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# Clinical evaluation of posterior cervical spinal canal decompression combined with enlarged intervertebral foramen in the treatment of multi-segmental cervical spinal canal stenosis with root symptoms

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***Abstract:*** *In order to evaluate the efficacy of posterior cervical spinal canal decompression combined with intervertebral foramen enlargement in the treatment of multi-segmental cervical spinal canal stenosis with root symptoms, the clinical data of 18 patients who underwent posterior cervical spinal canal decompression combined with intervertebral foramen enlargement in the first affiliated Hospital of Chongqing Medical University were studied retrospectively. Basic information of patients, length of stay, operation time, intraoperative blood loss and types of posterior cervical spinal canal decompression were collected. The effect of surgical treatment was evaluated by comparing JOA spinal cord function score, cervical dysfunction index (NDI), cervical VAS pain score, upper limb VAS pain score, Tsuji axial symptom score and related imaging parameters (including C2-7 cobb angle, C2-7 SVA, cervical CCI index, intervertebral foramen area and postoperative residual articular process spacing). The results showed that all the 18 patients completed the operation and follow-up successfully. The hospitalization time, operation time and intraoperative blood loss were 14.11 ±3.12d, 158.61 ±33.07and 147.78 ±79.52ml, respectively. The follow-up time of all patients was (19.22 ±13.40) months. JOA score, neck pain and upper limb pain VAS score, NDI score and Tsuji score at the last follow-up were better than those before operation. JOA score and upper limb pain VAS score at the last follow-up were better than those at 1 week after operation. There was no significant difference in neck pain VAS score, NDI score and Tsuji score between the last follow-up and 1 week after operation. There was no obvious sagittal imbalance of cervical vertebrae. Therefore, the author thinks that the short-term effect of posterior cervical spinal canal decompression combined with intervertebral foramen enlargement in the treatment of multi-segmental cervical spinal canal stenosis with root symptoms is good, the root symptoms are obviously relieved, and all the patients return to normal life. no adverse events such as affecting sagittal stability have been found.*

***Keywords:*** *single open door laminoplasty; laminoplasty; posterior approach intervertebral foramen enlargement; combination; multi-segmental cervical spinal canal stenosis; effect evaluation*

## 1. Introduction

Cervical spinal canal stenosis refers to a series of symptoms caused by developmental, acquired or degenerative factors, such as pathological changes in the corresponding bony or fibrous structure of the cervical spinal canal, resulting in the decrease of the sagittal diameter of the corresponding spinal canal and the narrowing of the spinal canal volume. It is a series of symptoms caused by the disturbance of blood circulation of the corresponding responsible segment of the spinal cord and the compression of the spinal cord and nerve root[1]. And with the increase of people's working time at their desk and the wide popularization of electronic products, the incidence rate is increasing and younger year by year[2]. In this kind of disease, multi-segmental cervical spinal canal stenosis with root symptoms is special. Because the spinal cord of multi-segmental cervical spinal stenosis is more likely to be compressed and cause spinal cord symptoms [3-4], and root symptoms often come from nerve root compression, it is necessary to solve the compression of spinal cord and nerve root at the same time to solve root symptoms and spinal cord symptoms at the same time. At present, the common surgical method for multi-segmental cervical spinal stenosis is posterior cervical spinal canal decompression, including laminectomy and single open-door laminoplasty, but this kind of operation only relieves the posterior compression of the spinal cord

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directly. There is no direct decompression of the nerve root. If the cervical spine is operated by one-stage posterior approach and two-stage anterior approach or combined anterior and posterior approach, it will cause more trauma to patients and cost more. Posterior cervical foramen incision (i.e. intervertebral foramen enlargement) can enlarge the intervertebral foramen through the posterior approach to achieve the purpose of decompression of the nerve root. Therefore, the purpose of this study is to explore the effect of posterior cervical spinal canal decompression combined with intervertebral foramen enlargement in the treatment of multi-segmental cervical spinal canal stenosis with root symptoms, and to provide relevant clinical experience.

## 2. Materials and methods

### *2.1 General Information*

The inclusion criteria of this study are as follows: 1 the standard lateral films of cervical vertebrae ≥ 3 segments with spinal cord symptoms measure Pavlov ratio & lt; 0.75 or cervical MRI spinal cord buffer space (SAC) & lt;5mm;2 has root pain or numbness symptoms and cervical CT indicates corresponding intervertebral foramen stenosis or cervical MRI indicates corresponding nerve root compression. (3) posterior cervical spinal canal decompression (single open door laminoplasty / laminectomy) combined with intervertebral foramen enlargement. Exclusion criteria: (1) diagnosis of cervical trauma, infection and tumor; (2) history of posterior cervical surgery; (3) incomplete imaging and follow-up data in our hospital. According to the above inclusion and exclusion criteria, the clinical follow-up data of 18 patients with multi-segmental cervical spinal canal stenosis with root symptoms treated by posterior cervical spinal canal decompression combined with intervertebral foramen enlargement in the first affiliated Hospital of Chongqing Medical University from January 2013 to December 2023 were studied retrospectively. There were 11 males and 7 females with an age of (58.44 ±9.84) years. This study was approved by the Ethics Committee of the first affiliated Hospital of Chongqing Medical University (K2023-518).

### *2.2 Surgical methods*

1) Single open door laminoplasty combined with enlargement of intervertebral foramen: after successful general anesthesia, the patient rolled over under the protection of cervical support, fixed with "three nails" head frame to maintain prone position, after fluoroscopy, the central approach and routine disinfection of towels. The skin, subcutaneous, deep fascia and paraspinal muscles were cut in turn, and the spinous process, lamina and articular process of the cervical vertebra were exposed. The medial edge of the contralateral mass of the root symptom was used as the "door shaft". The orthopedic micro-power system was used for high-speed grinding and ultrasonic bone knife was used to remove the bone cortex of the "door shaft". The lateral and medial cortical bones of the lamina were removed by high-speed grinding on the inside of the lateral mass of the root symptom, and the spinous process was pushed away to the side of the door axis. Titanium plate screws were fixed between each cervical lamina, and the position of the screws was proved by fluoroscopy. The entrance of the corresponding intervertebral foramen was opened under 3D microscope, the hyperplastic osteophyte was removed, and the corresponding nerve root decompression was released. Fully stop the bleeding, thoroughly rinse the incision, graft bone on the side of the door axis, insert the drainage tube and suture layer by layer.

2) Laminotomy combined with intervertebral foramen enlargement: after successful general anesthesia, the patient rolled over under the protection of the neck support, fixed with the "three nails" head frame to maintain the prone position, the central approach was taken after fluoroscopy, and the towels were routinely sterilized. The skin, subcutaneous, deep fascia and paraspinal muscles were cut in turn, and the spinous process, lamina and articular process of the cervical vertebra were exposed. The screw was implanted into the bilateral mass of the proposed segment, and the position of the screw was proved to be good by fluoroscopy. The medial side of the bilateral lateral mass was slotted with a high-speed grinding drill, and the spinous process and the whole lamina at the corresponding stage were decompressed completely from behind. The entrance of the corresponding intervertebral foramen was opened under 3D microscope, the hyperplastic osteophyte was removed, and the corresponding nerve root decompression was released. Cut the titanium rod of the corresponding length, bend it moderately, place the titanium rod, and lock the nut. Fully stop the bleeding, rinse the incision thoroughly, insert the drainage tube and suture layer by layer.

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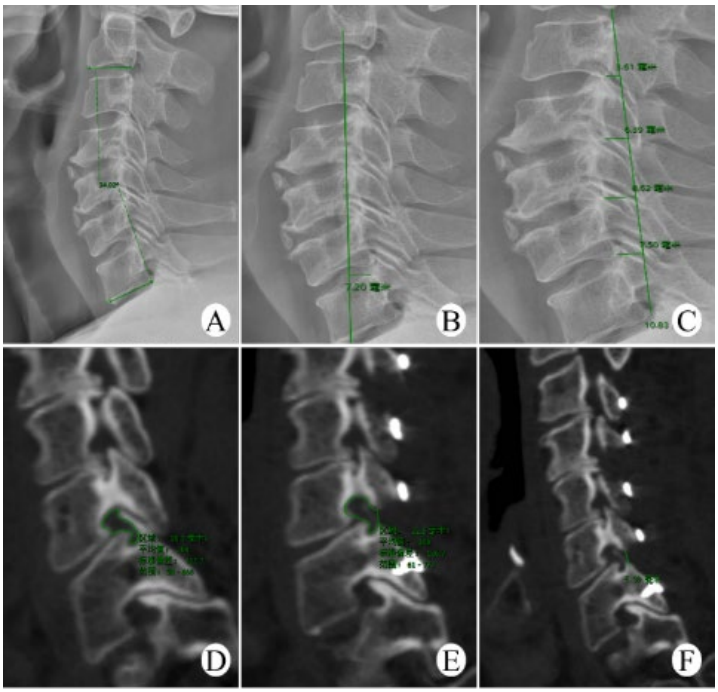
### *2.3 Follow-up and evaluation indicators*

General data: the age, sex, length of stay, operation time, type of posterior cervical spinal canal decompression, segment of root symptom and segment of operation were collected. The related indexes were collected before operation, 1 week after operation and at the last follow-up: 1. Clinical efficacy indicators: 1 Cervical spinal cord function score (Japanese orthopaedic association, JOA) recommended by Japanese Orthopaedic Association, which was evaluated by upper and lower limb motor function, upper and lower limb and drive sensory function and bladder function, the score was 0-17, the higher the score, the better the function. 2Visual analogue score (Visual analogue scale, VAS): draw a straight line of 10cm on the paper, one end is 0mm, which means "no pain"; the other end is 10mm, which means "pain to the extreme". The pain score increases from 0 to 10, and the higher the score is, the more severe the pain is. 3Cervical vertebra dysfunction index (Neck disability index, NDI). The effect of cervical pain on daily life was evaluated by 10 items of pain intensity, personal care, lifting, reading, headache, attention, work, sleep, driving and entertainment. The higher the score, the more severe the cervical dysfunction. 4Tsuji score, neck pain, neck stiffness, shoulder pain and shoulder stiffness were scored respectively. According to the severity of each item, from "persistent severity" to "asymptomatic", the total score was 12. The higher the score, the lighter the axial symptoms. two。 Imaging index: 1C2-7 cobb angle: two parallel lines were made along the inferior endplate of C2 and C7 on the standard lateral film of cervical vertebra, and the vertical angle was recorded. 2C2-7 SVA: a vertical line was made from the central or dentate process of the C2 vertebral body on the standard lateral film of the cervical vertebra, and the distance from the posterior superior edge of the C7 vertebral body to the plumb line was recorded. 3Cervical CCI index: the length of the line connecting the posterior lower edge of C2 and C7 cervical vertebrae was A line, and the length of the vertical line from the posterior lower edge of each vertebral body to line A was A1, a2, A3, A4. If the posterior inferior edge of C3-C6 was located on the back of line A, the a value was recorded as negative, and the CCI index was (a1+a2+a3+a4) / Azo100%. 4 area of intervertebral foramen: the largest section of cervical CT intervertebral foramen was drawn along the edge of intervertebral foramen. After operation, the line of residual articular process was taken as the posterior edge of intervertebral foramen, and the area of intervertebral foramen was measured by PACS system. 5residual articular process distance: the largest cross section of cervical CT intervertebral foramen was selected after operation, and the connection distance between the inferior articular process of the remaining upper vertebral body and the superior articular process of the lower vertebral body was recorded (see figure 1).




*A. C2-7 cobb angle measurement method. B. C2-7 SVA measurement method. C. CCI index of cervical vertebrae was measured by. D-E. The method of measuring the area of intervertebral foramen before and after operation. F. The method of measuring the distance between the residual articular processes.*

*Figure 1: Measurement method of imaging index*

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### *2.4 Statistical methods*

Data analysis and statistics were processed by SPSS 25.0 software. The measurement data are expressed as mean ±standard deviation (x ±s), t-test is given for normal distribution, rank sum test is used for non-compliance, $\chi$ 2 test is used for grade data with valid cases ≥ 40 and expected values ≥ 5, and Fisher test is used for grade data with effective cases < 40 or at least one expected value < 5. The test level of 0.05 was statistically significant ($P < 0.05$).

## 3. Result

### *3.1 Clinical efficacy*

All the 18 patients successfully completed the posterior cervical spinal canal decompression combined with intervertebral foramen enlargement, of which 5 patients underwent ipsilateral enlargement of 2 intervertebral foramen according to the preoperative clinical symptoms and root responsibility segment, and the remaining 13 patients underwent 1 intervertebral foramen enlargement. A total of 23 intervertebral foramen were enlarged. All patients passed the perioperative period smoothly. The hospitalization time, operation time and intraoperative blood loss were 14.11 ±3.12d, 158.61 ±33.07and 147.78 ±79.52ml, respectively. The follow-up time of all patients was (19.22 ±13.40) months (see Table 1). Among them, 2 patients had poor incision healing and 1 patient had transient kinetic energy disturbance of lower extremities after operation. The JOA score at 1 week and the last follow-up was higher than that before operation, and the JOA score at the last follow-up was higher than that at 1 week after operation. The VAS and NDI scores of neck pain at 1 week and the last follow-up were lower than those before operation, and the VAS and NDI scores at the last follow-up were lower than those at 1 week after operation, but the difference was not statistically significant. The VAS score of upper limb pain at 1 week and the last follow-up was lower than that before operation, and the VAS score of upper limb pain at the last follow-up was lower than that at 1 week after operation. The Tsuji scores of patients at 1 week and the last follow-up were higher than those before operation, and the Tsuji scores at the last follow-up were lower than those at 1 week after operation, but the difference was not statistically significant (see Table 2).

### *3.2 Imaging indicators*

The area of intervertebral foramen in the last follow-up was significantly larger than that before operation, and the difference was statistically significant. There was no significant difference in cervical CCI index, C2-7cobb angle and C2-7SVA between the last follow-up and pre-operation. The number of patients with SVA ≥ 40mm in the last follow-up was lower than that before operation, but the difference was not statistically significant (see tables 3,4).

*Table 1: Basic information of patients*

| Project | Total(n=18) |
|---|---|
| Age (x ±s, years old) | 58.44±9.84 |
| Gender [n (%)] | |
| Male | 11(61.11) |
| Female | 7(38.89) |
| Length of stay (x ±s, days) | 14.11±3.12 |
| Operation time (x ±s, min) | 158.61±33.07 |
| Intraoperative blood loss (x ±s, ml) | 147.78±79.52 |
| Type of posterior cervical spinal canal decompression [n (%)] | |
| Single open door laminoplasty | 15(83.33) |
| Laminectomy | 3(16.67) |
| Operative segment [n (%)] | |
| C3-6 | 5(27.78) |
| C3-7 | 11(61.11) |
| C4-6 | 2(11.11) |
| Root symptom segment [n (%)] | |
| C45 | 10(43.48) |
| C56 | 8(34.78) |
| C67 | 5(21.74) |

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*Table 2: Comparison of clinical effects before and after operation*

| | Before operation | One week after operation | Last follow-up |
|---|---|---|---|
| JOA score (score) | 13.28±2.42 | 14.89±1.78* | 15.78±1.31*△ |
| Neck pain VAS score (score) | 3.50±2.73 | 0.44±0.70* | 0.22±0.73* |
| Upper limb pain VAS score (score) | 3.61±3.09 | 0.72±0.75* | 0.28±0.67*△ |
| NDI score (%) | 25.79±18.76 | 6.31±5.73* | 3.58±7.71* |
| Tsuji score (score) | 8.56±2.18 | 11.17±0.86* | 10.61±1.54* |

Note: * compared with before operation, P < 0.05; compared with 1 week after operation, P < 0.05.

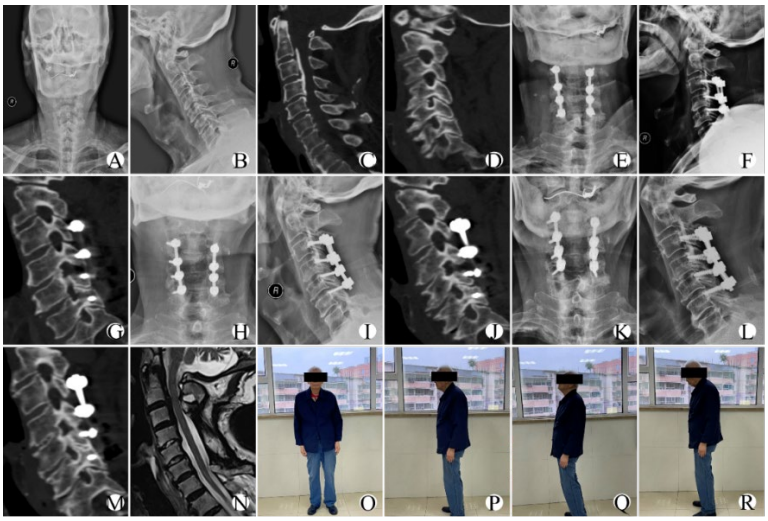
*Table 3: Comparison of imaging indexes before and after operation*

| | Before operation | One week after operation | *P* value |
|---|---|---|---|
| Intervertebral foramen area (mm2) | 32.61±12.08 | 48.38±12.90 | <0.001 |
| Residual articular process spacing (mm) | / | 7.17±1.54 | / |
| Cervical CCI index (%) | 7.30±13.16 | 9.27±8.92 | 0.407 |
| Cervical C2-7cobb angle (°) | 9.20±13.99 | 10.56±10.33 | 0.648 |
| C2-7SVA(mm) | 24.90±19.72 | 25.15±17.91 | 0.936 |

*Table 4: Comparison of cervical sagittal plane imbalance indexes before and after operation*

| | SVA<40mm | SVA≥40mm | Fisher exact test |
|---|---|---|---|
| | | | *P* value |
| Before operation | 13(72.2) | 5(27.8) | 0.691 |
| Last follow-up | 15(83.3) | 3(16.7) | |

### *3.3 Typical cases*




*A-D. CT showed continuous ossification of the posterior longitudinal ligament and stenosis of the right intervertebral foramen. E-G. One week after operation, the standard anterior and lateral radiography of cervical vertebra and the condition of C45 intervertebral foramen suggested that C45 intervertebral foramen had been decompressed successfully. H-J. One year after operation, the standard anterior and lateral radiographs of cervical vertebrae and C45 intervertebral foramen suggested that the cervical screws and rods were in place and had good stability. K-R. Five years after operation, the standard anteroposterior and lateral radiographs, the condition of C45 intervertebral foramen, MRI of cervical vertebrae and general photos of the patients suggested that the patient recovered well and that the C45 intervertebral foramen healed, but there was no recurrent intervertebral foramen stenosis.*

*Figure 2: Typical case photos*

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The patient, an 80-year-old male, was hospitalized for "vertigo and vomiting for 10 days, right shoulder and back with right upper limb pain and numbness for 1 week". The main symptoms were neck pain with pain and numbness in the right upper arm and forearm, and inflexibility of both hands and lower limbs. Cervical MRI showed continuous ossification of the posterior longitudinal ligament of the cervical spine. It was diagnosed as multi-segmental cervical spinal canal stenosis with right root symptoms. Before operation, JOA score was 14, neck pain VAS score was 6, upper limb pain VAS score was 6. Laminectomy combined with enlargement of C45 intervertebral foramen was performed. One week after operation, JOA score was 15, neck pain VAS score was 1, and upper limb pain VAS score was 1. The patients were followed up regularly for 5 years. At the last follow-up, the JOA score was 17, the neck pain VAS score was 0, and the upper limb pain VAS score was 0. The patient has returned to normal life. (see figure 2)

## 4. Discussion

According to the comparison of clinical results before and after operation, the spinal cord function of the patients was improved to a certain extent 1 week after posterior cervical decompression combined with intervertebral foramen enlargement, and with the prolongation of postoperative recovery time, the spinal cord function of the patients can be further improved. For neck, upper limb pain and cervical vertebra dysfunction, neck pain and cervical vertebra dysfunction will be relieved quickly after operation, and there is no significant change with time, while upper limb pain will be relieved to a certain extent after operation. Gradually recover over time. This may be because cervical pain and cervical dysfunction are mainly caused by cervical disc herniation, cervical facet degeneration, cervical instability and long-term cervical tension caused by cervical degeneration. Therefore, cervical pain and cervical dysfunction are resolved quickly. The spinal cord function because the operation only relieves the compression of the spinal cord and cannot repair the nerve directly, so the nerve needs time to repair itself, so the spinal cord function of the patient will be further improved over time. The nerve root may be compressed for a long time, and the nerve rebound pain occurs about 1 week after operation due to neuroedema and inflammatory reaction. After the neuroedema and inflammatory reaction is improved, the upper limb pain is further relieved, which is consistent with our clinical experience. The axial symptoms of the patients were rapidly improved at 1 week after operation, but the axial symptoms at the last follow-up were more serious than those at 1 week after operation, but there was no statistical significance. This may be because the axial symptom score is mainly composed of neck and shoulder pain and neck and shoulder stiffness, and the axial symptoms are relieved due to the rapid relief of neck pain 1 week after operation. With the extension of follow-up time, the stiffness of neck and shoulder caused by adhesion and inflammation appeared gradually. Liu and other studies showed that the causes of axial symptoms were related to the injury of facet joint capsule, the defect of facet joint and the injury of posterior ligament complex, which led to the decrease of cervical stability and the damage of posterior cervical muscle[5]. Compared with the axial symptom score of the last follow-up and 1 week after operation, the trend of axial symptom score was consistent with that of previous studies, and the reason for no statistical significance may be that the follow-up time was not long enough. At the last follow-up, the area of intervertebral foramen was significantly larger than that before operation, and there was no significant difference in cervical CCI index, C2-7cobb angle, C2-7SVA and sagittal imbalance of cervical spine compared with those before operation, which suggested that posterior cervical decompression combined with enlargement of intervertebral foramen was effective and did not affect the stability of cervical vertebra. It was previously believed that facetectomy would affect cervical stability[6], but biomechanical in vitro analysis suggested that removal of more than 50% of cervical facet joints would affect cervical stability[7]. Recent clinical studies have also proved this point of view[8-9], which is consistent with the experimental results of this study.

With the continuous improvement of medical level, various surgical methods for the treatment of cervical spondylosis are constantly improving, gradually developing in the direction of refinement and personalization. Multi-segmental cervical spinal stenosis due to long-segment spinal canal involvement, it is difficult to achieve decompression through partial resection of compression sources, while anterior multi-segmental laminectomy and fusion fixation will affect the stability and range of motion of cervical vertebrae. Therefore, single open-door laminoplasty has become the first choice for multi-segmental cervical spinal canal stenosis with relatively less trauma, risk and simple operation. However, for patients with multi-segmental cervical spinal stenosis with root symptoms, single open-door laminoplasty can not solve the root symptoms, and even due to the backward drift of the spinal cord, the nerve root may be angled or further compressed in the intervertebral foramina, resulting in the aggravation of root symptoms. The shape of the intervertebral foramen is similar to that of the funnel, and the entrance area

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is the narrowest part, while the shape of the nerve root is the conical shape of the calcaneal sheath, and the point starting from the central dura mater is the largest part, so the compression of the intervertebral foramen mainly occurs in the entrance area[10]. Therefore, relieving the stenosis of the entrance area of the intervertebral foramen can effectively relieve the compression of the nerve root. In recent years, more literature has proved that posterior intervertebral foramen enlargement surgery can relieve nerve root compression and effectively relieve root symptoms[11-12]. Therefore, our department uses posterior cervical spinal canal decompression combined with intervertebral foramen enlargement to treat multi-segmental cervical spinal canal stenosis with root symptoms. its advantages are as follows. Only through the posterior approach to complete the decompression of the spinal cord and nerve roots of multiple segments, and after the posterior approach spinal canal decompression surgery can complete the intervertebral foramen enlargement operation in a good and wide field of vision, the operation is less difficult and less risky. 2. Compared with the traditional one-stage posterior and two-stage anterior surgery or combined anterior and posterior surgery, this operation takes less time, causes less trauma to patients, and is more beneficial to the later recovery of patients. 3. Compared with the traditional posterior approach spinal canal decompression, this method of further decompression of the nerve root will not adversely affect the stability of the cervical spine. During the operation, we should pay attention to: 1. Since it is impossible to directly judge the degree of intervertebral foramen stenosis during the operation, in order to improve the safety of the operation and avoid nerve injury, the patients can be monitored by neuroelectrophysiology during the operation and reminded in time when there is nerve stimulation. to avoid irreparable nerve damage; 2. If the spinal canal is decompressed by single open door spinal canal enlargement, the intervertebral foramen should be enlarged on the open side; 3. When decompressing the intervertebral foramen, the destruction of the facet joint should be minimized while ensuring the full decompression of the nerve root, and the nerve root dissociation can be detected by the nerve retractor, and the stability of the cervical vertebra should not be affected by excessive enlargement of the intervertebral foramen. 4. In the process of intervertebral foramen enlargement, a clearer operative field can be exposed by 3D microscope, and the facet joint can be gradually removed by rongeur, and nerve retractor can be used to protect nerve in time after exposing nerve root.

However, as a modified method of posterior approach spinal canal decompression, this method still has the same problems as posterior approach spinal canal decompression. For example, posterior approach spinal canal decompression is not suitable for patients with kyphosis, but Narihito and other studies show that in patients with mild kyphosis, cervical curvature is significantly improved to kyphosis after posterior approach decompression, and the clinical effect is good[13]. C5 nerve root paralysis may also occur after posterior approach spinal canal decompression. Kim et al have shown that long-term intervertebral foramen stenosis can easily cause ischemic manifestations of nerve roots and cause C5 nerve root paralysis[14], while Masakazu et al believe that C5 nerve root paralysis is related to ischemia-reperfusion injury after relieving intervertebral foramen compression[15]. Correlation meta analysis shows that enlargement of C5 intervertebral foramen is beneficial to reduce the incidence of C5 nerve root paralysis[16], but because the mechanism is not clear and iatrogenic nerve root injury may be caused in the process of intervertebral foramen enlargement, whether intervertebral foramen enlargement is beneficial to reduce C5 nerve root paralysis remains to be further studied. Axial symptoms are also one of the complications of posterior approach spinal canal decompression. At present, it is believed that axial symptoms are mainly related to the destruction of posterior ligament complex and bony structure, resulting in continuous traction and fatigue of cervical extensor muscles, and finally causing axial pain[17]. Satoshi et al suggested that the incidence of axial symptoms can be reduced by modified laminectomy with preservation of muscle-spinous process[18]. Some studies have also pointed out that the incidence of axial symptoms can be reduced by preserving the muscle attachment points of C2 and C7[19].

To sum up, the short-term effect of posterior cervical spinal canal decompression combined with intervertebral foramen enlargement in the treatment of multi-segmental cervical spinal canal stenosis with root symptoms was good, the root symptoms were obviously relieved, and all the patients returned to normal life. No adverse events such as affecting sagittal stability were found. However, this study is a retrospective study, with a short follow-up time and a small sample size, and is not compared with the traditional posterior approach for spinal canal decompression. The next step is to compare with the traditional posterior approach spinal canal decompression surgery, and design a randomized, large sample prospective study to further explore.

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