

Endoscopic lumbar discectomy and minimally invasive lumbar interbody fusion: a contrastive review

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Abstract

Both percutaneous endoscopic lumbar discectomy (PELD) and minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) have been demonstrated as two common and effective choices for lumbar disc herniation (LDH) minimally invasive surgery. In order to get a better understanding of these two procedures, we made this contrastive review. By looking up recent literature and combining it with our clinical practice, the indications/contraindications, advantages/disadvantages as well as complications/recurrences of PELD and MIS-TLIF were summarized in this review. It was concluded that PELD and MIS-TLIF are safe and effective minimally invasive operative techniques for symptomatic LDH treatment. A better understanding of these two procedures will help to improve clinical outcomes by selecting proper indications, and also benefit the further development of minimally invasive spine surgery.

Key words: lumbar disc disease, discectomy, spinal fusion, minimally invasive surgical procedures.

Introduction

Lumbar disc herniation (LDH) is a clinically symptomatic condition caused by disc material localized displacement induced oppression on spinal nerve roots, in which either the nucleus pulposus or annulus fibrous is beyond the normal intervertebral disc margin [1]. The main symptoms of LDH are low back pain and sciatica, which are common health problems in adult workers and impose a heavy economic burden on individuals, families and countries [2]. For most LDH patients, low back and leg pain can be alleviated by traction, massage or other conservative treatments. However, for 10% to 20% of LDH patients refractory to conservative therapy, surgical treatment should be considered.

Surgical treatment of radicular pain has shown its important role in relieving patients' pain and decreasing the degree of disability. Surgical procedures for LDH can be classified into open surgery (OS) and min-

imally invasive surgery. Traditional open surgery often requires muscle, dural sac, nerve retraction and lamina as well as facet joint resection. Moreover, open surgery usually causes muscular injury and epidural space scarring, which are the main post-operative problems.

For decades, minimally invasive spine surgery (MISS) has been well developed, due to the advances and innovations of surgical instruments and techniques. MISS refers to any procedure that is less invasive than open surgery. The main purpose of MISS is to reduce approach-related soft tissue injury and associated complications without compromising clinical outcomes. Additionally, compared with open surgery, MISS has shown short-term benefits, including shorter operation time and hospital stay, less blood loss and post-operative pain as well as lower complication rates.

Lumbar discectomy and lumbar interbody fusion are the most commonly used surgical strategies for

LDH, while percutaneous endoscopic lumbar discectomy (PELD) and minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) are two common choices for LDH minimally invasive surgery. Kambin and Gellman first introduced PELD in 1983 [2], to remove affected disc material under local anesthesia for direct neural decompression. Next, PELD was further developed with the Yeung endoscopic spine system (YESS) and transforaminal endoscopic spine system (TESSYS) techniques [3, 4], and became a feasible alternative for LDH treatment. MIS-TLIF was first described by Foley *et al.* [5], and was a transforaminal lumbar interbody fusion procedure characterized by inserting a tubular retractor via muscle-dilating exposure to reduce approach-related complications [6]. Despite different mechanisms (direct vs indirect decompression), both PELD and MIS-TLIF were proved effective for LDH treatment.

Indications and contraindications

Although PELD and MIS-TLIF were demonstrated to be effective for LDH treatment, clinical indications and contraindications must be carefully considered.

The major indication for PELD is discogenic radicular symptoms caused by disc protrusions, without response to conservative treatment. Major neurological deficit, segmental instability, spondylolisthesis, extruded disc prolapse, narrow spinal canal or lateral recess are all considered as relative contraindications to PELD [7]. However, Lee *et al.* [8] showed that foraminoplasty would help patients to achieve favorable clinical outcomes when conducting PELD with relative contraindications, such as highly migrated disc protrusion, high canal compromised disc and foraminal stenosis. Although PELD is effective for preserving facet joint, indications must be carefully considered when local scoliosis and/or instability are present [9].

Lumbar disc herniation often occurs at the L4/5 or L5/S1 level, and approximately 5% of cases occur at the L1/L2, L2/L3 or L3/L4 levels. Owing to the unique characteristics of upper lumbar spine, upper LDH is always associated with more severe clinical symptoms and worse surgical outcomes after traditional microdiscectomy. Some spinal surgeons suggested that PELD was not suitable for highly migrated and sequestered upper LDH treatment. However, Wu *et al.* [10] found that PELD was also an efficacious choice for upper LDH patients. Even more recently, Xin *et al.* [11] reported that a mod-

ified translaminar osseous channel-assisted PELD was a safe and effective option for the treatment of highly migrated and sequestered upper LDH.

MIS-TLIF is a safe and effective technique for various lumbar degenerative diseases, including primary degenerative disc disease at one or more lumbar levels [12], which could directly decompress both ipsilateral exiting and traversing nerve roots. Therefore, severe discogenic low back pain caused by degenerative disc disease, segmental instability, postlaminectomy instability, multiple recurrent disc herniations, spinal trauma, foraminal stenosis associated with deformity and degenerative scoliosis, or pseudarthrosis are all potential indications of MIS-TLIF [6, 12]. Another indication for MIS-TLIF is mechanical low back or radicular pain due to spondylolisthesis, and usually grade I or II spondylolisthesis. Performing MIS-TLIF in patients with high grade spondylolisthesis is technically challenging, and for most surgeons, an open approach may be a better choice. It is important that a conjoined nerve root within the foramen is one of the contraindications to MIS-TLIF. Although the condition is rare, pre-operative magnetic resonance images should be closely inspected for these patients [6].

Disc reherniation

Disc reherniation is defined as disc herniation occurring at the LDH operative site for a second time after a postoperative pain-free period, which is usually 6 months or longer. It is the most common cause of reoperation, and the incidence of recurrent lumbar disc herniation (rLDH) ranges from 0.5% to 25% [13]. Surgery related to rLDH treatment, or spinal revision, is more challenging because of the indistinct anatomic structure and perineural scarring, so the optimal surgical approach for rLDH remains controversial.

Both PELD and MIS-TLIF are common operative choices for rLDH. An increasing number of PELD studies [2, 14, 15] have shown that PELD was a feasible alternative to the conventional posterior approach in rLDH treatment. A fusion procedure (such as MIS-TLIF) is recommended only under conditions such as lumbar instability, radiographic degenerative changes and/or chronic axial low back pain [16]. Recently, Yao *et al.* [17] compared rLDH outcomes after PELD revision with those after MIS-TLIF revision, and concluded that PELD revision was associated with great-

er satisfaction at the early stage after surgery, while the satisfaction associated with MIS-TLIF equalized 3 months later. As to clinical outcomes, there was no significant difference between these two surgical methods over time.

A revision operation is generally more difficult due to primary surgery related scar tissue, and an increased risk of dural tears or nerve root injury. The incidence of dural tear during repeated conventional open discectomy was reported to be up to 20%, and it was also found to be associated with long-term adverse sequelae and poor outcomes [18]. Compared with MIS-TLIF, PELD has more advantages such as shorter operation time and hospital stay, less blood loss and lower cost, but it is also associated with higher risk of recurrence. In a study involving 209 rLDH patients [19], only 2 cases were found with epidural burst during the PELD operation. These minimally invasive surgery data also showed a very low complication rate in rLDH treatment. Therefore, when choosing rLDH revision surgery, the indications and advantages of these two methods should be carefully evaluated against their potential contraindications and disadvantages. It is also important to ensure that patients are fully informed.

Advantages and disadvantages

Traditional open spine surgery may lead to laminectomies, muscle damage, yellow ligament excision and nerve retraction, which are the main causes of instability and epidural space scarring. As a potential solution to these problems, minimally invasive spine surgery aims at reducing intraoperative blood loss and wound infections as well as preserving paraspinal muscle innervations to preserve normal muscle function.

Compared with open discectomy, PELD shows obvious advantages, such as less soft tissue injury, less paraspinal muscle injury, minimal postoperative pain and low risk of epidural scarring. Many studies show that PELD offers significant short-term benefits to patients. Firstly, a short hospital stay may probably reduce total cost, resulting in a direct economic advantage. Secondly, most patients suffering from LDH are old people with various medical comorbidities, and a shorter operative time and less blood loss could help to reduce potential complications [2].

Despite advantages and inspiring clinical results, endoscopic discectomy has not been universally ad-

opted for several reasons, such as the steep learning curve, endoscopic approach related anatomical limitations and potential complications. As to novel techniques, the learning curve represents a process whereby people develop a skill by learning from their mistakes. The learning curve of PELD is perceived to be longer and steeper than that of conventional microsurgery. Hirano *et al.* [20] described various difficulties in learning PELD: (1) Posterior procedures have been performed for decades by spine surgeons, so they are familiar with posterior anatomy. But PELD is a posterolateral approach, and the intervertebral foramen anatomical structure is relative new to surgeons. (2) Anatomical landmarks are absent, and (3) tissue differences between the annulus fibrosus and posterior longitudinal ligament (PLL), or the PLL and dura matter, are vague. For all that, some studies reported an acceptable PELD learning curve with sufficient preparation and pre-operative training such as attending seminars, hands-on training or learning at advanced surgical centers [21, 22]. Wang *et al.* [23] and Lee and Lee [24] reported a remarkably decreased complication incidence after twenty operations. Additionally, Ahn *et al.* [21] recommended that epidural block via the same trajectory as the PELD route before the operation enables beginners to develop a stable learning curve.

MIS-TLIF has emerged as an acceptable and popular technique for lumbar fusion. Conventional lumbar fusion is associated with significant muscle stripping and retraction that affect both short-term and long-term outcomes. In contrast, MIS-TLIF is performed via a muscle-dilating approach and short-term outcomes including iatrogenic soft tissue injury, dural sac retraction, blood loss, post-operative pain, risk of infection and duration of hospitalization are all significantly improved [25–28]. In Lee's study [28], MIS-TLIF was associated with a significantly shorter operation time (167.10 vs. 216.58 min) and less blood loss (532.41 vs. 865.81 ml) compared with conventional TLIF. At the same time, this minimally invasive procedure could achieve equivalent fusion rates (93.4%) to conventional open surgery (93.8%) [12].

Compared with MIS-TLIF, PELD shows the following advantages. Firstly, PELD can be performed under local anesthesia, which supports the communication between patients and surgeons during the operation, and is beneficial to intraoperative protection of the nerve root and rapid mobilization postop-

eratively. Secondly, approach-related complications, such as dural tear and cerebrospinal fluid fistulas, seem irrelevant to patients receiving PELD. Liu *et al.* [19] reported only 2 cases with epidural burst in 209 PELD cases, and neither suffered from permanent nerve root injury or other obvious symptoms. Additionally, PELD could retain the motor segment, and decrease the incidence of fusion disease such as adjacent segment. However, PELD is also faced with several problems, such as higher incidence of postoperative chronic low back pain and recurrence. Theoretically, PELD was supposed to be superior in terms of postoperative low back pain because normal paraspinal structures were more likely to be preserved. However, there was no significant difference between PELD and MIS-TLIF groups for both visual analogue scale (VAS) back pain scores and VAS leg pain scores over time [29]. By contrast, Liu *et al.* [19] observed a higher incidence of chronic low back pain in PELD patients compared with the MIS-TLIF group, which is probably caused by intervertebral disk degeneration, lumbar instability and other reasons.

Complications and recurrences

Nerve root injury, dural tear, dysesthesia, discitis, headache, hematoma, visceral injury and wound infection are all major complications of PELD and MIS-TLIF, which possibly resulted from unskilled technology during the learning period.

Yao *et al.* [29] reported that some patients suffered from dysesthesia and headache during the PELD operation. Sairyo *et al.* [30] found that intracranial pressure might increase if the duration of the endoscopic maneuver was too long. Choi *et al.* [31] noted that the working sheath might compress the exiting root during the procedure, and thus a prolonged surgery time could lead to nerve irritation. These complications might depend on surgeons' proficiency. Furthermore, motor weakness and temporary dysesthesia were reported as common complications in PELD. These complications showed an incidence of 2–6.53% according to previous studies [8].

Lumbar fusion is also associated with serious complications such as adjacent segment degeneration [32]. Additionally, Liu *et al.* [19] reported that the incidence of cerebrospinal fluid leakage was 4.5% in the MIS-TLIF group, which is lower than that in the open transforaminal lumbar interbody fusion group.

Most of the complications were associated with the difficulties of minimally invasive spine surgery technique, because the learning curves of both MIS-TLIF and PELD are steep. It is reasonable to believe that expert knowledge of spine anatomy and skilled manipulation are necessary for procedural safety and prevention of complications.

Furthermore, recurrence after PELD should also be noted. The recurrence incidence after PELD was reported to be 0–7.4% [29, 33]. In a retrospective study that involved 10,228 PELD patients, Choi *et al.* [33] found that 78 (0.8%) patients had recurrence. Recently, a retrospective study enrolled 116 patients with recurrent herniation after successful PELD showed that obesity (body mass index ≥ 25 kg/m²) was the most robust risk factor responsible for recurrence [34]. Older age (≥ 50 years old), learning curve of surgeon (< 200 cases) and central location of herniation were also closely associated with recurrent herniation after successful PELD. Additionally, Yao *et al.* [17] reported recurrent herniation of micro-endoscopic discectomy (MED) revision in the PELD group rather than in the MIS-TLIF group. After primary MED surgery, artificial cracks in the annulus fibrosus will change into a laminate structure and increase the interlaminar shear stress, which makes the annulus more prone to delamination. So it is easier to form recurrent herniation on the basis of annulus fibrosus damage [35]. Under this circumstance, PELD might not be appropriate, and a thorough interbody fusion such as MIS-TLIF would be better.

Conclusions

PELD and MIS-TLIF are safe and effective minimally invasive operative techniques for symptomatic LDH treatment. Advances in instrumental technologies and operative techniques have evolved to maximize patients' outcomes and radiographic results. For example, modern nerve monitoring devices could alert surgeons to the stimulation of nerves, which may help to avoid nerve root damage intraoperatively.

Although PELD and MIS-TLIF are increasingly popular, minimally invasive surgery also brings no-negligible radiation exposure to surgeons, especially in lumbar spine surgery [36]. It is still unclear whether this exposure is harmful to patients, and this problem needs to be solved. Additionally, the steeper learning curve, limited anatomical space and high incidence of potential complications associated

with these methods are all challenges to surgeons. Recently, some researchers suggested that computer-assisted navigation has the potential to show anatomic structures dynamically and clearly, which could theoretically facilitate minimally invasive spine procedures. For instance, Fan *et al.* [37] introduced a novel technique named navigator-assisted spinal surgery (NASS), which could induce a definite and optimal trajectory in spinal surgery. This novel technique could possibly shorten the operation time, preoperative location time, puncture-channel time and fluoroscopy times, and finally reshape the learning curve and minimize radiation exposure.

As spine surgery continues to shift towards a 'less' or 'minimally' invasive model, for surgeons, degenerative disc tissue repair may be a better choice than disc removal. It is also recommended to retain motor function of the intervertebral disc without excessive fusion. Furthermore, with the development of stem cell transplantation and tissue regeneration technology, spine surgery in the future will probably focus on the repair and regeneration of degenerative intervertebral tissue.

Conflict of interest

The authors declare no conflict of interest.

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