Comparative Evaluation of Posterior Percutaneous Endoscopic Cervical Discectomy Using 3.7mm Endoscopic and 6.9mm Endoscopic for Cervical Disc Herniation: a retrospective comparative cohort study.

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Research article

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Abstract

Background. Posterior percutaneous endoscopic cervical discectomy (p-PECD) is an effective strategy for cervical diseases which working cannula ranges from 3.7 mm to 6.9 mm. However, no studies were performed to compare the clinical outcomes of endoscopes with different diameters in cervical disc herniation (CDH) patients. The purpose of this study was to compare the clinical outcomes of unilateral CDH patients treated with p-PECD applying the 3.7mm endoscopic with those treated with the 6.9mm endoscopic.

Methods. From January 2016 to June 2018, totally 28 consecutive patients presented with single-level CDH who received p-PECD using the 3.7mm endoscopic or the 6.9mm endoscopic were enrolled. The indications for this study were as follows: (1) Unilateral cervical spondylotic radiculopathy with pain irradiated to upper extremity, (2) MRI and CT scan show that foraminal CDH located lateral to the edge of spinal cord, from C4–C5 to C7–T1, (3) Unilateral symptoms caused by foraminal stenosis, (4) Failure after conservative treatment for at least 6 weeks or neurological symptoms aggravated. Patients were evaluated neurologically pre- and postoperatively. The clinical outcomes, including the operation time, the hospitalization, the visual analogue scale (VAS) and the modified MacNab criteria, were evaluated. Cervical fluoroscopy, CT, and MRI were performed during follow up.

Results. The mean surgical duration of the 3.7mm endoscopic was 76.5 minutes compared with 61.5 minutes for 6.9mm endoscopic ($P<0.05$). Moreover, there was significant difference with regard to average identification time of “V” point (18.608±3.7607min vs. 11.256±2.7161min, $p<0.001$) and mean removal time of overlying tissue (16.650±4.1730 min vs. 12.712±3.3079 min, $p<0.05$) between 3.7mm endoscopic and 6.9mm endoscopic. The VAS and MacNab scores postoperatively of the two endoscopies were significantly improved compared with that before operation ($p<0.05$).

Conclusion. Both 3.7mm endoscopic and 6.9mm endoscopic are effective methods for CDH in selected patients, and there is no significant difference in clinical outcomes. 6.9mm endoscopic is superior to 3.7mm endoscopic in the efficiency of “V” point identification, overlying soft tissue removal and spinal cord injury prevention. Furthermore, 6.9mm endoscopic is inferior to 3.7mm endoscopic in anterior decompression of the intervertebral foramen.

Background

For a long time, anterior cervical decompression and fusion (ACDF) seemed as the gold standard for the treatment of radicular pain triggered by CDH (1). However, it was related to various surgical complications, including dysphonia, dysphagia, recurrent laryngeal nerve palsy, accidental esophageal perforation, hematoma, cerebrospinal fluid leakage, more traumatic, slower recovery, implant failure, pseudoarthrosis, bone graft nonfusion, infection, and postoperative adjacent segment degeneration (2-8).

Subsequently, in order to minimize the surgical complications of ACDF, various surgical techniques have been carried out. Recently, PECD for the treatment of spinal diseases has become favorable. It offers the advantage of reducing trauma, promoting faster rehabilitation (9-21) and has a similar short-term clinical benefit to ACDF (22). PECD can be performed through the anterior approach and posterior approach (21) which depends on the site of pathology. Studies reported that anterior percutaneous endoscopic cervical discectomy (a-PECD) possesses the disadvantage of higher probability of intervertebral space decrease postoperatively due to the violation of the intervertebral disc (23). However, p-PECD, as a less invasive techniques with potential advantages, does not have this shortcoming.

To date, numerous studies reported p-PECD for management of cervical disorders (19) (13, 15-21, 23-27) and the inner diameter range of p-PECD working channel was from 3.7mm to 6.9mm (17, 22, 28). However, no studies were performed to compare the clinical outcomes of the 3.7mm endoscopic and 6.9mm endoscopic in CDH patients. Thus, the purpose of this study was to compare the clinical outcomes of unilateral CDH patients treated with p-PECD applying the 3.7mm endoscopic with those treated with the 6.9mm endoscopic.

Methods

Patient Characteristics

In the retrospective study we enrolled 28 patients with CDH who underwent p-PECD with 3.7mm endoscopic or 6.9mm endoscopic. All the procedures were performed by the same surgeon from June 2016 to July 2018. Besides, the demographic characteristics of the 28 patients in two groups were also collected.

Inclusion Criteria

The indications for p-PECD were as follows: (1) Unilateral cervical spondylotic radiculopathy with pain irradiated to upper extremity, (2) MRI and CT scan show that foraminal CDH located lateral to the edge of spinal cord, from C4–C5 to C7–T1, (3) Unilateral symptoms caused by foraminal stenosis, (4) Failure after conservative treatment for at least 6 weeks or neurological symptoms aggravated (21, 29, 30).

Exclusion criteria

The contraindications for p-PECD were as follows: (1) segmental instability of cervical spine, (2) Multiple-level cervical spinal stenosis, (3) cervical intervertebral disc with calcification, (4) a medial location of the herniated disc, (5) extradural lesions mimicking a lateral or foraminal disc herniation, (6) cervical deformity, (7) craniocaudal sequestering of more than half of the vertebral body, (8) anterior osteophyte of the vertebra, (9) bilateral symptoms, (10) the cause cannot be diagnosed by MRI or CT (23, 29, 30).

Endoscopic Instruments

The details were described in **table 2**.

Table 1. Endoscopic Characteristics				
Endoscopic	**OD (mm)**	**ID (mm)**	**OA (°)**	**WL/TL (mm)**
Delta	10mm	6.9mm	30	125/205
Keyhole	6.9mm	3.7mm	15	125/205
OD represents outer diameter; ID indicates inner diameter; OV, optics angle; WL and TL are working length and total length of the endoscopic, respectively.				

Surgical technique

3.7mm endoscopic: After general anesthesia, the patient was placed in a prone position. Then intraoperative neurological monitoring (INM) was performed by a surgeon, specializing in neurosurgery. The surgeon and assistant stranded on the same side of the pathology, and the endoscopic monitor was placed on the opposite side of the pathology **(Figure 1)**. Kerrison punch and endoscopic drill were applied to perform the laminoforaminotomy or foraminotomy. An endoscope characterized by an inner diameter of 3.7mm and 30° optics angle was also utilized (Shanghai Maoyu medical equipment CO., LTD. China). Besides, all manipulation was carried out under continuous irrigation of saline solution. The lamino-facet junction should be observed on the radiographic of true antero-posterior view in order to identify the entry-point. A Kirschner needle, with 18-gauge and 25cm, was inserted and placed on the level of pathology. A 1cm surperficial skin incision was done. Then, the obturator was installed and applied to feel the “V” point which is an anatomcal landmark confluenced by superior border of the inferior laminae, inferior border of the upper laminae, and the medial point of the facet joint **(Figure 1)**. Hence, the working cannula was advanced and obturator was removed **(Figure 2)**. At this point, the endoscope was inserted through the working cannula. Radiofrequency probe (joimax® GmbH, Germany) and endoscopic forceps was used to coagulate and remove the overlying soft tissue, under continuous irrigation with normal saline. Once the osseous anatomical structure has been observed, the inferior border of the upper laminae was resected with endoscopic drill until the ligamentum flavum was exposed, and then the endoscopic drill was directed caudally toward the cervical pedicle and laterally toward the facet joint. Finally, in order to expose the exiting nerve root, the ligamentum flavum and foraminal ligament were removed. Subsequently, the underlying disc space was detected with a dissector. Intraoperatively, to prevent excessive removal of the facet joint, a nerve hook was applied to feel the medial wall of the pedicle. After the exiting nerve root exposed successful, the intervertebral disc can be detected. The herniated cervical disc was removed through the shoulder or axilla of the exiting nerve root according to the lesion location **(Figure 3)**. It is critical to palpate the exiting nerve root using a nerve hook and should feel free after intervertebral disc adequately removed (30, 31). **Figures 4-6** show the case of a 60-year-old male with cervical discomfort with radiation pain of right shoulder and upper extremity. The patient was diagnosed with a C6–C7 CDH. Postoperative satisfied clinical results were achieved in the patient.

6.9mm endoscopic: The surgical tools applied in this technique were a little different from those applied in 3.7mm endoscopic. A larger endoscope with 6.9mm inner diameter **(Figure 7)** was used in this approach (Shanghai Maoyu medical equipment CO., LTD. China). The manipulation of foraminotomy, laminoforaminotomy and discectomy **(Figure 8)** was the same as 3.7mm endoscopic. A 54-year-old male patient presented with neck pain and right upper extremity numbness. He was diagnosed with a C5–C6 right foraminal CDH (**Figures 9-11**). Postoperative good clinical results were obtained in the patient.

Statistical Analysis

The 2-sample t test, Wilcoxon signed rank test and the Mann-Whitney U test were applied to compare parametric data between the 3.7mm endoscopic and the 6.9mm endoscopic. $P<0.05$ was regarded as the threshold of significance.

Results

Patients and surgical characteristics

The demographic characteristics of the 28 patients in two groups are listed in **table 2**.

Table 2. Summary of Demographic, Clinical Data, and Treatment Level

Baseline Characteristic	3.7mm endoscopic (n=12)	6.9 mm endoscopic (n=16)	p value*
Femal sex (%)	4(33)	8(50)	(P>0.05)
Mean age (range), yr	40.3(24-79)	40.5 (29–81)	(P>0.05)
Mean duration of symptoms (range), wk	14 (7–48)	16 (3–39)	(P>0.05)
Indications for surgery			
Radiculopathy	12	16	(P>0.05)
Treatment level			
C4–C5 (%)	2(16)	1(6)	(P>0.05)
C5–C6 (%)	3(24)	4(25)	(P>0.05)
C6–C7 (%)	7(60)	10(63)	(P>0.05)
C7–T1 (%)	0(0)	1(6)	(P>0.05)

*****p value represents the statistical difference in the basic characteristics of patients between the 3.7mm and 6.9mm endoscopic, and $P>0.05$ indicated no statistically significant difference.

The surgical characteristics and complications are shown in **table 3**. The blood loss of both groups was negligible. The mean hospital stay did not show significant difference between the 3.7mm endoscopic and 6.9mm endoscopic. However, the mean surgical duration of the 3.7mm endoscopic was 76.5 minutes compared with 61.5 minutes for 6.9mm endoscopic (P<0.05). Moreover, there was significant difference with regard to average identification time of "V" point (18.608±3.7607min vs. 11.256±2.7161min, p<0.001) and mean removal time of overlying tissue (16.650±4.1730 min vs. 12.712±3.3079 min, p<0.05) **(Figure 12)** between 3.7mm endoscopic and 6.9mm endoscopic.

Table 3. Operative Characteristic and Postoperative Course

Surgical Characteristic	3.7mm endoscopic (n=12)	6.9mm endoscopic (n=16)	p value*
Mean surgical duration	76.5 (58–131)	61.5 (40–98)	(p<0.05)
Mean hospital stays (range), d	5.1 (2–8)	4.8 (3–6)	(P>0.05)
Total complications			
Dura injury	0	1	(P>0.05)
Postoperative headache	0	0	-
Repeated surgery	0	0	-
Postoperative hematoma	0	0	-
Neurological deterioration	0	0	-

***P value represents the statistical difference in the surgical characteristics of patients between the 3.7mm and 6.9mm endoscopic, P<0.05 was regarded as the threshold of significance.

Complications

One case suffered nerve root outer membrane injury in the 6.9mm endoscopic (1 of 16, 6.25%). However, there was no cerebrospinal fluid leakage during operation and no neurological deterioration postoperatively. There were no other severe surgical complications in both groups, such as carotid artery injury, recurrent laryngeal nerve injury, esophageal injury or infection. None of the 28 patients experienced recurrences in the follow-up.

Clinical Outcomes

All the 28 patients completed the follow-up visits. Two of 28 patients, one case in each group, had no significant pain relief at 12 months follow-up. The VAS scores **(Figure 13)** and the modified MacNab criteria **(Figure 14)** of 28 patients were evaluated pre- and postoperative. There were no significantly different on mean VAS score or outcomes evaluated using the modified MacNab criteria between 3.7mm endoscopic and 6.9mm endoscopic. In addition, no difference was found in complication between the two groups (P>0.05).

Follow-up

For all patients, follow-up was performed at 1 day, 1, 3, 6 and 12 months postoperatively. The VAS scores and the modified MacNab criteria were performed pre- and postoperatively to evaluate clinical outcomes. Cervical CT or MRI was performed on all the patients during follow up period.

Discussion

In 1944, Spurling et al. first described the effectiveness of p-PECD for the treatment of cervical foraminal stenosis which induced by a lateral CDH or osteophytes (32). Studies proved that p-PECD is an effective treatment for cervical diseases and its inner diameter of working cannula ranges from 3.7 mm to 6.9 mm (17, 22, 28). In our opinion, different diameters of the working cannula may lead to different surgical efficiency. However, no studies were performed to compare the clinical outcomes of 3.7mm endoscopic and 6.9mm endoscopic of p-PECD in CDH patients. In this study, we described the clinical results of 28 consecutive patients diagnosed with unilateral CDH who performed p-PECD using the 3.7mm endoscopic or 6.9mm endoscopic.

Anaesthesia

Studies suggested that local and general anaesthesias are the effective strategies of PECD (17, 22, 23, 33). Wan et al. (17) claimed that local anaesthesia in selected CDH patients is a promising and feasible alternative. However, local anaesthesia still has unavoidable shortcomings, such as uncomfortable and psychentonia during operation. Moreover, if the patient is awake, hearing the voice of the surgical instrument may cause elevated blood pressure, increased heart rate, and poor surgical experience (17). General anaesthesia has been described in several previous studies, which could offer patients a comfortable experience during p-PECD surgery (22, 23, 33).

In the present cohort, to minimize their intraoperative anxiety and pain and to attain their better cooperation, general anaesthesia was carried out in all patients. Besides, INM technology were used in this study to prevent iatrogenic neurological deterioration intraoperatively. The detailed method refers to Yu et al. (17, 34). No nerve compromise was observed in both groups postoperatively and we attribute these positive results to reasonable choice of anesthesia method and application of INM.

Clinical Results

The mean hospital stays of traditional posterior foraminotomy or ACDF in China usually more than seven days (23). In our study, the mean hospitalization of 6.9mm endoscopic and 3.7mm endoscopic were 5.1 (from 2 to 8) and 4.8 (from 3 to 6) days respectively, and both groups had an improvement compared with China average results. Since all the surgeries in this study were performed under general anesthesia, it took about 2 days to complete the preoperative examination and the assessment of the general condition in order to meet the standard of general anesthesia. Usually, patients were discharged 2 days after postoperative observation. Thus, the total length of hospital stay was about 5 days. However, there was no significant difference between 3.7mm endoscopic and 6.9mm endoscopic in the average hospital stay period (P>0.05). The longer operative times were required in 3.7mm endoscopic (76.5min) than 6.9mm endoscopic (61.5min), we suggest this result may because of the small-diameter working cannula can only accommodate smaller-diameter endoscopic instruments, such as RF probe, forceps and drill, which obviously limits the efficiency of “V” point identification, overlying soft tissue removal and laminoforaminotomy.

On the basis of previous surgical experience (23, 35, 36), the average VAS score after surgery was significantly lower for both endoscopes, however, the difference in the average VAS scores between 3.7mm endoscopic and 6.9mm endoscopic was not significant (P>0.05). Meanwhile, considering to the modified MacNab criteria, the proportion of having a satisfied result (excellent or good recovery) improved during follow-up visit in both endoscopes, nevertheless, the difference between 3.7mm endoscopic and 6.9mm endoscopic was not significant (P>0.05). Therefore, the clinical outcomes of both endoscopes were similarly effective.

Operation Technique (Table 4)

Identification of “V” point

Identification of V-point is an extremely critical operation step, which dominates the success or failure of the p-PECD surgery. Furthermore, accuracy and rapid confirming V-point can provide sufficient confidence for the surgeon to proceed with the next step. In our study, identification of V-point was easier in the 6.9mm endoscopic than 3.7mm endoscopic (18.608±3.7607min vs. 11.256±2.7161min, p<0.001), which may be attributed to a large diameter of working cannula in the 6.9mm endoscopic.

Potential of spinal cord injury

In this study, neither the 3.7mm nor 6.9mm endoscopic had a surgical complication of spinal cord damage. However, our correspondence author argues that 3.7mm endoscopic has a higher risk of spinal cord injury than 6.9mm endoscopic. The minimal working cannula of 3.7mm endoscopic has a danger of trapping into the spinal canal through the iatrogenic hole and damaging the spinal cord. Meanwhile, 6.9mm endoscopic has a wide enough outer surface of working cannula to prevent negligently inserting into the spinal canal, which increases the safety of the operation. This idea was also agreed by Lin et al. (20), who suggested that increasing outer diameter of the working cannula can reduce the risk of spinal cord injury.

Anterior decompression

3.7mm endoscopic is better than 6.9mm endoscopic for anterior decompression of the intervertebral foramen due to its smaller outer diameter of working cannula which reduces the compression of the spinal cord. In contrast, through the delta working channel, which has a large inner diameter, may lead to spinal cord injury.

Table 4. Comparation of 3.7mm endoscopic and 6.9mm endoscopic in Surgical Characteristic*		
Parameter	3.7mm endoscopic	6.9mm endoscopic
Incision	Short	Long
Identification of “V”Point	Slow	Fast
Removal of overlying soft tissue	Slow	Fast
The efficiency of laminoforaminotomy	Slow	Fast
Operation time	Slow	Fast
Anterior decompression	Easy	Hard
Possiblity of spinal cord injury	High	Low

***** Represents the author's own view of the differences in surgical characteristics between groups 3.7mm and 6.9mm.

Complications

Surgical related complications, including headache, neck pain, dural damage, nerve roots or spinal cord injury, seizures or neurological deterioration due to the highly increased cervical epidural pressure by continuous saline irrigation, intraoperative bleeding or postoperative epidural bleeding, instability caused by surgical and infections, could happen in p-PECD for CDH patients (13, 23).

In 2007, Ruetten et al. (22, 30) described a rate of 3% of complications in 89 patients in p-PECD, and in 2008 he reported three postoperatively complications of transient, dermatoma-related hypesthesia. In 2009, Joh et al. (37) demonstrated that 8 of 28 patients complained of neck pain caused by the increased pressure of continuous irrigation system in a prospective study. In 2014, Yang et al. (23) observed a transient pain of the contralateral side in one patient, which due to excessive operation of the myelon, and concluded an incidence of 4.8% (2/42) in patients underwent p-PECD. In 2018, Wu et al. (27) reported that two patients suffered the bluntness of the pupillary light reflex, loss of consciousness, muscle weakness of extremities and weak spontaneous respiration in p-PECD under local anaesthesia. C6 lamina was perforated with the spinal needle, which lead to anaesthetics went through the iatrogenic hole and entered subarachnoid space.

In the present cohort, nerve root outer membrane was torn in one case in the 6.9mm endoscopic, but there was no cerebrospinal fluid leakage during operation and no neurological deterioration postoperatively. No other surgical complications were observed in both groups. The overall incidence of surgical complication in our study was 3.7% (1/28), and this result is similar to previous studies (22) (23).

Limitation

Despite positive clinical outcomes were achieved in this study, there were still many limitations. The limitations of our study include the small sample sizes, the lack of randomization, the use of single surgeon, the deficiency of multicenter research and the comparably short-term follow-up period. Therefore, multicenter randomized controlled trials with large sample size and long-term follow-up visit should be established.

Conclusions

In the present study, the clinical outcomes between the two endoscopes did not differ significantly. 3.7mm endoscopic and 6.9mm endoscopic have their respective advantages. When considering "V" point determination, overlying soft tissue removal and spinal cord injury prevention, 6.9mm endoscopic may be preferable. However, 3.7mm endoscopic may be a better option for anterior decompression of the intervertebral foramen. Overall, p-PECD, including 3.7mm endoscopic and 6.9mm endoscopic, is reliable alternative management of CDH.

Abbreviations

CDH
Cervical disc herniation
p-PECD
Posterior percutaneous endoscopic cervical discectomy
VAS
Visual analogue scale
ACDF
Anterior cervical decompression and fusion
a-PECD
Anterior percutaneous endoscopic cervical discectomy
INM
Intraoperative neurological monitoring

Declarations

Ethical approval and consent to participate

Patient has provided informed consent for publication of the case. This report was approved by the ethics committee of the Second Hospital of Jilin University, Changchun, China.

Consent for publication

We have obtained consent to publish from the participant to report individual patient data.

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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No funding was provided for this study.

Authors' contributions

TY, JPW, and QYL participated in the study design and surgery; JZ and HCY participated in surgery and radiographic outcome assessment. TY and JPW collected all data. Data analysis was performed by TY under supervision of QYL. All authors contributed in reviewal and interpretation of data. The manuscript was drafted by TY, reviewed by all authors and revised with contributions from all authors under supervision and final revision of QYL. QYL was responsible for the integrity of the work from inception to finished article. All authors read and approved the final manuscript.

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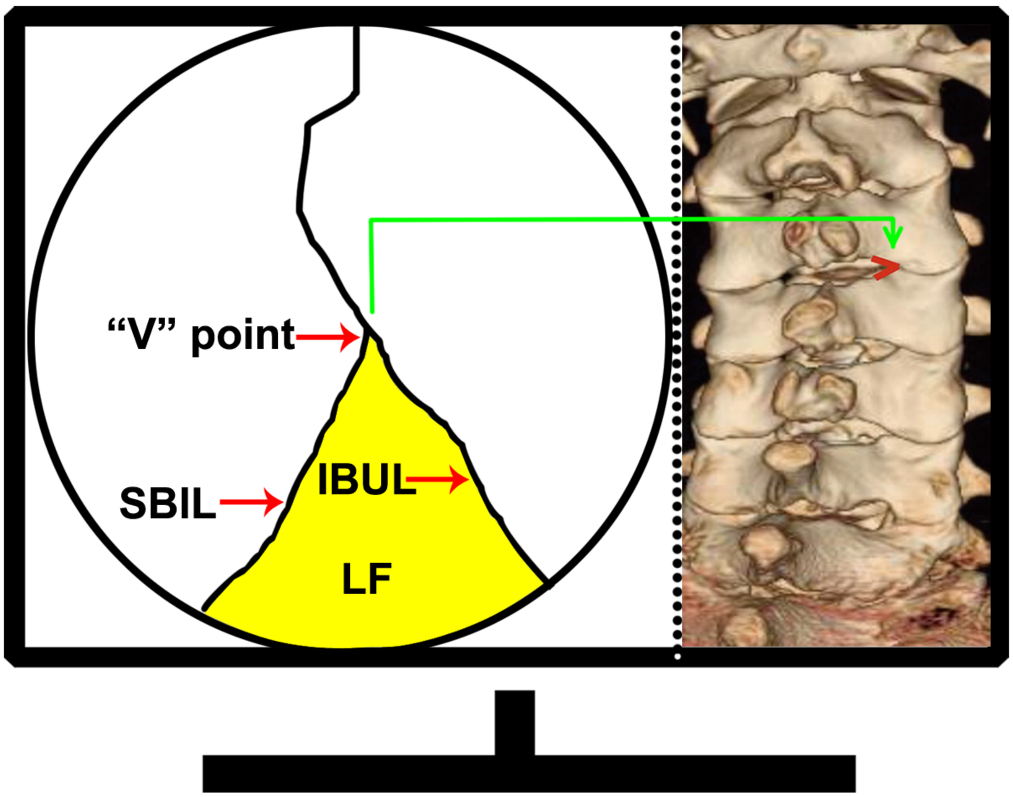
Figures



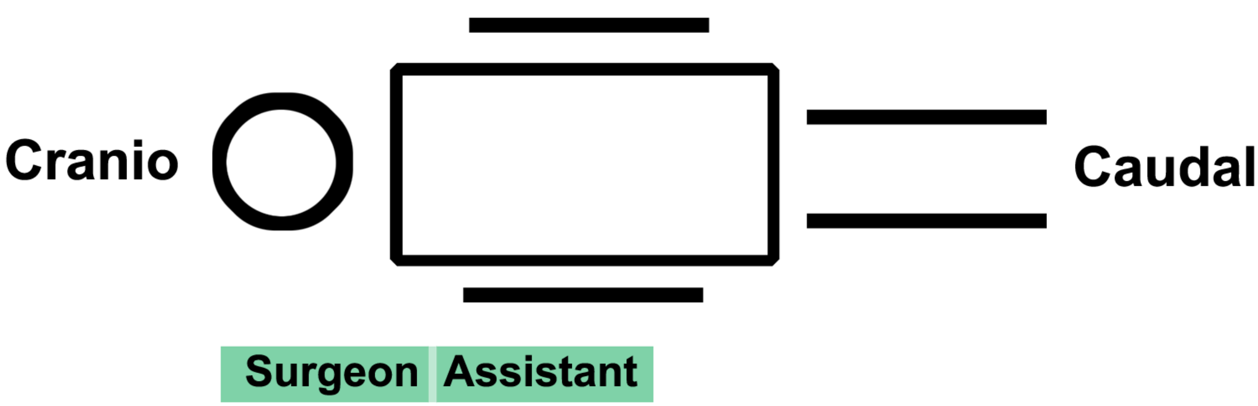


Figure 1

The patient was placed in a prone position. The surgeon and assistant manipulate on the same side of the pathology, while the endoscopic display was placed on the opposite side. SBIL indicates superior border of the inferior laminae; IBUL, inferior border of the upper laminae; LF, ligamentum flavum.

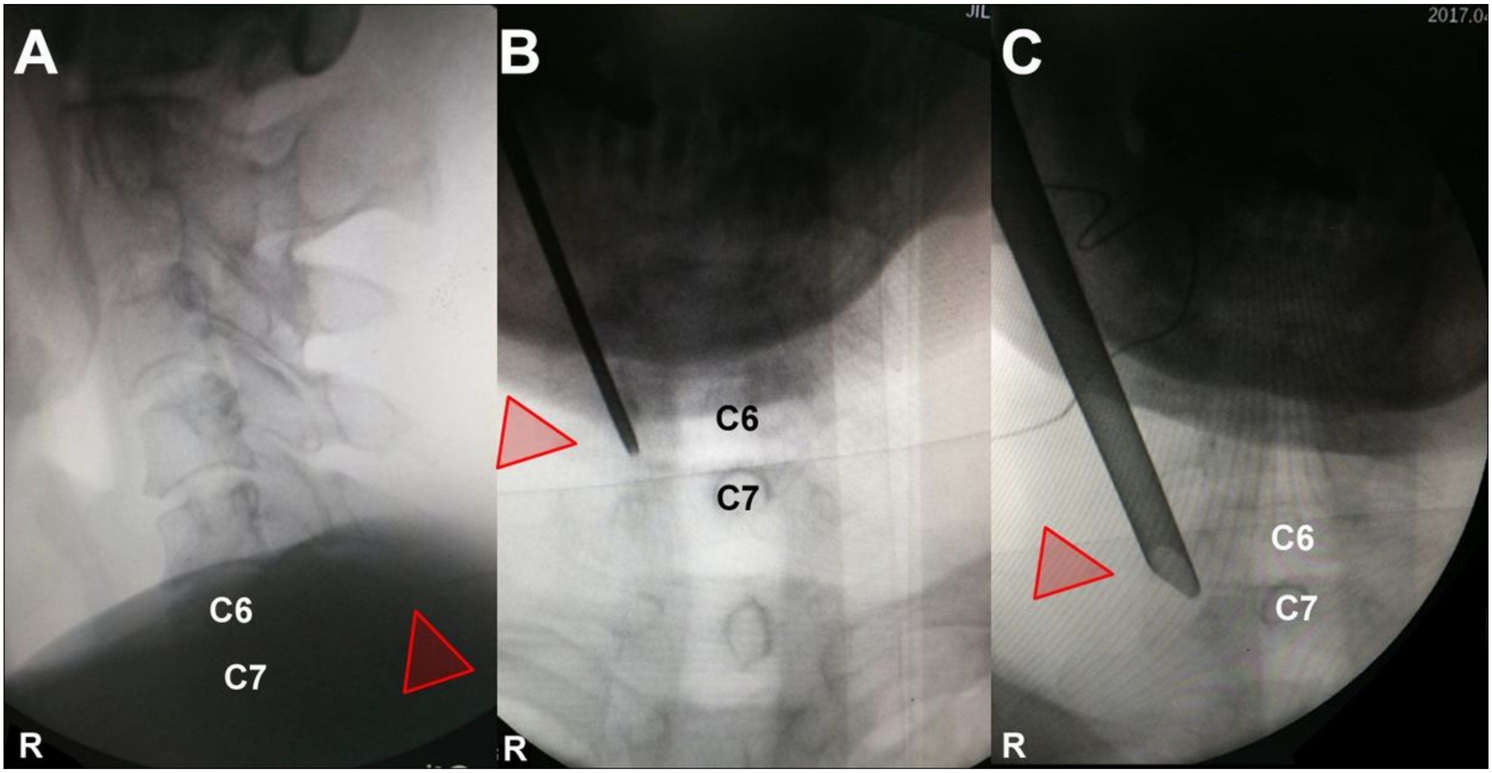


Figure 2

Intraoperative fluoroscopic images during p-PECD with 6.9mm endoscopic. (A) The lamino-facet junction is localized on anteroposterior view; (B) obturator is placed in the "V" point; (C) the working cannula is located over the "V" point.

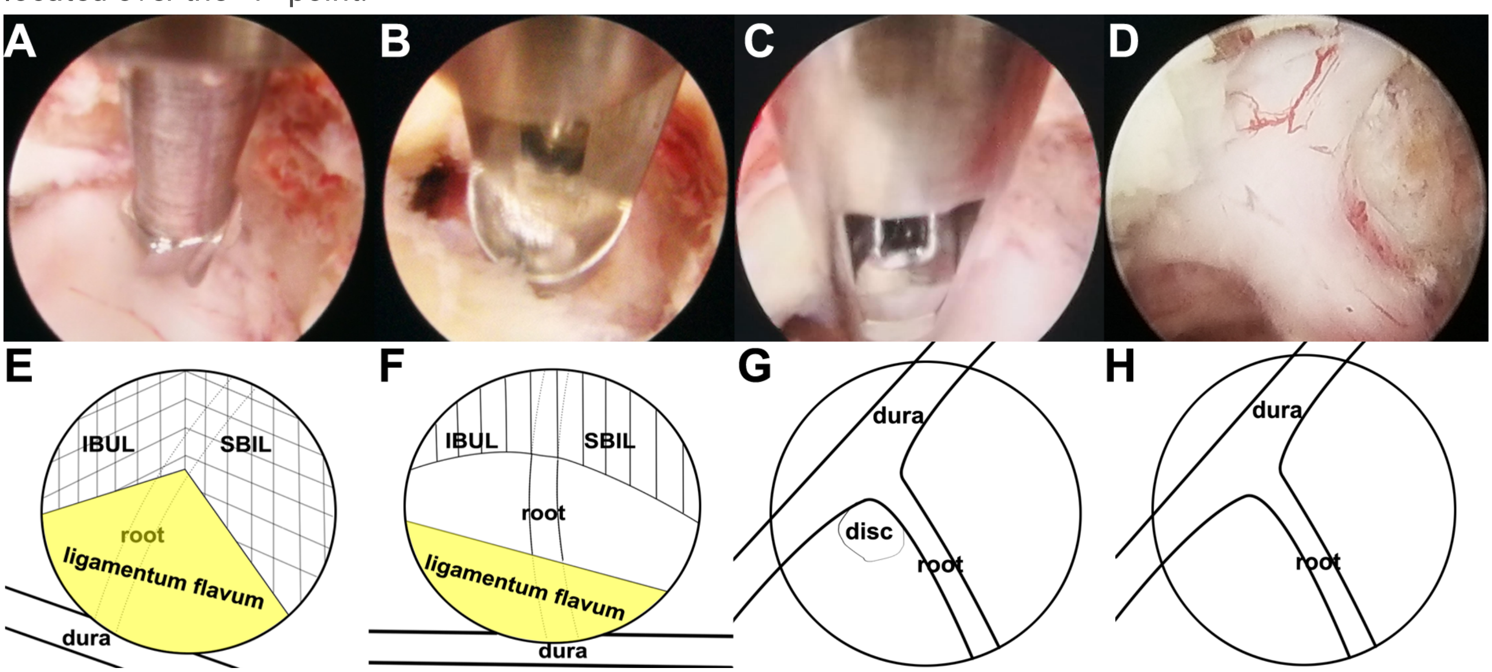


Figure 3

Intraoperative endoscopic images during p-PECD with 3.7mm endoscopic. (A) Endoscopic drill was used for performing the laminoforaminotomy; (B) removal the ligamentum flavum; (C) removing herniated disc through the axilla of the exiting nerve root (C) Intraoperative view after resection of the herniation and free C7 nerve; (E-H) represents (A-D), respectively. SBIL indicates superior border of the inferior laminae; IBUL, inferior border of the upper laminae; LF, ligamentum flavum.

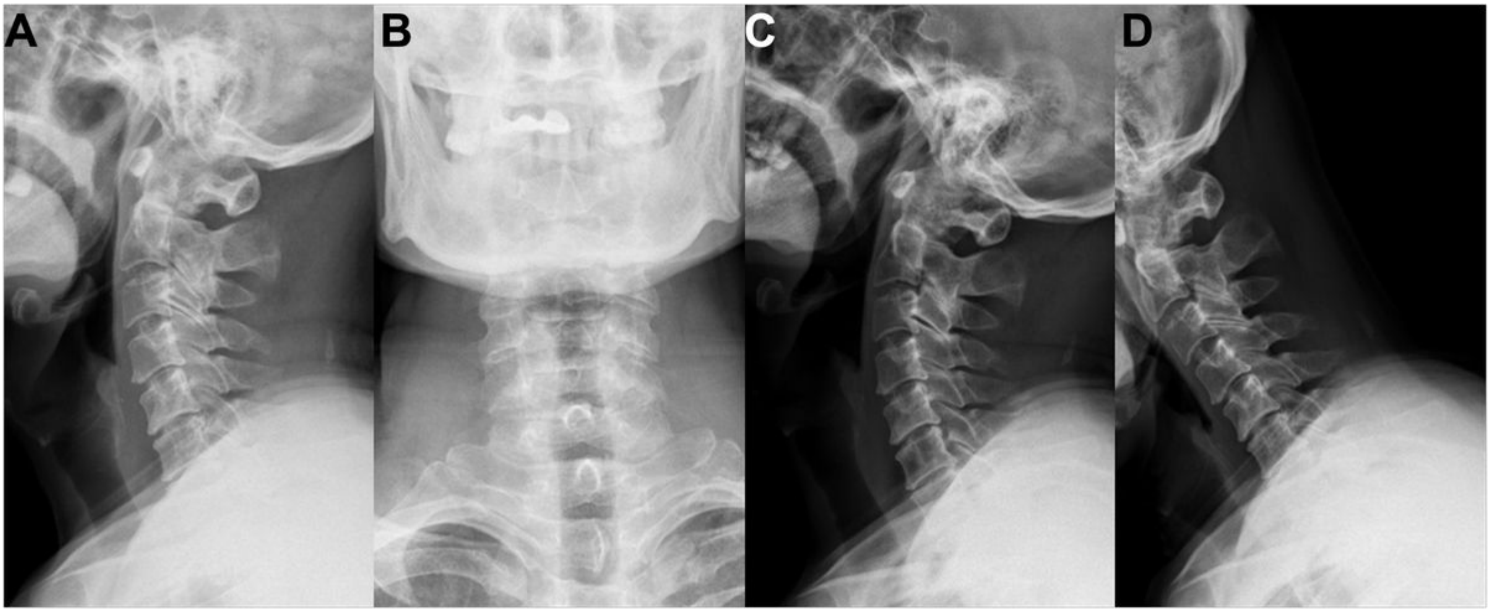


Figure 4

(A) The anteroposterior; (B) lateral and (C-D) dynamic cervical radiographs preoperatively.

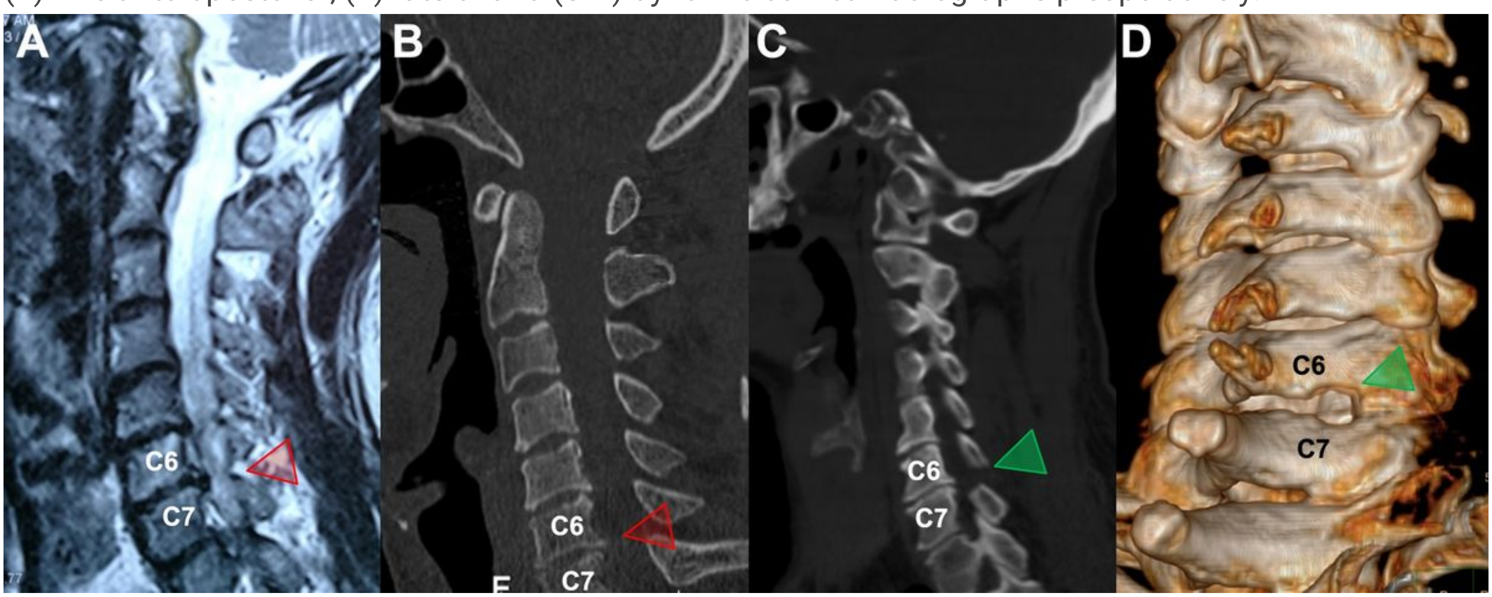


Figure 5

Pre- and postoperative cervical radiographs. (A) Red arrow in preoperative MRI demonstrates C6-C7 cervical disc herniation; (B) Preoperative sagittal CT image; (C) CT image after surgery; (D) Postoperative view of a 3D reconstruction of the keyhole decompression field (green arrow), which preserved most of the facet joint.

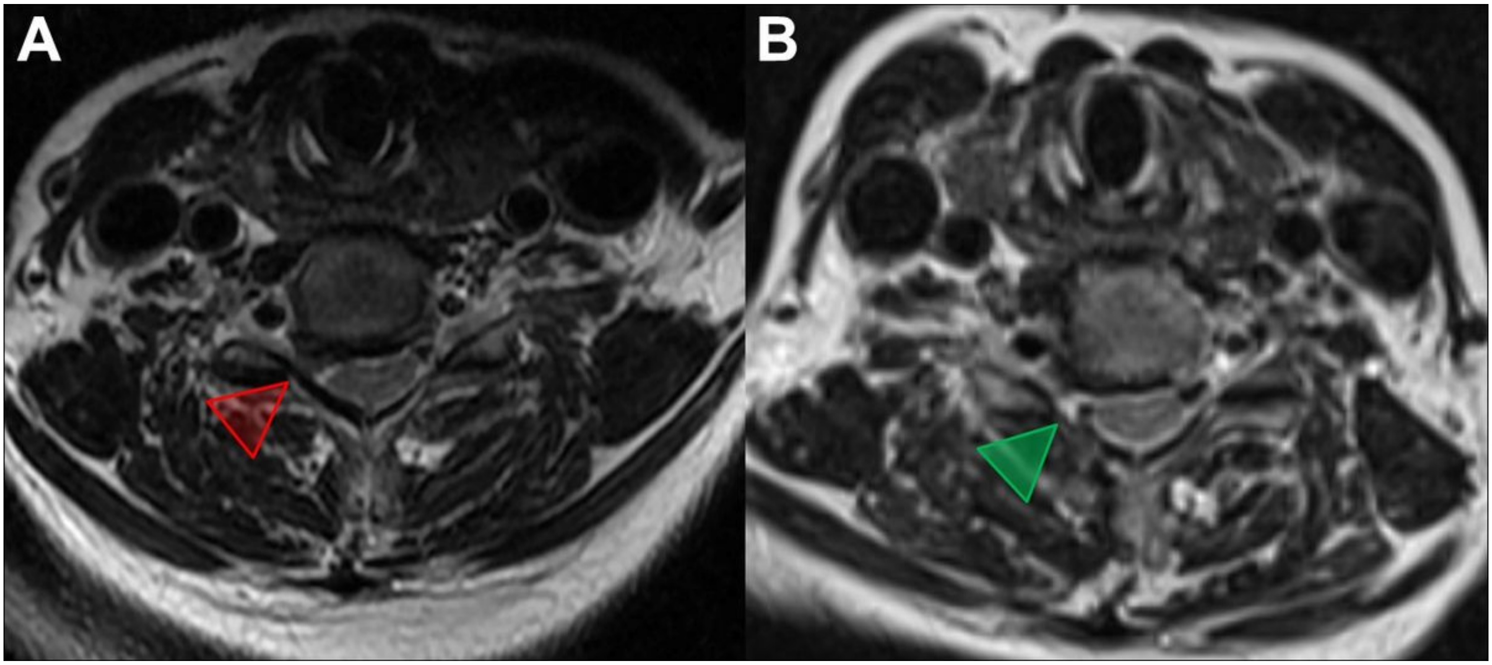


Figure 6

Pre- and postoperative C6-C7 MRI in axial view. (A) Red arrow demonstrates C6-C7 cervical disc herniation; (B) Green arrow indicates that C7 nerve root compression was removed.

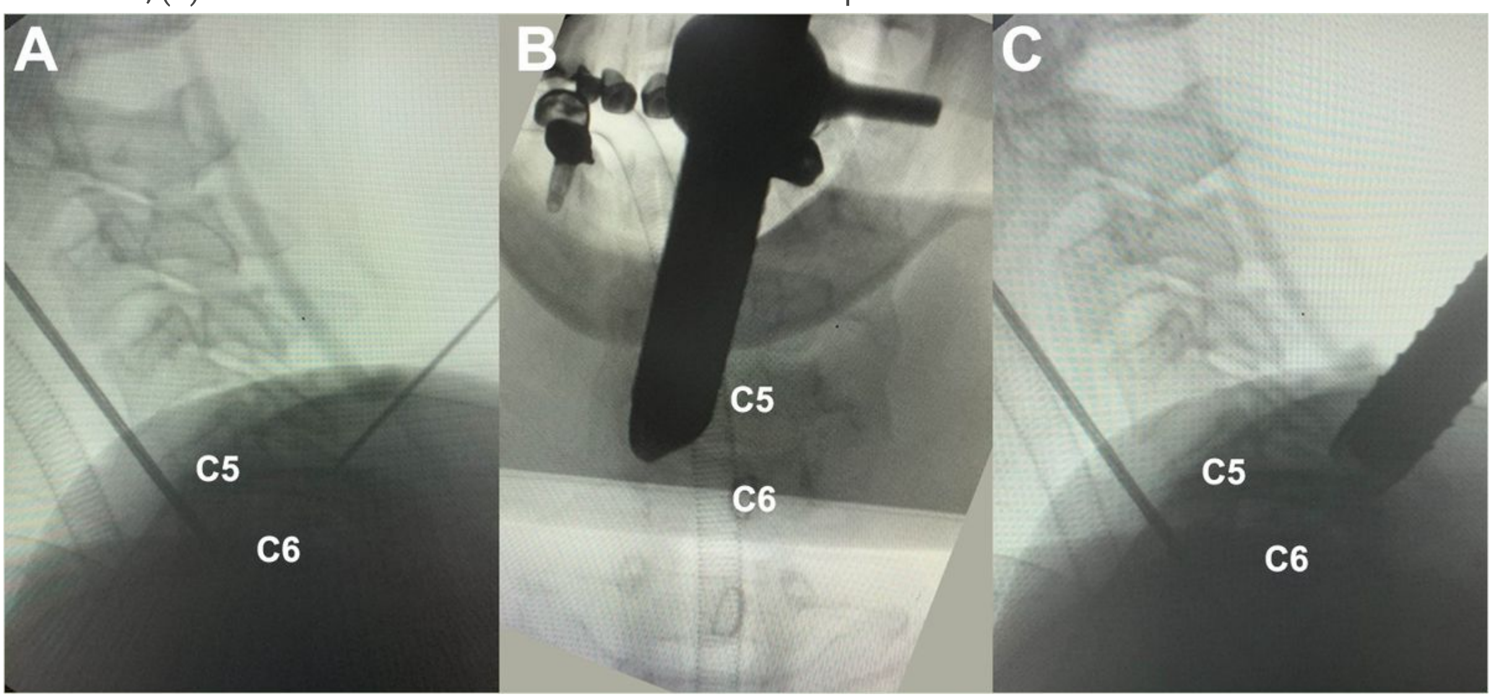


Figure 7

Intraoperative fluoroscopic images during p-PECD with 6.9mm endoscopic. (A) The C5-C6 level was localized on lateral view; (B-C) the working cannula is located over the “V” point on radiographs.

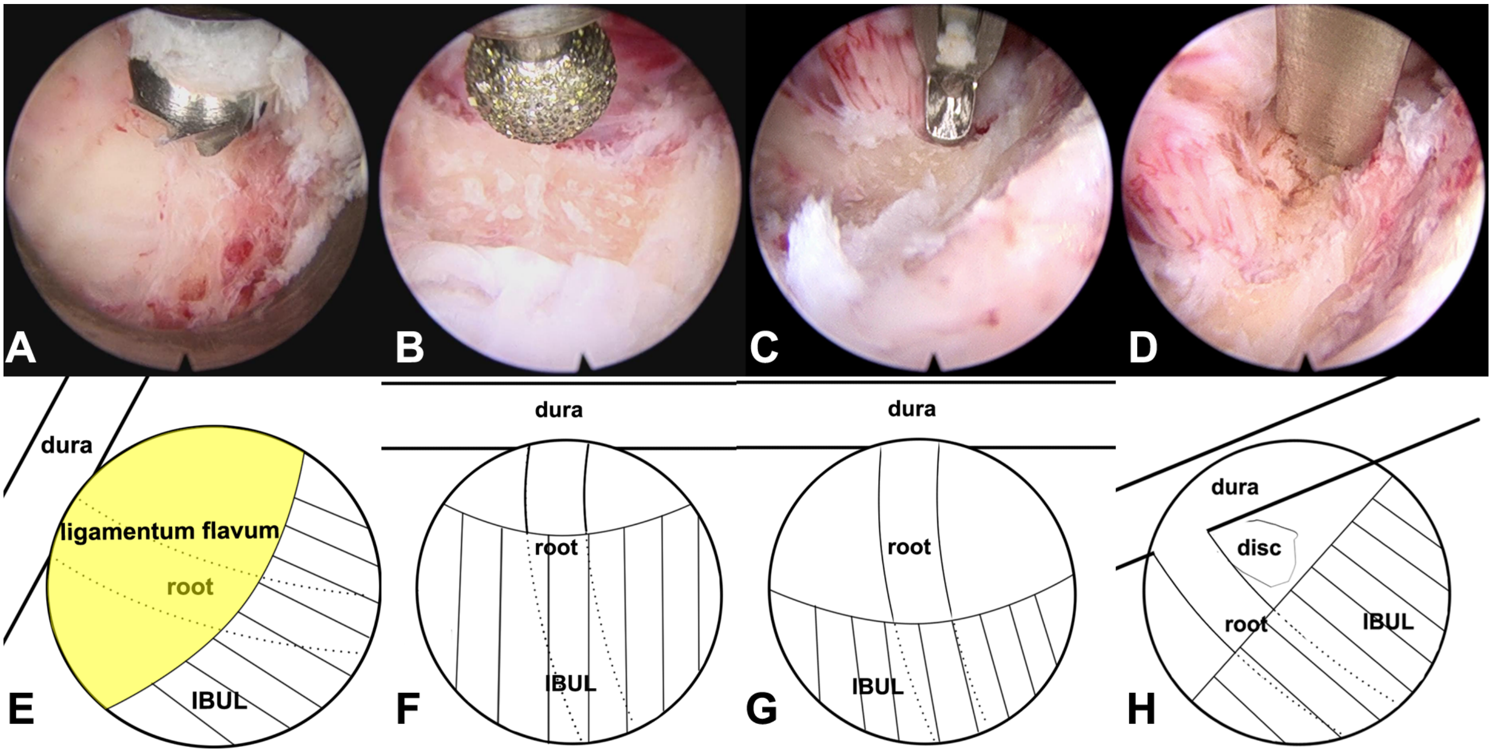


Figure 8

Intraoperative endoscopic images during p-PECD with 6.9mm endoscopic. (A-B) removal IBUL with different endoscopic drill tips; (C) removal IBUL with endoscopic forcep; (D) Intraoperative view of dissecting herniated disc through the axilla of the exiting nerve root; (E-H) represents (A-D), respectively. IBUL, inferior border of the upper laminae.

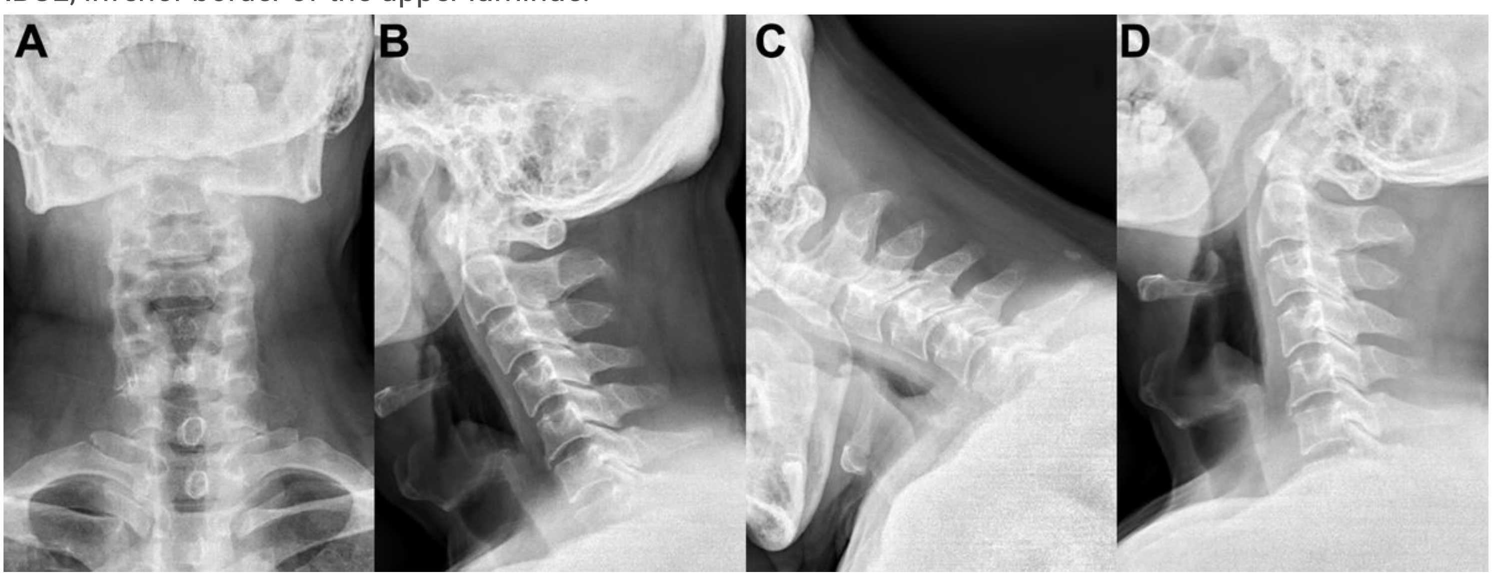


Figure 9

(A) The anteroposterior; (B) lateral and (C-D) dynamic cervical radiographs preoperatively.

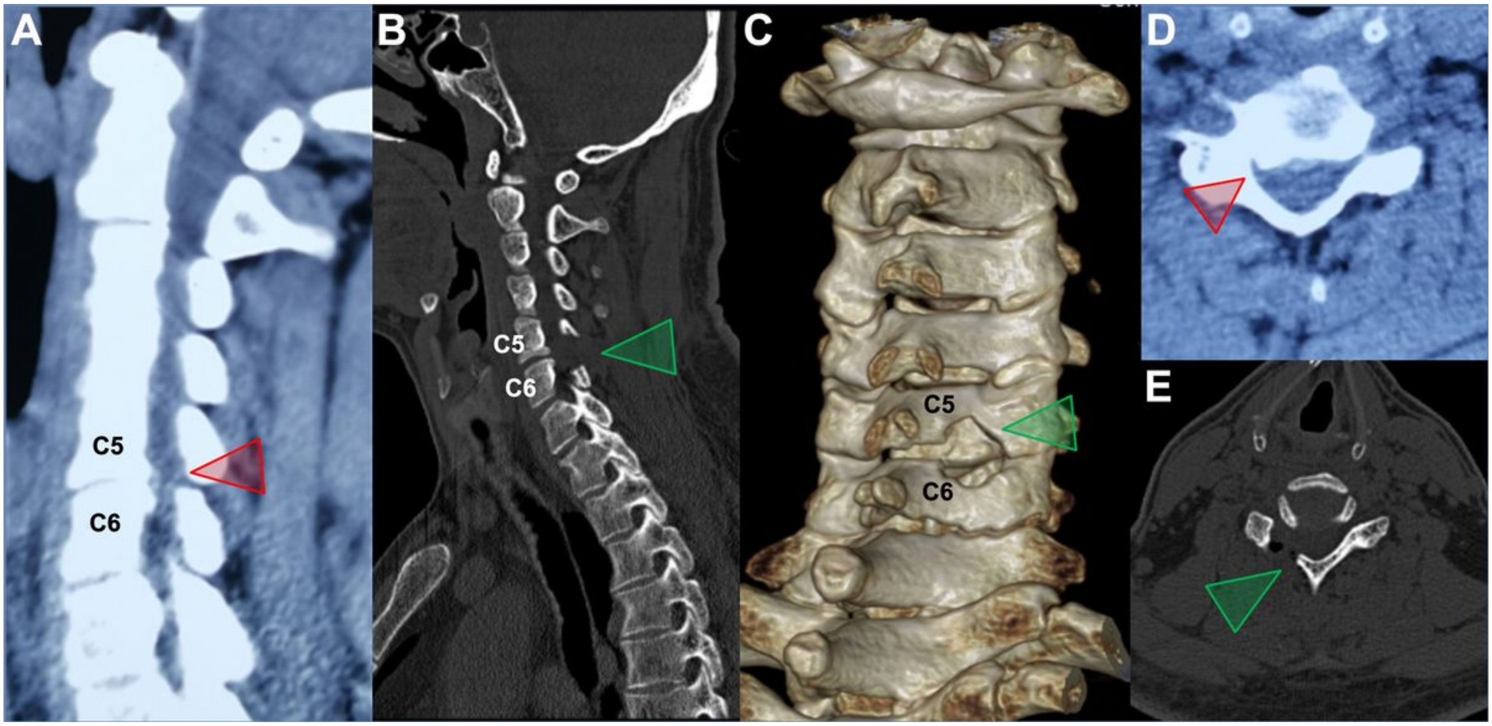


Figure 10

Pre- and postoperative CT images. (A, D) Red arrow demonstrates C5-C6 cervical disc herniation; (B, C, E) green arrow indicates the delta decompression field.

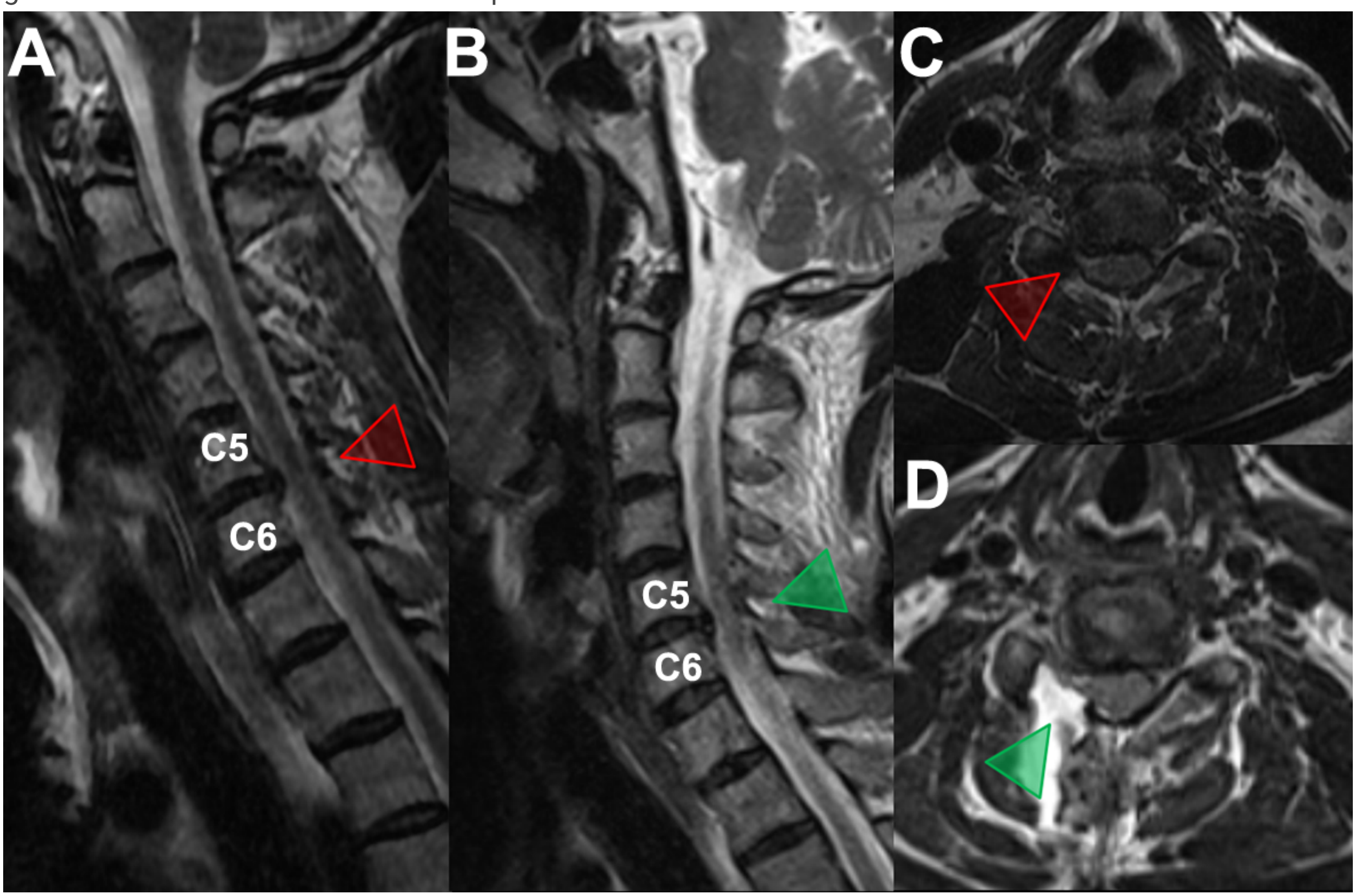


Figure 11

(A, C) Pre- and (B, D) postoperative MRI images.

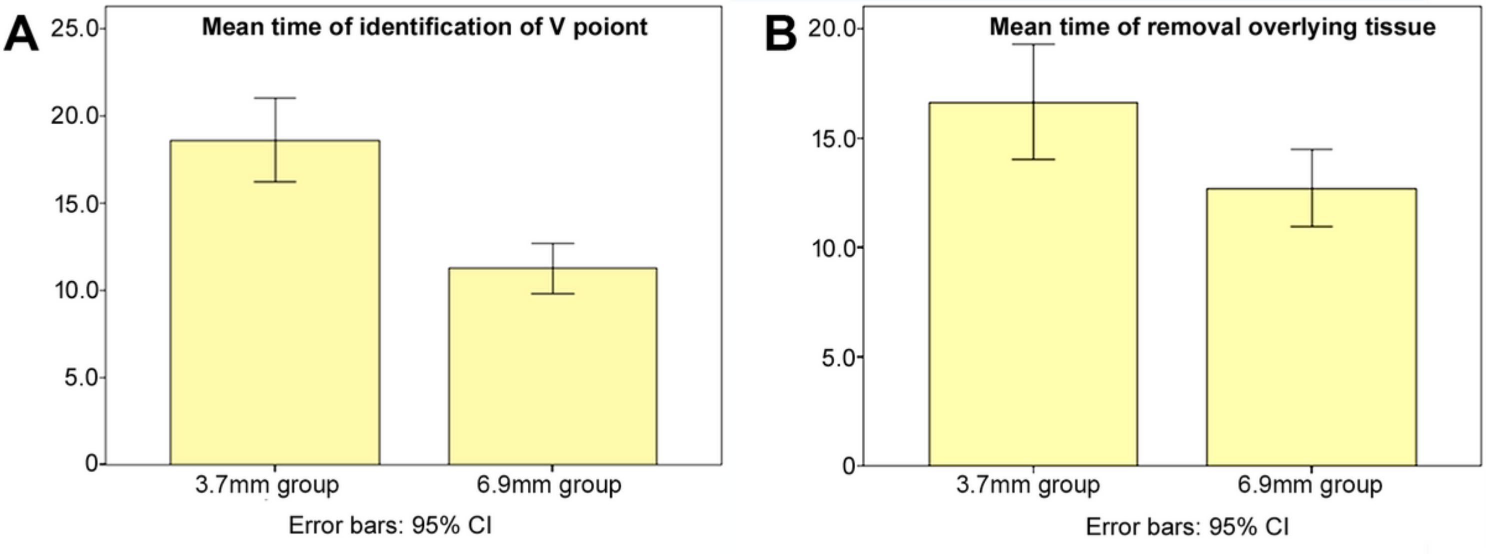


Figure 12

(A) The mean time of “V” point identification in 3.7mm endoscopic and 6.9 mm endoscopic was compared; (B) The mean time of removed overlying tissue in 3.7mm endoscopic and 6.9 mm endoscopic was also compared.

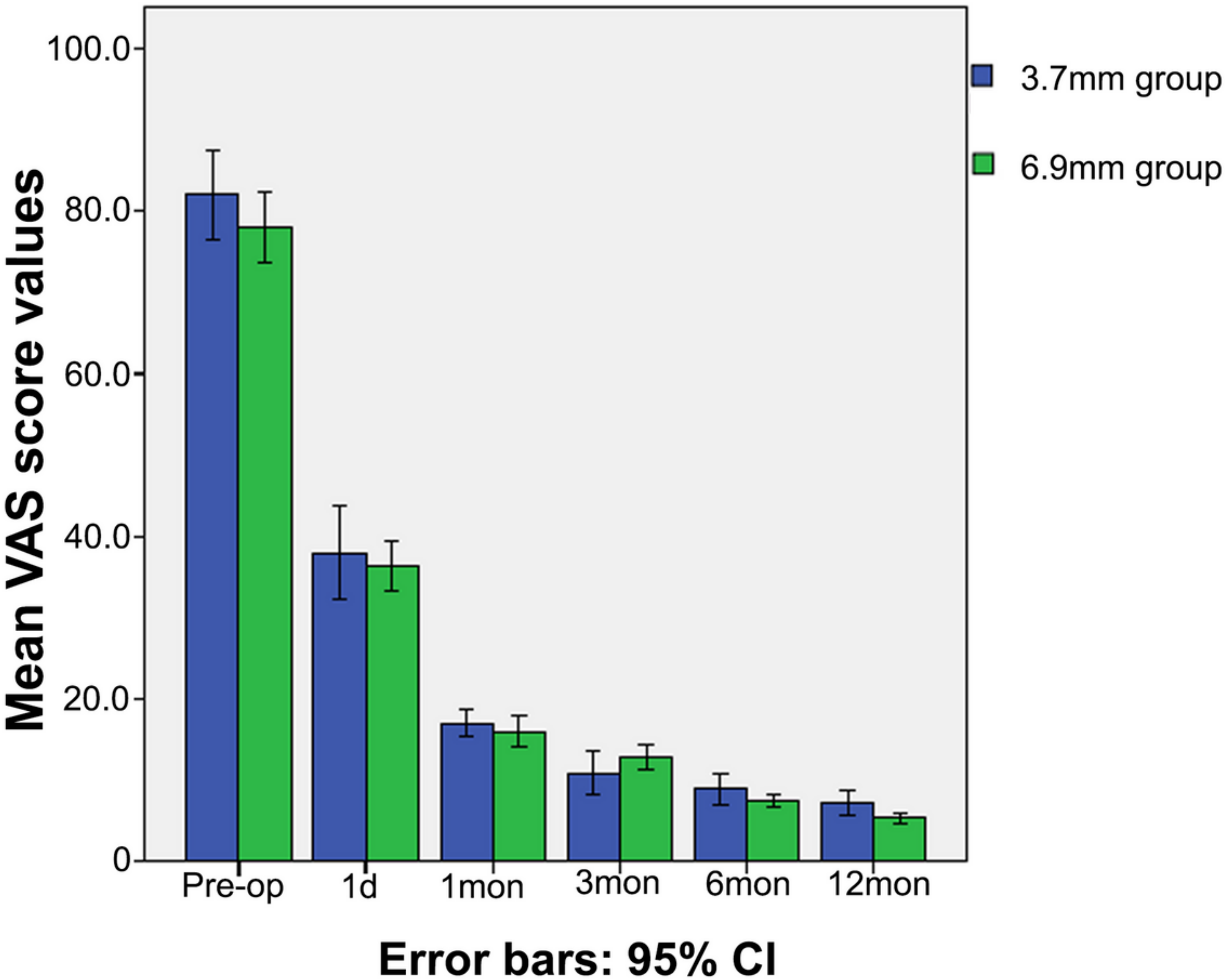


Figure 13

The course of the arm and neck pain in both groups, which was rated using the mean visual analogue scale values.

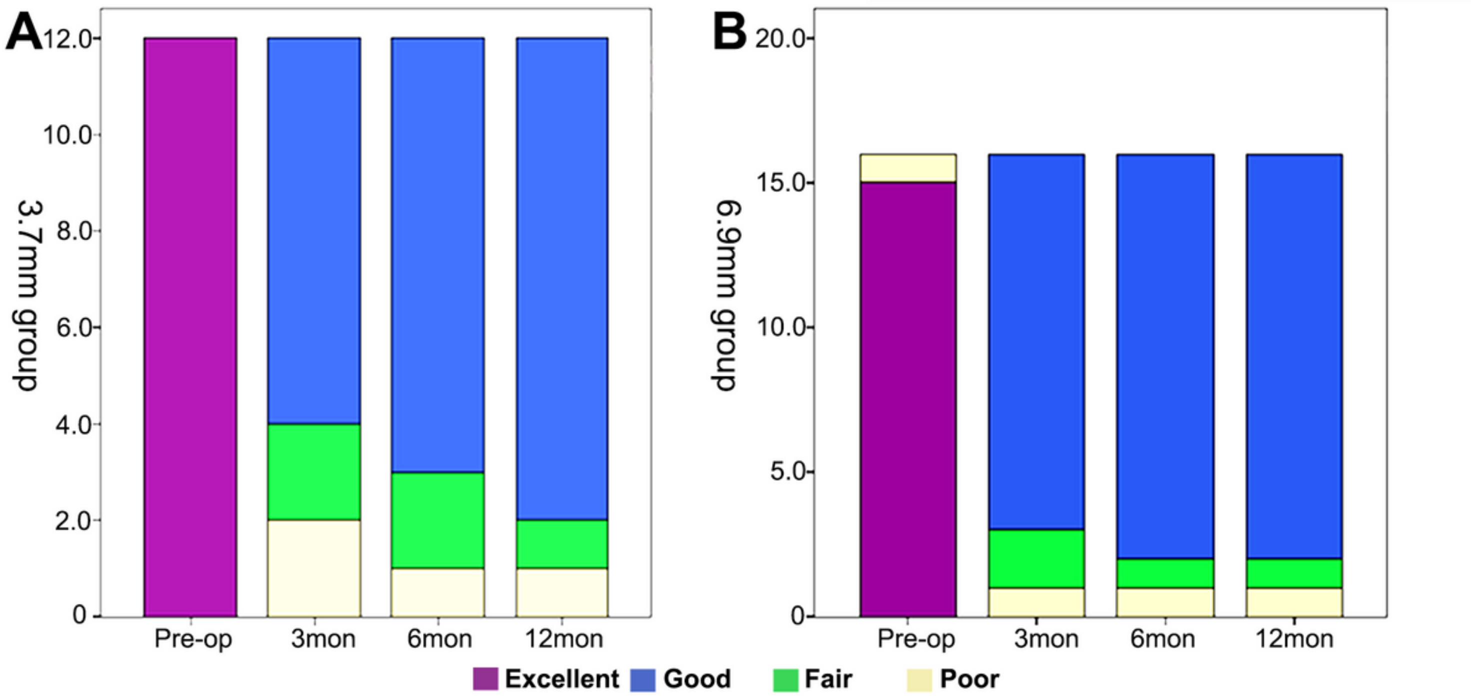


Figure 14

The clinical results of the (A) cervical discectomy with 3.7mm endoscopic and (B) cervical discectomy with 6.9mm endoscopic according to the modified MacNab criteria.