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# Full Endoscopic Key Hole Technique for Cervical Foraminal Stenosis: Is Mere Dorsal Decompression Enough?

*Chuan Guo, Lifeng Zhang, Qingquan Kong, Yu Wang, Jin Yang, Yuqing Yan, Hao Wu, Zhiyu Peng*

■ OBJECTIVE: **To study whether and when mere dorsal decompression is enough in the full endoscopic key hole technique for foraminal stenosis.**

■ METHODS: **We retrospectively reviewed a total of 22 patients with cervical foraminal stenosis who underwent full endoscopic key hole mere dorsal decompression in our institute from October 2016 to October 2017.**

■ RESULTS: **Preoperative neck disability index, neck visual analog scale score, and arm visual analog scale score were $25.8 \pm 0.8$, $4.9 \pm 0.6$, and $7.5 \pm 0.5$ in the group. Immediate postoperative scores were $6.9 \pm 0.9$, $1.3 \pm 0.9$, and $1.4 \pm 0.5$. Follow-up scores at 3 months ($7.0 \pm 0.9$, $1.9 \pm 0.6$, and $2.7 \pm 0.9$), 6 months ($7.3 \pm 0.9$, $2.1 \pm 0.9$, and $1.9 \pm 0.5$), and 12 months ($7.6 \pm 0.5$, $2.5 \pm 0.8$, and $2.1 \pm 0.7$). The symptoms had improved significantly ($P < 0.05$). According to the Macnab criteria, 15 patients reported excellent results, 2 reported good results, and 2 reported fair results at the 12-month follow-up.**

■ CONCLUSIONS: **Stenosis is mainly caused by dorsal structures; mere dorsal decompression is enough. In both cases, the ventral and dorsal structures contributed to the stenosis. When there is no herniated soft fragment contributing to the stenosis, ventral decompression is not always necessary. If intraoperative exploration detects less tension formed by the ventral abnormal structures, mere dorsal decompression is enough to settle the symptoms.**

## INTRODUCTION

Narrowing of the foramina on films is often observed, however, only when the nervous system symptoms include pain, numbness, and weakness a cervical foraminal stenosis is diagnosed. The incidence of radicular pain and radiculopathy was reported as 83 per 100,000 in a population between ages 13 and 91 years, and most were found to be aged 50 to 54 years. Further, C7 was the most frequently involved level that accounts for 45%—60% of the cases.[1]

Congenital and secondary factors cause the disproportion of the foramen. The disproportion of the foramen and nerve root caused the symptoms. Ventral compression is mainly attributed to disc bulges or herniations, and osteophytes and motor-neurons are often affected. Dorsal compression mainly results from metamorphic facets, ligamentum flavum, and the sensory-neurons are often affected. Since cervical nerve roots exit spinal cord 4—8 mm below the inter-vertebral disc level and locates in the inferior portion of foramen, nerve roots are well protected and less likely to be compressed by herniated discs,[2,3] in which hypertrophy and ossification of the zygopophysis facet and ligament flavum is often the pathogenic factor. Mechanical compression and pulposus irritation of the nerve root cause the inflation process and changes in ion-channel functioning, which eventually cause the hyperexcitability and spontaneous ectopic activity in the dorsal nerve root ganglion.[1,5]

Park et al.[5] developed a grading system based on oblique sagittal magnetic resonance imaging (MRI). According to the obliteration of the perineural flat and morphologic changes, cervical foraminal stenosis is graded from grade 1—3. Further, Kim et al.[6] described a grading system based on axial MRI images. According to the flexibility of the nerve root by comparing the width of the narrowest foramen with the width of the extraforaminal nerve

**Figure 1.** A 60-year-old man complained of pain and numbness in both upper limbs. (**A** and **B**) Preoperative x-ray shows the degenerative changes of the cervical spine. (**C** and **D**) In the function part, there is no instability. (**E** and **F**) Oblique x-ray shows bilateral foraminal stenosis.
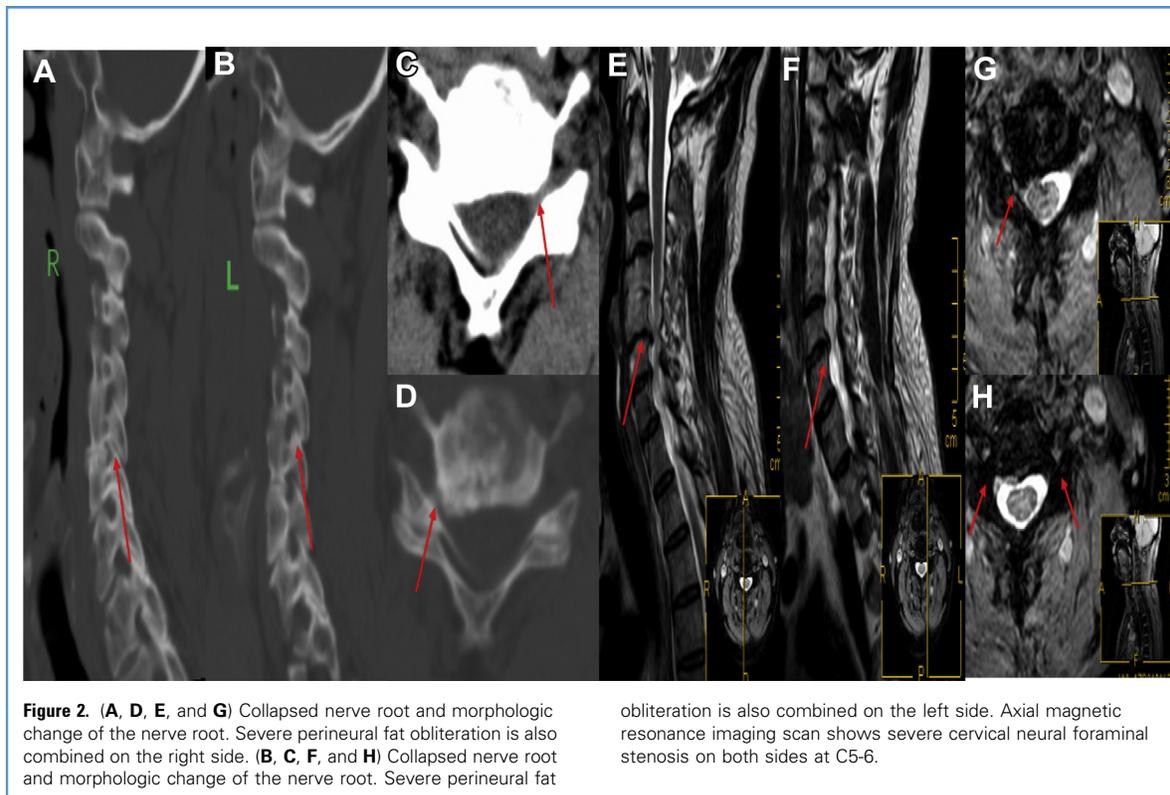
root, cervical foraminal stenosis is graded from 0—2.[6] Park et al.[7] confirmed the moderate to high clinical correlation of the grading system. Symptoms can be mild, moderate, and severe. However, severe radiographic stenosis does not necessarily reflect severe symptoms.[8-11]

Surgery is recommended for patients suffering from weakness, amyotrophy, failure of 3—6 months of conservative treatment, fluctuations in symptoms, and if normal life is seriously affected.

Key hole was introduced by Scoville in 1966. At the beginning, foraminotomy was performed through the open approach, however, it was later performed under microscopic visualization to minimize damage. In 2002, it was performed under endoscope and verified to be sufficient and safe for the laterally herniated disc.[12] The full endoscopic key hole technique avoids the overloading of the adjacent segments and the extensive dissection of the paraspinal tissues. Moreover, a steep learning

Figure 2. (**A**, **D**, **E**, and **G**) Collapsed nerve root and morphologic change of the nerve root. Severe perineural fat obliteration is also combined on the right side. (**B**, **C**, **F**, and **H**) Collapsed nerve root and morphologic change of the nerve root. Severe perineural fat obliteration is also combined on the left side. Axial magnetic resonance imaging scan shows severe cervical neural foraminal stenosis on both sides at C5-6.

curve and radiation exposure can be compensated for by the development of the navigation technique.[13,14]

The "V" point was described by Kim et al.[15] as the central point on sagittal image and the lateral border on coronal image of foraminotomy. Using the full endoscopic key hole technique to settle the compression from the ventral side is challenging. Since settling osteophytes on the ventral side of nerve roots will increase the risk of nerve root damage, exploring the effect and safety of mere dorsal decompression is necessary, therefore, will indirect decompression be enough for ventral compression? When is mere decompression enough?

## METHODS

We retrospectively reviewed a total of 22 patients who suffered cervical foraminal stenosis and underwent full endoscopic key hole mere dorsal decompression in our institute from October 2016 to October 2017. Consent was obtained from the patients for the acquisition of their medical information.

In cases foraminal stenosis is mainly caused by dorsal structures (**Figures 1** and **2**), mere dorsal decompression is performed. In cases in which both the ventral and dorsal structures contribute to the stenosis, when there is no herniated soft fragment and intraoperative exploration detects less tension formed by the ventral osteophytes, dorsal decompression and ventral release of the nerve root is performed.

Preoperative and postoperative x-ray, computed tomography, and MRI of the cervical spine were acquired. Follow-up evaluations were performed in the outpatient clinic. Neck disability

index (NDI) and visual analog scale (VAS) scores for the neck and upper extremities were documented preoperatively. The information described earlier was obtained at 3, 6, and 12 months postoperatively and the Macnab score was acquired at the last follow-up. The operation time and the blood loss were recorded.

### Procedure

All of the instruments were manufactured by Spinendos GmbH (München, Germany). After general anesthesia, patients were placed prone on a radiolucent frame equipped with a chest bar. Important organs such as eyes and genitals were carefully protected by compression-free devices. The neck was mildly flexed and retracted. The arms were positioned caudal on the lateral body and immobilized with adhesive tape. No neuromonitoring was used. After the location of the target interspinal interstice, a 7 mm incision of the skin and facia was made on the lateral edge of the spinous process. An 18-gauge spinal needle was introduced to the facet joint area; C-arm confirmed the location of the tip (**Figure 3**). A K-wire was inserted, a sequence of dilators were bluntly inserted, and an oblique working channel (Spinendos GmbH, length 178 mm, outer diameter 7.5 mm, and inner diameter 6.5 mm) was then established. Next, the endoscope (Spinendos GmbH, length 181 mm, outer diameter 6.3 mm, inner diameter 3.75 mm, visual field angle 80°, visual direction angle 30°) was placed. Further operation was performed under visual control and continuous irrigation with 0.9% saline solution. Following the cleaning of the soft tissues on the joint by a radio-frequent coagulation, the margins of the superior and inferior lamina were identified. Some of the
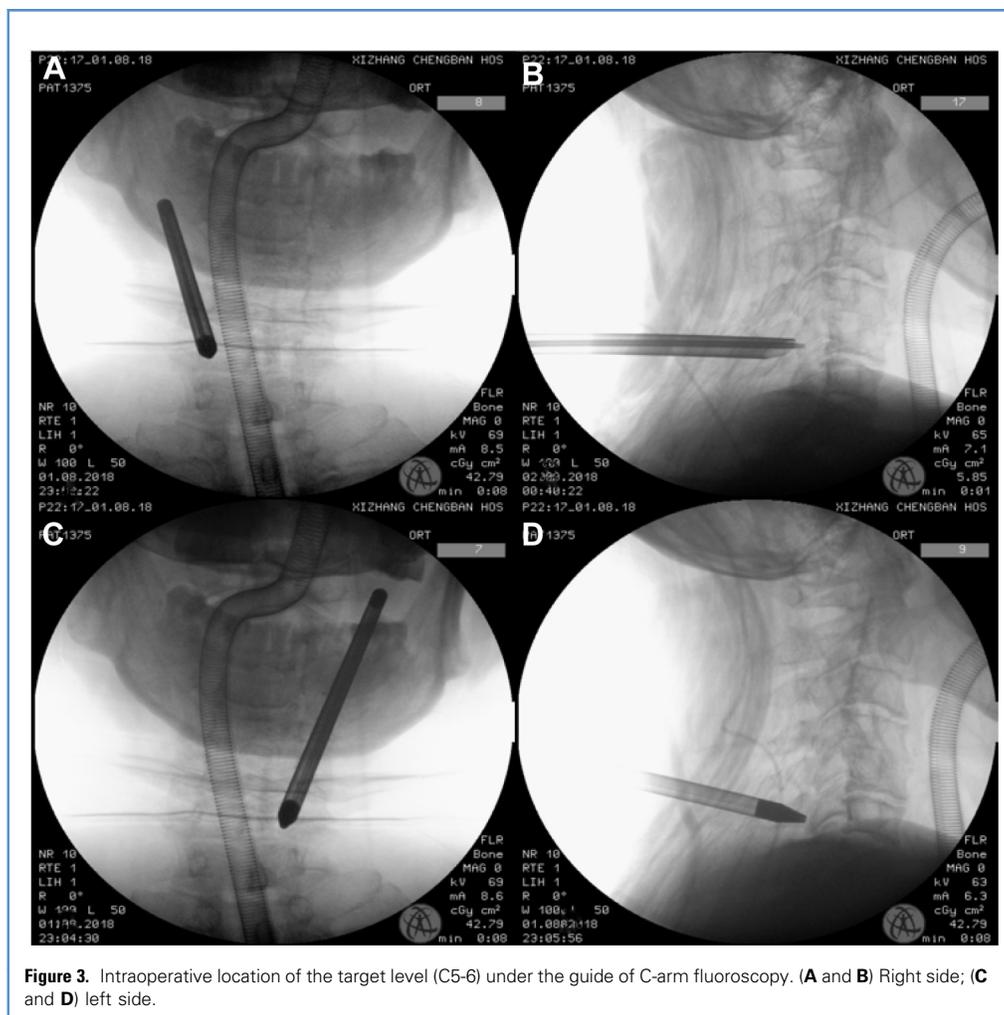
**Figure 3.** Intraoperative location of the target level (C5-6) under the guide of C-arm fluoroscopy. (**A** and **B**) Right side; (**C** and **D**) left side.

superior lamina margin and part of the inferior lamina were removed by a diamond burr. After the V point was identified, a key hole foraminotomy was performed with a 3 mm diamond burr and a bone punch (Figures 4–6), in which half of the facet was removed. Depending on the stenosis position, the foraminotomy could be extended toward lateral or craniocaudal. The lateral ligament flavum was dissected without infringing the venous plexus around the nerve root. Coagulation was performed carefully with a bipolar radio-frequent coagulation. The nerve root was carefully released with a nerve dissector.

For those there is an osteophyte on the ventral side of the nerve root, careful exploration of the ventral side is necessary to determine the local tension on the nerve root. For those in which there is an osteophyte forming less tension on the nerve root, no ventral decompression was necessary, but release of the nerve root was performed. The decompression ranges from the lateral edge of the dura sac to the inner 1/3 point of the facet (Figures 7 and 8), in which the nerve root canal was decompressed. After the anterior-posterior decompression was complete, the cranio-caudal diameter of the foramina

should be checked. It is common, in our experience, that if the cranio-caudal diameter is <3 mm, pedicle-dissection is recommended. When necessary, it should be performed with a diamond burr. Complete decompression was verified under an endoscope at the end of surgery.

Postoperative radiographic films identified total decompression of the nerve root. All of the patients were discharged on the following day after operation.

The data were analyzed with SPSS version 22.0 (IBM Corp., Armonk, New York, USA), and the paired $t$ test was performed for the pre- and postoperative relief.

## RESULTS

As 3 patients were lost for final follow-up, 19 patients (23 operation sides) were included in the final analysis. Among them, 2 received single-level bilateral operation and 2 received unilateral double-level operation. There were 11 (57.89%) women and 8 (42.11%) men. Mean age was 44.2 years (34–64 years) and the mean conservative treatment period was 5 months (range, 3–7
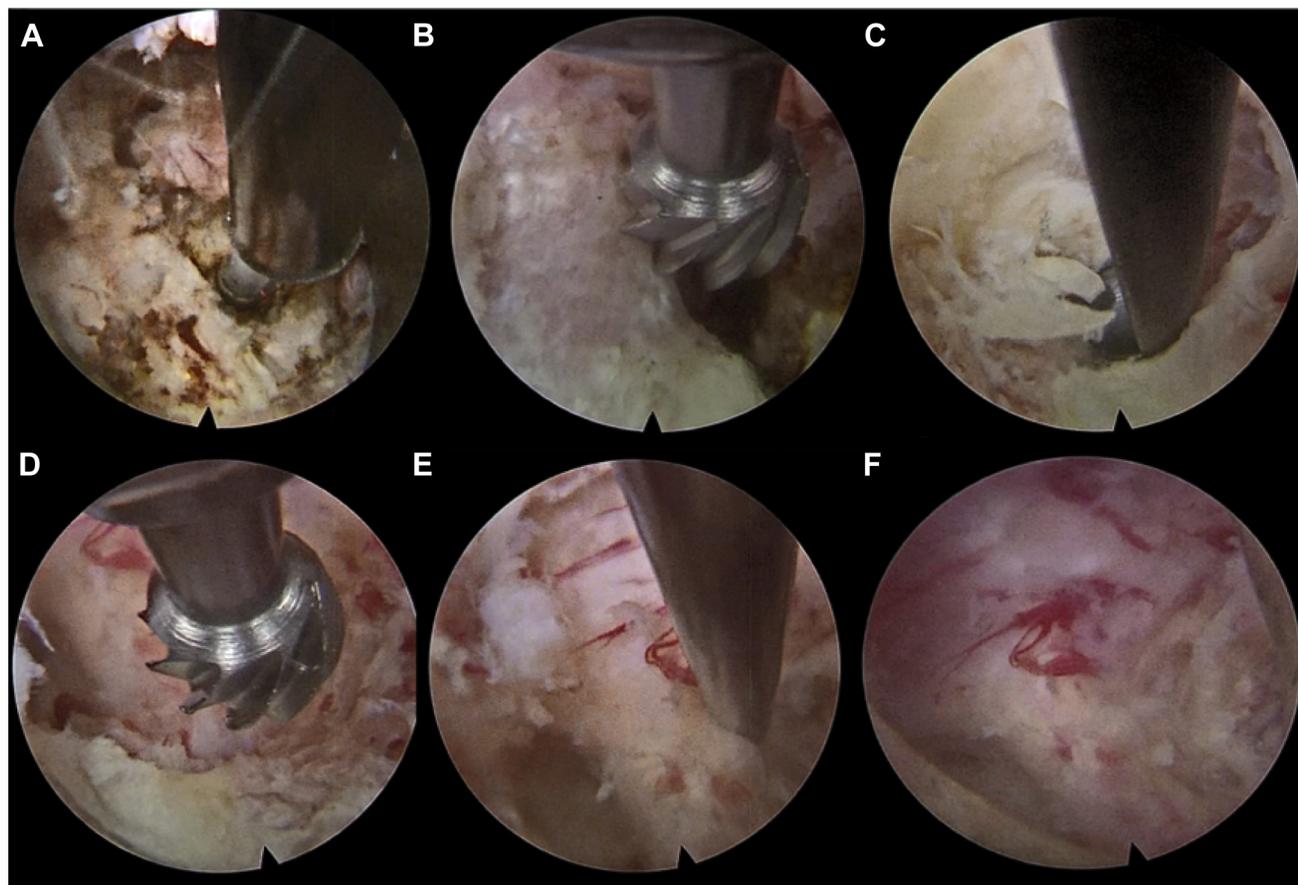
**Figure 4.** Patient undergoing full endoscopic key hole technique at C6-7 on the left side. (**A**) The exposure of the V point; (**B**) foraminotomy using the key hole technique; (**C**) removing of the ligament flavum; (**D**) shows the extensive decompression on the dorsal side of the nerve root; (**E**) shows the ventral release of the nerve root; (**F**) shows the completely decompressed nerve root.

months). Mean follow-up was 11.3 months (9–12 months). One patient underwent surgery at C3-4 level (4.35%), 4 at C4-5 level (17.39%), 6 at C5-6 level (26.09%), and 12 at C6-7 level (52.17%). Twelve (52.17%) on the left side and 11 (47.83%) on the right side (Table 1). Sufficient decompression was confirmed immediately after surgery. No serious complication was observed during the follow-up. No patient required revision surgery until the last follow-up.

Preoperative neck disability index, neck VAS, and arm VAS were $25.8 \pm 0.8$, $4.9 \pm 0.6$, and $7.5 \pm 0.5$ in the group. Immediate postoperative scores were $6.9 \pm 0.9$; $1.3 \pm 0.9$; and $1.4 \pm 0.5$. Follow-up scores at 3 months ($7.0 \pm 0.9$; $1.9 \pm 0.6$; and $2.7 \pm 0.9$), 6 months ($7.3 \pm 0.9$; $2.1 \pm 0.9$; and $1.9 \pm 0.5$), and 12 months ($7.6 \pm 0.5$; $2.5 \pm 0.8$; and $2.1 \pm 0.7$). The symptoms had improved significantly ($P < 0.05$) (Table 2).

According to the Macnab criteria, 15 patients reported excellent, 2 reported good, and 2 reported fair at the last follow-up. One patient complained of intermittent residual numbness on the ventral side of the index finger and another complained of continued numbness on the ventral side of the thumb, whereas the first patient is a tailor and latter is an autoworker; they think the numbness is interfering with their precise handling.

The mean blood loss was $10 \pm 4$ mL and the mean operation time was $30 \pm 10$ minutes.

## DISCUSSION

Spinal canal stenosis can be caused by multiple factors including congenital and secondary factors or both. The secondary factors mainly include degenerative factors, tumor, and inflammation.
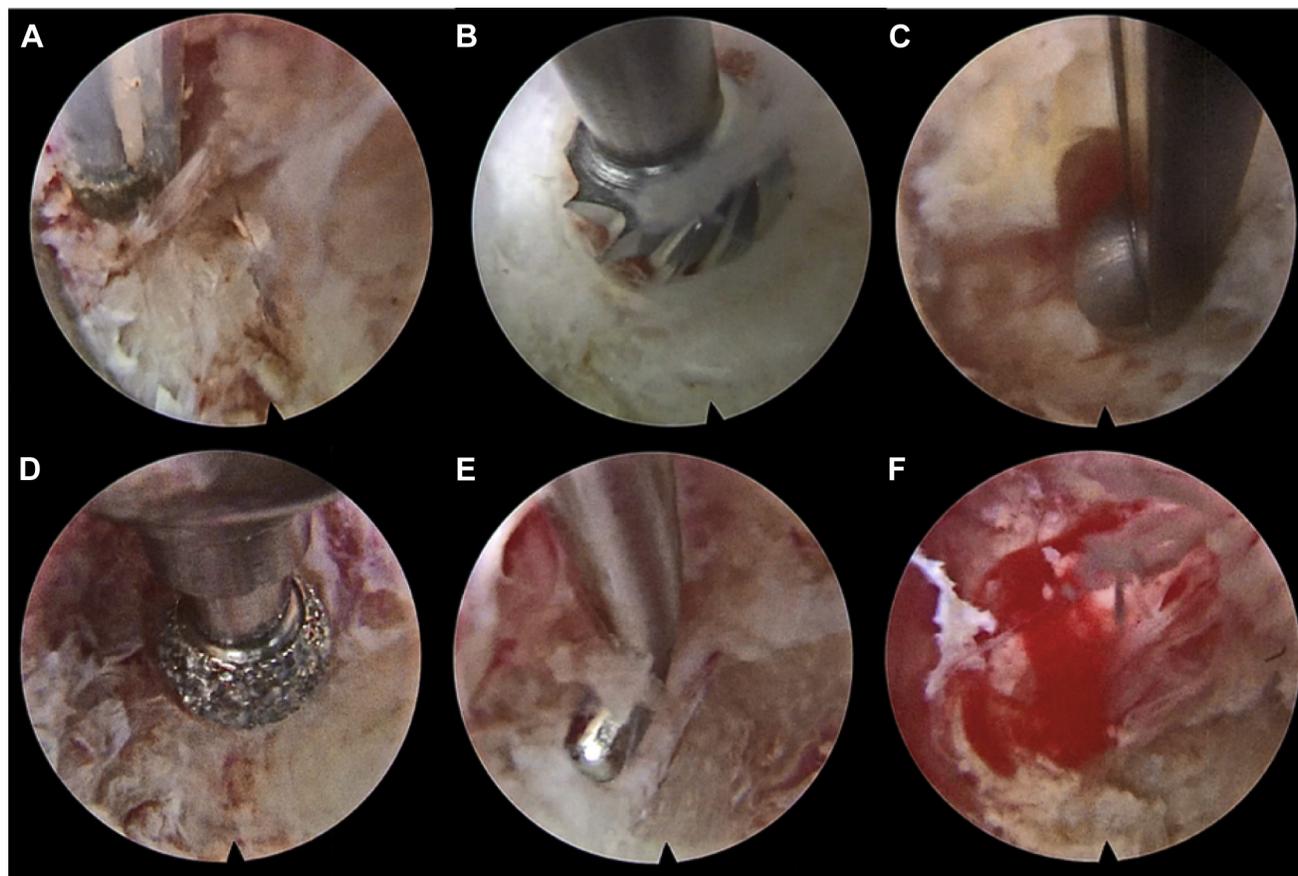
**Figure 5.** The same patient undergoing a full endoscopic key hole technique at C6-7 on the right side. (**A**) The exposure of the V point; (**B**) foraminotomy using the key hole technique; (**C**) removing of the ligament flavum; (**D**) shows the extensive decompression on the dorsal side of the nerve root; (**E**) shows the ventral release of the nerve root; (**F**) shows the completely decompressed nerve root.

Foraminal stenosis mainly causes radicular pain, numbness, and weakness of the upper limbs.[4] As the symptoms result from the ischemia and venous stasis caused by compression, the aim of the operation is decompression of the nerve root and the clearing of the herniated fragments that irritate the nerve root. The aim of treatment is to slow down the deterioration of the nervous element and relieve the symptoms.

The posterior approach was described by Scoville in 1944 and modified in 1951. The extensive invasiveness of the posterior open surgery causes various complications including C5 palsies, axial pain, and postoperative kyphosis.[16-18]

Next, the anterior approach was introduced by Smith, Robinson, Clow in 1958, and soon became the classic procedure for single-level degenerative diseases.[19,20] Introduced by Caspar et al.[21] in 1989, anterior cervical discectomy and fusion (ACDF) has become the standard procedure for 1- or 2-level cervical diseases, however, loss of the disc height and overloading of the adjacent

segments are the potential problems.[22,23] Next, total disc arthroplasty was introduced, but soon after, the risk of ASD in total disc arthroplasty was found to be equal to that of ACDF.[24] Further, anterior approach-related complications including visceral damage, postoperative laryngeal edema, neck hematoma, sore throat, loss of disc height, and increased reoperation ratio should also be of concern.[22,25,26]

Percutaneous endoscopic cervical discectomy (PECD) originates from percutaneous nucleotomy first described by Hijikata[27] in 1975.[27] Over the past decades, spinal surgeries involves to be more and more minimally invasive.[28] Following the description of lumbar arthroscopic discectomy by Kambin[29] in 1987, the full endoscope emerged in 1988.[30] PECD was introduced by Ruetten et al.[31,32] in 2007. The indications for PECD are foraminal disc herniations, single- or multi-level foraminal stenosis, and persistent symptoms despite previous ACDF. It is not an appropriate choice for axial neck pain, instability, and kyphosis. It has the
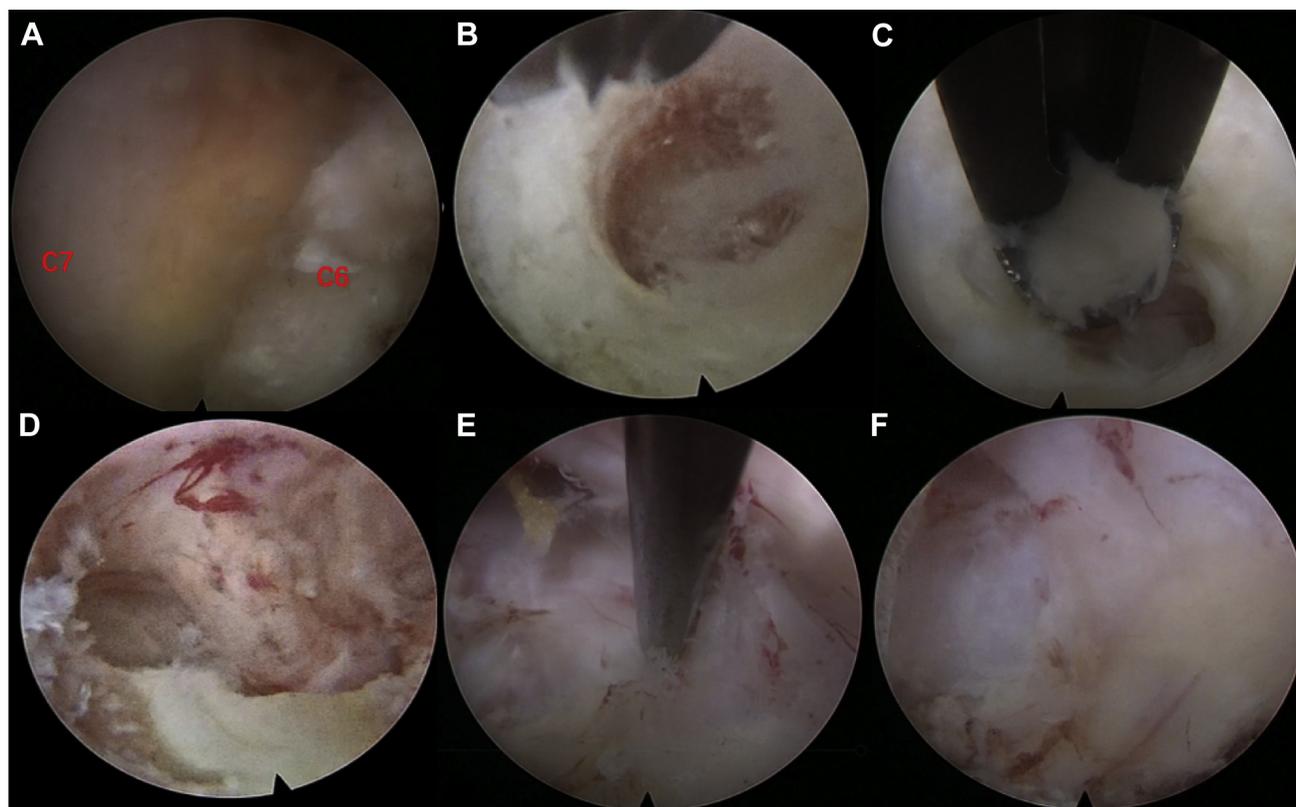
**Figure 6.** Another patient undergoing a full endoscopic key hole technique at C6-7. (**A**) The exposure of the V point; (**B**) foraminotomy using the key hole technique; (**C**) removing of the ligament flavum; (**D**) shows the extensive decompression on the dorsal side of the nerve root; (**E**) shows the ventral release of the nerve root; (**F**) shows the completely decompressed nerve root.

advantage of less muscular damage, less blood loss, better recovery, and shorter hospital stays.[33] Precise decompression and preservation in stability of the segment is pursued by surgeons. O-arm navigated location was found to be effective and safe in location and decompression.[14] Chen et al.[34] reported that lateral motion was only increased by 18% in the key hole technique. The facet removing is no more than 50%, and the stability will not be damaged.[33] The modification of this technique makes it more effective and minimally invasive. Park et al.[35] reported good clinical results using a biportal endoscope to treat soft herniated discs.
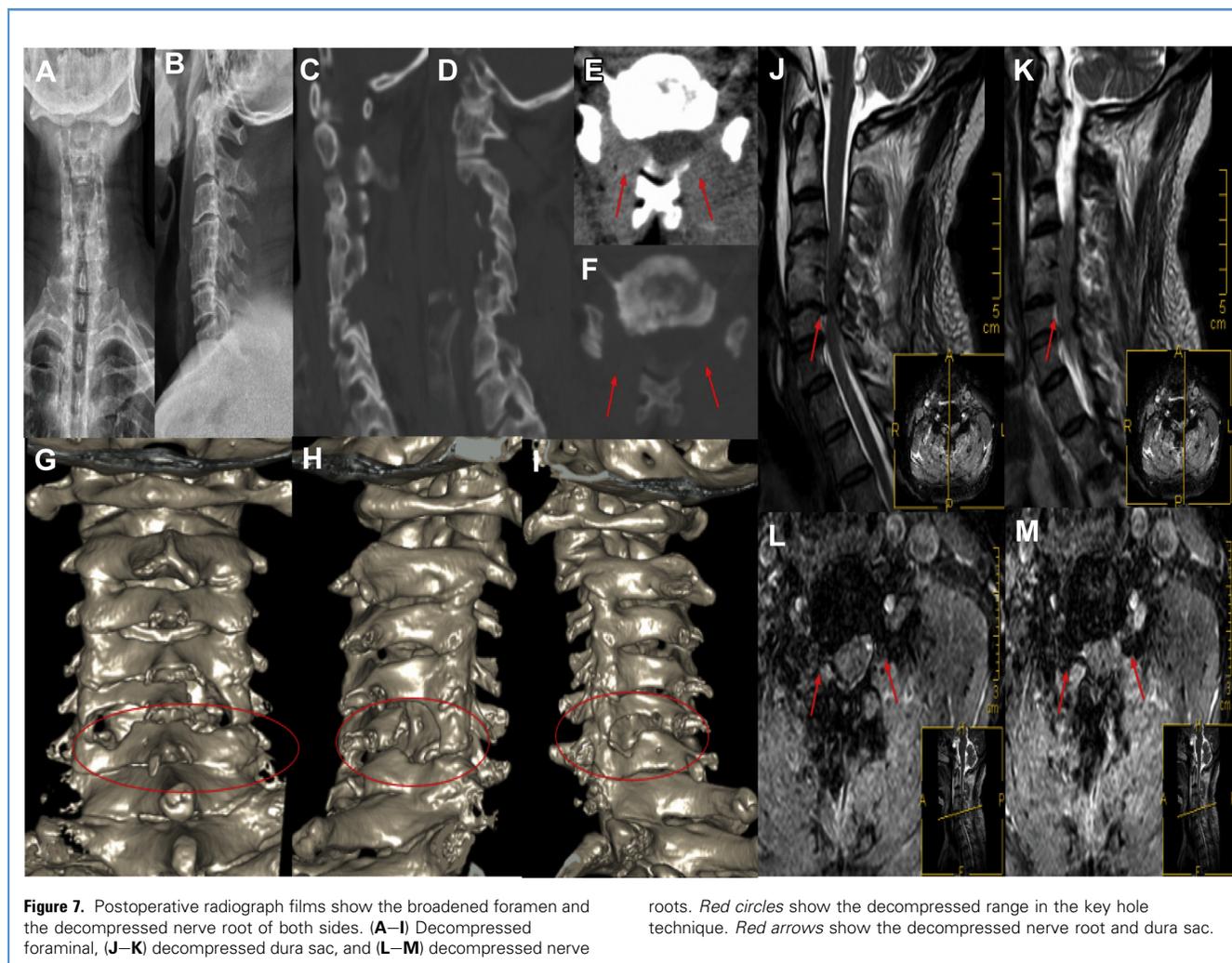
PECD can be performed via both the anterior and the posterior approach. Anterior cervical discectomy is minimally invasive and effective for foraminal stenosis. However, the damage of the cervical disc caused by the working cannula will affect the stability of the spine.[12] Further, complications including damage of the adjacent vessels and nerves by the puncture needle reduces the safety.[33,36]

Posterior percutaneous endoscopic technique is trendy for its minimal invasiveness of the paraspinal tissues and free of invasiveness of the intervertebral disc compared with anterior approaches.

The key hole technique was first introduced to treat the foraminal stenosis in posterior open surgeries by Scoville in 1966. Later, microscope-assisted key hole technique was reported to reduce the hospital stay and intraoperative bleeding.[37,38] Moreover, cadaveric studies found that it is more effective in decompression of the foramina than laminectomy.[39] The full endoscopic key hole technique is the most minimally invasive and effective technique for cervical foraminal stenosis. Although studies comparing micro-endoscopic discectomy and percutaneous endoscopic discecomy in the lumbar spine concluded that they are equally effective, and percutaneous endoscopic discecomy seems to be more minimally invasive due to less blood loss and shorter skin incision,[40] there is no study comparing the 2 technique in cervical surgery.

Using an endoscopic key hole technique to settle the nidus from the ventral side of the nerve root is challenging because of the higher risk of disturbing the nerve root, however, effective decompression of the nerve is required. To evaluate the indication of the ventral procedure is necessary to reduce the risk of

**Figure 7.** Postoperative radiograph films show the broadened foramen and the decompressed nerve root of both sides. (**A–I**) Decompressed foraminal, (**J–K**) decompressed dura sac, and (**L–M**) decompressed nerve roots. *Red circles* show the decompressed range in the key hole technique. *Red arrows* show the decompressed nerve root and dura sac.

disturbing the nerve root. Moreover, specifying the indication for ventral decompression can guide us to reach effective decompression when necessary.

In our study, when there were no herniated fragments and osteophyte forming less tension on the nerve root, therefore, mere dorsal decompression and ventral release of the nerve root is enough. In laminectomy surgeries, the range of decompression for paramedian soft herniated fragment is from the border of the dura sac to the inner edge of the lateral mass and the exposed nerve root is 5.1–7.1 mm.[41,42] In foraminotomy, the distance of exposed nerve root is reported 7.1–9.8 mm.[42] The inner opening of the bone nerve canal is the inner edge of the pedicle and the outer opening is the outer edge. In our study, the range of decompression is from the edge of the dur sac to the inner 1/3 point of the facet, which covers the whole bony nerve canal. The decompression range of spinal canal in our study is wider than that reported previously. Moreover, the vertical diameter of the foramina needs attention. In our experience, if the diameter is <3 mm, the vertical decompression should the performed. If

necessary, pedicle-plasty should be performed to achieve complete decompression of the foramina.

### Limitations

The intraoperative judgement of the tension formed by the osteophytes lacks objective standard. The judgement requires the doctor's experience. Additionally, the small sample size is another limitation of this report.

### CONCLUSIONS

Ventral decompression is not always necessary for cervical foraminal stenosis. If stenosis is mainly caused by dorsal structures, mere dorsal decompression is enough. In some cases, both the ventral and dorsal structures contribute to the stenosis. When there is no herniated soft fragment contributing to the stenosis, ventral decompression is not always necessary. If intraoperative exploration detects less tension formed by the osteophytes, mere dorsal decompression is enough to settle the symptoms.
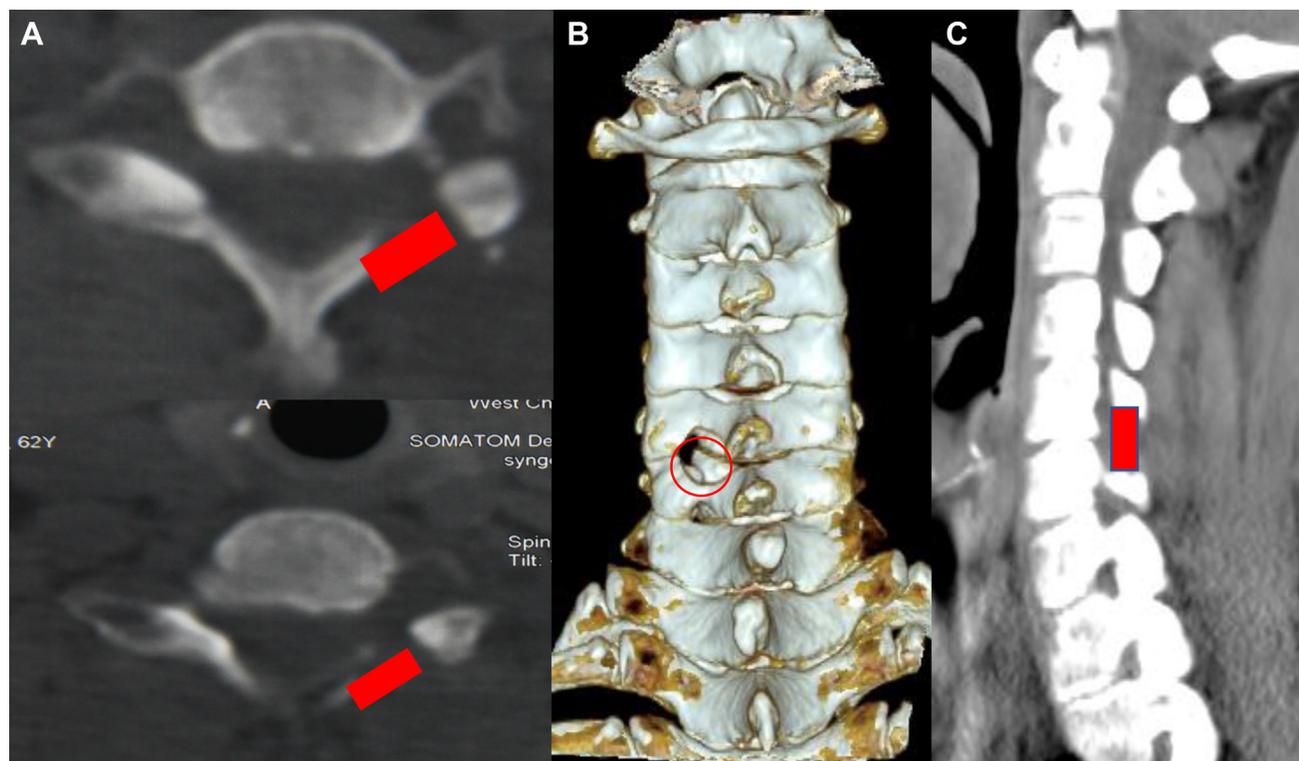
**Figure 8.** The *red zone* indicates the range of dorsal decompression. (**A**) Axial view of the decompression range, (**B**) coronal view of the decompression range, and (**C**) sagittal view of the decompression range.

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**Table 1.** Demographic and Clinical Information of the Patients

|  | Number of Patients | Percentage (%) |
|---|---|---|
| Sex |  |  |
| Male | 8 | 42.11 |
| Female | 11 | 57.89 |
| Target level |  |  |
| C3-4 | 1 | 4.35 |
| C4-5 | 4 | 17.39 |
| C5-6 | 6 | 26.09 |
| C6-7 | 12 | 52.17 |
| Operation side |  |  |
| Left | 12 | 52.17 |
| Right | 11 | 47.83 |

**Table 2.** Follow-Up Scores of the Patients Undergoing Mere Dorsal Decompression

| | |
|---|---|
| Preoperative neck VAS | 4.9 ± 0.6 |
| Preoperative arm VAS | 7.5 ± 0.5 |
| Preoperative NDI | 25.8 ± 0.8 |
| Postoperative neck VAS | 1.3 ± 0.9 |
| Postoperative arm VAS | 1.4 ± 0.5 |
| Postoperative NDI | 6.9 ± 0.9 |
| Neck VAS at 3 months | 2.7 ± 0.9 |
| Arm VAS at 3 months | 1.9 ± 0.6 |
| NDI at 3 months | 7.0 ± 0.9 |
| Neck VAS at 6 months | 1.9 ± 0.5 |
| Arm VAS at 6 months | 2.1 ± 0.9 |
| NDI at 6 months | 7.3 ± 0.9 |
| Neck VAS at 12 months | 7.6 ± 0.5 |
| Arm VAS at 12 months | 2.5 ± 0.8 |
| NDI at 12 months | 2.1 ± 0.7 |
| Macnab score (last follow-up) | |
| Excellent | |
| Good | 15 (78.95%) |
| Fair | 2 (10.53%) |
| Poor | 2 (10.53%) |
| VAS, visual analog scale; NDI, neck disability index. | |