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# Clinical efficacy of minimally invasive transforaminal lumbar interbody fusion and endoscopic lumbar interbody fusion in the treatment of lumbar degenerative diseases

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**Abstract: Objective** To compare the safety and clinical efficacy of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) and endoscopic lumbar interbody fusion (Endo-LIF) for lumbar degenerative diseases **Method** A restropective analysis was conducted on the data of 115 patients diagnosed with lumbar degenerative diseases at Ningguo People's Hospital and Hangzhou First People's Hospital from January 2019 to July 2021, including 14 cases in the MIS-TLIF group and 11 cases in the Endo-LIF group. The clinical outcomes were compared before operation, and at 1 week, 1 month, 3 months and 1-year post-operation, including visual analogue scale (VAS), Oswestry disability index (ODI) scores and modified MacNab criteria. **Results** The surgical time in the Endo-LIF group [(155.61± 8.50) min *vs* (128.00±8.40) min ] was longer than that in the MIS-TLIF group; however, the intraoperative bleeding volume [(60.39±5.54) mL *vs* (129.39±8.59) ml] and hospital stay [(3.91±0.74) d *vs* ( 4.96±1.57) d] in the Endo-LIF group were lower than those in the MIS-TLIF group, and the difference were statistically significant ($P$ <0.05). The VAS score of low back pain and ODI score in the two groups at each time point after operation were significantly lower than those before operation ($P$ <0.05). At each time point, the VAS score of the Endo-LIF group was slightly lower than that of the MIS-TLIF group, but the difference was not statistically significant ($P$ >0.05). The 1-year postoperative Macnab efficacy evaluation showed no statistically significant difference in the excellent and good rates between the MIS-TLIF group and the Endo-LIF group (96.3% *vs* 96.7%, $P$ >0.05). **Conclusion** There was no significant difference in medium-short term surgical outcomes between MIS-TLIF and Endo-LIF. Endo-LIF group has less damage to surrounding tissues, less intraoperative bleeding volume, and less low-back pain, which is more conducive to the recovery of patients in the long run. However, the indications of Endo-LIF are relatively limited, and the learning curve of Endo-LIF is deep, surgeons need to select indications strictly.

**Keywords:** Lumbar degenerative diseases; Minimally invasive transforaminal lumbar interbody fusion; Endoscopic lumbar interbody fusion; Oswestry disability index

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Lumbar interbody fusion is an effective surgical procedure for the treatment of lumbar degenerative diseases (LDD)[1]. Lumbar interbody fusion can be performed by anterior, lateral, and posterior approaches, among which the posterior approach is widely used as a typical surgical approach in clinical practice. With the introduction of posterior lumbar interbody fusion (PLIF) in the 1950s, transforaminal lumbar interbody fusion (TLIF) also emerged. Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) combines all the advantages of TLIF, utilizing decompression and fusion operations under the channel, and has become an effective alternative to TLIF[2]. In recent years, with the popularity and development of spinal endoscopic surgical techniques, endoscopic lumbar interbody fusion (Endo-LIF) has become a new trend in the development and selection of spinal surgical procedures. Compared with the traditional open fusion procedures including PLIF and TLIF, both MIS-TLIF and Endo-LIF, have the advantages of less surgical trauma, shorter operative time, and faster recovery. However, there is no consensus on which of the two is more effective and safer. One hundred and fifteen patients with lumbar degenerative diseases treated with MIS-TLIF and Endo-LIF, respectively, within the period from January 2019 to July 2021 were retrospectively analyzed. The clinical efficacy of the two groups of patients were also compared, which was reported as follows.

## 1 Materials and methods

### *1.1 General information*

**Inclusion criteria:** (1) different degrees of nerve root pain symptoms, single-segment or double-segment lumbar disc herniation or stenosis; (2) with persistent neurological symptoms and intermittent claudication, which were ineffective after standardized conservative treatment for more than 3 months; (3) patients with lumbar spine instability, lumbar spondylolisthesis of II degree or less based on X-rays, CT and MRI; (4) patients with intervertebral foraminal narrowing and central stenosis.

**Exclusion criteria:** (1) previous history of open or minimally invasive lumbar spine surgery; (2) obvious spinal deformity; (3) severe lumbar spinal stenosis, or high degree of slippage (greater than II degree); (4) combined with severe underlying diseases that can not tolerate the surgery; (5) combined with tumors, infections, or severe osteoporosis; (6) unable to cooperate with the strict postoperative follow-up or unwilling to cooperate with the follow-up patients.

According to the inclusion and exclusion criteria, 115 patients who underwent surgical treatment due to LDD within January 2019 to July 2021 in Ningguo People's Hospital and Hangzhou First People's Hospital affiliated with Westlake University School of Medicine were retrospectively analyzed, including 71 males and 44 females, with the age ranging from 42 to 68 (54.2 ± 7.02) years old, and the duration of the disease ranging from 14 to 29 (22.0 ± 4.96) months. All patients had varying degrees of low back pain, and the patients' lumbar degenerative disease sites: L3/4 and L4/5 segments in 10 cases, L4/5 and L5/S1 segments in 16 cases, L4/5 segments in 58 cases, and L5/S1 segments in 31 cases. Clinical diagnosis: lumbar disc herniation (LDH) in 47 cases; lumbar spondylolisthesis (LS) in 33 cases; and lumbar spinal stenosis (LSS) in 35 cases. Fifty-four patients received MIS-TLIF treatment and 61 patients were treated with Endo-LIF.

### *1.2 Surgical methods*

The MIS-TLIF procedure involved administering either epidural or general anesthesia, positioning the patient prone, and utilizing fluoroscopy with a C-arm machine to identify the upper and lower pedicle projection points. An incision site, typically 1-2 cm along the line between the two centers of the paracentral opening, was marked after routine disinfection and towel draping. Following the marking, an approximately 4 cm incision length was selected, and the Wiltse interspace was accessed for the placement of dilatation tubes. Full exposure of the upper and lower articular processes of the affected segment was achieved, followed by the removal of the medial margins using bone-biting forceps under direct visualization. Partial removal of the upper margin of the inferior lamina was performed if necessary to ensure complete decompression of the vertebral and neural root canals, as well as to assess neural root laxity. Subsequent steps included processing of intervertebral discs and cartilage endplates, clipping autogenous bone blocks into particles for implantation into the intervertebral space, and placement of a fusion device. Finally, pedicle screws were inserted, longitudinal titanium rods were attached, nuts were secured, and the wound was closed in a sequential manner.

In the Endo-LIF group, patients were positioned prone under general anesthesia. The surface needle entry point was determined using the YESS positioning technique, with the coronal head tilt angle of the puncture needle maintained between 0-10 °. Step-by-step expanders were carefully placed along the puncture needle and guidewire, and the articular eminence was shaped using either a milling drill or a circular saw until a large-bore working channel of 10-12 mm could be established through Kambin's triangle. Microscopic intradiscal and intradiscal decompression procedures were then performed. Lumbar disc tissue and endplates were managed within the working channel using specialized instruments such as nucleus pulposus forceps and scrapers. Bone grafting was conducted under fluoroscopic guidance and neural protection, followed by the insertion of a fusion device tapped parallel to the endplate orientation to minimize the risk of injury. Upon thorough examination of the dura mater and nerve roots for compression, the endoscope and working trocar were withdrawn, and the pedicle screw system was bilaterally implanted percutaneously at the responsible segment under fluoroscopic surveillance. The wound was subsequently closed as depicted in **Figure 1**.

### *1.3 Postoperative treatment*

Postoperatively, routine prophylactic antibiotics are administered for 48 hours, tailored to the patient's condition. Dehydration, hormone therapy, and neurotrophic medications are utilized as indicated to mitigate nerve root edema, while oral non-steroidal analgesics are prescribed for pain relief. The drainage tube may be removed 24 hours after surgery, and patients are encouraged to wear a brace for moderate activities starting 2 days after surgery. Discharge from the hospital typically occurs within 3 to 5 days after surgery, with the requirement to continue wearing the lumbar brace for 8 weeks following discharge. Preoperative and postoperative data are meticulously preserved, and patients are instructed to undergo regular outpatient follow-up appointments at 1 week, 3 months, and 1 year after surgery.

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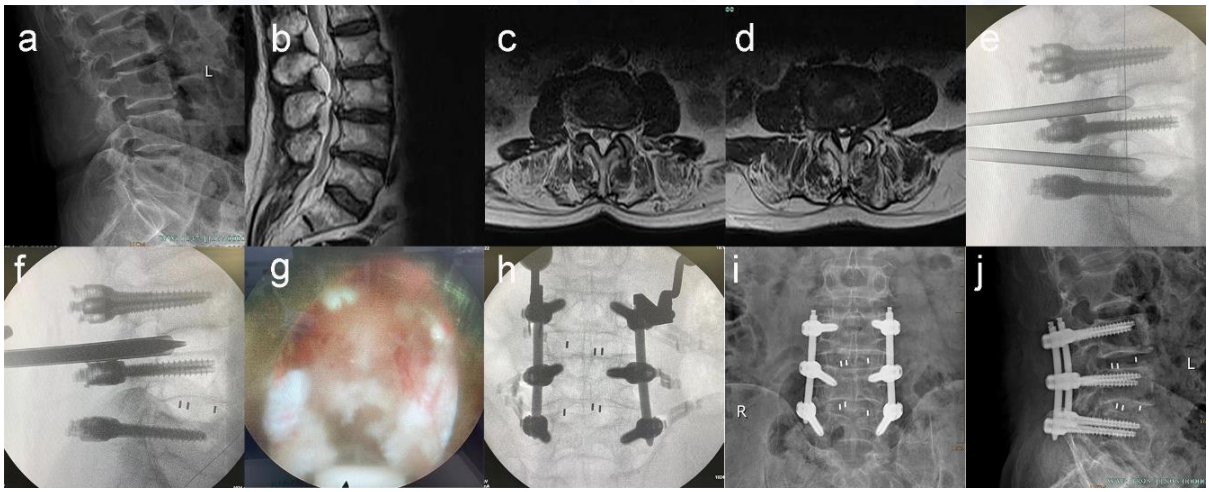


Note: One patient was diagnosed with a bi-segmental lumbar disc herniation at L3/4,L4/5.A,B,C,D are sagittal radiographs, sagittal and cross-sectional MRIs showing disc herniation at L3/4 and L4/5 levels; E,F are intraoperative cannulation and decompression; G is placement of a fusion device with a second decompression; H is confirmation of the position of the screws and titanium rods; and I,J are the 3-month postoperative follow-up radiographs.

**Fig. 1** Typical case of Endo-LIF operation

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### *1.9 Research indexes*

(1) Record and compare the operation time, intraoperative bleeding volume, hospital stay, postoperative complications, visual analogue scale (VAS) of low back pain and Oswestry dability index (ODI) of the two groups. The patients' VAS and ODI scores were assessed and recorded preoperatively, 1 week after surgery, 3 months after surgery, and 1 year after surgery, respectively, with higher VAS scores indicating worse pain and higher ODI scores indicating worse quality of life. (2) Clinical efficacy was evaluated by the modified Macnab criteria at the final follow-up at 1 year after surgery. Excellent: symptoms completely disappeared and resumed the original work and life; Good: slight symptoms, mild limitation of activities, no impact on work and life; Fair: symptoms reduced, limitation of activities, affecting the normal work and life; Poor: no difference before and after the treatment, or even aggravated.

### *1.10 Statistical methods*

SPSS 19.0 software was used to analyze the data. Measurement data were expressed by, $\bar{x} \pm s$, and independent sample *t*-test was used for comparison between groups; comparison of data at different time points was analyzed by repeated-measures ANOVA; count data were expressed as case, and comparison between groups was made by Chi-square test, adjusted Chi-square test, and Fisher's exact test. $P$ <0.05 was considered the difference statistically significant.

## 2 Results

### *2.1 General information*

The included patients all successfully completed the operation, and the difference between the two groups of patients in terms of gender, age, disease duration and lesion segments was not statistically significant ($P$>0.05). **[Table 1]**

### *2.2 Surgery-related indexes*

Compared to the MIS-TLIF group, the Endo-LIF group exhibited prolonged operative durations, albeit with reduced intraoperative hemorrhage and shorter hospital stays, with statistically significant differences between the two cohorts ($P$<0.05). Both groups experienced no instances of complications such as incisional dehiscence, infection, hematoma, internal fixation fractures, or fusion device subsidence and displacement. Within the MIS-TLIF group, two cases of cerebrospinal fluid leakage occurred during surgery, promptly addressed with hemostatic material application and pressure bandaging, yielding no postoperative discomfort. Conversely, two cases within the Endo-LIF group exhibited decreased dorsiflexion muscle strength in the lower limb, attributed to potential nerve root compression during fusion device placement. Symptomatic treatment involving hormone therapy and nutritional nerve support resulted in complete recovery within a fortnight post-surgery. Consequently, the disparity in surgical complications between the two groups was not statistically significant ($P$ >0.05). **[Table2]**

**Tab. 1** Comparison of general information between two groups

| Item | MIS-TLIF group ($n$=54) | Endo-LIF group ($n$=61) | $t/\chi^2$ value | $P$ value |
|---|---|---|---|---|
| **Male (case)** | 35 | 36 | 0.408 | 0.523 |
| **Age (year, $\bar{x} \pm s$)** | 54.1±6.84 | 53.87±7.23 | 0.175 | 0.862 |
| **Duration of disease (month, $\bar{x} \pm s$)** | 21.80±4.75 | 22.18±5.15 | 0.410 | 0.683 |
| **Stage of lesion (case)** | | | | |
| **L3/4, L4/5** | 4 | 6 | | |
| **L4/5, L5/S1** | 8 | 8 | 0.283 | 0.963 |
| **L4/5** | 27 | 31 | | |
| **L5/S1** | 15 | 16 | | |
| **Clinical diagnosis (case)** | | | | |
| **LDH** | 21 | 26 | | |
| **LS** | 16 | 17 | 0.165 | 0.921 |
| **LSS** | 17 | 18 | | |

### *2.3 VAS scores and ODI scores*

Patients in both groups underwent postoperative follow-up evaluation for 12-23 (16.02±2.82) months. There was no statistically significant difference in preoperative VAS and ODI scores between the two groups ($P$ >0.05). VAS and ODI scores were significantly lower at all time points of postoperative follow-up in both groups ($P$ <0.05). Although there was no statistically significant difference in VAS and ODI scores between the two groups ($P$ >0.05), VAS scores in the Endo-LIF group were lower than those in the MIS-TLIF group at all follow-up time points. **[Table 3]**

### *2.4 Assessment of MacNab efficacy at 1 year post-operatively*

The excellent and good rate of the MIS-TLIF group was 96.3%, including 48 cases of excellent, 4 cases of good, and 2 cases of fair. The excellent and good rate of the Endo-LIF group was 96.7%, including 54 cases of excellent, 5 cases of good, and 2 cases of fair. There was no statistical significance in the comparison of the two groups ( $\chi^2$=0.149, $P$ >0.05).

**Tab. 2** Comparison of operation related indicators between two groups ( $\bar{x}$ ±$s$)

| Groups | Case | Surgical time (min) | Intraoperative bleeding volume (ml) | Length of hospital stay (day) |
|---|---|---|---|---|
| **MIS-TLIF group** | 54 | 128.00±8.40 | 129.39±8.59 | 4.96±1.57 |
| **Endo-LIF group** | 61 | 155.61±8.50 | 60.39±5.54 | 3.91±0.74 |
| ***t*/$\chi^2$ value** | | 17.472 | 51.732 | 4.663 |
| ***P* value** | | <0.001 | <0.001 | <0.001 |

**Tab.3** Comparison of VAS score and ODI score between two groups ( $\bar{x}$ ±$s$)

| Groups | Case | VAS score | | | | ODI score | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Preoperative | 1 week after surgery | 3 months after surgery | 1 year after surgery | Preoperative | 1 week after surgery | 3 months after surgery | 1 year after surgery |
| **MIS-TLIF group** | 54 | 5.84±0.67 | 2.29±0.37$^b$ | 1.94±0.33$^b$ | 1.25±0.20$^b$ | 55.77±4.05 | 45.17±3.37$^b$ | 20.30±2.34$^b$ | 10.65±2.11$^b$ |
| **Endo-LIF group** | 62 | 5.62±0.22 | 2.31±0.55$^b$ | 1.70±0.43$^{ab}$ | 1.12±0.24$^{ab}$ | 52.83±3.61 | 43.57±2.55$^{ab}$ | 21.45±2.31$^{ab}$ | 11.80±2.55$^{ab}$ |
| ***F* / $P_{group}$ value** | | 6.679/0.020 | | | | 5.110/0.026 | | | |
| ***F*/ $P_{time}$ value** | | 3.879/0.011 | | | | 13.785/<0.001 | | | |
| ***F*/ $P_{interaction}$ value** | | 6.489/<0.001 | | | | 12.249/<0.001 | | | |

Note: compared with MIS-TLIF group,$^a$*P*>0.05; compared with preoperative,$^b$*P*<0.05.

## 3 Discussion

LDD is a disease that commonly cause lumbar pain, lower limb numbness, neurogenic claudication and other symptoms in clinical practice, and lumbar interbody fusion has become a classic procedure for the treatment of such diseases. With the evolution of minimally invasive concepts and instruments, they have gradually become the primary modality for lumbar degenerative diseases. In 2009, Foley *et al.*[3] proposed MIS-TLIF for the first time, which has precise clinical efficacy compared with traditional open TLIF surgery[4-5]. At the same time, it has a series of advantages such as shorter operation time, less intraoperative bleeding volume, less tissue damage, and less postoperative pain. A retrospective study by Lee *et al.*[6] showed that for LDD, patients in the MIS-TLIF group had less injury and quicker postoperative recovery. In addition, compared with OLIF and ALIF, MIS-TLIF remains the advantage of adequate decompression of open TLIF, and the approach from the intervertebral foramen can lead to more adequate nerve decompression, which is also suitable for more complex lumbar degenerative diseases.

With the popularization and expansion of endoscopic techniques in spinal surgery, Osman *et al.*[7] first reported an endoscopic lumbar spine procedure for decompression and fusion of the intervertebral foramina as well as percutaneous pedicle screw implantation, known as the Endo-LIF technique, in 2012. The core of this technique is to perform operations such as neural decompression and implant fusion through Kambin's triangle under endoscopic vision and access protection.Osman first reported that strong fusion was achieved in 29.6% of 60 patients, and internal fixation system stability was

achieved in 36.2% of patients, and that the reason for the relatively low fusion rate may be related to the absence of fusion implantation and autogenous bone. In 2013, Jacquot *et al.*[8] reported a case study of endoscopic transforaminal approach interbody fusion, the study included a total of 57 patients with an operative time of (60±30) min and a high complication rate of 36%. In 2016, Wang *et al.*[9] reported 10 cases of endoscopic transforaminal approach interbody fusion, with no intra-operative or postoperative morbidity and a fusion rate of 100%. Wang concluded that with the continuous improvement of the surgical details of Endo-LIF, it can also be used as an alternative to traditional fusion surgery. Similar to MIS-TLIF, the biggest advantage of Endo-LIF is also minimally invasive, in addition to other advantages such as faster recovery, shorter hospital stay, and lower cost[10].

In this study, we retrospectively analyzed a group of cases in which Endo-LIF was applied for the treatment of LDD and compared the cases with those of MIS-TLIF group. It was demonstrated that the data of intraoperative bleeding volume and hospital stay in the Endo-LIF group were significantly better than those in the MIS-TLIF group, whereas the duration of the operation was longer than that of the MIS-TLIF. In terms of postoperative complications, VAS, ODI, and assessment of modified Macnab criteria for the 1-year postoperative clinical outcomes, although both groups had similar results, the Endo-LIF group was less traumatizing to peripheral tissues, and the VAS scores for low back pain were lower than those of the MIS-TLIF group at all postoperative follow-up time points. Son *et al.* [11] used Meta analysis to compare the clinical efficacy and safety of the Endo-LIF and MIS-TLIF in the treatment of LDD. The study concluded that the immediate results of Endo-LIF in terms of bleeding volume and immediate VAS back pain were favorable compared to MIS-TLIF, although there were no differences in complication rates, intermediate clinical outcomes, and fusion rates. The results of our study were similar to this conclusion. In addition, Endo-LIF requires a longer learning cycle, and the operator's endoscopic decompression technique is also closely related to the patient's postoperative recovery and the occurrence of complications[12]. MIS-TLIF is an innovation based on open TLIF, which requires a relatively low level of operator skill.

Rational choice of surgery is closely related to efficacy. For some more complicated LDDs, such as severe foraminal stenosis, severe spinal stenosis or calcification, the choice of Endo-LIF is not appropriate. While more severe lumbar spondylolisthesis is not suitable for MIS-TLIF, and it is more difficult to complete the Endo-LIF endoscopically. As the details of the spinal endoscopic operation of Endo-LIF continue to be summarised, some of the problems that were difficult to solve in the past, such as the high iliac spine leading to difficulty in tube placement, insufficient autogenous bone affecting fusion, etc., have been gradually overcome and some useful experience has been gained. For example, if it is difficult to insert the needle into the L5/S1 segment due to obstruction of the iliac crest or hypertrophy of the L5 transverse process, it is possible to switch to Tom needle insertion or reduce the paracentesis distance between the needle insertion point and the midline of the spinous process. It is also advisable to perform preoperative planning based on MRI and CT transverse views of the involved segment to accurately measure the optimal paracentesis distance in the coronal position and the maximum safe angle in the sagittal position during puncture. To ensure optimal final placement of the fusion device, repeated x-ray electrodiagnostics should be performed to ensure that the end of the puncture needle is placed in the anterior 2/3 of the disc on the lateral view and past the midline of the spinous process on the orthopantomogram after the puncture needle has passed smoothly through the Kambin triangle. The ideal position for initial intraoperative decompression is to place the 10-12 mm channel "halfway" into the disc. A large circular saw is preferred for foraminal augmentation and arthroplasty. The circular saw removes a portion of autogenous bone from the ventral aspect of the superior articular process, which can be preserved for later grafting. Implantation of allograft bone mixed with a decalcified dental matrix containing BMP is also an option to improve the long-term fusion rate. Prior to implantation of the fusion device, a special nerve hook can be placed on the dorsal side of the great canal, biased towards the patient's head, and then withdrawn from the working canal to protect the exiting nerve root, and the units that have the conditions can choose to use neurophysiological monitoring in order to minimize the exit nerve root extrusion and injury.

In conclusion, the clinical efficacy and surgical safety of MIS-TLIF and Endo-LIF did not differ significantly in the short and medium term, and the Endo-LIF group had less damage to the surrounding tissues, less intraoperative bleeding volume and less postoperative low back pain, which was more favorable to the patient's recovery in the long run, but the indications for Endo-LIF were relatively limited, and with the long learning curve, the operator needed to strictly select the indications. With the continuous progress of spinal endoscopic surgery techniques, some of the problems that were difficult to solve in the past Endo-LIF surgery have gradually been overcome or optimized.

**Conflict of interest:** None

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·论　著·

# 微创经椎间孔腰椎椎间融合术与内镜下腰椎椎间融合术治疗腰椎退行性疾病的临床疗效

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**摘要：目的**　比较微创经椎间孔腰椎椎间融合术（minimally invasive transforaminal lumbar interbody fusion，MIS-TLIF）与内镜下腰椎椎间融合术（endoscopic lumbar interbody fusion，Endo-LIF）对腰椎退行性疾病的疗效及安全性。**方法**　对宁国市人民医院和杭州市第一人民医院 2019 年 1 月至 2021 年 7 月诊断为腰椎退行性变的 115 例患者的资料进行回顾性分析，其中 MIS-TLIF 组 54 例，Endo-LIF 组 61 例。记录和比较两组患者术前和术后 1 周、3 个月、1 年随访的腰痛视觉模拟评分（VAS）以及 Oswestry 功能障碍指数（Oswestry dability index，ODI），采用改良 MacNab 标准评价疗效等。**结果**　Endo-LIF 组的手术时间长于 MIS-TLIF 组[（155.61±8.50）min *vs*（128.00±8.40）min]；但 Endo-LIF 组的术中出血量[（60.39±5.54）mL *vs*（129.39±8.59）mL]和住院时间[（3.91±0.74）d *vs*（4.96±1.57）d]少于 MIS-TLIF 组，差异有统计学意义（$P<0.05$）。两组术后随访的各时间点 VAS 和 ODI 评分均较术前显著降低（$P<0.05$）。且术后 3 个月、1 年 Endo-LIF 组的 VAS 评分低于 MIS-TLIF 组（$P<0.05$）。术后 1 年 MacNab 疗效评估显示，MIS-TLIF 组和 Endo-LIF 组的优良率差异无统计学意义（96.3% *vs* 96.7%，$\chi^2=0.149$，$P>0.05$）。**结论**　MIS-TLIF 和 Endo-LIF 的临床疗效与手术安全性在中短期无明显差别，Endo-LIF 组对周围组织损伤更小、术中出血量更少、术后腰痛少，从长远来看更利于患者的恢复，但 Endo-LIF 适应证相对有限，学习曲线较长，术者需要严格选择适应证。

**关键词：**腰椎退行性疾病；微创经椎间孔腰椎椎间融合术；内镜下腰椎椎间融合术；Oswestry 功能障碍指数

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# Clinical efficacy of minimally invasive transforaminal lumbar interbody fusion and endoscopic lumbar interbody fusion in the treatment of lumbar degenerative diseases

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**Abstract: Objective**　To compare the safety and clinical efficacy of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) and endoscopic lumbar interbody fusion (Endo-LIF) for lumbar degenerative diseases. **Methods**　A retrospective analysis was conducted on the data of 115 patients diagnosed with lumbar degenerative disease at Ningguo People's Hospital and Hangzhou First People's Hospital from January 2019 to July 2021, including 54 cases in the MIS-TLIF group and 61 cases in the Endo-LIF group. The clinical outcomes were compared before operation, and at 1 week, 1 month, 3 months and 1-year post-operation, including visual analogue scale (VAS), Oswestry disability index scores (ODI) and modified MacNab criteria. **Results**　The surgical time in the Endo-LIF group was longer than that in the MIS-TLIF group [(155.61±8.50) min *vs* (128.00±8.40) min]; however, the surgical bleeding volume [(60.39±5.54) mL *vs* (129.39±8.59) mL] and hospital stay [(3.91±0.74) d *vs* (4.96±1.57) d] in the Endo-LIF group were lower than those in the MIS-TLIF group, and the differences were statistically significant ($P<0.05$). The VAS score of

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low back pain and ODI score in the two groups at each time point after operation were significantly lower than those before operation ($P<0.05$). At 3 month, 1 year post-operation, the VAS score of the Endo-LIF group was lower than that of the MIS-TLIF group ($P<0.05$). The 1 year post-operative MacNab efficacy evaluation showed no statistically significant difference in the excellent and good rates between the MIS-TLIF group and the Endo-LIF group (96.3% *vs* 96.7%, $\chi^2=0.149$, $P>0.05$). **Conclusion**　There was no significant difference in medium-short term surgical outcomes between MIS-TLIF and Endo-LIF. Endo-LIF group has less damage to surrounding tissues, less intraoperative blood loss, and less low-back pain, which is more conducive to the recovery of patients in the long run. However, the indications of Endo-LIF are relatively limited, and the learning curve of Endo-LIF is deep, surgeons need to select indications strictly.

**Keywords**: Lumbar degenerative diseases; Minimally invasive transforaminal lumbar interbody fusion; Endoscopic lumbar interbody fusion; Oswestry disability index

**Fund program**: Zhejiang Province Basic Public Welfare Research Plan Project (LGF22H060025); Zhejiang Province Medical and Health Technology Project (2023KY175)

腰椎椎间融合术是治疗腰椎退行性疾病(lumbar degenerative diseases, LDD)的有效手术方式。腰椎椎间融合术可以选择前路、侧路和后路等多种入路,其中,后入路作为一种典型的手术入路在临床广泛应用[1]。随着 20 世纪 50 年代提出了后入路腰椎椎间融合术(posterior lumbar interbody fusion, PLIF),经椎间孔腰椎椎间融合术(transforaminal lumbar interbody fusion, TLIF)也应运而生。微创经椎间孔腰椎椎间融合术(minimally invasive transforaminal lumbar interbody fusion,MIS-TLIF)集合了 TLIF 所有优点,利用通道下进行减压和融合操作,已成为 TLIF 的有效替代技术。近年来,随着脊柱内镜手术技术的流行与发展,内镜下腰椎椎间融合术(endoscopic lumbar interbody fusion, Endo-LIF)又成为了脊柱外科术式发展和选择的一个新趋势[2]。与传统开放融合手术 PLIF 和 TLIF 相比,MIS-TLIF 和 Endo-LIF 两种手术技术都有手术创伤小、手术时间短、恢复速度快等优势,但关于二者哪种疗效更好、更安全等问题还未达成一致意见。笔者回顾性分析自 2019 年 1 月至 2021 年 7 月内分别采用 MIS-TLIF 和 Endo-LIF 治疗的 115 例 LDD 患者,比较两组患者的临床疗效。现报告如下。

## 1　资料与方法

1.1　一般资料　纳入标准:(1) 不同程度的神经根疼痛症状,单节段或双节段腰椎间盘突出或狭窄;(2) 有持续的神经症状和间歇性跛行,经规范保守治疗超过 3 个月仍然无效者;(3) 依据 X 线片、CT 和 MRI 检查显示为腰椎不稳、腰椎滑脱Ⅱ度及Ⅱ度以下患者;(4) 伴有椎间孔狭窄和中央狭窄的患者。排除标准:(1) 既往有腰椎开放或微创手术史;(2) 存在明显的脊柱畸形;(3) 重度腰椎椎管狭窄,或高度滑脱(大于Ⅱ度);(4) 合并有严重基础疾病无法耐受手术者;(5) 合并肿瘤、感染,或重度骨质疏松者;(6) 无法配合术后严格随访或不愿配合随访的患者。

根据纳入和排除标准,回顾性分析宁国市人民医院和杭州市第一人民医院 2019 年 1 月至 2021 年 7 月内由于 LDD 接受手术治疗的 115 例患者,其中男性 71 例,女性 44 例,年龄 42~68(54.20±7.02)岁,病程 14~29(22.00±4.96)个月。所有患者均有不同程度的腰背部疼痛,患者腰椎退行性病变部位:$L_{3/4}$ 和 $L_{4/5}$ 节段 10 例,$L_{4/5}$ 和 $L_5/S_1$ 节段 16 例,$L_{4/5}$ 节段 58 例,$L_5/S_1$ 节段 31 例。临床诊断:腰椎间盘突出症(lumbar disc herniation, LDH) 47 例;腰椎滑脱症(lumbar spondylolisthesis, LS) 33 例;腰椎管狭窄(lumbar spinal stenosis, LSS)35 例。其中,54 例患者接受 MIS-TLIF 治疗,61 例患者接受 Endo-LIF 治疗。

1.2　手术方法　MIS-TLIF 组:患者接受硬膜外麻醉或全身麻醉,取俯卧位,用 C 臂机透视确定上下椎弓根体表投影点,沿两中心点连线旁开 1~2 cm 即为切口部位,常规消毒铺巾,在标记点切口长约 4 cm,选取 Wiltse 间隙入路并置入扩张管道。充分暴露病变节段上、下关节突关节,在直视下用咬骨钳去除下关节突和上关节突内侧缘,必要时可去除部分下位椎板上缘,使椎管和神经根管彻底解压,完成患侧的神经根松解。随后处理椎间盘及软骨终板,将取下的自体骨块剪成骨粒植入椎间隙,置入融合器。最后拧入椎弓根螺钉,连接纵行钛棒,螺帽固定,依次缝合伤口。

Endo-LIF 组:患者全麻取俯卧位,利用 YESS 定位技术确定体表进针点,穿刺针冠状位头倾角度宜保持 0°~10°。沿着穿刺针和导丝置入逐级的扩张器,使用磨钻或环锯进行关节突成型,直至可以通过 Kambin 三角置入 10~12 mm 大口径工作通道。在镜下进行盘内和椎管内减压。再使用髓核钳和刮刀在工作通道内处理腰椎间盘组织和终板。在透视监视以

及神经拉钩保护下进行植骨，置入和敲击融合器时注意平行终板方向以防止人为损伤。再次置入工作通道，探查硬脊膜及神经根无明显受压后，退出内镜及工作套管。透视下于责任节段双侧经皮植入椎弓根螺钉系统，并缝合伤口（图 1）。

1.3　术后处理　术后常规预防性使用抗生素 48 h，根据患者情况，配合使用脱水剂、激素和神经营养药减轻神经根水肿，酌情口服非甾体类止痛药缓解疼痛。术后 24 h 可拔除引流管，术后 2 d 可佩带支具进行适度活动，术后 3~5 d 观察无异常可出院，出院后仍需佩戴腰部支具 8 周。保存术前、术后病史资料，嘱患者在术后 1 周、3 个月、1 年进行定期的门诊随访。

1.4　研究指标　（1）记录和比较两组患者的手术时间、术中失血量、住院时间、术后并发症、腰痛视觉模拟评分（visual analogue scale，VAS）以及 Oswestry 功能障碍指数（Oswestry dability index，ODI）。其中，分别于术前、术后 1 周、术后 3 个月和术后 1 年评估与记录患者的 VAS 评分以及 ODI 评分。VAS 评分越高说明疼痛越严重；ODI 评分越高说明生活质量越差。（2）术后 1 年末次随访时以改良 MacNab 标准评价临床疗效。优，症状完全消失，恢复原来的工作和生活；良，有轻微症状，活动轻度受限，对工作生活无影响；可，症状减轻，活动受限，影响正常工作和生活；差，治疗前后无差别，甚至加重。

1.5　统计学方法　采用 SPSS 19.0 软件分析数据。计量资料采用 $\bar{x}\pm s$ 表示，组间比较采用独立样本 $t$ 检验；不同时点资料比较采用重复测量资料的方差分析及两两比较；计数资料以例数表示，组间比较行 $\chi^2$ 检验、校正 $\chi^2$ 检验或 Fisher 确切概率法。$P<0.05$ 为差异有统计学意义。

## 2　结　果

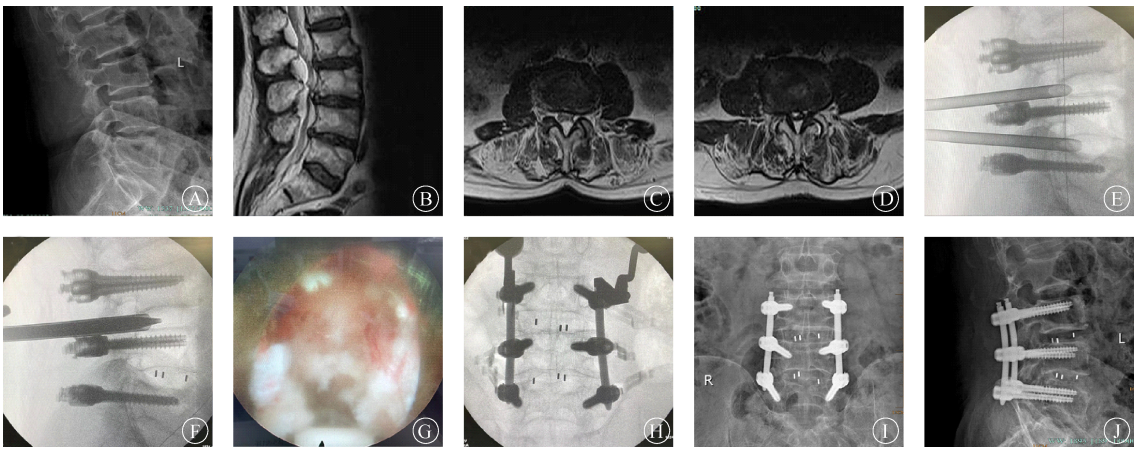
2.1　一般资料　纳入患者均顺利完成手术，两组患者性别、年龄、病程、病变节段比较差异无统计学意义（$P>0.05$）。见表 1。

2.2　手术相关指标　与 MIS-TLIF 组比较，Endo-LIF 组的手术时间长，但手术出血量少，住院时间短，两组比较差异有统计学意义（$P<0.05$）。见表 2。两组患者均未出现切口愈合不良、感染、血肿、内固定断裂、融合器下沉及移位等并发症。MIS-TLIF 组出现 2 例脑脊液漏，术中适当填塞止血材料并加压缝合和包扎，术后观察患者均无明显不适症状；Endo-LIF 组出现 2 例患侧下肢足背伸肌力下降，考虑为放置融合器时压迫出口神经根造成一过性神经损伤，术后对症予以激素、营养神经治疗，均于术后 2 周内恢复至正常。两组手术并发症情况差异无统计学意义（$\chi^2=0.149$，$P>0.05$）。

**表 1**　两组一般资料比较

**Tab. 1**　Comparison of general information between two groups

| 项目 | MIS-TLIF 组（$n=54$） | Endo-LIF 组（$n=61$） | $t/\chi^2$ 值 | $P$ 值 |
|---|---|---|---|---|
| 男性（例） | 35 | 36 | 0.408 | 0.523 |
| 年龄（岁，$\bar{x}\pm s$） | 54.10±6.84 | 53.87±7.23 | 0.175 | 0.862 |
| 病程（月，$\bar{x}\pm s$） | 21.80±4.75 | 22.18±5.15 | 0.410 | 0.683 |
| 病变阶段（例） | | | | |
| $L_{3/4}$，$L_{4/5}$ | 4 | 6 | | |
| $L_{4/5}$，$L_5/S_1$ | 8 | 8 | 0.283 | 0.963 |
| $L_{4/5}$ | 27 | 31 | | |
| $L_5/S_1$ | 15 | 16 | | |
| 临床诊断（例） | | | | |
| LDH | 21 | 26 | | |
| LS | 16 | 17 | 0.165 | 0.921 |
| LSS | 17 | 18 | | |



注：1 例诊断为 $L_{3/4}$、$L_{4/5}$ 双节段 LDH 的患者。A、B、C、D 为矢状面 X 线片、矢状面及横断面 MRI，可见 $L_{3/4}$ 和 $L_{4/5}$ 水平椎间盘突出；E、F 为术中置管和减压；G 为放入融合器后行二次减压；H 为确认螺钉及钛棒位置；I、J 为术后 3 个月随访的 X 线片。

**图 1**　行 Endo-LIF 手术的典型病例

**Fig. 1**　Typical case of Endo-LIF operation

2.3　VAS 评分和 ODI 评分　两组患者术后均接受随访评估,随访时间为 12~23(16.02±2.82)月。两组患者术前 VAS 和 ODI 评分差异无统计学意义($P$>0.05)。两组术后随访的各时间点 VAS 和 ODI 评分均显著降低($P$<0.05)。且 Endo-LIF 组的 VAS 评分在术后 3 个月和术后 1 年均低于 MIS-TLIF 组($P$<0.05)。见表 3。

2.4　术后 1 年 MacNab 疗效评估　MIS-TLIF 组的优良率为 96.3%,其中包括优 48 例,良 4 例,可 2 例;Endo-LIF 组的优良率为 96.7%,其中优 54 例,良 5 例,可 2 例;两组优良率比较差异无统计学意义($\chi^2$=0.149, $P$>0.05)。

**表 2**　两组手术相关指标比较　($\bar{x}\pm s$)

**Tab. 2**　Comparison of operation related indicators between two groups　($\bar{x}\pm s$)

| 组别 | 例数 | 手术时间(min) | 术中出血量(mL) | 住院时间(d) |
|---|---|---|---|---|
| MIS-TLIF 组 | 54 | 128.00±8.40 | 129.39±8.59 | 4.96±1.57 |
| Endo-LIF 组 | 61 | 155.61±8.50 | 60.39±5.54 | 3.91±0.74 |
| $t/\chi^2$ 值 | | 17.472 | 51.732 | 4.663 |
| $P$ 值 | | <0.001 | <0.001 | <0.001 |

**表 3**　两组 VAS 评分和 ODI 评分比较　($\bar{x}\pm s$)

**Tab. 3**　Comparison of VAS score and ODI score between two groups　($\bar{x}\pm s$)

| 组别 | 例数 | VAS 评分 | | | | ODI 评分 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 术前 | 术后 1 周 | 术后 3 个月 | 术后 1 年 | 术前 | 术后 1 周 | 术后 3 个月 | 术后 1 年 |
| MIS-TLIF 组 | 54 | 5.84±0.67 | 2.29±0.37$^{b}$ | 1.94±0.33$^{b}$ | 1.25±0.20$^{b}$ | 55.77±4.05 | 45.17±3.37$^{b}$ | 20.30±2.34$^{b}$ | 10.65±2.11$^{b}$ |
| Endo-LIF 组 | 61 | 5.62±0.22 | 2.31±0.55$^{b}$ | 1.70±0.43$^{ab}$ | 1.12±0.24$^{ab}$ | 52.83±3.61 | 43.57±2.55$^{ab}$ | 21.45±2.31$^{ab}$ | 11.80±2.55$^{ab}$ |
| $F_{组间}/P_{组间}$ 值 | | 6.679/0.020 | | | | 5.110/0.026 | | | |
| $F_{时间}/P_{时间}$ 值 | | 3.879/0.011 | | | | 13.785/<0.001 | | | |
| $F_{交互}/P_{交互}$ 值 | | 6.489/<0.001 | | | | 12.249/<0.001 | | | |

注:与 MIS-TLIF 组比较,$^{a}P$<0.05;与术前比较,$^{b}P$<0.05。

## 3　讨　论

LDD 是临床上常见的引起腰部疼痛、下肢麻木、神经性跛行等症状的一组疾病,腰椎椎间融合术已经成为治疗此类疾病的经典术式。随着微创理念和器械的发展,脊柱微创技术已经逐渐成为了治疗 LDD 的主流。2009 年 Foley 等[3]首次提出 MIS-TLIF,相较于传统的开放 TLIF 手术,MIS-TLIF 的临床疗效确切,同时具有手术时间短、术中出血量少、组织损伤小、术后疼痛轻等一系列优势[4-5]。Lee 等[6]的一项回顾性研究显示,对于 LDD,MIS-TLIF 组的患者损伤少、术后恢复早。除此之外,与 OLIF、ALIF 等相比,MIS-TLIF 还保留了开放 TLIF 充分减压的优势,从椎间孔入路可以使神经减压更充分,也适用于较为复杂的 LDD。

随着内镜技术在脊柱外科的普及和拓展,Osman 等[7]在 2012 年首次报道了一种内镜下椎间孔减压融合以及经皮椎弓根螺钉植入的腰椎术式,即 Endo-LIF 技术。该技术核心是在内镜视野下和通道保护下,通过 Kambin 三角进行神经减压和植骨融合等操作。Osman 首次报道 60 例患者有 29.6%的患者达到了坚强的融合,36.2%的患者内固定系统稳定,其融合率相对较低的原因可能与未植入融合器和自体骨有关。2013 年,Jacquot 等[8]报道了内镜下经椎间孔入路椎间融合术的病例研究,研究共包括 57 例患者,手术时间为(60±30)min,并发症发生率高达 36%。2016 年,Wang 等[9]报道了 10 例内镜下经椎间孔入路椎间融合术的病例,无术中及术后并发症发生,且融合率为 100%,认为随着 Endo-LIF 手术细节不断改良,也可以作为传统融合手术的一种替代方案。与 MIS-TLIF 类似,Endo-LIF 的最大优势也是微创,除此之外也有恢复快、住院时间少、费用低等其他优势[10]。

本研究回顾性分析了一组应用 Endo-LIF 治疗 LDD 的病例,并与 MIS-TLIF 组进行比较,研究显示 Endo-LIF 组的术中失血量、住院时间均显著优于 MIS-TLIF 组,而手术时间却长于 MIS-TLIF;在术后并发症、VAS、ODI 以及术后 1 年改良 MacNab 标准临床效果评估方面,尽管两组的结果都较为相似,但是 Endo-LIF 组对周围组织创伤更小,术后 3 个月、1 年的腰痛 VAS 评分皆低于 MIS-TLIF 组。Son 等[11]运用 Meta 分析比较了 Endo-LIF 和 MIS-TLIF 治疗 LDD 的临床疗效和安全性,研究认为与 MIS-TLIF 相比,尽管并发症率、中期临床结果和融合率没有差异,Endo-LIF 在失血量和即刻背痛 VAS 结果是有利的,本研究结果与之相似。此外,Endo-LIF 需要较长的学习周期,术者内镜下减压技术也与患者术后恢复和并发症发生息息相关[12]。MIS-TLIF 是在开放 TLIF 基础上进行革新,对术者技术要求相对较低。

术式的合理选择无疑与疗效密切相关。面对一些更复杂的 LDD,如严重的椎间孔狭窄、椎管狭窄或钙化,都不适合选择 Endo-LIF。较严重的 LS,不合适 MIS-TLIF,也更难在内镜下完成 Endo-LIF。随着

Endo-LIF 脊柱内镜操作细节不断总结,一部分过去难以解决的问题比如高髂棘导致难以置管、自体骨不足影响融合等都慢慢被克服,并形成了一些有益的经验。例如在 $L_5/S_1$ 节段若遇髂嵴遮挡或 $L_5$ 横突肥厚而导致穿刺针进针困难时,可以选择改用 Tom 针穿刺,或者减小进针点至棘突中线之间的旁开距离。更宜根据责任节段的 MRI 及 CT 横断位片进行术前规划,精确地测量穿刺时冠状位的最佳旁开距离及矢状位的最大安全角度。为了保证融合器最终植入最佳位置,应反复 X 线电透保证穿刺针顺利通过 Kambin 三角后,穿刺针的末端置于侧位片椎间盘前 2/3,而正位片上已过棘突中线。术中初次减压的理想置管位置是将 10~12 mm 大通道先置于“半盘内”状态。在进行椎间孔扩大以及关节突成形术时更宜选择大号环锯。环锯去除部分上关节突腹侧自体骨骨质,可以保留下来后期植骨备用。为了提高远期融合率,亦可选择植入同种异体骨并混合含有骨形态发生蛋白的脱钙牙基质等。在植入融合器前可先将特制的神经拉钩放置于大通道背侧并偏向患者头端,再退出工作通道,用以保护出口神经根,有条件的单位此时可选择使用神经电生理监测以减少出口神经根挤压和损伤。

综上所述,MIS-TLIF 和 Endo-LIF 的临床疗效与手术安全性在中短期无明显差别,Endo-LIF 组对周围组织损伤更小、术中失血量更少、术后腰痛少,从长远来看更利于患者的恢复,但 Endo-LIF 适应证相对有限,学习曲线较长,术者需要严格选择适应证。随着脊柱内镜操作技术不断进步,一部分过去 Endo-LIF 操作难以解决的问题已经被慢慢克服或优化。

**利益冲突**　无

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