



Minimally invasive discectomy for lumbar disc herniation: current concepts, surgical techniques, and outcomes

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Abstract

Purpose To date, various minimally invasive surgeries for lumbar disc herniation (LDH) have been performed in many countries, including microendoscopic discectomy (MED) and percutaneous endoscopic discectomy (PED). We herein report the surgical indications, current concepts, and techniques of minimally invasive discectomy for LDH, including MED and PED. The postoperative outcomes and risks of complications compared with conventional discectomy are also discussed.

Methods By reviewing past literatures, the current concepts, surgical techniques, and clinical outcomes were described.

Results Minimally invasive discectomy is generally performed using a transmuscular approach with an endoscopic technique and can reduce muscle and soft tissue damage. The minimal invasiveness can also reduce the severity of postoperative pain and improve patient satisfaction compared with conventional open discectomy. Based on the data of previous systematic reviews and meta-analyses, minimally invasive lumbar discectomy, such as MED and PED, appears to be safe and effective alternatives to open discectomy for patients with symptomatic LDH. These minimally invasive surgeries can provide beneficial effects to shorten the hospital stay and time to return to work. However, minimally invasive discectomy has a demanding learning curve. Only a well-trained surgeon and support team should perform these less invasive procedures.

Conclusions Clinical evidence supporting the superiority of MED and PED is still limited. Well-designed prospective multicentered randomized controlled trials with large samples are therefore needed in order to draw a convincing conclusion.

Keywords Disc herniation · Lumbar spine · Discectomy · Minimally invasive surgery · Endoscopic surgery

Introduction

Lumbar disc herniation (LDH) is one of the most common degenerative spinal diseases [1, 2], causing low back pain and sciatica [3]. Conservative treatments, including medication and injection, can reduce the clinical symptoms in most patients with LDH. However, symptoms occasionally persist following conservative treatments [4]. Surgical treatment should be considered if a patient is nonresponsive to a period of conservative therapy or has progressive neurological deficits [1, 2, 5]. Surgical treatment for LDH can be classified into conventional open discectomy and minimally invasive surgeries. To date, various minimally invasive surgeries for LDH

have been performed in many countries, including microendoscopic discectomy (MED) and percutaneous endoscopic discectomy (PED) [6–10].

Conventional open discectomy, first described by Mixter and Barr in 1934 [11], is able to relieve clinical symptoms and improve the neurological function. However, a major drawback associated with this conventional procedure is the destruction of paravertebral muscles and ligaments [12, 13]. In addition, this surgical approach induces extensive surgical scarring and adhesion, which may deteriorate the postoperative clinical outcomes [14, 15].

In 1997, the MED technique was developed by Foley and Smith [16]. This minimally invasive surgery is performed using a transmuscular approach with an endoscopic technique and can reduce muscle and soft tissue damage [17, 18]. The minimally invasive technique of MED reduces post-operative pain and improves the recovery of patients [16, 19, 20].

PED is another minimally invasive procedure that is commonly performed for LDH [8, 21]. With this technique, the affected disc can be resected under local anaesthesia. This minimally invasive method can avoid destroying the lamina the

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paraspinal muscles and soft tissue and consequently reduce the risk of post-operative segmental instability [22]. PED is performed through a transforaminal (TF) or interlaminar (IL) approach to remove the herniated disc [7, 9, 22]. PED can reduce the severity of post-operative pain and improve patient satisfaction compared with conventional open discectomy [23].

We herein report the surgical indications, current concepts, and techniques associated with minimally invasive discectomy for LDH, including MED and PED. The post-operative outcomes and risks of complications compared with conventional discectomy are also discussed.

General indications of surgical treatment for LDH

Overall, surgical treatment for LDH should be indicated in carefully selected patients showing severe sciatica with serious or progressive neurologic deficits. Diagnostic imaging should reveal disc herniation compressing the nerve root that is related to the patient's neurological findings [24]. In addition, surgical treatment is commonly recommended for patients who show little therapeutic effect of adequate conservative treatment after several weeks. Emergency surgery should be considered if the patient shows severe cauda equina syndrome causing ischuria or severe progression of muscle weakness.

Conventional open discectomy

Conventional open discectomy has been the commonly adopted surgical treatment for removing herniated discs with or without the use of an operating microscope or other magnifying tools [24]. This procedure was originally described by Mixter and Barr in 1934 [11] and Love in 1939 [25]. In the original procedure, the ligamentum flavum was removed with minimum resection of the lamina, such as hemilaminectomy, or without the removal of any bones [25]. However, the ligamentum flavum and part of the lamina are usually removed in standard procedures of open discectomy. In brief, after general anaesthesia, the patient is placed in a prone position, and the corresponding laminae are exposed. Partial laminectomy on the affected side is performed using a Kerrison rongeur and/or an air drill. The ligamentum flavum is removed in order to confirm the nerve root and to resect the disc herniation. The corresponding nerve root is confirmed and gently retracted medially. The posterior longitudinal ligament is cut at the peak of disc herniation, and the herniated mass and disc material are removed with a pituitary rongeur. Following removal of the herniated disc, it should be carefully confirmed that the affected nerve root has been fully decompressed with no residual hernia around the disc level.

MED

MED can be indicated for all forms of disc herniation and that combined with lumbar canal stenosis [26, 27]. This technique can decrease iatrogenic injury to the paraspinal musculature and shorten the hospital stay. However, there is a learning curve that requires patience and experience. Only a properly trained surgeon and support team should perform this procedure.

MED is usually performed under general anaesthesia. The MED system consists of serial dilators, a tubular retractor with a diameter of 16 or 18 mm, a rigid endoscope, a flexible arm, and a standard video monitor system (Fig. 1a). Following the insertion of the serial dilators into the affected level, the tubular retractor is set on the lamina, and the rigid endoscope is inserted into the retractor (Fig. 1b). Using the video monitor system, flavectomy, laminotomy, nerve root retraction, and discectomy can be performed as in the open technique (Fig. 1c).

For surgery of extraforaminal herniation in the lumbar spine, the MED technique can be a useful treatment option [27]. Extraforaminal herniation is defined as a herniation located at the space lateral to the pedicle and thus, is also referred to as “far-lateral” herniation. It accounts for 7–12% of all LDHs [28]. In the conventional open procedure, the surgical exposure of the extraforaminal region is performed through the midline or preferably Wiltse's paraspinal muscle splitting approach. Following removal of the intertransversarius ligament and fascia, the extraforaminal herniation can be confirmed. To remove the extraforaminal herniation, full/partial facetectomy with or without spinal fusion is occasionally needed. Recently, the MED technique has been utilized for extraforaminal herniation in order to reduce damage to the paraspinal muscle as well as to achieve a direct approach to the lesion site without large removal of the facet joint [27].

PED through the TF approach

In general, intracanal disc herniation without migration at L1–2 to L4/5 is a good indication for PED through the TF approach [9, 29]. A herniated disc outside the spinal canal also can be treated through the TF approach [21, 30]. It is not indicated for sequestered disc herniation. PED via the TF approach can be performed under local anaesthesia.

In PED through the TF approach, a hollow tube (cannula) approximately 6 mm in diameter is passed through the skin and muscle layers and inserted through the intervertebral foramen using Hijikata's percutaneous nucleotomy technique under fluoroscopic guidance [31]. To prevent injury to the exiting nerve root, the TF approach is performed through the so-called safety triangle (Fig. 2a, b) [21, 32]. The PED cannula

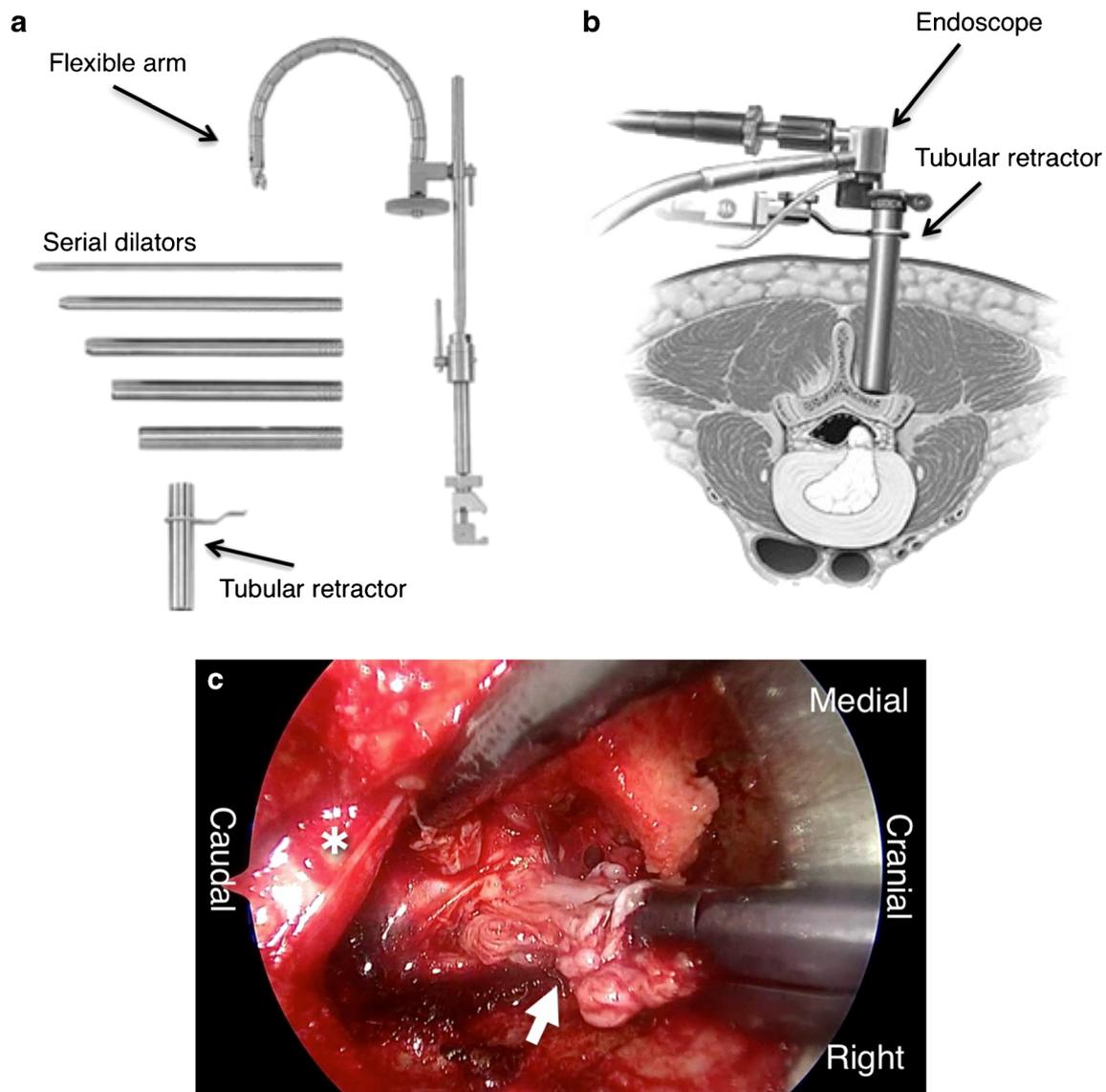


Fig. 1 Microendoscopic discectomy (MED). **a** MED system of serial dilators, tubular retractor, and flexible assembly. **b** The tubular retractor is set on the lamina, and a rigid endoscope is inserted into the tubular

retractor. **c** Endoscopic view of discectomy for disc herniation at L5/S1 on the right side. The asterisk indicates the right S1 nerve root. The white arrow indicates the herniated disc

is set under the outer layer of the annulus, which can be confirmed using fluoroscopy. Fragments that have herniated beyond the posterior annulus or posterior longitudinal ligamentum can then be identified and removed (Fig. 2c). This procedure can reduce the volume of the nucleus and the herniated disc, which consequently relieves symptoms by decreasing tension on the fibers of the annulus and the posterior longitudinal ligament.

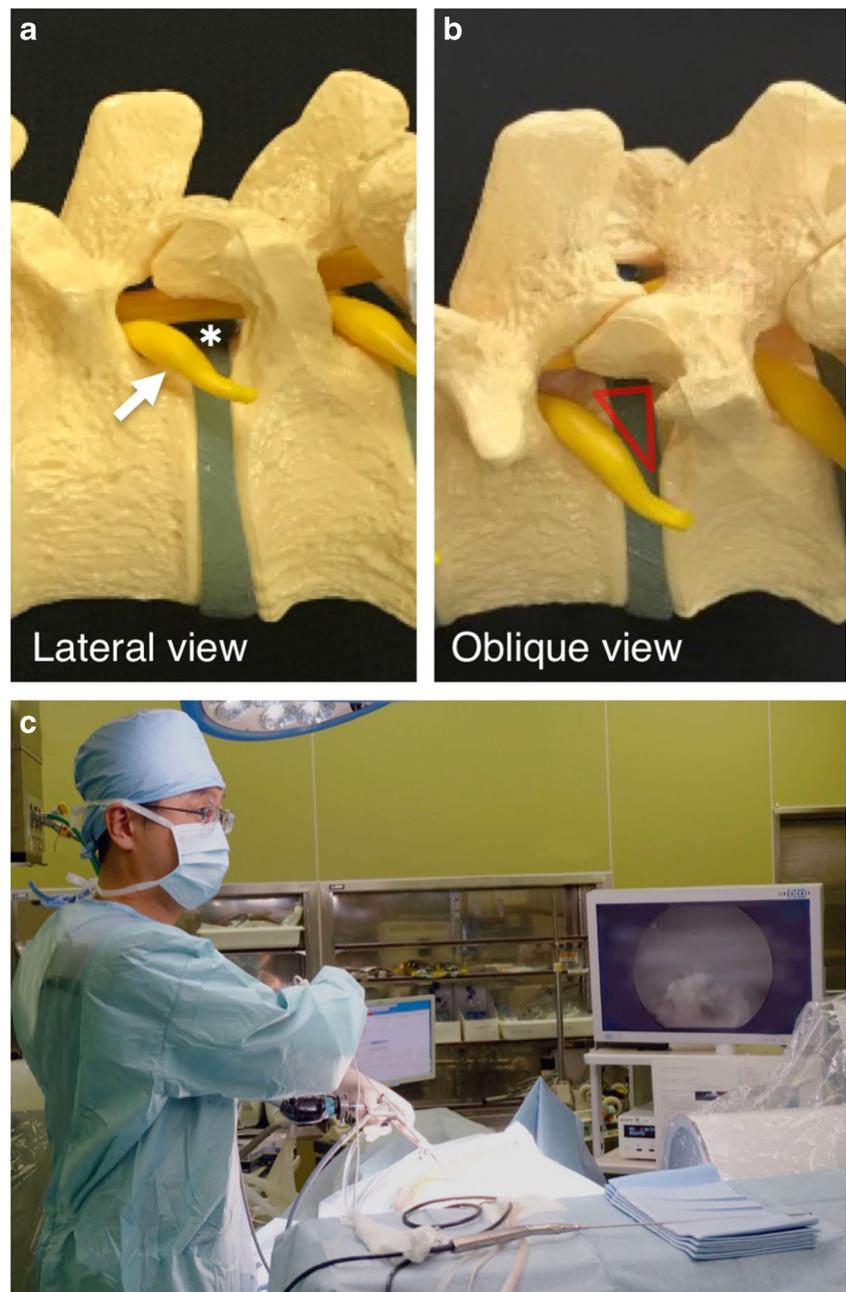
PED through the IL approach

PED through the TF approach is sometimes difficult to perform for disc herniation at the L5-S1 level because of anatomical constraints, such as a high iliac crest [8, 29]. In contrast,

the IL approach is more useful for herniation at the L5-S1 level because the interlaminar space at L5-S1 is generally larger than those at other levels. Therefore, the surgical approach through the interlaminar space to the herniated disc can be more easily performed without bone resection of the laminae at L5-S1 [9]. PED via the IL approach is usually performed under general anaesthesia.

In PED through the IL approach, the affected intervertebral level of disc herniation is confirmed using fluoroscopic guidance, and then, the optimal entry point of the PED cannula can be determined. The optimal entry point of the cannula is located at the medial edge of the pedicle in the AP view and the direction of the cannula towards the superior endplate of S1 vertebra on lateral view [8]. Following the insertion of the

Fig. 2 Percutaneous endoscopic discectomy (PED) through transforaminal (TF) approach. **a** The lateral view of the intervertebral foramen (asterisk) and the exiting nerve root (white arrow). **b** The oblique view shows the safety triangle in the intervertebral foramen. **c** Operative scene of PED through TF approach



cannula, the first structure encountered is the ligamentum flavum. If the ligamentum flavum is split, the epidural fat can be observed. A bipolar radiofrequency coagulator is useful for removing the epidural fat. When the dural sac and the S1 nerve root are confirmed, the cannula is inserted into the spinal canal and then used to protect the nerve root [9]. Finally, the herniated disc is identified and removed with forceps. Following the removal of the herniation, the free movement of the nerve root can be confirmed.

Overall, the learning curve of PED may be steeper than those of conventional open discectomy [33] and MED because the working space is quite narrow and the number of

surgical instruments that can be used in the operating field is limited. All members of the surgical team must be well-trained concerning these procedures.

Outcomes of surgical treatments

According to large prospective studies [34, 35], the surgical treatment for sciatica secondary to LDH provided greater improvement of the clinical outcome than nonsurgical treatment for four to five years.

A meta-analysis showed that there were no significant differences in the visual analogue scale (VAS) or Oswestry

disability index (ODI) between open discectomy and MED [36]. In addition, a systematic review found no significant difference in the postoperative outcome between open discectomy and MED as evaluated using the ODI [37]. However, compared with open discectomy, MED was associated with less blood loss, a shorter length of hospital stay, and a faster return to work [36, 38].

Several meta-analyses have also shown that there are no significant difference in the clinical outcome between PED and open discectomy as evaluated by the VAS and ODI. In addition, the operation time and incidence of recurrence and re-operation were similar between the two procedures [39, 40]. Notably, PED was associated with a shorter hospital stay and time to return to work than open discectomy [39–41]. Taken together, these findings suggest that minimally invasive discectomy, such as MED and PED, provides clinical outcomes similar to the conventional open procedure and may shorten the duration of hospital stay and time until returning to work. However, firm evidence supporting the superiority of these less-invasive techniques is limited. Thus, high-quality randomized controlled trials with sufficiently large sample sizes are necessary to further confirm the effectiveness and clinical benefit of MED and PED.

Complications

In addition to general adverse effects, such as intra-operative anesthetic complications, nerve root or sciatic nerve injury and tearing of the dura mater during decompression of the nerve root are possible complications during lumbar disc surgery. If a disc rongeur or curette is inserted too deeply and penetrates the anterior longitudinal ligament, abdominal major vessels or viscera injury, including injury to the ureter, small bowel, and bladder, may occur, which can be fatal.

A meta-analysis showed that there was no significant difference in the rate of complications, including dural tear, root injury, and wound infection, between open discectomy and MED [36]. In addition, the complication rate and incidence of recurrence and re-operation were similar between the PED and conventional open procedures [39, 40]. Thus, assuming a careful pre-operative assessment is performed and proper surgical techniques are practiced in order to ensure safe and complete decompression, the risk of complications with minimally invasive discectomy is similar to that of a conventional open procedure.

Conclusions

Based on the data of previous systematic reviews and meta-analyses, minimally invasive lumbar discectomy, such as MED and PED, appears to be safe and effective alternatives to open discectomy for patients with symptomatic LDH.

These minimally invasive surgeries can provide beneficial effects to shorten the hospital stay and time to return to work. However, minimally invasive discectomy has a demanding learning curve. Only a well-trained surgeon and support team should perform these less-invasive procedures. Clinical evidence supporting the superiority of MED and PED is still limited. Well-designed prospective multicentered randomized controlled trials with large samples are therefore needed in order to draw a convincing conclusion.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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