CLINICAL ARTICLE

Transforaminal Endoscopic Lumbar Discectomy for Lumbosacral Junction Adolescent Lumbar Disc Herniation with High Iliac Crests

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Abstract

Objective: To investigate the clinical results of transforaminal endoscopic lumbar discectomy for lumbosacral junction adolescent lumbar disc herniation with high iliac crest.

Methods: From February 2014 to September 2020, a retrospective analysis of 96 patients less than 21 years old with intervertebral disc herniation was carried out. We enrolled 44 patients diagnosed with lumbosacral junction disc herniation with high iliac crest who required transforaminal endoscopic lumbar discectomy. Pain in the back and the lower extremity was scored on Numeric Rating Scales (NRS) scores. Patient outcomes were graded as excellent, good, fair, and poor using modified MacNab criteria. The NRS scores before and after the operation were compared using the Wilcoxon two-sample test.

Results: There were 30 male patients and 14 females. One patient underwent repeat surgery for an intervertebral disc pseudocyst. The NRS scores decreased significantly in both early and late follow-up evaluations ($p < 0.05$). At the last follow-up, 42 patients (95.45%) had an excellent outcome, one patient (2.27%) had a good outcome, and one patient (2.27%) had a fair outcome. The overall success rate was 97.7%.

Conclusion: This study's data suggest that targeted individualized foraminoplasty can effectively overcome the lumbosacral anatomical obstacles, and transforaminal endoscopic lumbar discectomy is an effective and valid option for lumbosacral junction adolescent lumbar disc herniation with high iliac crest.

Key words: discectomy; endoscopic; foraminoplasty; herniation; high iliac crest

Introduction

There is no accepted standard surgical approach to treating lumbosacral junction (L_5–S_1) symptomatic adolescent lumbar disc herniation (ALDH) with high iliac crest[1–3]. The choice of surgical approach is still controversial. In the past decades, conventional discectomy options still considered as standard technique have been used for adolescent lumbar disc herniation[1–3]. However, conventional open discectomy that necessitates dissection of the sacrospinalis muscle and removal of parts of lamina or facet joint and ligamentum flavum carries more surgical trauma and potentially a longer time for postoperative recovery[4]. Because of excessive manipulation of the nerve root and dorsal root ganglion during surgery, some patients suffer postoperative radicular pain or dysesthesia.

Minimally invasive lumbar surgery has been established as effective for lumbar disc herniation for a long time. However, choosing the most appropriate way for a given case is

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still a challenge. In fact, different endoscopic techniques currently exist, with each invasive technique covering a specific and limited range of indications. Some surgeons advocate the percutaneous endoscopic interlaminar discectomy approach[5], trans-articular approach, the transverse process/transiliac transforaminal approach, and transdural approach[6–8] to overcome the natural anatomic obstacles at the lumbosacral junction. However, those methods have many potential disadvantages and contraindications.

At present, even though transforaminal endoscopic lumbar discectomy (TELD) is the preferred choice for treating lumbar degenerative diseases[3,6,9], because of specific lumbosacral junction (L_5/S_1) anatomic peculiarities, the choice of surgical approach is still controversial[7–11]. Currently, there is still no universally accepted surgical method in treating lumbosacral junction adolescent lumbar disc herniation with high iliac crest. To our knowledge, only studies with a small sample size and short follow-up have been reported for adolescent lumbar disc herniation[2,3,9,12]. To date, there are no reports focusing on targeted individualized foraminoplasty using the 7.5-mm diameter trephine for lumbosacral junction adolescent lumbar disc herniation with high iliac crest. This is the first study on individualized foraminoplasty for adolescent lumbar disc herniation with high iliac crest to date.

The objective of this retrospective study was to: (i) elucidate the technical details of individualized transforaminal endoscopic lumbar discectomy for adolescent lumbar disc herniation with high iliac crest; (ii) assess the clinical results of this method; (iii) establish feasibility and safety of this technique for adolescents.

Materials and Methods

Inclusion and Exclusion Criteria

Ethics approval (2020ZDSYLL080-P01) for the present study was obtained from the ethics committee. All procedures were performed in accordance with the Helsinki Declaration. Patients diagnosed with L_5/S_1 lumbar disc herniation who required TELD from February 2014 to September 2020 were analyzed in the study.

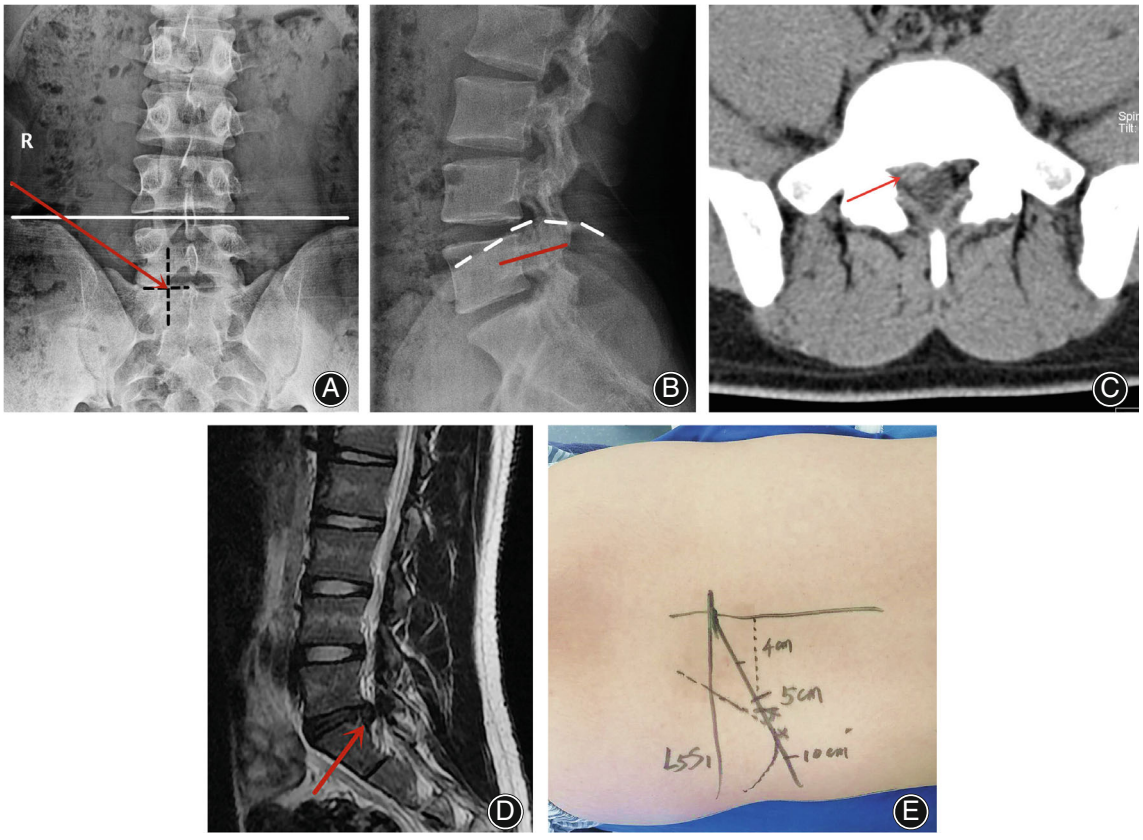

Fig. 1 Case 1: A 20-year-old female with a history of 4 months of severe low back pain and right S_1 radiculopathy undergoing percutaneous endoscopic lumbar discectomy. (A) Preoperative X-ray in anteroposterior view showing the imaginary trajectory (red arrow). The black line showing the targeted point. (B) Preoperative X-ray in lateral view showing the iliac crest height is classified using the L_5 pedicle (red line). (C) Preoperative CT showing L_5–S_1 protruded disc material. (D) Preoperative MRI showing L_5–S_1 subarticular lumbar disc herniation. (E) The patient is positioned in a modified knee chest position with 25°–40° hip flexion and 20°–30° knee flexion. The entry point was located 8–10 cm lateral from the midline

The inclusion criteria were: (i) patients under 21 years old with single-segment lumbosacral junction adolescent lumbar disc herniation; (ii) clinical symptoms did not respond to conservative treatments for 4–6 weeks; (iii) iliac crest above the mid-L5 pedicle in lateral radiography. The exclusion criteria were: (i) the presence of segmental instability; (ii) caudal equine syndrome; (iii) patients with incomplete data or patients lost to follow-up; and (iv) iliac crest below the mid-L5 pedicle. In patient selection, high iliac crest was defined as the highest point of the iliac crest above the mid-point of the L5 pedicle in lateral radiography.

Preoperative Imaging Parameters

Preoperative MRI, CT, and anteroposterior (A/P) and lateral lumbar spine X-rays are needed for the surgeon to be able to orient the endoscopic instruments in the operative field. Carefully superimposing the MRI and CT images of the ruptured fragment on the A/P and lateral X-ray images (Figures 1–4) of the herniated fragment in the A/P and lateral views and correlation during surgery with the X-ray fluoroscopic images.

Operative Procedures

Patient Position and Surface Marking

The patients were positioned in a modified knee chest position with 25°–35° hip flexion and 20°–30° knee flexion to widen the intervertebral foramen on the radiolucent table (Figure 1, E). By adjusting the radiolucent operation table, the true AP and lateral X-ray fluoroscopic views of the target disc space were obtained. The suprailiac entry point on the skin was generally superior to the iliac crest and approximately 7–13 cm from the mid-line (Figure 1 (E)). According to preoperative axial MRI, the designed trajectory and the distance was measured and planned.

Anesthesia and Targeted Point or Trajectory Planning

Patients were given local infiltration anesthesia with 1% lidocaine.

For paramedian disc herniations, the final targeted point of the spinal needle was the medial pedicular line on the AP view and the posterior vertebral line on the lateral view (Figure 2 (B), (C)). For central disc herniations, the spinal needle was targeted to the midpoint of the spinous process and the medial surface of the pedicle in the AP view

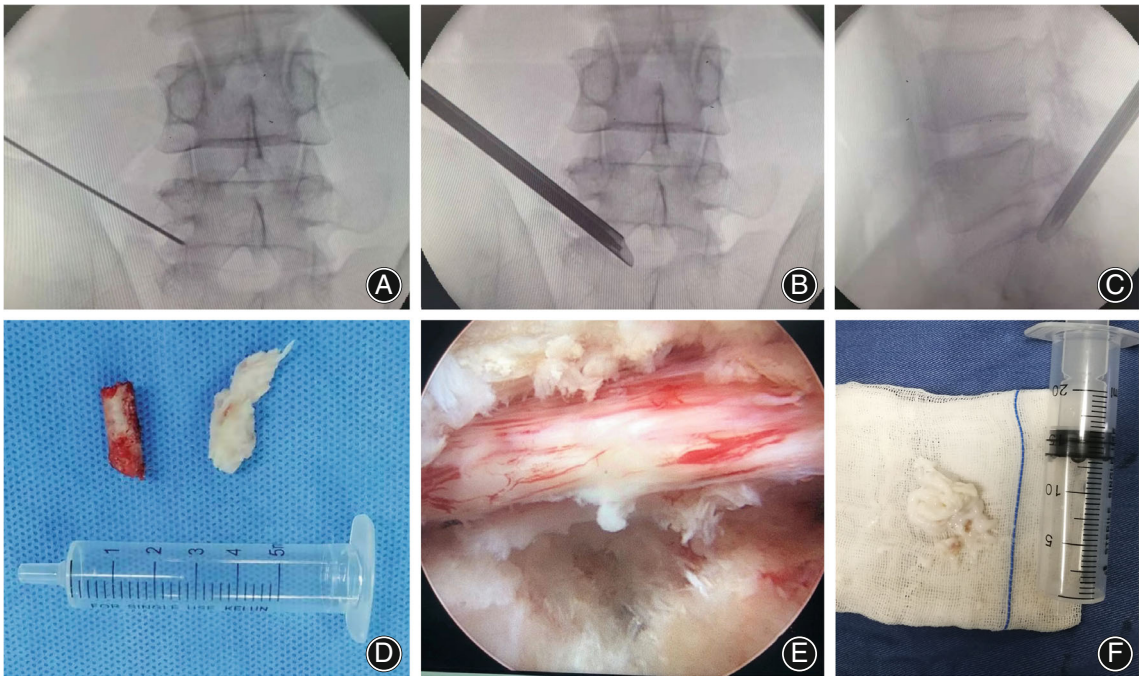

Fig. 2 Case 1: Intraoperative images. (A) Intraoperative fluoroscopic image showing placement of the long 18-gauge spinal needle (anteroposterior view). (B) Intraoperative fluoroscopic image showing placement of the working channel located near the herniated disc fragment (anteroposterior view). (C) Intraoperative fluoroscopic image showing placement of the working channel (lateral view). After foraminoplasty, the working cannula was inserted into the foramen under fluoroscopic guidance. (D) The removed bony structure including part of SAP. (E) Intraoperative endoscopic view showing the complete decompression of the exiting nerve root. (F) The more hydrated and viscous herniated nucleus pulposus

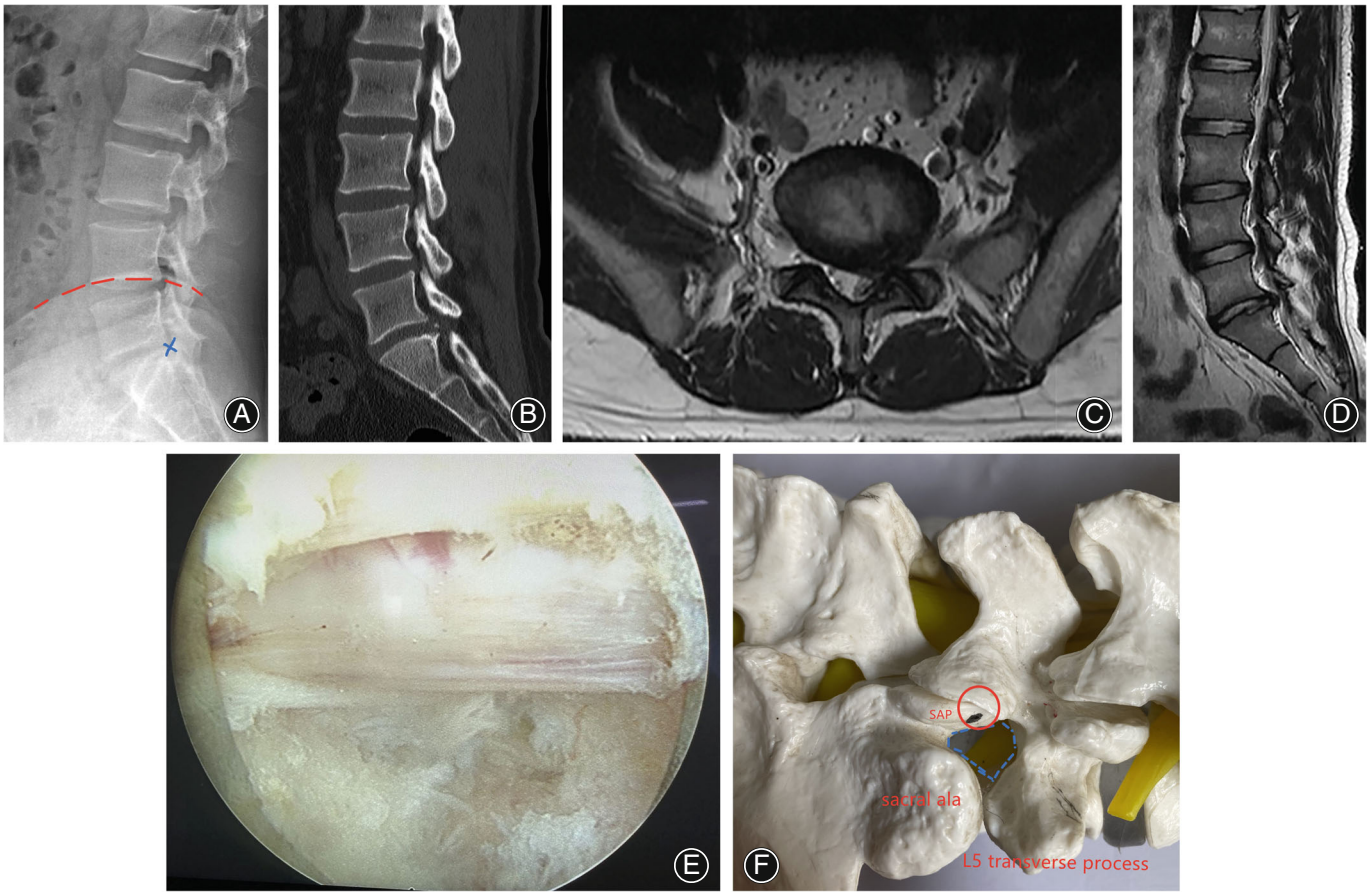

Fig. 3 Case 2: A 17-year-old male with symptomatic lumbar disc herniation undergoing percutaneous endoscopic lumbar discectomy. Preoperative X-ray in lateral view showing the iliac crest height. Preoperative CT showing L_5–S_1 protruded disc material. Preoperative axial MRI showing lumbar disc herniation (L_5/S_1). Preoperative sagittal MRI showing lumbar disc herniation (L_5/S_1). (E) Intraoperative endoscopic view showing the complete decompression of the exiting nerve root. (F) Schematic diagram of lumbar skeletal specimen showing targeted point on the facet joint

and the ventral boundary of the S_1 superior articular process (SAP) in the lateral view.

Targeted Foraminoplasty and Working Channel Insertion

Individualized targeted foraminoplasty was performed using a 7.5-mm diameter trephine. The bony structure was removed according to its localization by foraminoplasty on different parts of the ventral section of the S_1 SAP (Figures 2 (D), 3 (F), and 5 (A)). The position for inserting the beveled working cannula through the dilator was visualized under fluoroscopy (Figures 2 (B), (C) and 5 (B), (C)).

Removal of the Herniated Disc and Closure

The lumbar protruded disc material was excised with forceps. After discectomy, epidural meticulous hemostasis was conducted using a bipolar coagulator (Trigger-Flex Probe, Elliquence, Baldwin, NY, USA).

Free movement of the decompressed S1 nerve root and the pulsation of the dural tube should be observed at the end of decompression (Figures. 2 (E), 3 (E), and 5 (D)). Most patients could feel relief of symptoms during surgery. The endoscope was removed after no active bleeding was confirmed and the wound closed.

Clinical Outcome Measurements

Numeric Rating Scales Scores

Clinical outcomes were analyzed utilizing the Numeric Rating Scales scores (NRS, 0–10, with 0 = no pain). NRS scores divided the degree of pain from 0 to 10: 0 represents no pain, 1 to 3 represents mild pain, 4 to 6 represents moderate pain, 7 to 9 represents severe pain that patient could not tolerate, and 10 represents the most pain.

The Modified MacNab Criteria

Modified MacNab criteria were used to evaluate the overall effectiveness of the surgery, using four grades: Excellent: no pain, no restriction of mobility, return to normal work and level of activity; Good: occasional nonradicular pain, relief of presenting symptoms, able to return to modified work; Fair:

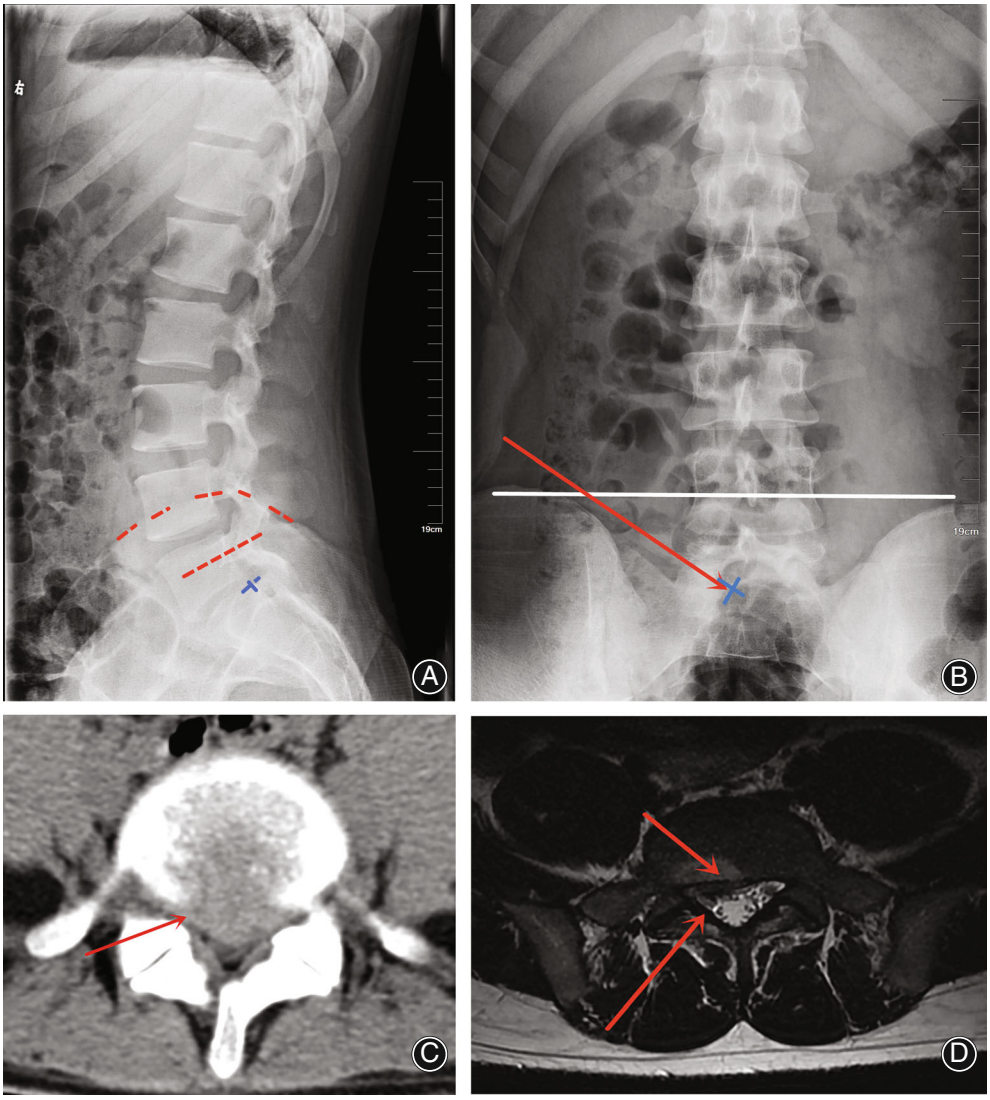

Fig. 4 Case 3: A 21-year-old male hospitalized for unilateral radicular leg pain for 7 months undergoing percutaneous endoscopic lumbar discectomy. (A) Preoperative X-ray in lateral view showing the iliac crest height. (B) Preoperative X-ray in anteroposterior view showing the imaginary trajectory (red arrow). The blue line shows the targeted point. (C) Preoperative CT showing L_5–S_1 protruding disc material. (D) Preoperative axial MRI showing lumbar disc herniation (L_5/S_1).

Some improved functional capacity, still handicapped. Poor: No relief of symptoms.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD). Preoperative and postoperative NRS scores were compared using the Wilcoxon two-sample test. Analyses were performed with IBM SPSS Statistics for Windows, Version 19.0 (IBM, Armonk, NY, USA). Statistical significance was set at $p < 0.05$.

Results

General results

A total of 96 patients under 21 years old were screened, and of those patients, 50 were diagnosed with level L_4/L_5 adolescent lumbar disc herniation; two patients diagnosed with lumbosacral junction adolescent lumbar disc herniation without high iliac crest were excluded. There were 44 patients diagnosed with lumbosacral junction adolescent lumbar disc herniation with high iliac crest who required transforaminal endoscopic lumbar discectomy surgery who were enrolled (Table 1). Thirty patients were male and 14 were female with a mean age of 17.7±2.2 years (range, 14–21 years). There were 18 cases diagnosed as central lumbar disc herniation and 26 as subarticular lumbar disc herniation. There were 20 patients diagnosed as having protrusion and 24 as having extrusion. The mean follow-up time was 17.4 ± 3.2 months (range, 6–48 months).

Clinical Outcomes

Numeric Rating Scales Scores

The NRS scores (lumbar and leg) between preoperative and at postoperative immediately, as well as at 3 and 6 months

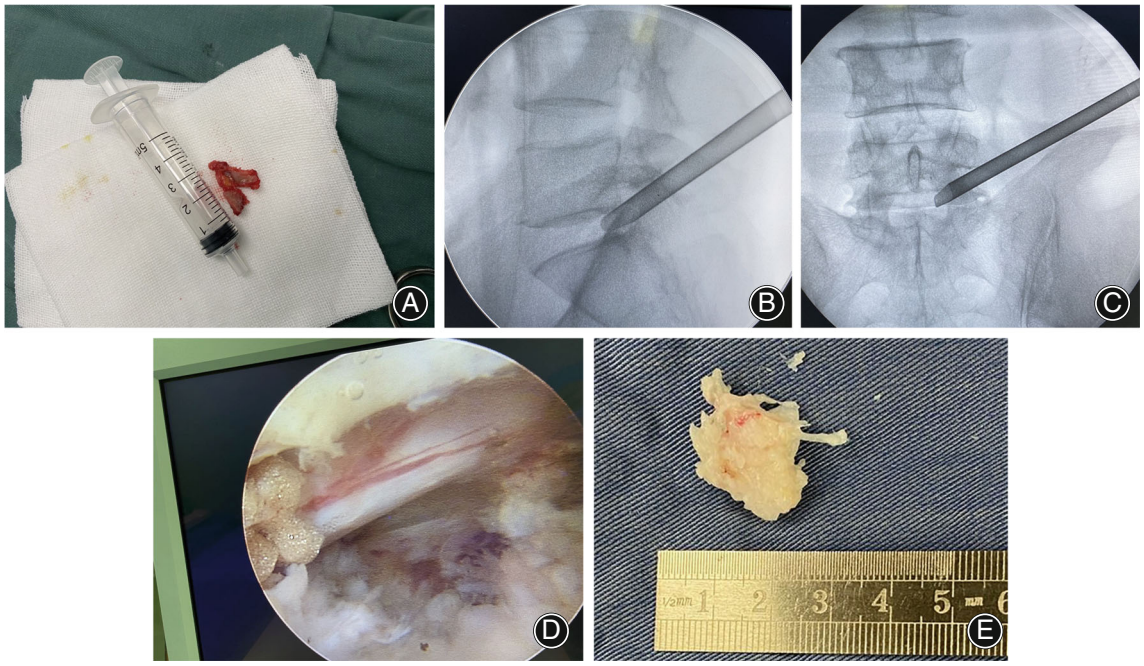

Fig. 5 Case 3: Intraoperative images. (A) The removed bony structure of the different ventral part of the S1 superior articular process and a part of articular facet. (B) Intraoperative fluoroscopic image showing final placement of the working channel (lateral view). The working cannula was inserted into the foramen under fluoroscopic guidance. (C) Intraoperative fluoroscopic image showing placement of the working channel located near the herniated disc fragment (anteroposterior view). (D) Intraoperative endoscopic view showing the complete decompression of the exiting nerve root. (E) The more hydrated herniated nucleus pulposus

TABLE 1 Demographic data of the studied patients

Variable	Value
Age (years)	17.7 ± 2.2
Sex	
Male	30 (68.18%)
Female	14 (31.82%)
Follow-up time (month)	17.4 ± 3.2
Type of herniation	
Protrusion	20 (45.45%)
Extrusion	24 (54.54%)
Location of herniation	
Central	18 (40.90%)
Paramedian	26 (59.09%)
Foraminal	0

and final follow-up assessments were significantly improved. ($p < 0.05$) (Table 2).

Modified MacNab Criteria

At the last follow-up, 42 patients (95.45%) had an excellent outcome, one patient (2.27%) patient had a good outcome, one patient (2.27%) had a fair outcome, and the overall success rate was 97.7%.

Complications

One patient underwent repeat operation during the follow-up period for intervertebral disc pseudocyst. Symptoms abated after the reoperation. There were no cases of neurologic injury, cerebrospinal fluid leak, segmental instability, infection, or further recurrence at the time of the final follow-up.

Discussion

Symptomatic adolescent lumbar disc herniation (ALDH) is an infrequent pathology[13,15]. Prolonged conservative treatment confines the adolescents to bed with significant ramifications, which has adverse physical and psychological effects[9,14,15]. Over the last two decades, more minimally invasive approaches have been introduced as alternatives for symptomatic ALDH[9,11,16,17]. However, evidence has failed to demonstrate which surgical option is best for lumbosacral junction ALDH with high iliac crest[12,18].

Surgical Plan and Targeted Foraminoplasty

To target precisely protruded disc material at lumbosacral junction with high iliac crest by transforaminal access can be challenging even for the experienced endoscopic spine surgeons. Some studies[2–5,10,18] recommended that preoperative evaluation for operability of transforaminal endoscopic

TABLE 2 Clinical outcome using NRS scores

Scoring system	Pre-op	Post-op immediate	Post-op 3 months	Post-op 6 months	Final follow up	*p-value*	t-value
NRS(lumbar)	6.1 ± 1.4	1.4 ± 0.3	1.3 ± 0.2	0.6 ± 0.3	0.4 ± 0.3	0.03	0.503
NRS(leg)	7.4 ± 1.5	1.3 ± 0.3	1.7 ± 0.3	0.8 ± 0.2	0.5 ± 0.7	0.02	0.307

Abbreviations: Pre-op, pre operation; Post-op, post operation,; *Note:* Differences were significant ($p < 0.05$) before and after operation for Numeric Rating Scales (NRS) scores at each time point. No significant difference existed after operation at every follow-up period.

lumbar discectomy for L_5–S_1 should consist of plain radiography, CT images, and CT 3D reconstruction and stimulation, which may provide guidance for surgical treatment. Taking into account the published articles[9,19] and our study[9], we suggest that individualized preoperative assessment should be performed accurately, including the location of the protruded disc material, the size of protruded disc material, accurately targeted foraminoplasty site, and direction of the reamer trajectory. In addition, a preoperative surgical plan combining targeted foraminoplasty allows the surgeon to perform resection of the superior articular process accurately without excessive resection of the superior articular process. Only with precise preoperative planning of the surgical approach can an optimal targeted trajectory be achieved.

TELD can be sometimes impossible to perform because of the blockages of the surrounding anatomic structures, including a large L_5 transverse process, the sacral ala, high iliac crest, narrow foramen, and disc inclination resulting from lumbar lordosis, which can impede direct transforaminal access to the L_5–S_1 neuroforamen with a straight, rigid spinal endoscope, and can increase the risk of nerve root injury and iatrogenic endplate injury[17]. However, such anatomical particularities can be overcome by using individualized targeted foraminoplasty[6–8,10] and by removing different parts of the S_1 SAP according to the site of herniated mass. Anatomically, foraminoplasty is highly advised, because the foraminal width is smallest at the lower lumbar levels and the nerve root lies ventrally[9,10,14–17,20,21]. Taking into account the published articles and our study[9], we suggest that targeted foraminoplasty should be individualized for each situation.

Advantages of Targeted Foraminoplasty

In this retrospective study, targeted foraminoplasty using trephines under fluoroscopic guidance was not time-consuming when approaching a target herniated disc, and in addition, it removed only a few different parts of the S_1 superior articular process, according to the site of herniated mass. A little undercutting of the S_1 SAP rarely causes iatrogenic lumbar instability[10]. Furthermore, the ligamentum flavum also protects the nerve root and dural sac from direct injury[10,11]. In addition, surgeons can get instant feedback from patients because the procedures are performed under local anesthesia[9]. After targeted foraminoplasty, the working zone can be widened, and the endoscopic trajectory can directly target the herniated disc mass.

Disadvantages of Interlaminar Approach

The interlaminar approach is an alternative option that is not obstructed by the iliac crest[14,22]. However, it may cause nerve root traction and increase the possibility of early nerve root injury as well as a dual tear, leading to difficulty managing lateral and extreme lateral disc herniation. Moreover, percutaneous endoscopic interlaminar discectomy (TEID) usually requires general or epidural anesthesia, which is its main disadvantage compared with TELD. One of the advantages of TELD is that it does not require general anesthesia. TELD can be done with the local anesthesia, which can allow for pain and anxiety management while communicating with the patient, checking leg movements, and detecting sudden pain complaints. Xu *et al.*[21] described 23 adolescent patients who underwent TEID for L_5/S_1 lumbar disc herniation, and they found that two patients complained of leg numbness, which may be a result of obvious irritation to the nerve root during operation, and another patient underwent a subsequent open discectomy due to re-herniation. Comparing microendoscopy discectomy to TEED, Li *et al.*[14] concluded in 2018 that TELD for adolescent lumbar disc herniation leads to a greater decrease in lower back pain at final follow-up and a faster improvement in leg pain and ODI. However, those studies did not mention TELD with foraminoplasty in the management of lumbosacral junction adolescent lumbar disc herniation with high iliac crest.

Targeted Individualized Foraminoplasty is a Valid Option

This study indicated that the NRS scores decreased significantly in both early and late follow-up evaluations ($p < 0.05$). For the modified MacNab criteria, the overall excellent rate was 95.45%. Taking into account the published articles[9,11,12,18,22,23] and our study, we suggest that by targeting individualized foraminoplasty, TELD is a valid option for lumbosacral junction adolescent lumbar disc herniation with high iliac crest. This method is safe, feasible, and effective over our 17.4 ± 3.2 months follow-up interval.

Limitations

This was a retrospective single-center study, and the sample size was relatively small because of rarity of the condition's

incidence. There was no control group, and the follow-up period was short. Surgery was performed at different times, so the particular surgeon's preference and experience in surgical techniques may also affect the result. The aim of the study was to investigate the clinical results of TELD for lumbosacral junction adolescent lumbar disc herniation with high iliac crest rather than to compare it with other methods. To overcome the limitations, the long-term efficacy of this technique still needs a large-sample, prospective, controlled cohort study to further determine its benefits.

Conclusion

This study's data suggest that targeted individualized foraminoplasty can effectively overcome lumbosacral anatomical obstacles. Targeted individualized TELD showed promising outcomes in the treatment of lumbosacral junction adolescent lumbar disc herniation with high iliac crest at a mean follow-up period of 17.4 ± 3.2 months. In consideration of distinctive anatomical peculiarities of the lumbosacral junction, expectation for rapid recovery, and acceptability of the procedure, further investigations will be needed to evaluate long-term maintenance of the treatment effect.

AUTHORS' CONTRIBUTIONS

Lu Mao and Yong Huang put forward the concept of the study and prepared the manuscript. Rui Zhang contributed to the data acquisition. Kun Wang and Feng Wang analyzed the data and interpretation. Bin Zhu and Xiaotao Wu checked all of the data used in the manuscript and reviewed the manuscript. All authors read and approved the final manuscript.

DISCLOSURE

This study was conducted according to the Declaration of Helsinki and approved by the Southeast University Zhongda Hospital Medical Science Research Ethics Committee (approval number:2020ZDSYLL080-P01).

GRANT SOURCES

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CONFLICT OF INTEREST

The authors have no conflicts of interest.

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