

## CLINICAL ARTICLE

# One-Stage Percutaneous Endoscopic Lumbar Discectomy for Symptomatic Double-Level Contiguous Adolescent Lumbar Disc Herniation

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**Objective:** To assess the clinical efficacy of one-stage percutaneous endoscopic lumbar discectomy (PELD) for symptomatic double-level contiguous adolescent lumbar disc herniation (ALDH).

**Methods:** This retrospective study included 16 patients who presented with back and/or leg pain due to double-level disc herniation underwent PELD for symptomatic lumbar disc herniation (0.27%, 16/5877) from January 2014 to September 2019. After follow-up period of 17.3 months in average, numeric rating scale (NRS) scores and modified Macnab criteria were used to assess the preoperative and postoperative clinical results. Quantitative data were expressed as mean standard deviation (SD) and the data for the variation in the NRS scores before and after the operation were compared using the Wilcoxon two-sample test. Analyses were performed with IBM SPSS Statistics for Windows, version 19.0 (IBM, Armonk, NY, USA). Values of  $P < 0.05$  were considered significantly different.

**Results:** There were 11 male and 5 female patients, with an average age of 19.3 years (range, 15–22 years). One case affected the L<sub>2</sub>-L<sub>3</sub>/L<sub>3</sub>-L<sub>4</sub> level, seven cases affected the L<sub>3</sub>-L<sub>4</sub>/L<sub>4</sub>-L<sub>5</sub> level, and eight cases affected the L<sub>4</sub>-L<sub>5</sub>/L<sub>5</sub>-S<sub>1</sub> level. The NRS scores decreased significantly in both early and late follow-up evaluations and these scores demonstrated significant improvement in late follow-up ( $P < 0.05$ ). For the modified Macnab criteria, the final outcome results were excellent in 14 patients (87.5%), good in 1 patient (6.25%), fair in 1 patient (6.25%), and the overall success rate was 93.75%.

**Conclusion:** This study's data suggest that one-stage PELD is promising treatment strategy for selected symptomatic double-level contiguous adolescent lumbar disc herniation.

**Key words:** Adolescent; Discectomy; Endoscopic; Herniation; Percutaneous

## Introduction

Symptomatic lumbar disc herniation is rarely seen among adolescents<sup>1–4</sup>. The incidence of adolescent lumbar disc herniation varies from 1% to 5% in those aged 22 years or younger<sup>2,3</sup>. Clinically, single-level involvement is common in this special subgroup of young patients, double-level

adolescent lumbar disc herniation is even rarer. Due to the rarity of adolescent lumbar disc herniation in this special subgroup of young patients, as a result, these young patients are commonly misdiagnosed initially and may experience a prolonged length of time from onset of symptoms to diagnosis and appropriate managements<sup>4</sup>.

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Occurring in line with a spinal degenerative process, adult lumbar disc herniation is characterized by dehydrated degenerative discs<sup>3-5</sup>, although adolescent lumbar disc herniations have unique natural and clinical histories, which cannot be assumed to be the same disease as in adults. Attention was given to adult lumbar disc herniation with adolescent lumbar disc herniation remaining partially ignored. At what age there is a relevant distinction from adult disease is unclear. So far, the pathogenesis and etiology of adolescent lumbar disc herniation has been poorly studied, but trauma or sports-related incidents, genetics and dysfunctional bio-mechanical conditions (being overweight or being tall, congenital lumbosacral malformations) are likely contributory.

The goal of the treatment of adolescent lumbar disc herniation is to relieve pain, function improvement and allow an early return to routine life. Although a trial of conservative management before surgery is widely considered the appropriate first-line treatment in the absence of neurological compromise, conservative treatment is not as effective for adolescent lumbar disc herniation as it is for adults. Pathologically and anatomically, the herniated nucleus pulposus of adolescents is less degenerated and more hydrated that is difficult to absorb, spine trauma may result in rupture of the epiphyseal ring and annulus fibrosus, which are difficult to repair. What is more, adolescents are active and less likely to comply with strict bed rest. Additionally, delaying surgery for conservative treatment is warranted, but for how long remains unclear.

Nowadays, various methods of discectomy have been described, but, the treatments available for double-level adolescent lumbar disc herniation and the effect of each treatment have not been fully reviewed<sup>5-8</sup>. Even though percutaneous endoscopic lumbar discectomy has rapidly evolved and gained popularity, the efficacy of PELD is still controversial for symptomatic double-level contiguous percutaneous endoscopic lumbar discectomy<sup>5,6,9</sup>.

The treatment of adolescent lumbar disc herniation involving double-segments is more technically demanding for spinal surgeons. If the surgical option is used, the patient needs to be admitted to hospital for related examinations twice, the medical expenses may be increased, the period of rehabilitation is prolonged, and work or study is affected. However, the one-stage operation of double-level contiguous ALDH simultaneously undoubtedly resulted in prolonged operation time, increased radiation exposure and poor patient tolerance.

To our knowledge, currently, few studies have emphasized the operative technique to treat symptomatic double-level contiguous adolescent lumbar disc herniation simultaneously<sup>9-11</sup>. This is the first study on one-stage percutaneous endoscopic lumbar discectomy for symptomatic double-level contiguous adolescent lumbar disc herniation so far.

In this retrospective study, our objectives were to: (i) to improve the level of treatment for adolescent lumbar disc herniation; (ii) to explore the feasibility and elucidate the technical details of one-stage PELD for symptomatic double-level contiguous adolescent lumbar disc herniation; and (iii) to provide references for operational option for the treatment of adolescent lumbar disc herniation.

## Materials and Methods

### Inclusion and Exclusion

Inclusion criteria: (i) patient under 22-years old; (ii) double-level contiguous lumbar disc herniations causing radicular leg pain; (iii) failure of conservative measures for a minimum of 3 months; and (iv) progressive neurologic deficit or debilitating pain. Exclusion criteria: (i) the presence of segmental instability; (ii) cauda equina syndrome; (iii) patients with other serious systemic diseases; and (iv) patients with incomplete data or patients who were lost to follow-up. This study was approved by the Ethic Committee (2020ZDSYLL080-P01). All research was performed in accordance with relevant guidelines of the ethical review board of institution.

### Operative Procedures

In the case of one-stage double-level transforaminal PELD, procedures were performed as described by Hoogland *et al.*<sup>7</sup> and Jung-Woo *et al.*<sup>12</sup> (Figs 1 and 2).

### Anesthesia and Exposure

For 14 patients with herniated disc on the same side (all levels) (Figs 1, 2), transforaminal PELD was performed under local anesthesia in the prone position on a radiolucent table using C-arm fluoroscopy.

### Trajectory Planning

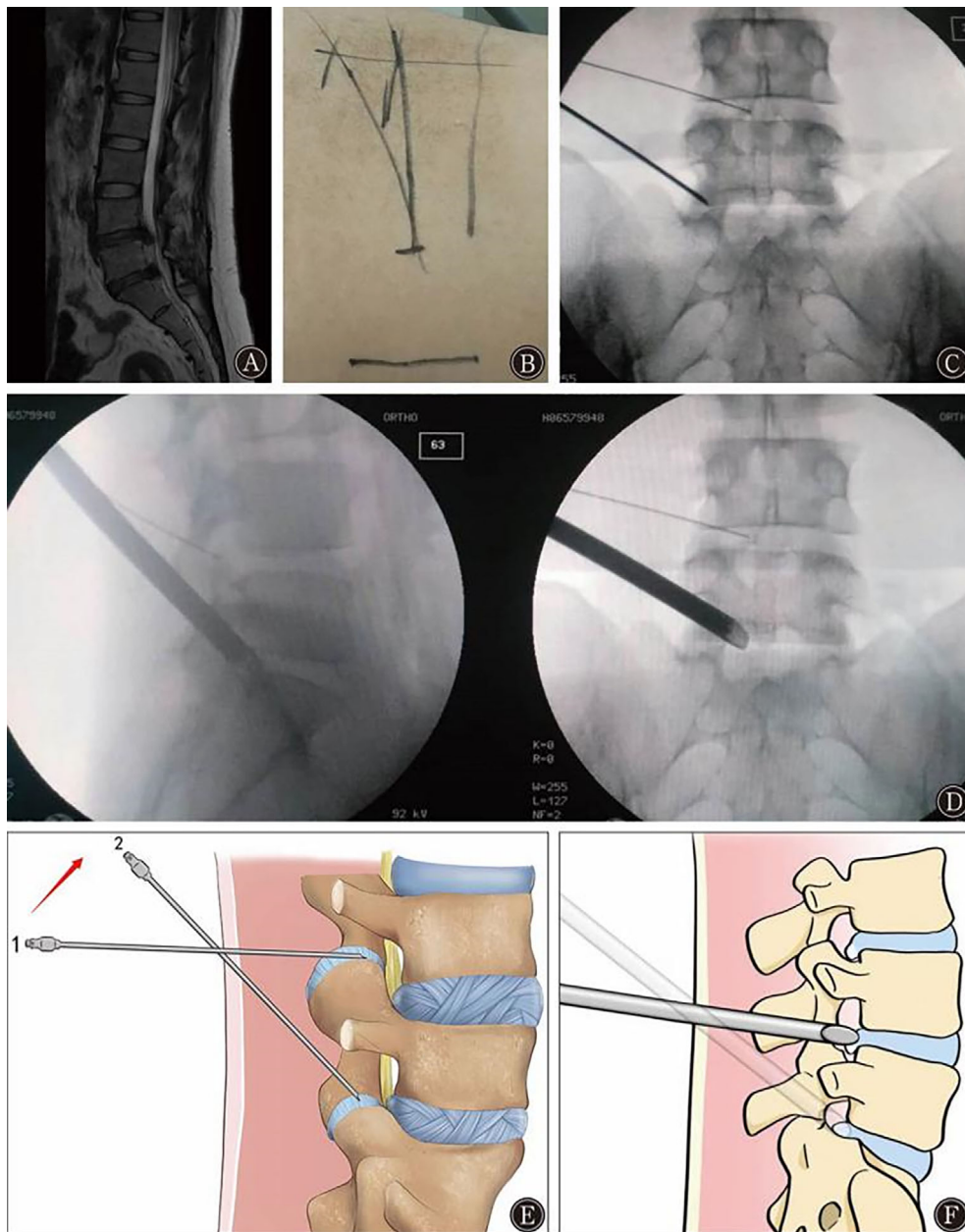
Surgery was performed on the same side with severe symptoms or imaging findings. To determine an appropriate entry point and approach angle, preoperative images should be used to calculate and determine an appropriate puncture point and approach angle. (Figs 1A,B; 2). The point also depends on the location of the herniated disc and patient's body size. Under lateral x-ray fluoroscopy, the line connecting the superior facet margin was marked as the safety line (Fig. 1B)<sup>7,8</sup>. After routine disinfection and infiltrating the intended needle entry point with 5 to 10 ml of 0.5% lidocaine, a long 18-gauge spinal needle was inserted from the entry point toward the mid-line under intermittent fluoroscopic guidance (Figs 1C,D,E,F and 2). The needle was then replaced with a 1-mm-diameter guide wire. After a 10-mm skin incision was made close to the guide wire, and serial dilators are introduced.

### Foraminoplasty and Adjustment of Working Cannula

The foramina were enlarged with a trephine. (Figs 1D,F; 2). Since the intervertebral foramen was adequately enlarged with trephine, additional maneuvers like levering the working cannula to make it more horizontal (Figs 1F and 2), downward or upward tilting could be easily achieved.

### Endoscopic Discectomy

The intervertebral disc was excised with the aid of an endoscope. An endoscopic rongeur was used to remove the degenerated nucleus, which was then sent for pathological



**Fig 1** A 17-year-old male was hospitalized for same-side double-level lumbar disc herniations causing unilateral radicular leg pain for 5 months undergoing one-stage percutaneous endoscopic lumbar discectomy. (A) Preoperative sagittal MRI showing double-level lumbar disc herniation (L<sub>4</sub>-L<sub>5</sub>, L<sub>5</sub>-S<sub>1</sub>). (B) The single puncture point is determined by the intersection of two lines. The point also depends on the location of the herniated disc, patient's body size. (C) The long 18-gauge spinal needle was replaced with two guide wire. A 10-mm skin incision was made close to the guide wire, and serial dilators are introduced. (D) After foraminoplasty, the working cannula was inserted into the foramen under fluoroscopic guidance. The surgeons usually operate the lower level at first. (E) Schematic diagram showing adjustment of spinal needle. (F) Schematic diagram showing adjustment of working cannula intraoperatively

examination<sup>7,8,13</sup>. The decompression was concluded when the dura and spinal nerves were clearly visibly decompressed and the pulsation of the dural tube and the nerve root was confirmed, which was an important indicator of thorough decompression and surgical termination<sup>12,13</sup>. After complete removal of disc, the ventral dura demonstrated free pulsation with the Valsalva maneuver.

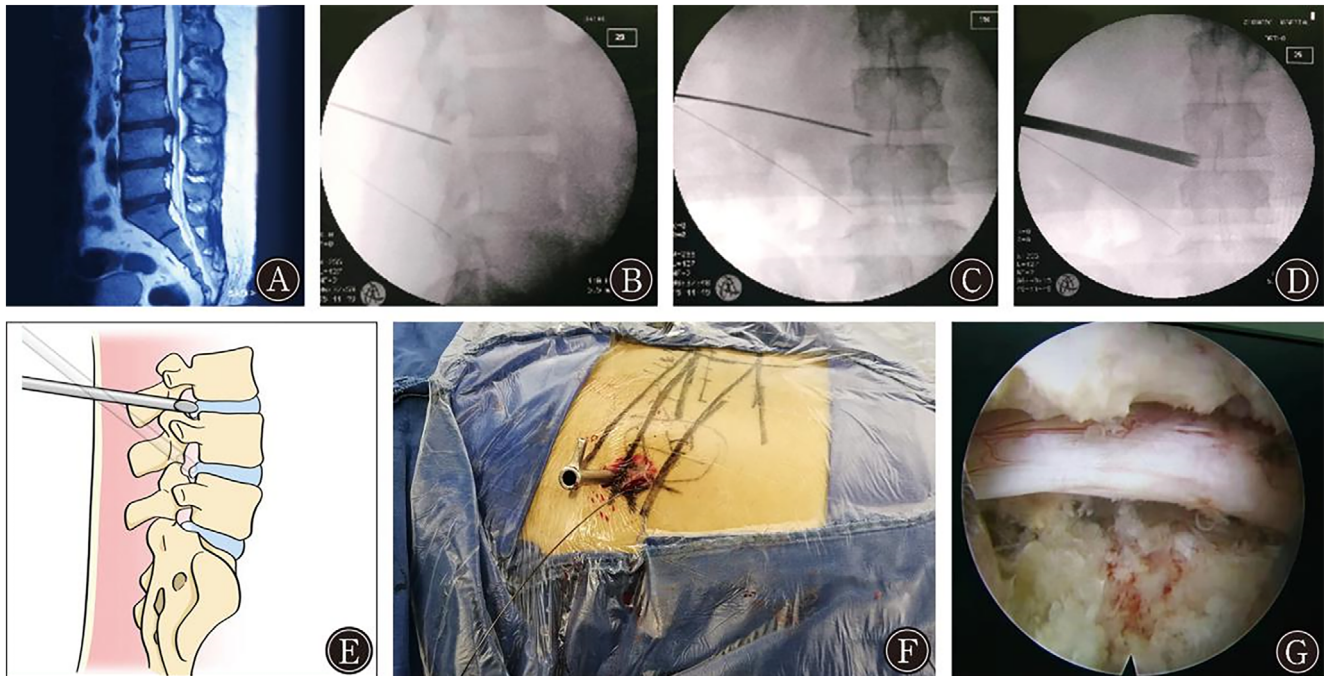
#### Close

The working cannula and endoscope were removed following adequate hemostasis, and the skin was finally sutured<sup>13</sup>.

#### **One-Stage Transforaminal Approach Combined Interlaminar Approach**

For two patients with L4-L5 disc herniation in one side and L5-S1 disc herniation in the other side, one-stage transforaminal approach for L4-L5 level combined interlaminar approach for L5-S1 level was applied. (Fig. 3 A-F). After resting in bed for 1 day postoperatively, the patients could have appropriate off-bed activity with a protective belt and begin lumbodorsal muscle and straight leg-raising exercises. One week later, the patients resumed light physical labor. To achieve favorable healing of the ruptured annular fibrosis and decrease recurrence of disc herniation, wearing the





**Fig 2** A 21-year-old male was hospitalized for same-side double-level lumbar disc herniations causing unilateral radicular leg pain for 17 months undergoing one-stage percutaneous endoscopic lumbar discectomy. (A) Preoperative sagittal MRI showing double-level lumbar disc herniations causing unilateral radicular leg pain (L<sub>3</sub>-L<sub>4</sub>, L<sub>4</sub>-L<sub>5</sub>). (B) The long 18-gauge spinal needle was replaced with two guide wire. (lateral). (C) The long 18-gauge spinal needle was inserted into the foramen under fluoroscopic guidance (anterioposterior). (D) The trephine inserted over the guide wire into the L<sub>3</sub>-L<sub>4</sub> (anterioposterior). (E) Schematic diagram showing rod adjustment of working cannula intraoperatively. (F) The working cannula was inserted into the foramen under fluoroscopic guidance. The surgeons usually operate the upper level at first. (G) Intraoperative image showing exploration of the ipsilateral transversing nerve root after decompression

lumbar back brace for approximately 2–3 weeks was recommended.

#### **Pain Measurement (Numeric Rating Scales)**

Electronic medical records of 16 patients who underwent PELD were reviewed retrospectively. Outpatient follow-up and telephone survey were performed. Low back pain and leg pain were measured utilizing the Numeric Rating Scales (NRS, 0–10, with 0 = no pain) scores. It is a continuous scale composed anchored by a score of zero, indicated no pain, and a score of 10, represented the worst pain.

#### **Assessment of Disability**

The modified Macnab criteria were applied to evaluate the surgical outcomes: excellent indicates no pain and no restriction of movement, allowing the patient to work normally; good indicates occasional pain, allowing the patient to work normally; fair indicates slight progress; poor indicates no progression<sup>14</sup>.

#### **Statistical Analysis**

Quantitative data were expressed as mean standard deviation (SD) and the data for the variation in the NRS scores before

and after the operation were compared using the Wilcoxon two-sample test. Analyses were performed with IBM SPSS Statistics for Windows, version 19.0 (IBM, Armonk, NY, USA).  $P < 0.05$  were considered significantly different.

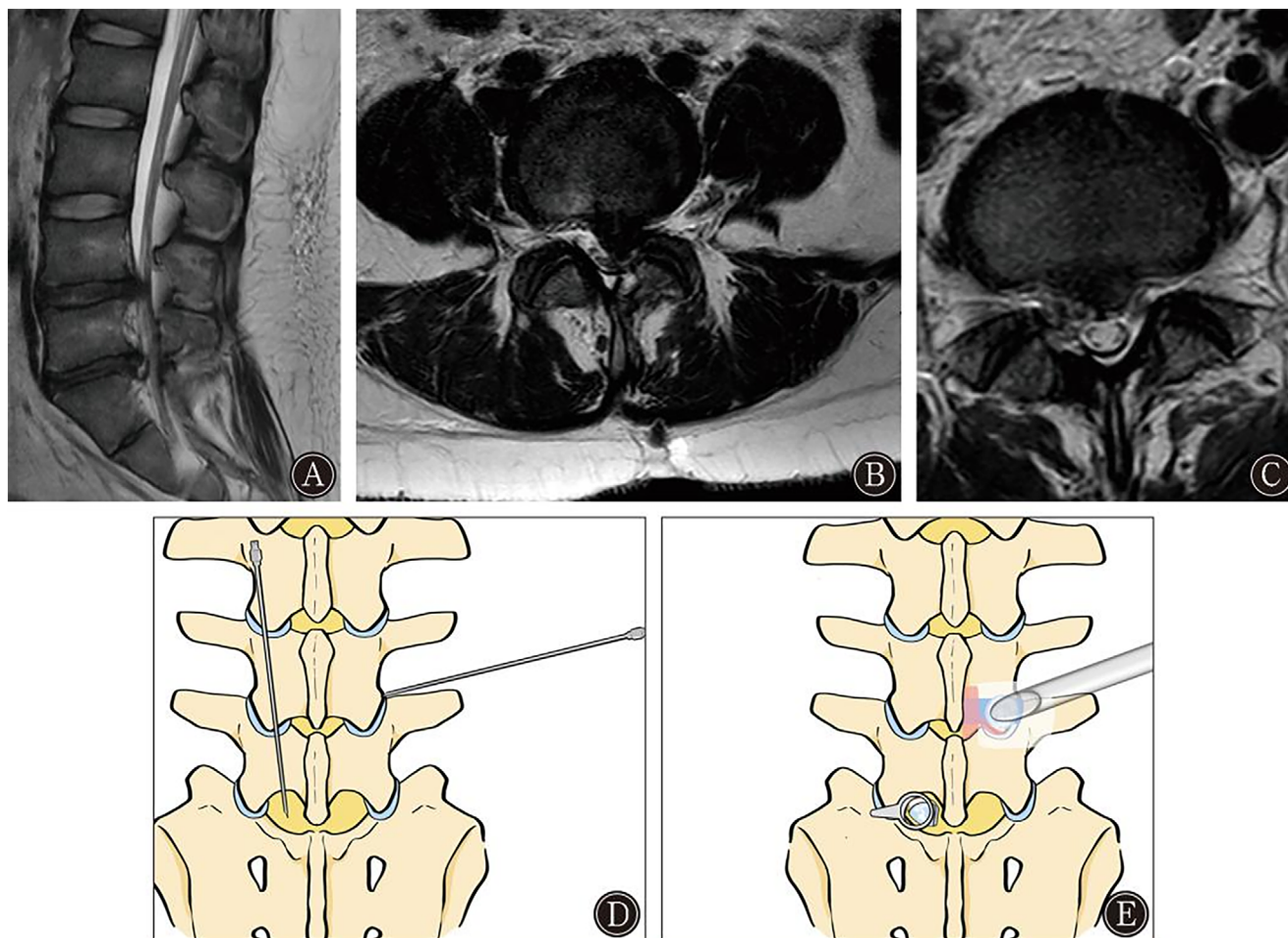
## **Results**

#### **General Results**

In this retrospective study, a total of 16 patients (female/male: 5/11) were enrolled with a follow-up period of 17.3 (12–72) months in average. Surgeries were successfully completed (0.27% of all PELD surgeries) in the two minimally invasive spine centers. One case affected the L<sub>2</sub>-L<sub>3</sub>/L<sub>3</sub>-L<sub>4</sub> level, seven cases affected the L<sub>3</sub>-L<sub>4</sub>/L<sub>4</sub>-L<sub>5</sub> level, and eight cases affected the L<sub>4</sub>-L<sub>5</sub>/L<sub>5</sub>-S<sub>1</sub> level (Table 1).

#### **Clinical Outcomes**

The operation time was 75.4 (57–125) minutes. Clinical outcomes in follow-up were measured for all patients according to the criteria used by the NRS scores and modified Macnab criteria. Low back pain and leg pain were significantly relieved immediately after surgery. The significantly improved NRS scores occurred between preoperative and early follow-up assessments with little changes



**Fig 3** A 19-year-old female with bilateral symptomatic double-level lumbar disc herniation undergoing combined transforaminal and interlaminar PELD. (A) Preoperative sagittal MRI showing double-level lumbar disc herniation (L<sub>4</sub>-L<sub>5</sub>, L<sub>5</sub>-S<sub>1</sub>). (B) Preoperative axial MRI showing lumbar disc herniation (L<sub>4</sub>-L<sub>5</sub>, right). (C) Preoperative axial MRI showing lumbar disc herniation (L<sub>5</sub>/S<sub>1</sub>, left). (D) Schematic diagram showing spinal needle of combined transforaminal and interlaminar PELD intraoperatively. (E) Schematic diagram showing working cannula of combined transforaminal and interlaminar PELD intraoperatively

**TABLE 1** Demographic data of the studied patients

No. patients	16
Age (years)	18.7 (15-22)
Sex (male:female)	11:5
Operated level	
L <sub>2</sub> -L <sub>4</sub>	1 (6.25%)
L <sub>3</sub> -L <sub>5</sub>	7 (43.75%)
L <sub>4</sub> -S <sub>1</sub>	8 (50.00%)
Duration of surgery(min)	75.4 (57-115)
Follow-up (months)	17.3 (12-72)

between early and final follow-up ( $P < 0.05$ )(Fig. 4, Table 2). The relief of pain during walking, standing, and sitting positions were identified. For the modified Macnab criteria, the final outcome results were excellent in 14 patients (87.5%), good in one patient (6.25%), fair

in one patient (6.25%), and the overall success rate was 93.75%.

#### **Recurrence and Adverse Events**

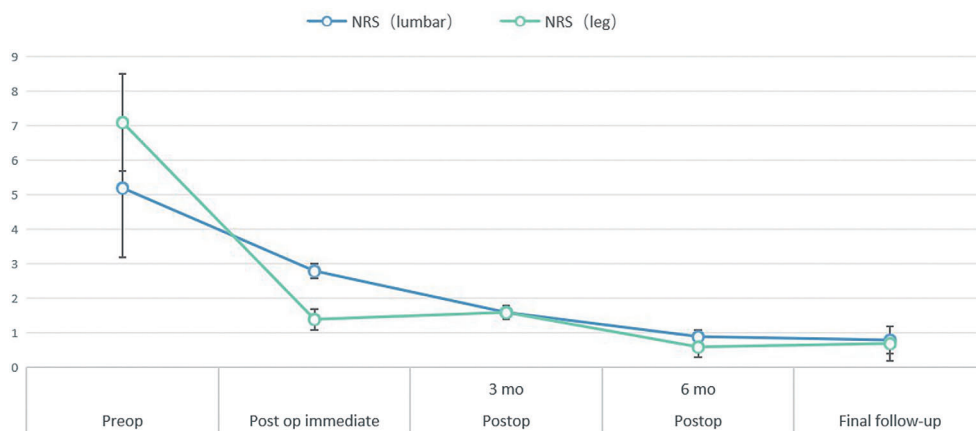
All operations were successfully performed. There were no cases of neurologic injury or cerebrospinal fluid leak. Furthermore, there were no cases of infection, instability, or further recurrence at the time of the final follow-up.

#### **Discussion**

##### **Choice of Surgical Technique**

Disease occurring under 22-years of age is termed “adolescent disease”<sup>9,10,15</sup>. Great care should be taken when operating on the immature spine due to that it is unknown whether operating on the immature spine may increase their risk for having spinal surgery in the future<sup>9</sup>.

Clinical Outcome Using NRS Scores



**Fig 4** Clinical outcome using NRS scores.

**TABLE 2** Clinical outcome using NRS scores

Scoring system	Preop	Post op immediate	Postop 3 mo	Postop 6 mo	Final follow-up	P Value
NRS(lumbar)	5.2 ± 1.4	2.8 ± 0.3	1.6 ± 0.2	0.9 ± 0.3	0.8 ± 0.5	0.03
NRS(leg)	7.1 ± 2.0	1.4 ± 0.2	1.6 ± 0.1	0.6 ± 0.2	0.7 ± 0.4	0.04

Values of  $P < 0.05$  were considered significantly different.

Appropriate conservative treatment is the first choice for adolescents, but, in actual fact, the young patients do not respond as well to nonsurgical treatment as adults, as adolescent disk material often remains well hydrated<sup>9-11</sup>. Additionally, delaying surgery for conservative treatment is warranted, but for how long remains unclear.

The surgical aim of treatment for adolescent lumbar disc herniation is to achieve appreciable pain relief and function improvement. Mixer and Barr<sup>16</sup>, published the first report of a herniated nucleus pulposus in 1934, with another report of surgical treatment for a 12-year-old boy by Wahren in 1945<sup>17</sup>. Traditionally, open discectomy (OD) and microendoscopy discectomy (MED) were employed as the standard operations for ALDH<sup>18,19</sup>. In recent years, minimally invasive techniques are an attractive alternative to OD and MED with a view to improving management of adolescent lumbar disc herniation patients<sup>18,19</sup>. Endoscopic techniques have been widely used for lumbar disc herniation since the first introduction by Ruetten *et al.*<sup>8</sup> It has the unique advantage of minimizing trauma to the normal spinal structures, reducing intraoperative bleeding and allowing earlier return to work. Most studies<sup>9,10,12,14,15</sup> have since been published on the surgical management of single-level (especially L4-L5 or L5-S1) disc herniation in children and adolescents. Due to the sample size of double-level contiguous adolescent lumbar disc herniation is relatively small and rare in its incidence, even though PELD has rapidly evolved and gained popularity, but, there is no

uniform standard of surgical approach for symptomatic double-level contiguous adolescent lumbar disc herniation, and this issue has engendered some controversy.

In addition, the efficacy of one-stage PELD is still debatable for double-level symptomatic contiguous adolescent lumbar disc herniation. Theoretically, the one-stage operation of double-level contiguous adolescent lumbar disc herniation undoubtedly resulted in prolonged operation time, increased radiation exposure and poor patient tolerance. Furthermore, it is more technically demanding for spinal surgeons, even for experienced ones. To our knowledge, currently, few studies conducted to elucidate the clinical results of PELD for symptomatic double-level contiguous adolescent lumbar disc herniation simultaneously.

Anatomically, inclination of L5-S1 disc spaces steeper than the L4-L5, which making single entry puncture point is enough to perform PELD at both the L4-L5 and L5-S1 levels. According to described technique<sup>5,12</sup>: in cases of L4/L5-L5/S1 adolescent lumbar disc herniation, under fluoroscopic guidance the meeting point of two lines crossing the L5 and S1 facet joint, indicating the point through which the surgeon can perform PELD for double-level adolescent lumbar disc herniation. In the case of L3/L4-L4/L5 herniation, a small single skin puncture point is also possible, which relies on the technique of rod adjustment of a working cannula (Fig. 1F).



### Indications

The favorable indications for one-stage operation of transforaminal PELD are same-side double-level lumbar disc herniations causing unilateral radicular leg pain.<sup>12</sup> However, the transforaminal approach at L5-S1 has limitations in cases with contralateral symptoms caused by different side lumbar disc herniations<sup>15</sup>. In this study, two patients underwent single-level transforaminal endoscopic lumbar discectomy combined with single-level endoscopic interlaminar discectomy. Because of this two patients indicated different side lumbar disc herniations causing bilateral radicular leg pain.

### Advantage of one-stage PELD

Approximately 93% of symptomatic disk herniation occurs predominantly at vertebral levels L4-L5 and L5-S1. Wang *et al.*<sup>20</sup> revealed that among 121 adolescents patients, L4-5 disease accounted for 50.4% (61 cases) of patients, L5-S1 for 34.7% (42/61), L3-4 for 3.3% (4/61). However, these cases undertook the single-level traditional open discectomy such as OD and MED. In our research, all operations were successfully performed and have achieved satisfactory effect in the process of follow-up. The advantage of this surgical option can: (i) optimize the operation process; (ii) shorten the operation time; (iii) reduce the hospitalization time; and (iv) shorten the rehabilitation period.

### Possible pathogenesis

The distinguishing feature of adult lumbar disc herniation was a result of age-related degenerative process of the spine. However, adolescent lumbar disc herniation can be explained by another cause such as micro-trauma, because degeneration is infrequent in adolescents<sup>21-23</sup>. But in actual fact, the pathogenesis of adolescent lumbar disc herniation is unclear, trauma or sports-related incidents, genetics and dysfunctional

bio-mechanical conditions (being overweight or being tall, congenital lumbosacral malformations) are likely contributory<sup>21-25</sup>. In our study, flattening of the sagittal lumbar curvature happened in seven cases (43.75%). Other studies also demonstrated that flattened spines are often associated with degeneration of multiple discs and back muscle weakness, which further significantly decreases spinal flexibility and stability<sup>25-27</sup>. The relationship between sagittal morphology of the spine and intervertebral disc degeneration in adolescents will be discussed in another study we did.

### Limitation

Several limitations were inherent to this study. The sample size is relatively small with retrospective design, the absence of a control group and the follow-up period is too short to comment on the subsequent degeneration of the disc. The aim of the study was to investigate the clinical results of one-stage PELD for symptomatic double-level contiguous adolescent lumbar disc herniation rather than to compare it with other methods. To overcome the limitations, further studies with a larger number of cases are needed to determine long-term therapeutic effects of one-stage operation of PELD for symptomatic double-level contiguous adolescent lumbar disc herniation. Further investigations such as the postoperative lumbar MRI and dynamic radiograph of the lumbar spine will be needed to evaluate the degeneration of lumbar disc and lumbar segmental stability.

### Conclusion

This study's data suggest that one-stage PELD is promising and valid treatment strategy for selected symptomatic double-level contiguous adolescent lumbar disc herniation.

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