

Full-endoscopic lumbar decompression versus open posterior interbody fusion for surgical treatment of stable lumbar disc herniation in patients over 65 years: A retrospective cohort study with 2-year follow-up

Tong Li

Peking University Third Hospital

Bin Zhu

Peking University Third Hospital

Xiaoguang Liu (✉ lxg_pku@outlook.com)

Peking University Third Hospital

Research article

Keywords: Full-endoscopic lumbar decompression (FELD), Lumbar disc herniation (LDH), Open posterior lumbar interbody fusion (O-PLIF), Elderly patients, Adverse events

Posted Date: May 26th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-29765/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: In the last decade, full-endoscopic techniques to treat lumbar disc herniation (LDH) have gained popularity in clinical practice. However, few studies have described the safety and efficacy of full-endoscopic lumbar decompression (FELD) in treating older patients with LDH. The aim of this study is to evaluate the safety and efficacy of FELD and open posterior lumbar interbody fusion (O-PLIF) for stable LDH in patients over 65 years of age.

Methods: Data of 251 consecutive patients over 65 years received surgical treatment for stable LDH in 2 separated groups (minimally invasive spinal surgical group and open spinal surgical group) in single center between January 2014 and April 2018 were retrospectively analyzed. Patients were categorized into 2 groups (FELD group and O-PLIF group) according to the operative procedure. Clinical outcome evaluations were performed preoperatively, at 3, 6, 12, 24 months postoperatively, including Oswestry disability index (ODI) score and Japanese orthopaedic association (JOA) score for function assessment, visual analog scale (VAS) score for low-back pain and leg pain, MacNab criteria for assessment of life quality. In addition, the surgical information, including operative time, blood loss, hospitalization time, and adverse events were assessed.

Results: Among 251 patients, 153 underwent FELD and 98 underwent O-PLIF. There was no significant difference in baseline data between 2 groups ($p>0.05$). The mean operative time was significantly shorter, blood loss and hospitalization time were significantly reduced in patients having FELD than O-PLIF ($p<0.001$). The mean ODI, JOA, and VAS postoperative scores were significantly improved over the preoperative scores in both groups ($p<0.05$). No significant difference was between 2 groups in postoperative ODI, JOA, VAS scores, and MacNab evaluation ($p>0.05$). The adverse event rate was 5.2% in FELD group, which was significantly lower than that in O-PLIF group (16.3%, $p<0.05$). The recurrence rate was 7.2% in FELD group and the rate of adjacent segment disc herniation was 6.1% in O-PLIF group.

Conclusions: FELD could achieve satisfactory safety and efficacy for the treatment of stable LDH in the patients over 65 years of age. With less trauma, faster recovery, and lower adverse event rate, FELD may be an alternative surgical treatment for stable LDH in elderly patients.

Introduction

Lumbar disc herniation (LDH) accounts for a large proportion of low-back pain as it affects over 90% of individuals in their lifetime[1]. With an average onset age of 45 years, LDH usually occurs in people between 20 and 50 years of age and is relatively rare in the elderly[2]. LDH is often combined with ligamentum flavum hypertrophy and lateral recess stenosis in older population, which lead to lumbar spinal stenosis (LSS)[3]. Although most patients recover spontaneously or by conservative management, a considerable number of patients will eventually undergo surgical procedures[4]. LSS is the most common reason requiring lumbar spine surgery in patients older than 65 years and the decompressive spine surgery for older patients has increased substantially over the last decade[5,6]. However, surgical

measures are associated with an increased risk of complications and poor outcomes in this population with multiple risk factors including general condition, comorbidities, and pathophysiological changes[7].

Conventional open posterior lumbar interbody fusion (O-PLIF) for spinal decompression and fusion has been an effective surgical treatment for lumbar degenerative disease. Nevertheless, denervation of paraspinal muscles caused by open dissection may lead to postoperative low-back pain and muscle atrophy of the surgical segment[8]. As relevant comorbidities for both surgery and anesthesia occur more frequent in elderly than in a younger population, the older patients take greater risks in open procedure[9]. With the development of endoscopes instrument and great demands of patients for minimally invasive procedure, minimally invasive spinal surgery has achieved rapid advancement in the past four decades[10]. Percutaneous endoscopic lumbar discectomy (PELD) is a minimally invasive procedure for treating LDH first reported in 1973[11]. It became popular with the invention of Yeung endoscopic spine system (YESS) technique and transforaminal endoscopic spine system (TESSYS) technique[12-14]. However, endoscopic treatment for elderly LDH remains controversial due to a single lumbar discectomy without excision of facet joints and ligamentum flavum could not achieve adequate decompression for elderly patients.

Full-endoscopic lumbar decompression (FELD) is a newly developed technique, which has been used in the treatment of LDH and LSS. With further development of PELD, FELD could achieve visualized satisfactory spinal decompression from dorsal to ventral and avoid the damage of posterior structures under local anesthesia[15], which made it a potential alternative for older patients. Nevertheless, to the best of our knowledge, few studies have described the safety and efficacy of FELD in treating older patients with LDH. Our study has performed both FELD and O-PLIF as treatment for LDH in patients over 65 years. Therefore, we attempted to evaluated the clinical outcomes, adverse events, and recurrence of FELD versus O-PLIF for LDH in patients over 65 years.

Materials And Methods

This retrospective study was performed after achieving the approval of the Ethic Committee of our hospital, and the patient outcomes were collected independently from informed consent. Case assignment was from the result of the whole section discussion before surgery and eventually determined by experienced surgeons. A total of 251 consecutive patients over 65 years received surgical treatment for stable LDH in 2 separated groups (minimally invasive spinal surgical group and open spinal surgical group) in single center between January 2014 and April 2018 were retrospectively enrolled. Patients were categorized into 2 groups, FELD group (n=153) and O-PLIF group (n=98), according to the operative procedure.

Inclusion criteria were: 1) single-level LDH, 2) verified by magnetic resonance imaging (MRI) and computed tomography (CT); 3) clinical symptoms and signs in accordance with imaging changes; 4) and failure of standard conservative treatment for at least 12 weeks. Exclusion criteria were: 1) lumbar

spondylolisthesis, or segmental instability suggested by radiographic findings; 2) vertebral infection, vertebral tumor, or other vertebral lesions; 3) and a surgical history involving the same level.

Radiographic measurements

Radiographic measurements were performed by 2 independent physicians. The chief physician examined and determined the measured results when the 2 observers were in disagreement. The digital images were stored in the picture archiving and communication system (PACS) (GE, USA). Preoperative MRI was used to determine lumbar disc degeneration and nerve root compromise in the lateral recess. Preoperative CT scans were used to measure lumbar facet joint degeneration. Disc degeneration was classified into 5 grades according to the grading system proposed by Pfirrmann et al[16]. Nerve root compromise in the lateral recess was graded as follows: Grade 0, no contact of the disc with the nerve root; Grade 1, contact without deviation; Grade 2, nerve root deviation; Grade 3, nerve root compression[17]. Facet joint degeneration was divided into 4 grades according to the CT scan using Weishaup grading[18].

Surgical technique

Full-endoscopic lumbar decompression (FELD)

All procedures were carried out under local anesthesia with mixed anesthetic (2% lidocaine 15ml, 1% ropivacaine 10ml and saline 20ml) and sedated with midazolam and fentanyl, which allowed for monitoring of any change of the patients' symptoms and made it possible for surgeons to get instant feedback from patients so as not to cause damage to any neural structure. The patients were placed in a prone or lateral position on the radiolucent operating table. Preoperative posteroanterior and lateral radiographs were obtained by C-arm fluoroscopy to determine an appropriate entry point and approach angle. There were 2 approaches for endoscopic surgeries of LDH, Transforaminal (TF) approach and interlaminar (IL) approach, the indications for each approach were showed in Figure 1. Special instruments were designed and constructed for foraminotomy and laminectomy, including outer working cannula, trepan, and inner working cannula (Endosurgi, China) (Figure 2).

(1) TF approach

The entry point was 10-12 cm lateral to spinal midline above the iliac crest. A long 18-gauge puncture rod was inserted from the entry point toward the midline under intermittent fluoroscopic guidance. The superior facet joint was the anatomic marker to avoid puncturing injuries and compressions of nerve root. The working cannula and endoscopic surgical system were inserted toward the intervertebral foramina along the puncture rod and all the subsequent steps were performed under constant endoscopic visualization. With a saw to remove the hyperplastic facet joint, full-endoscopic visualized foraminoplasty was performed to enlarge the intervertebral foramina. Then the hyperplastic ligamentum flavum were removed to ensure clearly visible decompression of dura and spinal nerves. Herniated disc, degenerated nucleus, and ventrally hypertrophic osteophytes were removed at last. The endoscopic was removed after freed nerve root could be identified and no active bleeding was confirmed (Figure 3).

(2) IL approach

The entry point was 1-2 cm lateral to the spinal midline. Likewise, the working cannula and endoscopic system were inserted from the entry point to the interlaminar ligamentum flavum. Laminectomy and subsequent procedures were performed under constant endoscopic visualization. Sufficient decompression of bony structure was necessary to expose the cranial and caudal insertion points of interlaminar ligamentum flavum. En-bloc resection of the unilateral hyperplastic ligamentum flavum was performed to expose the axillary and under-shoulder space of nerve root. Then the herniated disc was removed to achieve adequate decompression. The endoscopic was removed after freed nerve root could be identified and no active bleeding was confirmed.

Open posterior lumbar interbody fusion (O-PLIF)

O-PLIF was performed with the patient under general anesthesia, conventional posterior midline incision, dissection. A standard decompression was carried out at the lumbar disc herniation segment bilaterally, and a single cage packed with an autologous bone graft was inserted. Posterior pedicle screw instrumentation was used in all cases.

Efficacy evaluation

Operative time, blood loss, hospitalization time, and adverse events were recorded. Oswestry disability index (ODI) score (range, 0-50) and Japanese orthopaedic association (JOA) score (range, -6-29) for function assessment, and visual analog scale (VAS) score for back and leg pain (range, 0-10) were evaluated preoperatively and at 3, 6, 12, and 24 months postoperatively. Patient satisfaction was evaluated according to the modified MacNab criteria.

Statistical analysis

The data were analyzed using SPSS (version 26.0, Chicago, Illinois, USA). All data were presented as mean value \pm standard deviation. The independent-samples t tests and chi-square tests were used to evaluate group differences. The paired-samples t tests were used to compare preoperative and postoperative data. Statistical significance was defined as $p < 0.05$.

Results

Demographic results

153 patients in FELD and 98 in PLIF groups were not significantly different in age (72.3 ± 6.1 years; 71.8 ± 4.5 years) and other demographic comparisons ($p > 0.05$, Table 1). For the chronic diseases, 82(53.6%) patients had hypertension, 36(23.5%) had type 2 diabetes, and 28(18.3%) had coronary heart disease in the FELD group and 49(50.0%) patients had hypertension, 26(26.5%) had type 2 diabetes, and 10(10.2%) had coronary heart disease in the O-PLIF group (Table 1). The distribution of these chronic diseases in 2 groups were similar ($p > 0.05$).

Radiographic results

The preoperative evaluation of lumbar disc degeneration, nerve root compromise in the lateral recess, and facet joint degeneration were summarized in Table 2-4. The grade distribution of these evaluations between 2 groups were also similar ($p>0.05$).

Clinical outcomes

FELD and O-PLIF were technically successful and well tolerated in all patients. Each patient underwent single-level FELD and O-PLIF, and the mean operative time, blood loss, and hospitalization time of both groups were summarized in Table 5. Mean operative time was shorter in the FELD group than in the O-PLIF group ($p<0.001$). The FELD group was superior to the O-PLIF group with less mean blood loss ($p<0.001$) and less hospitalization time ($p<0.001$).

In both FELD group and O-PLIF group, mean ODI, JOA, and VAS postoperative scores were improved significantly over the preoperative scores ($p<0.05$, Table 6). No significant difference was found between 2 groups in preoperative and postoperative ODI, JOA, and VAS scores ($p>0.05$). According to the modified MacNab criteria, the outcomes rated as excellent and good were 108(70.6%) and 34(22.2%) in FELD group, 75(76.5%) and 16(21.3%) in O-PLIF group at last follow-up, respectively (Table 6). There was no difference between 2 groups ($p>0.05$).

Adverse events and recurrence

During the follow-up period, adverse events occurred in 8(5.2%) patients in FELD group and 16(16.3%) patients in O-PLIF group, which summarized in Table 7. The adverse event rate in O-PLIF was significantly higher than that in FELD group ($p<0.05$). Among 11(7.2%) patients who were found recurrence in FELD group, 8 patients underwent FELD once again and 3 underwent O-PLIF for further treatment. New disc herniation was found in 6(6.1%) patients at the adjacent segment of fusion in O-PLIF group, and they all underwent open surgery for treatment.

Discussion

The therapeutic management of symptomatic LDH includes conservative treatment, epidural infiltrations, percutaneous therapeutic techniques, and surgical treatment. Most patients are responded well to physiotherapy, pharmacotherapy, and epidural steroid injection, while some patients still require percutaneous therapeutic techniques or surgery. LDH is most common in middle-aged patients, and early results has showed good outcomes for lumbar discectomy in younger populations[19-21]. In addition, short-term clinical efficacy of PELD has been showed reliable in treating young patients with LDH[22]. Although early study has reported the outcome of lumbar discectomy in elderly patients is as good as in younger patients[23], the surgical options for patients over 65 years with worse general conditions and more comorbidities is challenging and controversial. Both surgeons and patients should balance the surgical risks and benefits of functional improvement and quality of life.

With less trauma, shorter operative time and hospitalization, and local anesthesia, the endoscopic procedures are considered to be an alternative choice for LDH in older population to reduce the occurrence of surgical complications. However, the degenerative changes of all lumbar spine structure gradually occur in normal aging process and mainly cause central spinal stenosis which affects the elderly most[24]. These changes, including disc herniation, ligament flava hypertrophy, and ossification of longitudinal ligament, increased the complexity of surgery in for elderly patients. Conventional PELD is an effective minimally invasive technique to treat LDH in recent years[13,14], but it is still of several limitations. The working cannula of YESS technique and TESSYS technique were established with the aid of intervention technique, which may lead to the neurological injury. In addition, without adequate foraminoplasty, the nerve root could not be fully exposed and intraspinal adequate decompression is difficult to achieve. Due to the obstructive anatomy, foraminoplasty is challenging at L5-S1 level and the nerve root is not possible to achieve adequate decompression via TF approach[25,26]. Hence, conventional PELD can hardly meet the complex surgical requirement for older patients with severe LDH.

As a developed technique of PELD, FELD is performed with full-endoscopic visualized foraminoplasty, which can ensure adequate decompression of nerve root and spinal canal safely. The fluoroscopy is only used to confirm the surgical level and location of intervertebral foramina in the process of FELD, and all the sequent procedures, including foraminoplasty and discectomy, are performed under endoscopic visualization[27]. Thus, compared with conventional PELD, FELD could significantly reduce the fluoroscopy time and the radiation exposure, and ensure adequate and safe decompression. Besides, IL approach is applied in L5-S1 level to avoid the obstacle of iliac crest. In our current study, we were able to directly compare the clinical outcomes and complications of FELD with O-PLIF for stable LDH in patients over 65 years. Chronic diseases, including hypertension, diabetes, and heart disease, accounted for a significant proportion of 2 groups and the distributions were matched. Meanwhile, the degenerative changes were severe in these elderly patients and the distributions of disc degeneration, facet joint degeneration, and lateral recess stenosis between the 2 groups were also similar. The mean ODI, JOA, and VAS postoperative scores were significantly improved over the preoperative scores in both FELD group and O-PLIF group. Besides, no significant difference was found between the 2 groups in postoperative ODI, JOA, VAS scores, and MacNab evaluation. Therefore, the results suggest FELD is as efficacy as conventional O-PLIF in improving function, low-back and leg pain, and quality of life for patients over 65 years.

Compared with open surgery, endoscopic techniques have significant advantages in the following aspects, including local anesthesia, preserving the normal posterior paraspinal structures, less operative time, less blood loss, and short hospital stay. Although annulus fibrosus fenestration and intraoperative nerve root irritation may be painful under local anesthesia, the surgeon could communicate with patient during the operation to confirm that the symptoms have improved, which indicate adequate decompression of the nerve root[12]. Furthermore, with relatively worse cardiopulmonary function, elderly patients have a lower risk of local anesthesia during surgery. In addition, minimal traumatization of FELD reduces the intraoperative blood loss and further shorten hospital stay. In this study, FELD also showed a

significantly shorter mean operative time, less mean intraoperative blood loss, and shorter mean hospitalization time than O-PLIF.

Previous studies showed a neurological complication rate of endoscopic techniques of 0%-12.4%[27]. The neurological adverse event rate of FELD in current case series was 1.3% (2/153), which was lower than that of O-PLIF (3.1%, 3/98). Therefore, FELD was relatively safe even for patients over 65 years. As for total adverse event rate of our study, 8(5.2%) patients in FELD group and 16(16.3%) patients in O-PLIF group developed postoperative adverse events during the follow-up period. The total adverse event rate was significantly higher in elderly patients who underwent O-PLIF and the main adverse events were wound infection, pulmonary, and implant related complications. This may be related to open wound of O-PLIF and long-term postoperative bed rest after surgery. Recurrence is another important problem for endoscopic surgery. Early studies have showed a recurrence rate of 3.7%-6.9% during the follow-up period in all patients with LDH[28,14,26]. In current study, 11(7.2%) in 153 patients over 65 years underwent FELD had recurrence. The recurrence was relatively higher in older people than in the general population. Among the 11 patients who were found recurrence in FELD group, 8 patients underwent FELD once again and the other 3 underwent open surgery for further treatment. Adjacent segment degeneration is common after lumbar fusion surgery, with a high rate ranging from 5.2% to 18.5%[29]. In this study, new disc herniation was found in 6(6.1%) elderly patients at the adjacent segment of fusion, which was consistent with previous reports. Therefore, the patients underwent FELD are at risk for recurrence, while the patients underwent O-PLIF are at risk for new disc herniation at the adjacent segment.

Although our study showed some reliable results, there were several limitations. First, since it was a single-centered retrospective study, the generalizability of our findings was limited and a randomized control trial may be more convincing. Second, the follow-up period was relatively short and a long-term follow-up should be required in the future. In addition, some older patients were illiterate and could not complete the clinical assessments by themselves, therefore, their family members were contacted to help them finish these assessments.

Conclusions

The traditional surgical treatment of lumbar disc herniation has been PLIF but there has been a trend towards minimally invasive procedures. FELD could achieve satisfactory safety and efficacy for the treatment of stable LDH in the patients over 65 years of age. Moreover, with less trauma, faster recovery, and lower adverse event rate, FELD may be an alternative surgical treatment for stable LDH in elderly patients. Further comparative studies and prospective, randomized, controlled studies should be conducted to assess the clinical outcomes.

Abbreviations

Lumbar disc herniation (LDH), Full-endoscopic lumbar decompression (FELD), Open posterior lumbar interbody fusion (O-PLIF), Oswestry disability index (ODI), Japanese orthopaedic association (JOA),

Visual analog scale (VAS), Spinal stenosis (LSS), Percutaneous endoscopic lumbar discectomy (PELD), Yeung endoscopic spine system (YESS), Transforaminal endoscopic spine system (TESSYS), Magnetic resonance imaging (MRI), Computed tomography (CT), Picture archiving and communication system (PACS), Transforaminal (TF), Interlaminar (IL), Body mass index (BMI)

Declarations

Ethics approval and consent to participate

This study was approved by the Ethic Committee of The Peking university Third Hospital, and patient outcomes were collected independently from informed consent.

Consent for publication

Written informed consent for publication of their clinical details and clinical images was obtained from the patient.

Availability of data and materials

We state that data will not be shared because all raw data were used to prepare the figures included in the article.

Competing interests

The authors declare that they have no competing interests.

Funding

This research did not receive any specific grant from any funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

TL, BZ, and XGL designed the study. TL collected the data, performed the statistical analysis and interpreted the results. TL and BZ drafted the manuscript. The final manuscript was approved by all authors.

Acknowledgements

The authors wish to thank the medical staff of the Surgical Department at Peking University Third Hospital where all of the surgeries were performed.

References

1. Andersson GB. Epidemiological features of chronic low-back pain. *Lancet*. 2009;354 (9178):581-585. doi:10.1016/S0140-6736(99)01312-4.
2. Fjeld OR, Grovle L, Helgeland J, Smastuen MC, Solberg TK, Zwart JA, Grotle M. Complications, reoperations, readmissions, and length of hospital stay in 34 639 surgical cases of lumbar disc herniation. *Bone Joint J*. 2019;101-B (4):470-477. doi:10.1302/0301-620X.101B4.BJJ-2018-1184.R1.
3. Xiong C, Li T, Kang H, Hu H, Han J, Xu F. Early outcomes of 270-degree spinal canal decompression by using TESSYS-ISEE technique in patients with lumbar spinal stenosis combined with disk herniation. *Eur Spine J*. 2019;28 (1):78-86. doi:10.1007/s00586-018-5655-4.
4. Gadjradj PS, Arts MP, van Tulder MW, Rietdijk WJR, Peul WC, Harhangi BS. Management of Symptomatic Lumbar Disk Herniation: An International Perspective. *Spine (Phila Pa 1976)*. 2017;42 (23):1826-1834. doi:10.1097/BRS.0000000000002294.
5. Mazanec DJ, Podichetty VK, Hsia A. Lumbar canal stenosis: start with nonsurgical therapy. *Cleve Clin J Med*. 2002;69 (11):909-917. doi:10.3949/ccjm.69.11.909.
6. Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. *JAMA*. 2010;303 (13):1259-1265. doi:10.1001/jama.2010.338.
7. Aalto TJ, Malmivaara A, Kovacs F, Herno A, Alen M, Salmi L, Kroger H, Andrade J, Jimenez R, Tapaninaho A, Turunen V, Savolainen S, Airaksinen O. Preoperative predictors for postoperative clinical outcome in lumbar spinal stenosis: systematic review. *Spine (Phila Pa 1976)*. 2006;31 (18):E648-663. doi:10.1097/01.brs.0000231727.88477.da.
8. Ruan W, Feng F, Liu Z, Xie J, Cai L, Ping A. Comparison of percutaneous endoscopic lumbar discectomy versus open lumbar microdiscectomy for lumbar disc herniation: A meta-analysis. *Int J Surg*. 2016;31:86-92. doi:10.1016/j.ijisu.2016.05.061.
9. Katz JN, Stucki G, Lipson SJ, Fossel AH, Grobler LJ, Weinstein JN. Predictors of surgical outcome in degenerative lumbar spinal stenosis. *Spine (Phila Pa 1976)*. 1999;24 (21):2229-2233. doi:10.1097/00007632-199911010-00010.
10. Telfeian AE, Veeravagu A, Oyelese AA, Gokaslan ZL. A brief history of endoscopic spine surgery. *Neurosurg Focus*. 2016;40 (2):E2. doi:10.3171/2015.11.FOCUS15429.
11. Mayer HM. A History of Endoscopic Lumbar Spine Surgery: What Have We Learnt? *Biomed Res Int*. 2019:4583943. doi:10.1155/2019/4583943.
12. Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: Surgical technique, outcome, and complications in 307 consecutive cases. *Spine (Phila Pa 1976)*. 2002;27 (7):722-731. doi:10.1097/00007632-200204010-00009.
13. Yeung AT, Yeung CA. Advances in endoscopic disc and spine surgery: foraminal approach. *Surg Technol Int*. 2003;11:255-263.
14. Hoogland T, Schubert M, Miklitz B, Ramirez A. Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: a prospective randomized study in 280

- consecutive cases. *Spine (Phila Pa 1976)*. 2006;31 (24):E890-897.
doi:10.1097/01.brs.0000245955.22358.3a.
15. Kim HS, Paudel B, Jang JS, Oh SH, Lee S, Park JE, Jang IT. Percutaneous Full Endoscopic Bilateral Lumbar Decompression of Spinal Stenosis Through Uniportal-Contralateral Approach: Techniques and Preliminary Results. *World Neurosurg*. 2017;103:201-209. doi:10.1016/j.wneu.2017.03.130.
 16. Pfirrmann CW, Metzdorf A, Zanetti M, Hodler J, Boos N. Magnetic resonance classification of lumbar intervertebral disc degeneration. *Spine (Phila Pa 1976)*. 2001;26 (17):1873-1878.
doi:10.1097/00007632-200109010-00011.
 17. Weishaupt D, Schmid MR, Zanetti M, Boos N, Romanowski B, Kissling RO, Dvorak J, Hodler J. Positional MR imaging of the lumbar spine: does it demonstrate nerve root compromise not visible at conventional MR imaging? *Radiology*. 2000;215 (1):247-253.
doi:10.1148/radiology.215.1.r00ap06247.
 18. Weishaupt D, Zanetti M, Boos N, Hodler J. MR imaging and CT in osteoarthritis of the lumbar facet joints. *Skeletal Radiol*. 1999;28 (4):215-219. doi:10.1007/s002560050503.
 19. Smorgick Y, Floman Y, Millgram MA, Anekstein Y, Pekarsky I, Mirovsky Y. Mid- to long-term outcome of disc excision in adolescent disc herniation. *Spine J*. 2006;6 (4):380-384.
doi:10.1016/j.spinee.2005.10.015.
 20. Mariconda M, Galasso O, Secondulfo V, Rotonda GD, Milano C. Minimum 25-year outcome and functional assessment of lumbar discectomy. *Spine (Phila Pa 1976)*. 2006;31 (22):2593-2599; discussion 2600-2591. doi:10.1097/01.brs.0000240726.26096.be.
 21. Weinstein JN, Lurie JD, Tosteson TD, Tosteson AN, Blood EA, Abdu WA, Herkowitz H, Hilibrand A, Albert T, Fischgrund J. Surgical versus nonoperative treatment for lumbar disc herniation: four-year results for the Spine Patient Outcomes Research Trial (SPORT). *Spine (Phila Pa 1976)*. 2008;33 (25):2789-2800. doi:10.1097/BRS.0b013e31818ed8f4.
 22. Zhou YL, Chen G, Bi DC, Chen X. Short-term clinical efficacy of percutaneous transforaminal endoscopic discectomy in treating young patients with lumbar disc herniation. *J Orthop Surg Res*. 2018;13 (1):61. doi:10.1186/s13018-018-0759-4.
 23. Fujii K, Henmi T, Kanematsu Y, Mishiro T, Sakai T. Surgical treatment of lumbar disc herniation in elderly patients. *J Bone Joint Surg Br*. 2003;85 (8):1146-1150. doi:10.1302/0301-620x.85b8.14625.
 24. Cummins J, Lurie JD, Tosteson TD, Hanscom B, Abdu WA, Birkmeyer NJ, Herkowitz H, Weinstein J. Descriptive epidemiology and prior healthcare utilization of patients in the Spine Patient Outcomes Research Trial's (SPORT) three observational cohorts: disc herniation, spinal stenosis, and degenerative spondylolisthesis. *Spine (Phila Pa 1976)*. 2006;31 (7):806-814.
doi:10.1097/01.brs.0000207473.09030.0d.
 25. Ruetten S, Komp M, Godolias G. An extreme lateral access for the surgery of lumbar disc herniations inside the spinal canal using the full-endoscopic uniportal transforaminal approach-technique and prospective results of 463 patients. *Spine (Phila Pa 1976)*. 2005;30 (22):2570-2578.
doi:10.1097/01.brs.0000186327.21435.cc.

26. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: a prospective, randomized, controlled study. *Spine (Phila Pa 1976)*. 2008;33 (9):931-939. doi:10.1097/BRS.0b013e31816c8af7.
27. Hua W, Zhang Y, Wu X, Gao Y, Li S, Wang K, Yang S, Yang C. Full-Endoscopic Visualized Foraminoplasty and Discectomy Under General Anesthesia in the Treatment of L4-L5 and L5-S1 Disc Herniation. *Spine (Phila Pa 1976)*. 2019;44 (16):E984-E991. doi:10.1097/BRS.0000000000003014.
28. Li ZZ, Hou SX, Shang WL, Song KR, Zhao HL. Modified Percutaneous Lumbar Foraminoplasty and Percutaneous Endoscopic Lumbar Discectomy: Instrument Design, Technique Notes, and 5 Years Follow-up. *Pain Physician*. 2017;20 (1):E85-E98.
29. Park P, Garton HJ, Gala VC, Hoff JT, McGillicuddy JE. Adjacent segment disease after lumbar or lumbosacral fusion: review of the literature. *Spine (Phila Pa 1976)*. 2004;29 (17):1938-1944. doi:10.1097/01.brs.0000137069.88904.03.

Tables

Table 1. General information of patients in the 2 groups

	FELD group	O-PLIF group	p value
n	153	98	
Follow-up period (mo)	33.6±5.4	33.3±6.6	0.770
Male/female	74/79	53/45	0.377
Age (yrs)	72.3±6.1	71.8±4.5	0.487
BMI	24.8±4.6	25.5±3.4	0.223
Duration of back pain	38.3±82.9	59.6±85.1	0.051
Duration of leg pain	27.6±67.7	29.2±58.3	0.849
Location			0.220
L1/L2	0	3	
L2/L3	4	4	
L3/L4	16	10	
L4/L5	110	70	
L5/S1	23	11	
Chronic diseases			
Hypertension	82	49	0.578
Diabetes	36	26	0.591
Coronary heart disease	28	10	0.081

Significance difference (p<0.05)

FELD, full-endoscopic lumbar decompression; O-PLIF, open posterior lumbar interbody fusion; BMI, body mass index.

Table 2. Comparison of preoperative disc degeneration in the 2 groups

Disc degeneration	FELD group	O-PLIF group	p value
Grade I	3	2	
Grade II	15	8	
Grade III	47	27	
Grade IV	67	46	
Grade V	21	15	
			0.961

Significance difference (p<0.05)

FELD, full-endoscopic lumbar decompression; O-PLIF, open posterior lumbar interbody fusion.

Table 3. Comparison of preoperative nerve root compromise in the lateral recess in the 2 groups

Lateral recess stenosis		FELD group	O-PLIF group	p value
Right	Grade 0	12	7	
	Grade 1	33	22	
	Grade 2	69	43	
	Grade 3	39	26	
			0.991	
Left	Grade 0	17	12	
	Grade 1	30	18	
	Grade 2	58	40	
	Grade 3	48	28	
			0.940	

Significance difference (p<0.05)

FELD, full-endoscopic lumbar decompression; O-PLIF, open posterior lumbar interbody fusion.

Table 4. Comparison of preoperative facet joint degeneration in the 2 groups

Facet joint degeneration		FELD group	O-PLIF group	p value
Right	Grade 0	3	2	0.210
	Grade 1	50	20	
	Grade 2	67	50	
	Grade 3	33	26	
Left	Grade 0	1	3	
	Grade 1	46	27	
	Grade 2	72	45	
	Grade 3	34	23	
				0.501

Significance difference (p<0.05)

FELD, full-endoscopic lumbar decompression; O-PLIF, open posterior lumbar interbody fusion.

Table 5. Comparison of surgical information in the 2 groups

	FELD group	O-PLIF group	p value
n	153	98	
Mean operative time (min)	70.7±34.4	125.0±45.0	<0.001
Mean blood loss (ml)	6.9±5.7	241.7±127.0	<0.001
Mean hospitalization time (d)	4.6±1.9	8.2±3.7	<0.001

Significance difference (p<0.05)

FELD, full-endoscopic lumbar decompression; O-PLIF, open posterior lumbar interbody fusion.

Table 6. Comparison of clinical outcomes in the 2 groups

		FELD group (n)	O-PLIF group (n)	p value
ODI scores	preop	25.1±7.5 (153)	25.4±10.1 (98)	0.797
	3 mo postop	14.4±5.5* (153)	15.8±7.8* (98)	0.133
	6 mo postop	12.7±5.5* (151)	12.9±5.5* (96)	0.740
	12 mo postop	11.7±5.1* (143)	12.2±4.5* (93)	0.459
	24 mo postop	11.6±4.8* (142)	12.2±4.5* (93)	0.324
VAS back pain scores	preop	4.5±2.5 (153)	4.3±2.3 (98)	0.544
	3 mo postop	2.6±1.5* (153)	3.0±1.6* (98)	0.056
	6 mo postop	2.1±1.4* (151)	2.3±1.3* (96)	0.309
	12 mo postop	2.0±1.3* (143)	2.1±1.2* (93)	0.548
	24 mo postop	2.0±1.3* (142)	2.1±1.2* (93)	0.495
VAS leg pain scores	preop	6.1±1.5 (153)	5.6±2.2 (98)	0.067
	3 mo postop	2.7±1.5* (153)	2.7±1.8* (98)	0.936
	6 mo postop	2.3±1.3* (151)	2.1±1.5* (96)	0.186
	12 mo postop	2.1±1.1* (143)	2.0±1.3* (93)	0.337
	24 mo postop	2.1±1.1* (142)	2.0±1.4* (93)	0.702
JOA 29 scores	preop	15.6±4.8 (153)	14.2±6.4 (98)	0.066
	3 mo postop	21.1±3.7* (153)	20.4±5.7* (98)	0.249
	6 mo postop	22.7±3.6* (151)	22.1±4.1* (96)	0.297
	12 mo postop	23.2±3.2* (143)	22.5±3.8* (93)	0.154
	24 mo postop	23.3±3.1* (142)	22.6±3.8* (92)	0.092
MacNab evaluation				0.615
	Excellence	108	75	
	Good	34	16	
	Fair	8	4	
	Poor	3	3	
	Excellence/good rate	92.8% (142/153)	92.9% (91/98)	

Significance difference (p<0.05); *p<0.05 versus preoperative data.

n indicates number of patients included in the statistical analysis; FELD, full-endoscopic lumbar decompression; O-PLIF, open posterior lumbar interbody fusion; ODI, Oswestry disability index; Postop, postoperative; Preop, preoperative; VAS, visual analog scale; JOA, Japanese orthopaedic association.

Table 7. Adverse events in the 2 groups

	FELD group	O-PLIF group	p value
Adverse events			
New neurological deficit	2	3	
Wound infection	1	4	
Pulmonary	2	3	
Non-fatal hematologic	0	2	
Durotomy	3	1	
Implant related	0	3	
Total complications	8	16	0.004
	8/153 (5.2%)	16/98 (16.3%)	

Significance difference ($p < 0.05$)

FELD, full-endoscopic lumbar decompression; O-PLIF, open posterior lumbar interbody fusion.

Figures

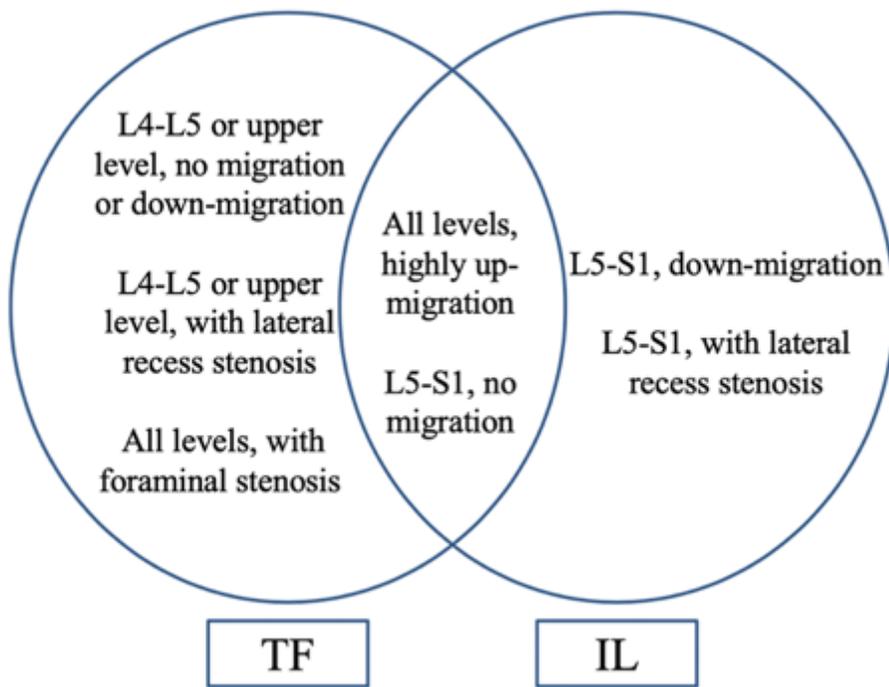


Figure 1

The indications for transforaminal approach and interlaminar approach

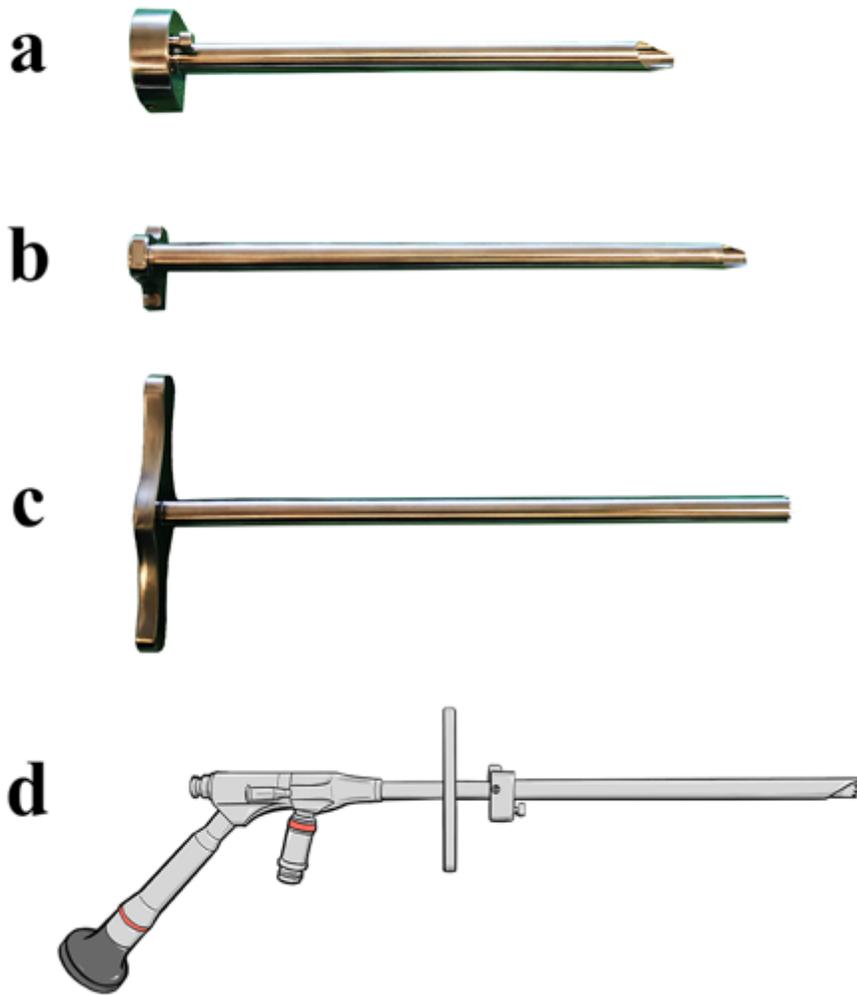


Figure 2

Instruments designed for foraminotomy and laminectomy a. An outer working cannula was applied as an anchor on the lamina and articular processes. b. A trepan was applied to remove the osteophyte through the working cannula. c. An inner working cannula was applied as a channel of the endoscope. d. The assembled instruments with endoscopic system.

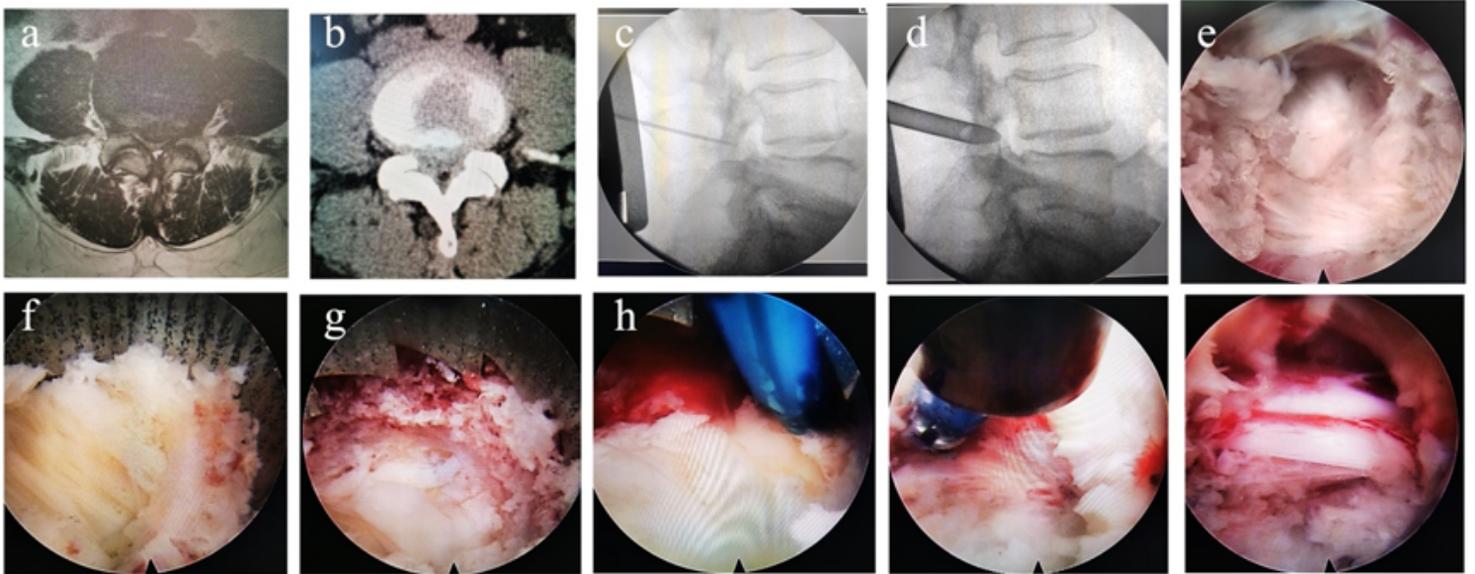


Figure 3

A 68-year-old male had L4/5 central disc herniation with left ligamentum flavum hypertrophy and lateral recess stenosis. a and b. MRI and CT revealed central disc herniation with left ligamentum flavum hypertrophy and lateral recess stenosis in the axial section. c. The puncture rod was located by sagittal X-ray. d. Working cannula inserted toward the intervertebral foramina along the puncture rod. e. The surrounding ligaments and muscle tissue were separated under endoscopy to expose the capsule of facet joints. f. Endoscopic foraminoplasty was performed to expose ligamentum flavum. g. The cephalic ligamentum flavum was excised. h. The caudal insertion of the yellow ligament was revealed. i. The caudal ligamentum flavum and intervertebral disc were removed to expose the nerve root. j. Nerve root was fully exposed under full-endoscopic surgical system.