), multiple alternative and newer techniques were developed in the recent years to provide further less invasiveness and cost effectiveness (25, 26). The technical
advancement in endoscopes and instruments in recent years have led to the development of multiple approaches, including the transforaminal, the extra foraminal and the interlaminar approach. The interlaminar approach is used in lumbar spinal stenosis and disc herniation located mainly inside the spinal canal, which is technically difficult to treat using the transforaminal technique, and especially at L5-S1 due to the large transverse processes, facets, the narrow disk space and the iliac crest (27). At the authors’ institution different sorts of endoscopic systems for lumbar discectomy have been used. Currently, the authors prefer the application of endoscopic tube systems to approach herniated disc prolapses endoscopically within the spinal canal.

**MATERIAL AND SURGICAL TECHNIQUE**

The most frequently used endoscopic tube systems for lumbar disc surgery are Medtronic Med system and Karl Storz’ Easy GO system. The authors have gained most of their experience with EASY GO system.

**INDICATION**

The tube system can be used in all types of spinal surgery via a posterior approach. Particular indications are lumbar disc herniation from medial to far lateral, lumbar spinal and foraminal stenosis. The procedure can be performed under the status of general anesthesia or local anesthesia. Local anesthesia has the advantage of reproduction symptoms and of patient feedback at all time. However it can be uncomfortable for the patients when maneuvers for lateral or sequestered fragments are required (28).

A careful selection of patients is recommended, particularly in the beginning of a surgeons’ surgical experience with this technique. In contrast to an open microscopic approach angulation of instruments is much more limited due to the narrow tube system. Thus, particularly an indication when an intense manipulation is required and when the space occupying lesion which has to be resected in far medial can become very challenging and are not recommended to start with a initial experience.

**SURGICAL TECHNIQUE OF THE APPROACH**

The patient is put in prone position to decompress the abdomen and to open the interlaminar window. The ideal surgical approach is determined by lateral as well as anterior-posterior X-ray. A paramedian skin incision about 2 cm lateral of the spinous process is performed, and the surgical site is approached via a direct straight trajectory. If no straight approach to the target point was made, there was always difficulty with remnant connective and muscle tissue prolapsing in the surgical field underneath the work sheath, which frequently caused a delay of the surgical procedure. The incision has to be about 0.9 – 2.2 cm long depending on the selected working trocar. A too short skin incision makes insertion of the work sheath impossible and harbors a risk of skin ischemia if the work sheath was inserted under too much tension. Next important step is the opening of the muscle fascia with a sharp knife to prevent a compression of the paravertebral muscles at the tip of the work sheath by subsequent dilation and insertion of the work sheath. Once the muscle fascia is punctured, the smallest dilator is put in direct contact to the bone. An accidental opening of the spinal canal due to perforation of the lamina or the interlaminar window can be avoided by seeking bony contact at all time and employing lateral Xray control if...
felt to be helpful. Dilators were inserted one over another and the working trocar in the end. Lateral fluoroscopy is recommended to control the position and trajectory of the work sheath. The ideal positioning of the trocar was perpendicular to the lamina and with a trajectory towards the disc or disc sequester. Subsequently, the work sheath was put in a fixed position by connection to the endoscope holding arm. Working insert and the endoscope can be introduced and connected to the three-chip high definition (HD) camera head as well as the light cable. Surgery should be guided by continuous endoscopic HD vision which has been proven to be superior to the standard resolution (29).

With a fully installed working environment the bimanual endoscopic operation can start.

**SURGICAL TECHNIQUE FOR INTERLAMINAR FENESTRATION**

Once the inserted telescope is connected with the camera and the light source via the light cable the surgeon can see the surgical field on 16:9 HD screen if an HD camera system is available. At least, the authors highly recommend an HD camera system since optical resolution is about 2 Mega pixels in contrast to 400.000 pixels in standard definition (ZitatOertel Philipps or PhilippsOertel MIN 2009 oder 2010). Surgery is done in bimanual technique. Once the endoscope is inserted, remnant connective tissue is removed to display the bony part of the lamina. At this stage, the ligamentum flavum is identified and the infralateral edge of the superior lamina. The ligamentum flavum is either directly exposed if an interlaminar approach is feasible, and further opening of the window is done with a Kerrison punch. A diamond burr can be used for resection of the lamina and exposure of the ligamentum flavum underneath. Using a standard burr would have a very high risk of a dural injury including damage of neural structures. Thus exclusive use of a diamond burr is highly recommended. Opening of the ligament is done with a knife or hook if indicated the neighboring laminar bone are removed with a punch or diamond drill to enlarge the intralaminar fenestration. Once the epidural fat tissue is removed, the dura and nerve roots are identified then the interlaminar fenestration is continued with a high speed drill or Kerrison punch. After palpation of the lateral recess, more of the lateral lamina can be removed depending on the necessity of exposure.
Remaining bone fragments are removed using the punch until clear view of the posterior spinal ligament is possible. Neighboring vessels are coagulated with bipolar forceps. The sequester is subsequently extracted with a grasping forceps with avoidance of any tension on the nerve root. Also the disc space can be evacuated. At the end of the procedure, decompression of the dural sack and the nerve root is checked. A sequester of a size as large as almost 4 cm can be removed with this technique. Some studies also propose sealing of the annulus to decrease the recurrence rate (30). However, the authors have no experience with this technique. After removal of the trocar the well perfused fascia should be coagulated sufficiently to prevent an intramuscular and epifascial hematoma.

**DISCUSSION**

Why should we think about Minimally Invasive Spine Surgery? A basic tenet of surgery is to effectively treat pathology with minimal disturbance of normal anatomy: leaving “the smallest footprint.” The theoretical advantages of endoscopic discectomy are reduced post-operative pain and small scar due to minimal opening leading to shorter recovery time and hospital stay. More and more patients are demanding this surgery with better aesthetic results. Endoscopic technique is theoretically less invasive with minimal trauma during approach. This is possible due to continued improvement in illumination and focus with greater circumferential view by applying angled optics.

Standard open approach leads to iatrogenic injury of the paraspinal muscles which is correlated to an decrease strength in paraspinal muscle as well as the presence of atrophy after extensive muscle retraction (31, 32). Biomechanical studies have investigated the function of the posterior column and its importance in maintaining lumbar spinal stability (33, 34). As a result of technological improvements and development of new equipment, microendoscopy is accepted for interlaminar fenestration and decompression of the spinal canal or lumbar disc surgery. Besides the length of skin incision the endoscopic technique yields advantages in preservation of the posterior spine structures compared to the microsurgical technique. Serial tube dilators and retractor were designed to split the back muscle gently and therefore to minimize retraction and disruption of the paraspinal muscular integrity.

Taylor H et al studied the impact of self retaining retractors on paraspinal muscles by measuring intramuscular pressure at 5, 30 and 60 min during surgery in 20 patients. (24) They took muscle biopsies before and after retraction using ATP birefringence and found significant increase in intramuscular pressure during retraction with decreased ATP suggesting reduced function following retraction. Further other studies demonstrated that the postoperative recovery of CK and CRP levels occurred within 1 week and that the intensity of low back pain was mild (35, 36). Mayer et al studied the postoperative muscle architecture on CT scan and its relevance for failed-back syndrome (31). They found that the integrity of paraspinal muscles might be of utmost importance for the postoperative result. It seems reasonable to consider the microendoscopic technique for interlaminar fenestration as a relatively minimal invasive procedure with concern to the paraspinal muscles. The tubular retraction systems provide direct and focal access to the diseased anatomy via a less invasive approach (37, 38).
The risk of failed back syndrome and postoperative lumbar back pain potentially can be reduced with the application of tube retractor systems.

Microendoscopic discectomy (MED) is emerging as a minimally invasive alternative to conventional microsurgical discectomy (MSD). Intralaminar endoscopic spinal endoscopy claims smooth transition from open microscopic to Endoscopic Discectomy, with a reduced learning curve period. However, before MED can be considered a surgical alternative at least similar results in comparison with open microdiscectomy have to be demonstrated.

In a human cadaveric study, Guiot et al. showed that the microendoscopic technique can be performed with the same effectiveness concerning decompression of the spinal canal as standard open technique does (38). Akihito studied 366 patients with Microendoscopy with lumbar stenosis with bilateral decompression via a unilateral approach (1). They could preserve the supraspinous and interspinous ligaments and contralateral musculature by partial resection of the base of the spinous process. At 2 years follow-up for 310 patients, they had excellent and good results in 70% of the patients, and fair and poor in 22% and 9%. They concluded that Microendoscopic laminotomy is a safe and very effective minimally invasive surgical technique for the treatment of degenerative LSS.

Martin-Laaz studied 138 patients for complications during learning curve with 37 using Microendoscopic Discectomy (MSD) approach and 101 had conventional Microdiscectomy (MED). MED had 8 AND MSD HAD 9.8% complications with symptoms relieved in 69% of MSD and 90% of MED patients. No revision surgery was required in the MED group, but it was necessary in ten patients of the MSD group. They suggested that between 25 and 30 cases are needed to reach the learning curve. Even during this learning period MED was a safe procedure, with comparable results to conventional MSD and with a similar complication rate. They concluded that adequate expertise in surgery, proper selection of cases, surgical planning and a careful technique are mandatory to avoid unnecessary neurological injury in an otherwise secure surgical approach (18).

To assess the learning curve seems to be challenging but the operative time has the tendency to be longer in the beginning and surgical complications occur more often in the in early cases(36). New cameras allow a visualization of the surgical in field in high definition (HD) which accounts for a more reliable identification of anatomical structures compared to standard definition (SD) (29). A plurality of further studies have investigated the microendoscopic technique for lumbar spinal surgery and highlighted similar results concerning clinical outcome compared to the traditional technique including patient satisfaction (23, 35, 39).

Several complications of standard open lumbar surgery, such as wound infection, CSF leakage due to intraoperative durotomy, nerve injury, vascular injury and bleeding, over drilling, and postoperative epidural hematoma have been reported. In contrast other studies demonstrated that microendoscopy offers decreased blood loss, shorter operative time, shorter in-hospital-stay, decreased need for pain medication, decreased rate of infection and a shorter return-to-work-time (35, 39-43). Concerning durotomy and CSF leak different incidence rates have been reported in the literature varying from 1.9% to 9.4% depending on the surgical approach for decompression (26, 35, 39, 44). The incidence is similar to results (range from 1% to 12%) of studies assessing the traditional technique. However, wrong level surgery due to angulation of the sheath and scope and failure of conversion to minimally open procedure and peculiar complications unique to this procedure such as juxtafacet cyst which can be symptomatic have been reported (19, 30, 45). The combination of oblique view with the endoscope and thin and curved surgical instruments make it possible to access also the blind corners (36).

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In all, application of endoscopic spine surgery is mainly in lumbar but is possible in a wide range of indication in degenerative spine disease. There have been very good reported results in cervical spine. There is evidence that complication rate is no longer higher than with microsurgery and outcome can be as good as with the standard technique with a faster postoperative recovery and less postoperative pain.
CONCLUSION

Microendoscopic interlaminar fenestration is possible with full endoscopic technique and is a safe and effective treatment of degenerative lumbar spine diseases. The fact that the morbidity rate after surgery is decreased by the microendoscopic technique should make this procedure to be seen as an option along with the traditional technique for every spine surgeon. With recent advancements in instruments, optics and flexible endoscopes the rigid patient selection that was required previously is no more longer required(10, 19, 24, 26, 46, 47).

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