

CERVICAL SPINE

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Anterior or Posterior Approach of Full-Endoscopic Cervical Discectomy for Cervical Intervertebral Disc Herniation?

A Comparative Cohort Study

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Study Design. This is a retrospective comparative cohort study.

Objective. To compare the outcomes of patients with symptomatic cervical intervertebral disc herniation (CIVDH) treated with full-endoscopic cervical discectomy (FECD) using the anterior approach with those treated with the posterior approach.

Summary of Background Data. The optimal FECD surgical approach for CIVDH remains controversial.

Methods. From March 2010 to July 2012, a total of 84 consecutive patients with symptomatic single-level CIVDH who underwent FECD using the anterior approach (42 patients) or the posterior approach (42 patients) were enrolled. Patients were assessed neurologically before surgery and followed up at regular outpatient visits. The clinical outcomes were evaluated using the visual analogue scale and the modified MacNab criteria. Radiographical follow-up included the static and dynamic cervical plain radiographs, computed tomographic scans, and magnetic resonance images.

Results. In both groups, shorter mean operative time (63.5 min vs. 78.5 min), increased mean volume of disc removal (0.6 g vs. 0.3 g), larger mean decrease in the final postoperative mean intervertebral vertical height (1.0 mm vs. 0.5 mm), and longer mean hospital stay (4.9 d vs. 4.5 d) were observed in the anterior full-endoscopic

cervical discectomy group. Postoperatively, the clinical outcomes of the 2 approaches were significantly improved, but the differences between the 2 approaches were not significant ($P = 0.211$ and $P = 0.257$, respectively). Four surgery-related complications were observed among all enrolled patients (complications in each group were 2; overall 4 of 84, 4.8%).

Conclusion. In our study, the clinical outcomes between the 2 approaches did not differ significantly. Nevertheless, posterior full-endoscopic cervical discectomy may be preferable when considering the volume of disc removal, length of hospital stay, and the postoperative radiographical changes. As an efficacious supplement to traditional open surgery, FECD is a reliable alternative treatment of CIVDH and its optimal approach remains open to discussion.

Key words: cervical intervertebral disc herniation, minimally invasive spine surgery, endoscopes, discectomy, anterior, posterior.

Level of Evidence: 3

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In 1934, the posterior laminoforaminotomy was first reported by Barr¹ and used to surgically treat cervical intervertebral disc herniation (CIVDH). The anterior cervical discectomy and fusion (ACDF) was proposed in the late 1950s.² Since then, further explorations of ventral and dorsal surgical techniques have produced anterior cervical decompression with or without fusion, anterior foraminotomy using various techniques, posterior microscope-assisted or endoscope-assisted “key-hole foraminotomy,” and cervical disc replacement.³⁻¹⁴ Although these techniques generally produce adequate results, ACDF has gradually developed as the gold standard surgical treatment of CIVDH and has generally been described as a safe and efficacious procedure with good fusion rates.¹⁵⁻²⁰ Nonetheless, with the increasing application of the surgery, additional problems have been encountered, including pseudarthroses, loss of height of the intervertebral space (IVS), degeneration of adjacent segments, or access-related complications, which may all have a catastrophic influence on the efficacy of the therapy.²¹⁻²⁵

TABLE 1. Summary of Demographic, Clinical Data, and Treatment Level

Baseline Characteristic	AFECD (N = 42)	PFECD N = 42
Female sex (%)	16 (38)	14 (33)
Mean age (range), yr	41.3 (28–57)	40.5 (32–68)
Mean duration of symptoms (range), wk	15 (6–46)	18 (2–48)
Indications for surgery		
Radiculopathy	33	36
Myelopathy*	9	6
Treatment level		
C3–C4 (%)	3 (7)	5 (12)
C4–C5 (%)	11 (26)	10 (24)
C5–C6 (%)	23 (55)	24 (57)
C6–C7 (%)	5 (12)	3 (7)

*All the patients with myelopathy were classified in Nurick classification system: Grade 0: no evidence of spinal cord disease; grade I: symptoms of spinal cord disease, but no difficulty in walking; grade II: slight difficulty in walking; grade III: difficulty in walking but not so severe as to require assistance; grade IV: able to walk only with another person's assistance or with the aid of a frame; and grade V: chair- or bed-bound.

AFECD indicates anterior full-endoscopic cervical discectomy; PFECD, posterior full-endoscopic cervical discectomy.

Full-endoscopic cervical discectomy (FECD) was developed on the basis of the advances in endoscopic techniques and their successful use in various fields. With continuous development, this operation has come to be generally divided into 2 categories: anterior full-endoscopic cervical discectomy

(AFECD) and posterior full-endoscopic cervical discectomy (PFECD).^{26,27}

To the best of our knowledge, no comparative study between the anterior and posterior approaches for FECD in the treatment of CIVDH has been performed. In the present cohort, we report the results of 84 consecutive patients with symptomatic CIVDH who underwent FECD using the anterior or posterior approach.

MATERIALS AND METHODS

Patient Population

A total of 84 consecutive patients with symptomatic CIVDH were treated in our center from March 2010 to July 2012. All FECD procedures were performed by the same surgeon (42 AFECD and 42 PFECD). The demographic characteristics of the patients are shown in Table 1.

Patient Selection

The inclusion criteria were as follows: (1) failed conservative therapy of at least 4 weeks or symptom deterioration to the extent of being unbearable, (2) neurological symptoms (radiculopathy and/or myelopathy) consistent with the preoperative magnetic resonance image (Figures 1 and 2A) and discogram, (3) single-level posterolateral disc herniation, (4) a ventral IVS height of 4 mm or more, and (5) mild myelopathy (Nurick grade 3 or below).

The exclusion criteria were as follows: (1) clear segmental instabilities or deformities, (2) anterior osteophyte of the vertebra and/or cervical intervertebral disc with calcification, (3) anterior disc height of 4 mm or less, (4) craniocaudal sequestering of more than half of the vertebral body, (5) isolated neck pain for which the cause could not be determined by magnetic resonance imaging (MRI) or discography, (6) foraminal stenosis without disc herniation,

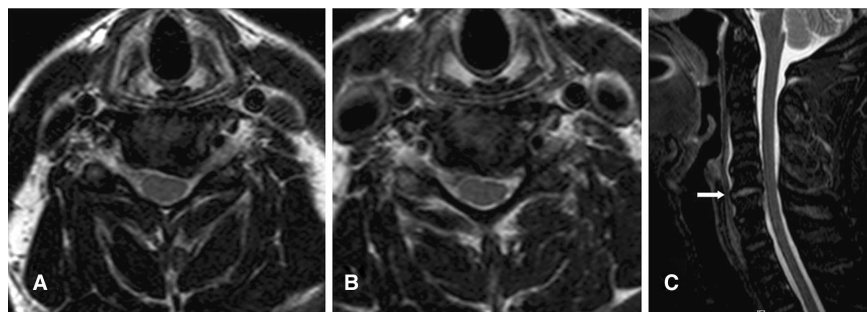


Figure 1. A, T2-weighted axial magnetic resonance image (MRI) shows a paramedial herniated disc on the left side of the C5–C6 disc space. B, Axial MRI after anterior full-endoscopic cervical discectomy (AFECD) shows that most of the disc that was affecting the nerve was removed, and the remaining capsule had shrunk slightly. C, Sagittal fat suppression MRI after AFECD. Note the signal change along the trajectory of the operation (arrow).

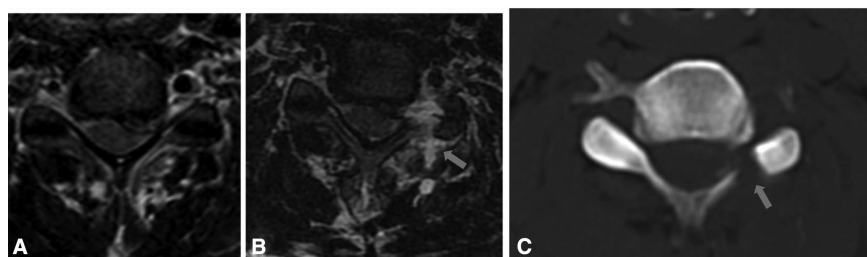
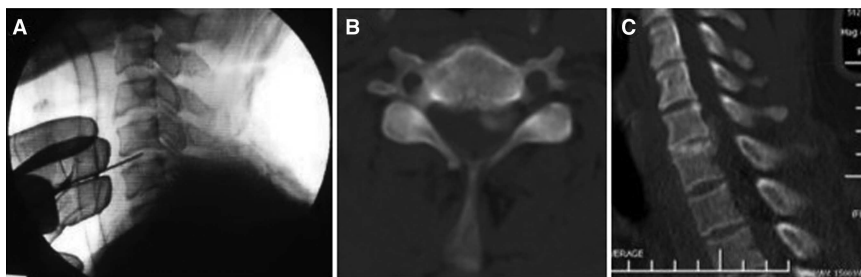


Figure 2. A, T2-weighted axial magnetic resonance image (MRI) shows a ruptured disc on the left side of the C5–C6 disc space. B, Axial MRI after PFECD shows that most of the ruptured disc had been removed. Note the signal change along the trajectory of the operation (arrow). C, Axial computed tomographic scan after posterior full-endoscopic cervical discectomy shows the partial defect of the left lamina (arrow).

Figure 3. A, Cervical discography. Immediate post-operative axial computed tomographic (CT) (B) and sagittal CT reconstructions (C) show a paramedial herniated disc on the left side of the spinal canal.



(7) multiple-level disc herniation, (8) previous surgery at the same segment, (9) severe myelopathy (Nurick grade 4 or above), and (10) a suspected infection or tumor in the cervical spine.

Preoperative Preparation

In addition to the routine preoperative preparations, discography was performed in all enrolled patients. The contrast medium consisted of 0.5 to 1 mL of a compound of iohexol and methylene blue at a ratio of 3:1. For better evaluation, an additional cervical computed tomographic scan and sagittal reconstruction were obtained less than 2 hours after the injection of the contrast agent (Figure 3A–C). Besides pain provocation, the parameters of volumetry, manometry, and radiography were also used to locate the offending neural disc.

Operative Technique

The operations were performed principally following the previously described conventional AFECD or PFECD techniques.^{28–32}

AFECD: Under general anesthesia, the patient was placed in a supine position with the neck in slight extension. The site medial to the sternocleidomastoid muscle at the pathological level where the pulsation of the carotid artery could be palpated was chosen as a suitable skin entry point. The 2-finger technique was used: the lateral carotid artery and the medial tracheoesophagus were pushed toward the opposite side, and the tissue space between them was enlarged with the index and middle fingers of the left hand. This creates a small safe window between the tips of these 2 fingers for the insertion of the spinal needle where the anterior edge of the target disc is perceived. The puncture needle was inserted

and passed successively through the following structures: the cervical fascia between the carotid artery (laterally) and the tracheoesophagus (medially), the anterior longitudinal ligament, and the anterior annulus fibrosus inside the window between the bilateral longus colli muscles. After the depth of the tip of the guide wire, which replaced the puncture needle, was verified using lateral fluoroscopic imaging, a 5-mm transverse skin incision was made. Then, a combined dilator-sheath system was bluntly inserted until sequential dilation was achieved along the guide wire; then, the final oval operation sheath was laid diagonally toward the IVS (Figure 4A). After complete insertion of the endoscope, the operation was performed under visualization and continuous irrigation with 0.9% saline solution. On the pathological side, on the dorsal segments of the vertebral body, the endplates were prepared using a burr. When the annulus fibrosis and posterior longitudinal ligament were opened together, the stained extruded disc material was exposed and excised using a Rongeur. Finally, a low-energy bipolar radiofrequency was used for coagulation and nucleoplasty after complete decompression was confirmed.

PFECD: The patient was placed in a prone position under general anesthesia with the neck in slight flexion. After an 8-mm transverse incision above the zygapophyseal joint on the pathological side was made, an 18-gauge puncture needle was inserted through the incision in the direction of the posterior arch to the interlaminar space of the affected level; then, the guide wire was placed and the needle was withdrawn. After sequential dilation along the guide wire, the opened bevel of the cannula sheath was directed toward the medial side to avoid accidental entrapment of the spinal cord. When the guide wire was removed, the operating sleeve was inserted

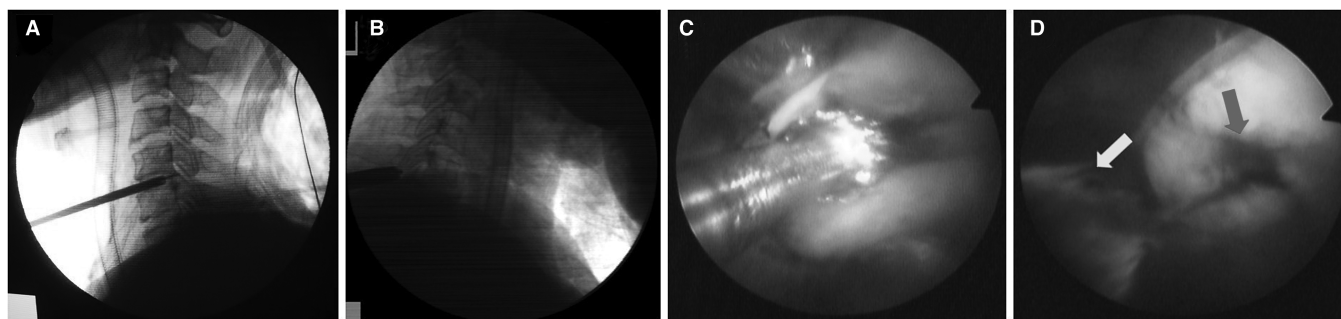


Figure 4. Fluoroscopy with the intraoperative C-arm shows that both the working systems of anterior full-endoscopic cervical discectomy (A) and posterior full-endoscopic cervical discectomy (B) have been satisfactorily assembled. C, The intraoperative view shows that the interlaminar window between C5 and C6 is opened stepwise using the burr. D, The crevasse of the annulus fibrosis (red arrow) and the dyed herniated nucleus pulposus (yellow arrow) are both shown in endoscopy.

TABLE 2. Operative Characteristic and Postoperative Course

Surgical Characteristic	AFECD	PFECD
Mean surgical duration (range), min	63.5 (40–105)	78.5 (60–128)
Mean volume of removal disc (range), g	0.6 (0.4–0.8)	0.3 (0.2–0.4)
Mean hospital stay (range), d	4.9 (2–8)	4.5 (1–5)
Total complications		
Neurological deterioration	0	1
Postoperative hematoma	1	0
Repeated surgery	1	1
Postoperative headache	1	0

AFECD indicates anterior full-endoscopic cervical discectomy; PFECD, posterior full-endoscopic cervical discectomy.

with its endoscope (Figure 4B). Two adjacent vertebral laminae and the ipsilateral facet joint between them, which formed a Y-shape arrangement, were clearly exposed under endoscopy. Using a burr, the interlaminar window above the herniation was opened from the medial to the lateral margin according to the pathology (Figure 4C). Once the dural sac was identified with a partial resection of the ligamentum flavum, coagulation of the epidural venous plexus was performed using a low-energy bipolar radiofrequency to maintain a clear visual field and to precisely identify the branching of the spinal nerves. The nerves were mobilized, and the posteriorly protruded nucleus pulposus was resected (Figure 4D). When thorough neural decompression was confirmed, nucleoplasty was performed in some cases depending on the pathology. When meticulous hemostasis and drainage was achieved, all of the instruments were removed.

The incisions were sutured and covered with a water-impermeable dressing; the patients were allowed to resume oral intake after postanesthesia recovery and were advised to wear a neck collar for at least 3 weeks.

Follow-up

In the clinic or telephone follow-up, the visual analogue scale (VAS) for neck and arm pain and the modified MacNab criteria were used to evaluate the postoperative outcomes. During follow-up at 1 and 12 months postoperatively, neutral and dynamic cervical radiographs of each patient were obtained. In addition, cervical computed tomography and MRI were performed on a random sample of patients with excellent or good outcomes and in all patients with fair or poor recovery (Figure 1B, C; Figure 2B, C).

Statistical Analysis

The 2-sample *t* test, Wilcoxon signed rank test, and the Mann-Whitney *U* test were used to compare parametric data between the 2 cohorts. A probability level of less than 0.05 was considered to be the threshold of significance.

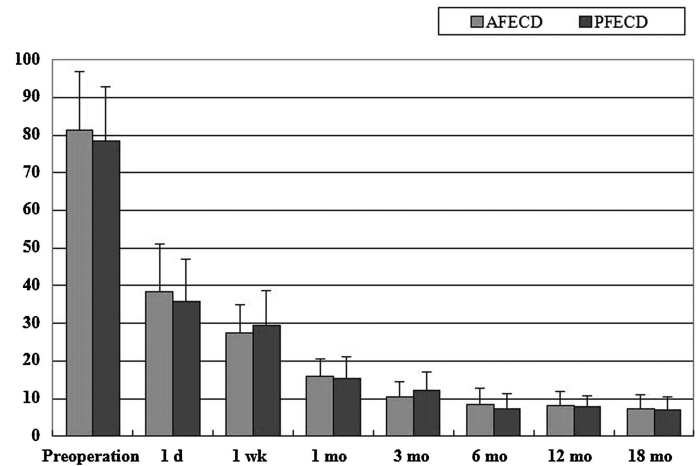


Figure 5. The course of the arm and neck pain in both groups, which was rated using the mean visual analogue scale values. AFECD indicates anterior full-endoscopic cervical discectomy; PFECD, posterior full-endoscopic cervical discectomy.

RESULTS

Surgical Findings and Postoperative Course

The surgical findings and postoperative course are shown in Table 2. The mean operative time of AFECD was 63.5 minutes compared with 78.5 minutes for PFECD ($P < 0.001$), and AFECD had a relatively higher mean volume of the removed discs (0.6 g *vs.* 0.3 g; $P < 0.005$). The mean hospital stay (4.9 d *vs.* 4.5 d; $P = 0.391$) did not differ between the 2 procedures, and both procedures were associated with negligible blood loss.

There were no severe sequelae, such as esophageal injury, recurrent laryngeal nerve injury, carotid artery injury, or infection. There were a total of 4 surgery-related complications among all enrolled patients (2 after AFECD, 2 after PFECD, 4 of 84, 4.8%). In the AFECD group, 1 patient complained of a temporary postoperative headache, which was attributed to excessive height of the drip stand (80 cm) as well as the prolonged high intraoperative irrigation pressure to address the high levels of epidural venous bleeding. Another patient developed a postoperative hematoma, which was most likely due to penetration of the longus colli muscle when the working sleeve was set up. In this patient, an ACDF revision was performed to remove the large hematoma, which had compressed the spinal cord. Among the PFECD group, neurological exacerbation of the contralateral lower limb was reported by 1 patient because of intraoperative mobilization of the spinal cord, but the symptoms were gradually eliminated over 3 months with conservative therapy. Another patient underwent a repeat ACDF because of a large disc herniation toward the posterior spinal canal, as herniated nucleus material had been entrapped by myelon, which was too tight to be released.

Recurrence

Three patients (3.6%) experienced the symptom recurrence after a pain-free interval and lost to follow up later.

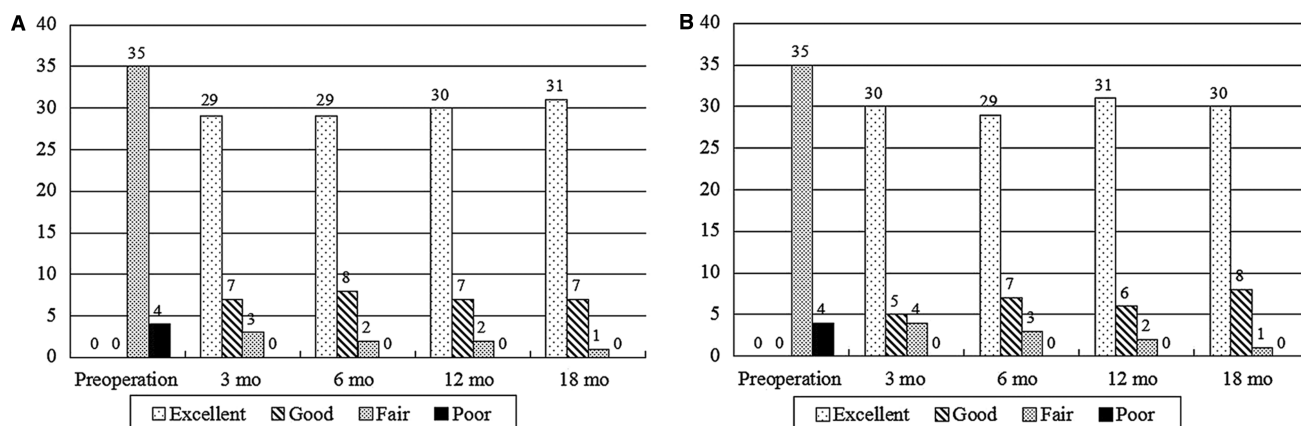


Figure 6. The clinical results of the anterior full-endoscopic cervical discectomy (A) and posterior full-endoscopic cervical discectomy (B) according to the modified MacNab criteria.

Clinical Outcomes

A total of 80 patients completed all follow-up visits. Except for the 2 revisions, the preoperative and postoperative VAS scores (Figure 5) and classification of modified MacNab criteria (Figure 6A, B) of 78 patients are presented. The 2 approaches did not differ with regard to mean VAS score or outcomes evaluated using the modified MacNab criteria ($P = 0.211$ and $P = 0.257$, respectively).³³

Radiographical Outcomes

The mean postoperative decrease between preoperatively and 12 months postoperatively in vertical height at the center of the treated disc was evaluated using cervical lateral radiographs in the neutral position, and the mean decrease differed significantly between the groups (the vertical height decrease with AFECD was 1.0 mm, with a reduction in height from 6.03 ± 1.49 to 5.01 ± 1.45 mm; PFECD was 0.5 mm, with a reduction in height from 6.08 ± 0.93 to 5.55 ± 1.03 mm; $P < 0.005$). The postoperative dynamic radiographical follow-ups showed that no patient developed cervical instability or increasing kyphosis (Figures 7 and 8).

DISCUSSION

Patient Selection

Our criteria were somewhat similar to those of other studies.^{29,31} For multiple-level CIVDH, the reported sporadic sample was too small to verify the efficacy of FECD.¹² Besides, due to the different indications for each approach (central herniation was more commonly treated with AFECD, but lateral herniation was more commonly treated with PFECD),^{29,32} only single-segment paramedial segmental disc herniation, which could be addressed using both approaches, was included for a better comparison. Some other clinical situations were contraindicated, including those involving difficulties in inserting a working cannula because of a vertical intervertebral distance of less than 4 mm, a large anterior vertebral osteophyte, or discal calcification. In addition, cases involving substantial craniocaudal disc sequestration, which is contraindicated for AFECD because of a high likelihood of causing

intraoperative iatrogenic injury and postoperative instability, were also excluded from our study.

Operation Technique

In addition to the 2-finger technique, the following are helpful for successfully inserting a cannulated needle during AFECD: (1) the landmark of the bilateral longus colli muscles, which are soft and bulky and extend along the vertical axis of the cervical spine and can be recognized by pressing firmly down to the anterior surface of the cervical vertebrae, and (2) the optimal trajectory, which is approximately 10° from the perpendicular to the coronal plane directly toward the disc space on cross section. In assembling the cannula in FECD, repeated multiple-plane fluoroscopy is essential to confirm the accurate depth and position of the cannula. For anterior regions of the neck where the vessels are widely distributed and the cellular distribution is too loose to stop bleeding, the possibility of postoperative hematocoele is often a concern.

Clinical Results

Compared with traditional posterior foraminotomy or ACDF, which in China results in hospital stays that are usually more than 7 days, the average of 4.5 to 4.9 days for FECD is an improvement. The longer operative times required for PFECD were most likely caused by obstruction by the anterior spinal cord. Consistent with the experience of other authors,^{10,30,31,34–36} the postoperative mean VAS scores were significantly lower for both approaches, especially on the first postoperative day, but the difference in the mean VAS scores between the 2 techniques was not significant ($P = 0.211$). Meanwhile, according to the modified MacNab criteria, the rate of having a favorable outcome (excellent or good recovery) increased during follow-up in both groups, but the difference between the groups was not significant ($P = 0.257$). Consequently, the clinical outcomes of both approaches were similarly favorable.

Radiographical Outcome

In addition to the loss of total disc volume, the subsequent local biomechanical changes resulted in decreased postoperative vertical height of the IVS, and the difference between the

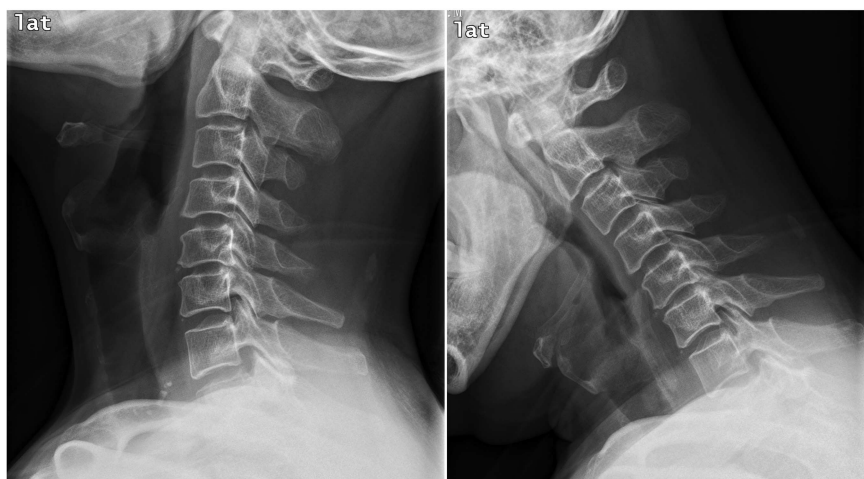


Figure 7. The dynamic cervical radiographs after an anterior full-endoscopic cervical discectomy in C5–C6.

2 groups was attributed to the anterior transdiscal approach in which more disc tissue was likely removed. However, even with the larger decrease in the IVS with AFECD, similar clinical improvements were obtained in both groups, which is consistent with other studies.^{31,34–36} In addition, the postoperative instability or the increasing kyphosis with FECD was not found in the dynamic radiographical follow-up because of the relatively better preservation of the anterior nucleus pulposus without unnecessary disruption of the surrounding structures.

Controversy

Whereas the guidelines still advise against using provocative discography in lumbar nonradicular pain,^{37,38} cervical provocative discography in patients with back pain remains controversial. Because of the use of provocative discography, which is applied in our department for reconfirming the symptomatic levels and improving endoscopic visualization, in our cohort, there were no instances of surgery being performed on the wrong segment. Furthermore, the relatively low rate of discitis after cervical discography and its significant role in selecting surgical candidates and improving outcomes were

demonstrated.^{39,40} Most importantly, the contrast medium used in our research was a mixture of iohexol and methylene blue, which differs from the traditional contrast agent. With this mixture, the nerve-compressing discs and the annular tears are highlighted, which facilitates targeted decompression without substantial disruption of the surrounding structure. Among all the disadvantages of discography, as a main concern, wrong level localization is still worrisome to some researchers and affecting their decisions of discography. Hence, how to balance the advantages and disadvantages of discography is extremely significant in successive researches and seeking a more safe and reliable detecting technique ultimately. In our preliminary experience, an overall consideration, combining neurological symptoms and the preoperative MRI, is benefit for locating the right level and reducing the unnecessary puncture in most cases.

The efficacy of methylene blue in chronic discogenic low back pain has been proven⁴¹; however, whether it facilitates endoscopic surgery and the extent of its long-term influence remain unknown. When considering the neurotoxin of methylene blue, indigo carmine could be considered as a



Figure 8. The dynamic cervical radiographs after a posterior full-endoscopic cervical discectomy in C5–C6.

replacement in further clinic studies, and further comparative studies are warranted.

It is a concern that the discrepancy in nucleoplasty will degrade the homogeneity of the PFCD group. However, only in 2 cases with relatively large herniations, nucleoplasty was performed after PFCD. And compared with the other 37 patients' unperformed nucleoplasty, there is no significant difference in postoperative VAS scores. In our experience, in case of recurrence, we performed only nucleoplasty in the patients with relatively large herniations. Whereas, whether nucleoplasty is necessary in such cases and the impact in clinic outcomes are uncertain, which need to be explored in the further comparative cohort study.

In the era of minimally invasive surgery, FECD, which allows targeted decompression under continuous visualization with concurrent minimization of operation-related trauma and maximization of functional preservation, bridges the gap between conservative therapy and traditional surgery. Our procedures were facilitated by the methylene blue dye, which was mixed into the contrast medium and highlighted the nerve-compressing discs and their annular tears, and the good illumination and the 25° optics,^{29,31} which expanded the field of vision by rotation. In the prospective research by Ruetten *et al*,²⁹ the 2-year postoperative recurrence rate after AFCD was 3.7%. In another study by Ruetten *et al*,³¹ which included 2 years of postoperative follow-up in 87 patients, the recurrence rate of PFCD was low (3.4%), and the success rate was satisfactory (96%). Consistent with these 2 studies, postoperative recurrence in our cohort was 3.5%, and the long-term effect was satisfactory during 18 months of follow-up. However, the low-reported recurrence rate and the long-term efficacy remain controversial and require further examination in multicenter studies. Even so, FECD should not be neglected as a supplement to conventional procedures. Its advantages include less iatrogenic damage to the spinal column, minimal soft tissue damage, rapid rehabilitation, and easier surgical revisions, and these advantages lead to reduced recurrence rates and maintenance of symptom remission.^{42,43}

Limitation

The main limitations of our research include the use of a single surgeon and institution, the lack of randomization, the specific patient selection criteria, and the comparably short-term radiographical follow-up. Therefore, the robustness of our conclusions should be verified at spine centers, with a high volume of patients and extensive experience.

CONCLUSION

In our study, the clinical outcomes between the 2 approaches did not differ significantly. Nevertheless, when considering the volume of disc removal, the length of hospital stay, and the postoperative radiographical changes, PFCD may be preferable. As an efficacious supplement to traditional open surgery, FECD is a reliable alternative treatment of CIVDH, and the optimal approach remains open to discussion.

➤ Key Points

- ❑ This is a retrospective comparative cohort study that first compared the outcomes of symptomatic CIVDH patients with FECD, using the anterior approach with those treated with the posterior approach.
- ❑ In our study, the clinical outcomes between the 2 approaches did not differ significantly. Nevertheless, when considering the volume of disc removal, length of hospital stay, and the postoperative radiographical changes, PFCD may be preferable.

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