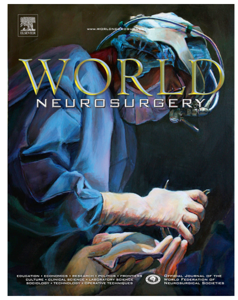

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Technical Note

Posterior biportal endoscopic discectomy for the treatment of central cervical disc herniation: technical note and preliminary results

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Keywords: Posterior biportal endoscopic technique, minimally invasive spine surgery, central cervical disc herniation, surgical efficacy.

Running title： Posterior biportal endoscopic discectomy for CCDH

Abstract

Objective: to evaluate the preliminary outcomes and clinical efficacy of a novel posterior biportal endoscopic technique in the treatment of CCDH.

Method: A total of eleven patients with symptomatic CCDH who met the inclusion criteria underwent posterior biportal endoscopic discectomy between December 2021 and May 2023. The surgical procedure involved flavectomy, foraminotomy, pediculoplasty, and discectomy using 30° and 45° arthroscopes and specialised minimally invasive tools. Functional outcomes were assessed using the Japanese Orthopedic Association (JOA) scoring system, Neck Disability Index (NDI), and visual analogue scale (VAS) for axial neck pain. Clinical efficacy was evaluated at the final follow-up using the modified Macnab criteria.

Results: All eleven patients successfully underwent posterior biportal endoscopic discectomy with a mean operative time of 82.7±10.1 minutes and mean estimated blood loss of 31.8±9.8 ml. The mean hospital stay was 5.2±1.1 days, and the mean follow-up period was 13.8±2.4 months. Significant improvements were observed in NDI, JOA and VAS scores. Clinical efficacy was rated as excellent in three patients, good in six patients, and fair in two patients according to the modified Macnab criteria. No cases of cervical instability or kyphosis were observed during postoperative follow-up.

Conclusion: The novel posterior biportal endoscopic technique demonstrated significant clinical efficacy and safety in treating CCDH, with marked improvements in clinical outcomes, rapid postoperative recovery, and a low incidence of complications.

Keywords: Posterior biportal endoscopic technique, minimally invasive spine surgery, central cervical disc herniation, surgical efficacy.

1. Introduction

Central cervical disc herniation (CCDH) is a common cause of myelopathy and radiculopathy [1]. Traditional anterior open surgical techniques, while effective, are associated with significant morbidity, including the loss of segment motion, adjacent segmental degeneration, and approach-related problems [2]. Minimally invasive techniques, such as full endoscopic surgery, have emerged as alternatives. However, anterior cervical transdiscal endoscopic discectomy itself causes damage to the disc, with potential risks of intervertebral space collapse and revision surgery in the long term [3]. Transcorporeal discectomy, while more advanced, operates within a fixed bony portal and is constrained by this portal, leading to the risk of residual nucleus pulposus [4]. The posterior transpedicular trench approach is similar to the anterior transcorporeal technique, featuring a long learning curve and a narrow, fixed portal, making it difficult to perform and prone to incomplete decompression [5].

Unilateral biportal endoscopic discectomy (UBED) has been widely performed in patients with cervical spondylotic radiculopathy and has achieved favourable clinical outcomes [6-7]. Unlike biportal endoscopic cervical foraminotomy, arthroscopy should be performed at an angle of 45° (Fig 1a), and a more lateral portal should be added to observe the CCDH due to the obstruction of the cervical cord. Moreover, UBED offers a larger surgical space, a clear surgical view, and flexible manipulation of the endoscope and instruments [8-10], theoretically providing greater advantages in the treatment of CCDH. Currently, there are no reports of posterior UBE treatment for CCDH. We designed this method to avoid the disadvantages of the aforementioned techniques. This study aimed to evaluate the technical aspects and preliminary clinical outcomes of the posterior biportal endoscopic technique in the treatment of CCDH.

2. Materials and Methods

2.1. Ethics Statement and Subjects

This study was approved by our institutional review board (No. 20210722303000015394). Informed consent was obtained from all patients. Eleven patients with CCDH were treated with posterior UBED between December 2021 and May 2023.

The inclusion criteria for UBED were as follows: 1) symptomatic signs of myelopathy, such as hyperreflexia and the presence of pathological signs; 2) CCDH demonstrated on magnetic resonance imaging (MRI) and computed tomography (CT) scans; 3) soft disc herniation without calcification or ossification; 4) no response to conservative treatment for more than 6 weeks.

The exclusion criteria were as follows: (1) segmental instability or cervical kyphosis, (2) history of prior posterior surgical intervention, (3) CCDH involving more than one segment, and (4) other comorbidities, such as heart failure or mental disorders, that precluded tolerance or cooperation with surgery.

The general condition, surgical details, and radiological images of the patients were examined (Table 1). Functional outcomes were assessed using the Japanese Orthopedic Association (JOA) scoring system and Neck Disability Index (NDI), and axial neck pain was measured using the visual analogue scale (VAS). The clinical efficacy at the final follow-up was assessed using the modified Macnab criteria.

2.2. Surgical procedure

2.2.1 Surgical instruments

A 30° arthroscope, a 45° arthroscope, and tools for minimally invasive spinal surgery, including a 1 mm Kerrison punch, mini pituitary forceps, angled probes, mini retractors, a 90° high-power ball-tip adjustable-radiofrequency (RF) instrument with coagulation and ablation modes, and high-speed diamond burrs (Jiangsu BONSS Medical Technology, China), were used (Fig 2). Intraoperative electrophysiological monitoring (IONM) was indispensable in this procedure.

2.2.2 Position and creation of the portals

Taking C4–C5 discectomy as an example, the patient was placed in the prone position with the head fixed in a horseshoe headrest. The neck was slightly flexed and stabilized with tape. Two horizontal lines were marked along the C4 and C5 pedicles, and a vertical line was drawn along the lateral edge of the left lateral mass in the anteroposterior view. The left-sided junctional point was used as a viewing portal, while the right-sided junctional point served as a working portal. On the outside of the working portal, a third additional portal was made 5 cm lateral to the midline (Fig 1b).

2.2.3 Flavectomy and foraminotomy

After triangulation with the arthroscope and RF probe at the C4 lamina, the "V" point was exposed, and a 4 mm diamond burr was used to drill the inferior lamina of C4 and superior lamina of C5 until the craniocaudal insertions of the ligamentum flavum (LF) were exposed. A mini bush-hook was used to liberate the LF, and flavectomy was performed with a Kerrison punch. Then, partial foraminotomy was extended along the pathway of the C5 root until the medial wall of the C5 pedicle was exposed; adequate decompression and perineural adhesiolysis had to be performed in the axilla region, and the C5 root was confirmed to be free through gentle endoscopic manipulation (Fig 3).

2.2.4 Pediculoplasty and discectomy

A needle was used as a guide to establish the third portal, which was employed as the second working portal. In order to approach the ventral space of the spinal cord, the medial wall of the C5 pedicle was adequately drilled using a 2 mm diamond burr through the third portal. Thereafter, we replaced the 30° arthroscope with a 45° one. The 45° arthroscope was inserted along the drilled track of the medial wall of the pedicle, and the CCDH was visualized. The annulus fibrosus and posterior longitudinal ligament were cut open using the ball-tip RF probe. The retractor was inserted through the working portal to protect the cervical cord, and the nucleus pulposus was pulled out using the probe and removed using a mini pituitary through the third portal. At the end of the procedure, the pulsation of the cord was observed, the facet joint preservation was confirmed to be more than 50%, and neurological function was confirmed to be normal with an electrophysiological monitoring device. Bone wax was used to conduct haemostasis at the bone surface, and bleeding around the soft tissue was controlled with the help of the RF probe (Video S1). A drainage tube was inserted, the arthroscope was withdrawn, and the incision was closed intradermally (Fig 4).

3. Statistical Analysis

One-way repeated-measure ANOVA was employed to compare the JOA scores, NDI, and VAS before and after the operation. All statistical analyses were conducted using SPSS version 19, with statistical significance being defined as $p < 0.05$.

4. Results

The perioperative findings are shown in Table 1. All 11 of the cases enrolled were successfully operated on. The mean operative time was 82.7±10.1 minutes, the mean estimated blood loss (EBL) was 31.8±9.8 mL, the mean hospital stay was 5.2±1.1 days, and the mean follow-up period was 13.8±2.4 months. The mean JOA scores at baseline and at three days and one year postoperatively were 10.6±1.1, 11.6±1.3, and 14.2±1.1. The mean VAS scores at baseline and at three days and one year postoperatively were 3.2±0.6, 2.9±0.5, and 2.0±0.4. The mean NDI (%) at baseline and at three days and one year postoperatively were 38.8±5.2, 31.9±6.5, and 22.5±3.4. The three above-mentioned parameters showed a significant improvement between the time before the operation and 3 days after surgery ($P<0.05$) and further improvement at 1 year postoperatively (Table 2). According to the modified Macnab criteria, the effects were excellent in three patients, good in six patients, and fair in two patients (Fig 5). One patient experienced a transient disappearance of MEP (motor evoked potential) during the operation. The procedure was paused and resumed once MEP reappeared. Postoperatively, the patient's symptoms improved significantly without a neurological deficit. No patients demonstrated cervical instability or kyphosis, as identified by postoperative dynamic radiographic follow-up.

4. Discussion

This study evaluated the preliminary outcomes of UBE technology in the treatment of soft CCDH, to our knowledge, this is the first report about the technique. Basing on the existing technical advantages of UBE, we designed new incisions and improved the method, the results indicated that this technique had significant advantages in surgical efficacy, with noticeable improvements in various clinical indices. The initial findings showed rapid postoperative recovery, a low incidence of complications, and avoidance of issues such as dysphagia and adjacent segment disease (ASD), which are commonly associated with anterior fusion surgery [11-12].

Although ACDF and artificial disc replacement (ADR) have shown excellent clinical outcomes in treating soft CCDH, many spine surgeons are still willing to explore posterior endoscopic approaches for this condition to avoid loss of motion segments and approach-related complications. Consistently with the findings for other posterior endoscopic techniques [13-14], our technology also showed marked clinical improvements. However, we observed shorter surgical time than those reported by Yu et al. [15], which was possibly due to the use of larger tools facilitated by the biportal technique, which offered a larger operative space and field of vision, thereby enhancing surgical flexibility.

Most importantly, when combined with previously reported surgical protocol [10, 16], UBE technology makes it feasible to address "pincer mechanism" spinal cord compression via a single approach, eliminating the need for staged anterior–posterior and combined surgeries. Using the described method, it is possible to excise the herniated disc anterior to the cervical cord. By employing the spinous process floating technique, the posterior LF and lamina can be removed, achieving 360° decompression around the spinal cord. This approach also avoids unnecessary internal fixation and related complications. This contributes to reduced surgical risks and medical costs.

The main innovation of this study lies in the introduction of a same-side third auxiliary incision and a 45° arthroscope, providing a good ventral view of the spinal cord from the posterior approach and ensuring thorough decompression. We used a 30° endoscope to expose and partially excise the lamina and facet joints. After partially drilling the medial wall of the pedicle, we inserted a 45° endoscope into the position of the posterior wall of the vertebral body. By rotating the lens, we obtained a view of the ventral side of the spinal cord. Using a mini pituitary through a more lateral third incision, we removed the herniatied nucleus pulposus. This allowed us to achieve decompression without disturbing the spinal cord. Additionally, the use of IONM further reduces the risk of iatrogenic spinal cord injury. Posterior surgery is also a better option for ASD (Fig 6), given the high incidence of postoperative swallowing disorders reported by some scholars, affecting up to 62% of patients following anterior revision surgery [17].

This surgical technique has broad potential for clinical application, particularly for patient groups requiring meticulous operations and rapid recovery. The preliminary results indicate that employing this technique can significantly enhance patients' postoperative experience and clinical outcomes. Literature report indicates that the sacrificed portion of the medial wall of the pedicle during minimally invasive surgery can regenerate in the future [15]. Therefore, we anticipate that this method can be used to perform cervical discectomy while preserving the integrity of the motion segment.

The limitations of this study included the small sample size, short follow-up period, and clinical data limited to a single centre. Future research requires multi-centre, large sample randomised controlled trials to validate our results. Li found that mastering percutaneous endoscopic transforaminal discectomy (PETD) requires a learning curve of 40 cases, whereas UBE discectomy only requires 15 cases to reach proficiency [18]. Kang reported that the posterior UBE cervical foraminotomy has a learning curve requiring only 20 cases to achieve 90% proficiency, along with a significant reduction in operation time [19]. However, UBE surgery remains an endoscopic procedure that requires specialized training and sufficient experience accumulation. Specifically, in this innovative posterior cervical discectomy, proficient surgical skills and a thorough understanding of endoscopic manipulation will facilitate the successful implementation of this technique. Furthermore, although multi-portal endoscopic technique results in greater tissue damage compared to uniportal full-endoscopic technique, the use of multiple portals offers enhanced flexibility and operability, enabling the treatment of conditions that are not amenable to conventional spinal endoscopy.

With proficient mastery of the biportal endoscopy technique, intraoperative monitoring of neural function using a neuromonitor, and preparation to convert to ACDF if necessary, this surgery can be considered as an extreme indication for the application of UBE in cases of soft CCDH. Future studies should include larger-scale clinical trials to further substantiate our preliminary findings. The development of adjustable-angle drills and flexible endoscopes should be considered for future equipment improvements to achieve better ventral views of the spinal cord and more flexible operations during posterior surgery, thereby overcoming the contraindication of calcified disc herniation. Additionally, research should investigate the efficacy of this technique across different patient populations to explore its applicability in various clinical scenarios.

5. Conclusions

In conclusion, this study preliminarily demonstrated the safety and efficacy of the UBE technique in treating soft CCDH, which holds significant clinical importance. We anticipate that future research will validate these initial findings and facilitate the widespread clinical adoption of this technique.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Video S1: the UBE removal of CCDH.

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Fig. 1 **a** and **b** Schematic representation of the portal locations; **c** Compared with the 30° arthroscope, the 45° arthroscope contacted a smaller portion of the lateral mass to approach the central CCDH.

Fig. 2 **a** Mini UBE instruments used for the CCDH; **b** three different types of RF probes; **c** 4 mm and 2 mm diamond burrs; **d** 45° and 30° arthroscopes.

Fig. 3 **a** Caudal insertion of the LF was exposed (red arrow). **b** Flavectomy was performed. **c** Foraminotomy was performed. **d** Root (yellow arrow) adhesiolysis with a mini bushhook. **e** Root (yellow arrow) adhesiolysis with a ball-tip RF probe. **f** Buffer space was established.

Fig. 4 **a** The direction of the third portal was confirmed with a needle. **b** An adjustable RF probe was used to incise the posterior longitudinal ligament. **c** The nucleus pulposus (red arrow) was removed. **d, e** The nucleus pulposus (red arrow) was completely removed when the cord was protected. **f** Full decompression was confirmed.

Fig. 5 **a, b, c** Preoperative MRI and CT images showing a soft central CCDH at C4–C5. **d, e** Postoperative MR showing the removal of the herniated nucleus pulposus. **f, g** Postoperative CT images showing the partial removal of the lateral mass, lamina, pedicle, and vertebral body.

Fig. 6 **a** Five years after anterior cervical fusion, distal ASD presenting as C5–C6 cervical disc herniation was observed. **b** Intraoperative fluoroscopy showing decompression reaching the midline. **c** The nucleus pulposus was removed using a mini pituitary. **d** Postoperative MRI confirmed complete removal of the anterior nucleus pulposus, and adequate spinal cord decompression was achieved.

Table 1. Patients' characteristics.
Table 2. Pre- and postoperative outcomes.

Table 1

Characteristic	Value
Age, years	67.6± 7.8
Sex, male/ female	7/4
Operation time, minutes	82.7±10.1
Estimated blood loss, mL	31.8±9.8
Level of discectomy	
C4/5	1
C5/6	2
C6/7	8
Hospital stay, days	5.2±1.1
Surgical complication	
transient disappearance of MEP	1
Follow-up periods, months	13.8±2.4

Table 2

Outcomes	Preoperative	3 days-Postoperative	1 year-Postoperative
JOA	10.6±1.1	11.6±1.3[a]	14.2±1.1 [a,b]
VAS of axial pain	3.2±0.6	2.9±0.5 [a]	2.0±0.4 [a,b]
NDI(%)	38.8±5.2	31.9±6.5 [a]	22.5±3.4 [a,b]

[a] Compared with preoperative measurements, $p < 0.05$; [b] compared with measurements taken
3 days postoperatively, $p < 0.05$

Figure 1

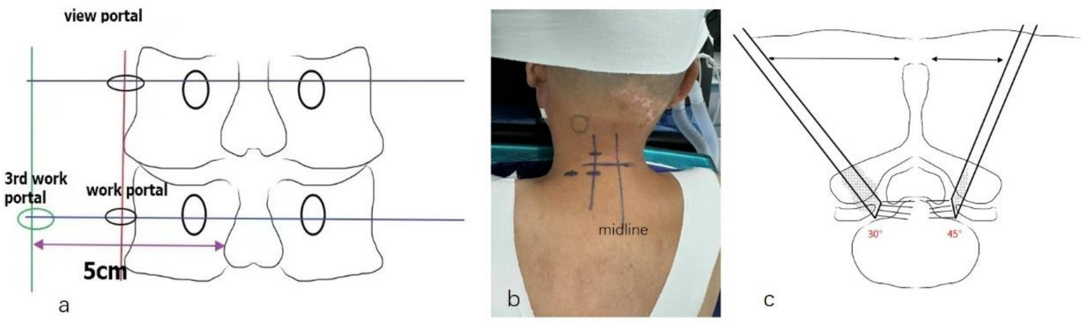
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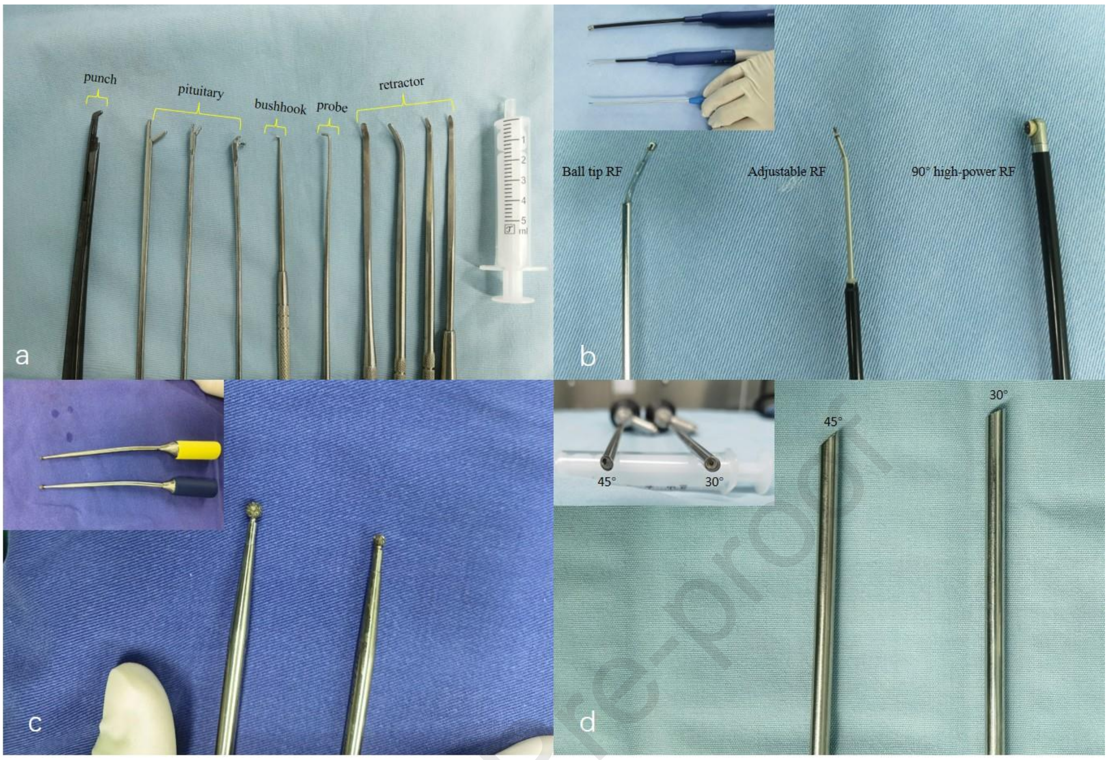
Figure 2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30°
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Figure 3

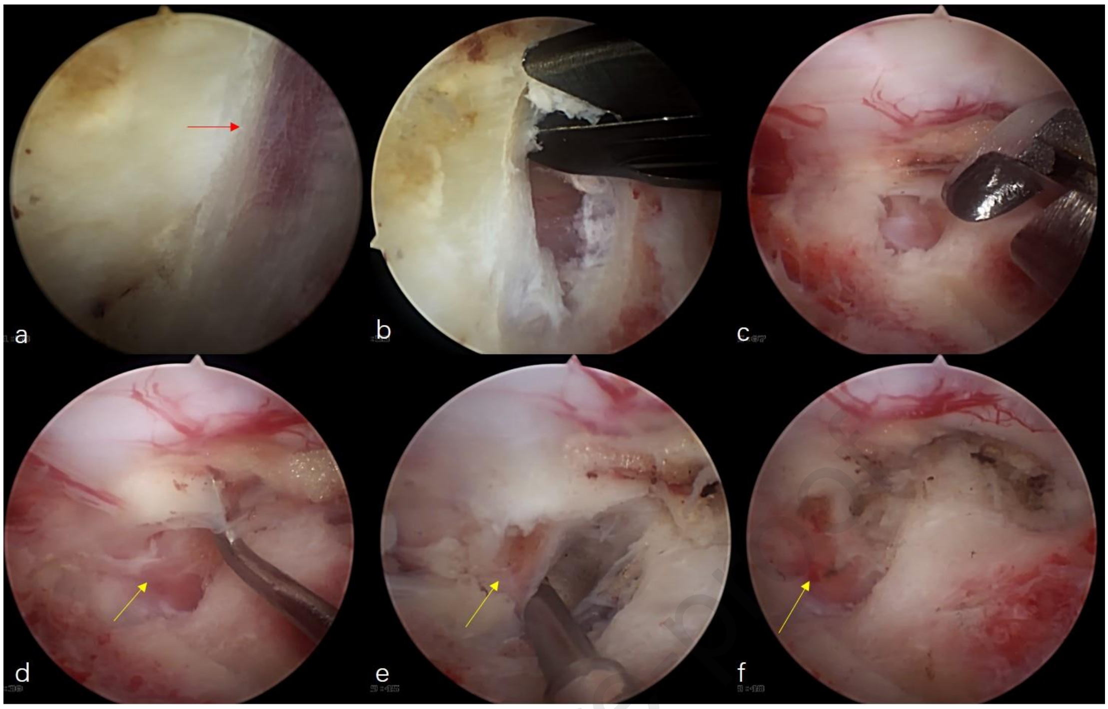


Figure 4

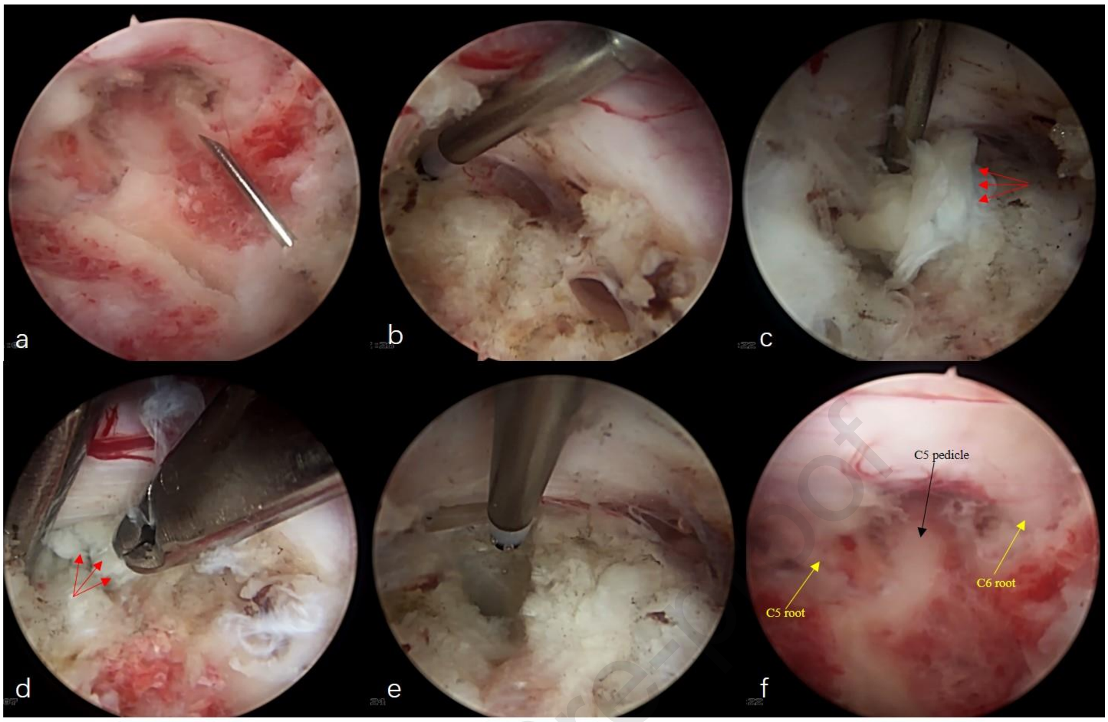


Figure 5

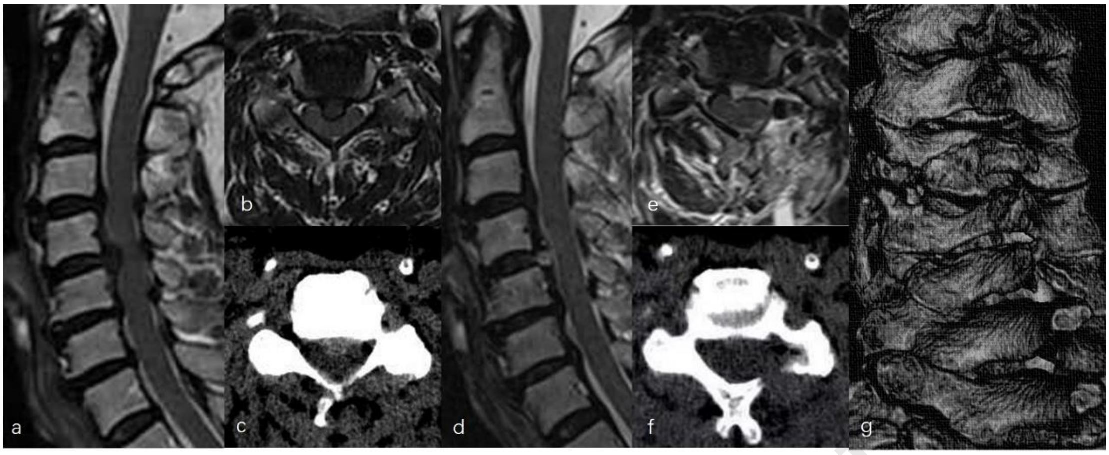
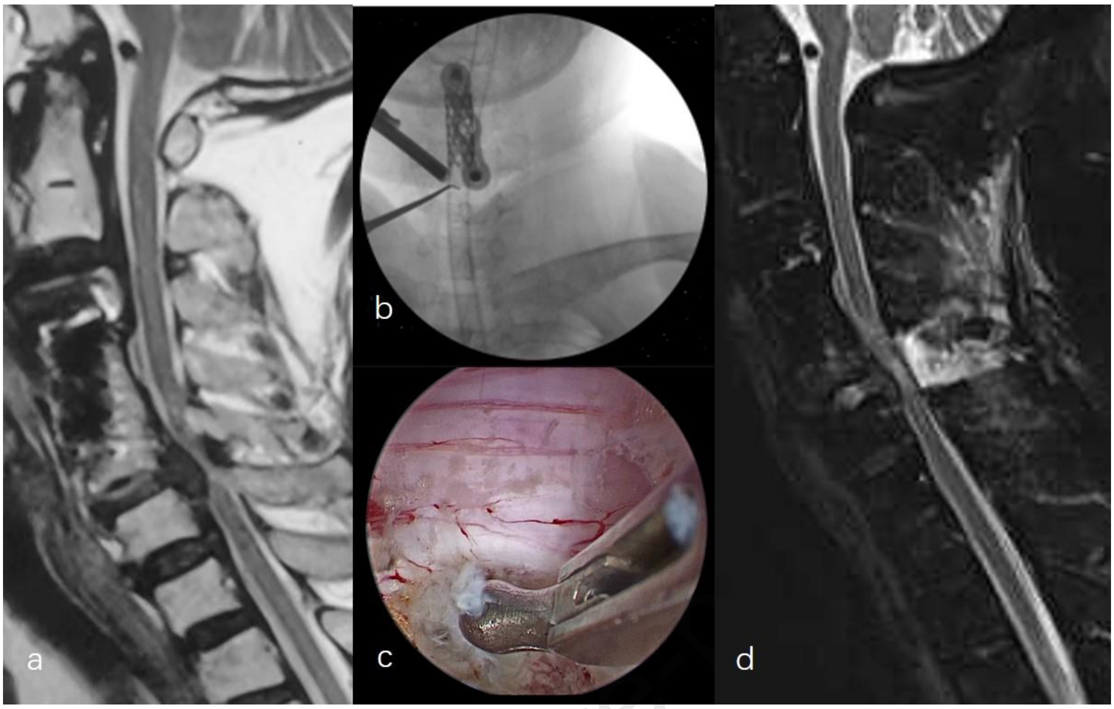


Figure 6



Abbreviations: CCDH: central cervical disc herniation; ACDF: anterior cervical discectomy and fusion; ADR: artificial disc replacement; UBE: unilateral biportal endoscopy; CT: computed tomography; MRI: magnetic resonance imaging; JOA: Japanese Orthopaedic Association; NDI: Neck Disability Index; VAS: visual analogue scale; UBED: Unilateral biportal endoscopic discectomy; IONM: Intraoperative electrophysiological monitoring; LF: ligamentum flavum; MEP: motor evoked potential; ASD: adjacent segment disease; PETD: percutaneous endoscopic transforaminal discectomy;

Disclosure

Conflicts of Interest: The authors declare no conflict of interest

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study

Data Availability Statement: The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.