Original Article
Single-stage surgical treatment of complex cervical spondylosis by combined anterior and posterior approach: an observational study

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Abstract: This study aimed to analyze the indications and outcomes of surgical treatment of complex cervical spondylotic myelopathy (CSM) by a single-stage combined anterior and posterior approach. Eighteen patients with CSM were operated between March 2007 and October 2012 by using the single-stage combined anterior and posterior approach to achieve decompression of the spinal cord. Patients' clinical and radiological data were analyzed to evaluate the clinical efficacy of the procedure. The mean operation time was 3.2 hours (range, 2.5-5 hours). Mean intraoperative blood loss was 650 mL (range, 480-1000 mL). Four cases had cerebrospinal fluid leakage during the surgery. Patients were followed-up for a mean duration of 38 months (range, 18 months to 7 years). The rates of neurological improvement and eligible rate of nerve function were 78.1% and 67.4%, respectively. Magnetic resonance imaging demonstrated repositioning of the dura mater posteriorly to its expected position and confirmed achievement of anterior and posterior decompression of the spinal cord. Computed tomography demonstrated a fully expanded spinal canal, and an average laminar opening angle of 45.2°. Our results demonstrated that single-stage surgical treatment of CSM by a combined anterior and posterior approach successfully achieved complete spinal cord decompression and was associated with good mid-term clinical efficacy.

Keywords: Cervical spondylotic myelopathy (CSM), anterior approach, posterior approach, combined approach, single-stage, spinal cord decompression

Introduction

The incidence of cervical spondylotic myelopathy (CSM) has increased substantially in recent years [1, 2]. CSM is commonly observed in men and in elderly people [3, 4]. There is consensus regarding the surgical strategy to be applied for cases of CSM that are attributed to a single causative factor [5-7]. However, management of complex CSM, with the involvement of two or more types of compressive factors, is controversial, especially with respect to the method of surgery and its timing [8-10]. Herein we present our experience in managing CSM by applying a single-stage combined anterior and posterior approach for spinal cord decompression.

Materials and methods

General data

This study included 18 patients with CSM who were managed at our hospital during the period from March 2007 to October 2012 by using a single-stage combined anterior and posterior approach. There were 11 male and 7 female patients with an average age of 45.1 years (range, 35-63 years). Patients were symptomatic for an average of 3.5 years (range, 3 months to 6 years). Co-morbid conditions included hypertension (n = 8), chronic obstructive pulmonary disease (n = 2), and diabetes mellitus (n = 5). Patients were adequately optimized with respect to their co-morbid conditions. All patients underwent imaging studies including cervical radiograms (lateral and frontal views), and computed tomography (CT) or magnetic resonance imaging (MRI). Enhanced MRI scans were also examined for confirmation of high intramedullary signals. Pavlov index calculated based on the lateral view of the cervical radiogram was less than 0.8 in 14 patients. MRI demonstrated the dura mater as beaded compressed multiple segments. The compressive factors were identified, including one or two

large intervertebral disc herniation. Osteophytes were identified at the posterior rim of the vertebral body with local ossification of the posterior longitudinal ligament. The partial encroachment of the spinal canal exceeded 50% in all cases. The mean value of the pre-operative scores calculated according to the Japanese Orthopaedic Association (JOA) scale was 11.5 (standard deviation, 2.6; range, 7-14). The score was more than 10 in 11 patients and less than 7 points in 7 patients. This study was conducted in accordance with the declaration of Helsinki and was approved by the Ethics Committee of Nanjing Medical University and the Ethics Committee of Guizhou Provincial Orthopedics Hospital. Written informed consent was obtained from all participants.

Operation methods

A patient was initially placed in the prone position and the operative procedure began by using a posterior approach with skull traction. First, a unilateral open-door expansive laminoplasty was performed. In cases of clear bony stenosis in the fifth intervertebral foramina, a root-canal plasty was performed. The "small articular capsule suspension" method was used in five cases and an "anchored method" in 13 cases [11]. The patient was then shifted to a supine position, and an anterior approach discectomy or corpectomy along with interbody fusion were performed. Corpectomy and interbody fusion were performed in four cases. In all other cases, a single segment discectomy and interbody fusion was performed. Among these patients, "cage interbody fusion" was performed for five patients, "iliac bone autograft intervertebral fusion" was performed for seven patients, and "fixed autologous interbody fusion" of the seventh cervical spine was performed for two cases. As a final step, anterior plate fixation was performed for all patients.

Postoperative management

Conventional antibiotics, methylprednisolone, mannitol, and other drugs were administered to all patients following the surgery, with prioritized respiratory management. A cervical collar was used for three days postoperatively to provide protection during ambulation, following which, early neck-muscle-function exercises were initiated and continued for 3-4 weeks.

Follow-up

Surgical follow-up involved outpatient review, telephone assessments, and questionnaires. In addition, lateral and frontal views of cervical radiograms were examined at 3, 6, and 12 months, and 2, 3, and 5 years post-operatively. CT and MRI were reviewed when felt necessary. The Bohlman method [12] was used to evaluate the status of bonegraft fusion. The JOA scale was used (1994 version with a maximum score of 17) to evaluate neurological recovery 6 months and 2 years following surgery. The calculation of the neurological improvement rate was performed as follows: 100 × (follow-up scores-pre operative scores)/(17-pre operative scores) to give values as percentages. An improvement rate ≥75% was considered excellent, 50%-75%, good, 25%-50%, fair, and < 25%, poor.

Statistical analysis

The visual analog scale (VAS) and Neck Disability Index (NDI) were used to evaluate neck axial symptoms, including neck and shoulder pain, muscle spasms, and further. All values were expressed as mean ± standard deviation (SD). The significance of differences among the groups was determined by Student's t-test and one-way analysis of variance. A *P*-value of < 0.05 was considered as statistically significant. Statistical analysis was performed using SPSS 11.0 software.

Results

Surgery

The average operation time was 3.2 hours and the average intraoperative blood loss was 650 mL. Leakage of cerebrospinal fluid was detected intraoperatively in four cases, and was managed by using deep seam packing after withdrawal of the tube. None of the included patients had any injury to the spinal cord or recurrent laryngeal nerve, infections, or delayed wound healing. There were no deaths in the study population. Three patients experienced obvious difficulty in swallowing, neck pain, and shoulder pain. These complaints were substantially alleviated following symptomatic treatment.

Figure 1. Preoperative cervical X-ray examination showed the cervical degeneration, with good physiological lordosis, and without developmental spinal canal stenosis or obvious intervertebral instability. MRI showed the C3-4-5-6-7 intervertebral disc herniation complicated with degenerative spinal canal stenosis and dural sac beaded change. The C6-7 intervertebral disc had huge herniation which moved up the C5-6 intervertebral disc. CT suggested cervical C4-6 vertebral osteophyte, without posterior longitudinal ligament ossification or bony malformation.

Follow-up

In this study, two patients died due to causes unrelated to CSM. Follow-up was conducted for 16 (out of 18) cases for an average period of 38 months. Three patients experienced obvious axial symptoms with VAS scores of 4-6 and NDI scores of 10-15 at 6 months postoperatively. These symptoms improved substantially after conservative treatment, with no long-term residual symptoms. The neurological improvement rate was 78.1% and the eligible rate of nerve function was 67.4%. These improvements were statistically significant ($P < 0.05$). However, no significant changes in nerve function were observed after 2 years. All patients expressed satisfaction with their surgical results.

Imaging follow-up

The frontal and lateral views of cervical radiograms confirmed a restored and maintained cervical curvature. There was evidence of obvious adjacent segment degeneration on postoperative imaging in five patients two years after surgery. However, none of them had any corresponding symptoms. The CT scan demonstrated a fully expanded spinal canal, with an average opening angle of 45.2°. The healing of the intervertebral bone graft and hinge were confirmed by imaging at 3 to 5 months. MRI dem-
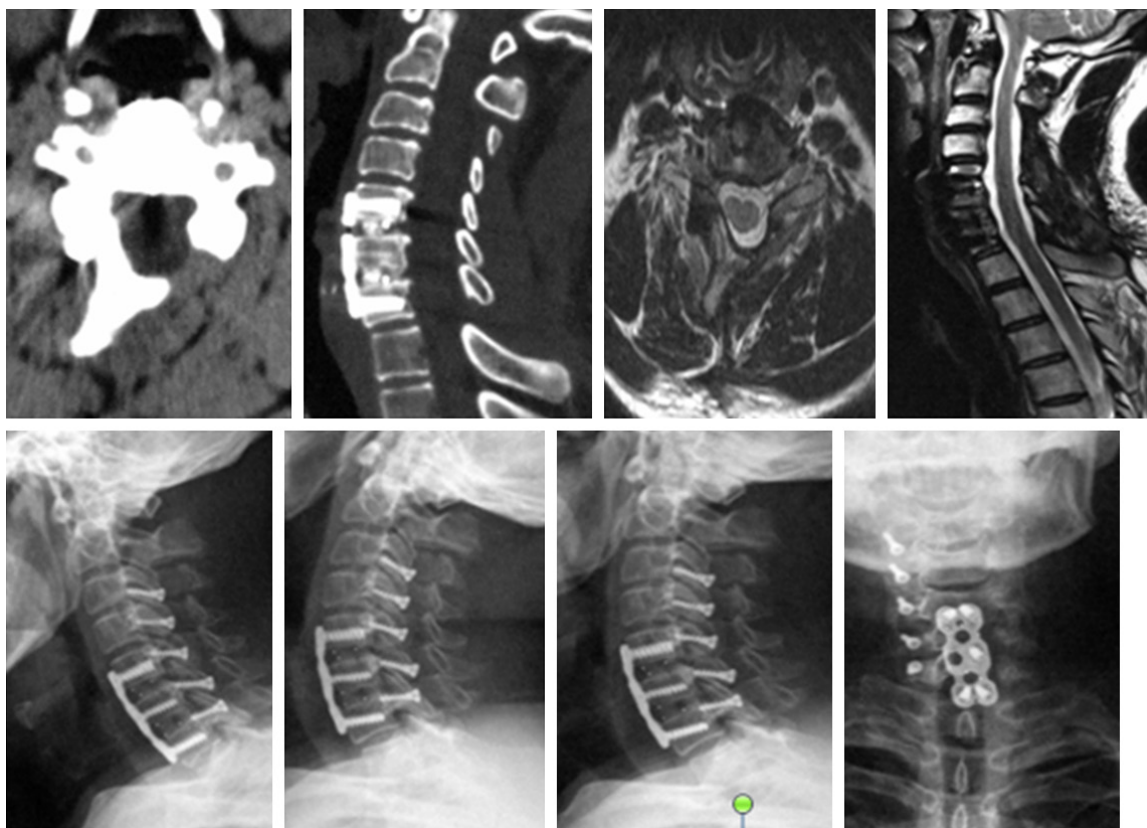
Figure 2. Postoperative cervical X-ray examination showed the internal fixation, with good cervical physiological lordosis and intervertebral stability. MRI showed the full decompression of the spinal canal. CT showed good intervertebral bone fusion. There was no loosening or displacement of internal fixation. The fenestration angle was appropriate, withbone healing at the hinge gutter.

onstrated a substantial posterior shift of the dura mater, and confirmed relief of compression and unobstructed flow of cerebrospinal fluid. In addition, the high signal within the spinal cord disappeared in three cases, and remained unchanged over two years of follow-up in two patients (**Figures 1** and **2**).

Discussion

The primary goal of the operative procedure was to relieve the cervical dural compression and stabilize the cervical spine, which affects the surgical efficacy for patients with CSM. The common compression factors [13, 14] in complex CSM include herniation of the front cervical disc, osteophyte formation around the vertebral or hook vertebral joints, ossification of the cervical posterior longitudinal ligament, hypertrophy or ossification of the ligamentum flavum, proliferation of small joints resulting in cervical stenosis, limited rearward motion, and instability of the intervertebral joints. The pro-

gression of CSM is often undetected. Therefore, even if the symptoms are of recent onset or secondary to minor trauma, the patient may be diagnosed as having severe cervical myelopathy with relatively poor postoperative outcomes. Therefore, decision-making regarding the timing and choice of surgical intervention, and the choice of approach to minimize complications, are key challenges in optimally treating patients with CSM.

It is generally accepted that when surgery is needed to relieve a short segmental compression, instability of the spinal cord and intervertebral kyphosis, the anterior approach for resection is appropriate [15-19]. The posterior approach with laminoplasty or laminectomy-decompression surgery, merged internal fixation, and fusion surgery are more appropriate in cases with more than three segmental compression factors or merged cervical stenosis and a continuous longitudinal ligament. Indications for a single-stage combined anterior

and posterior approach are controversial [20-22]. In patients with complex CSM, with multi-segmental compression factors of the canalis spinalis, and dural sac compression of the anterior spinal canal encroachment rate exceeding 50%, posterior decompression alone may be inadequate to achieve spinal cord decompression. In such situations, the addition of anterior decompression is necessary to enable more thorough decompression. This is particularly important for patients presenting with straightening of the cervical physiological curvature, rearward curvature of the spine, or original intervertebral instability. The significant improvement demonstrated by the patients in our series in terms of the parameters studied, JOA, NDI, and VAS scores, confirm that a combined approach is associated with good outcomes.

Single-stage procedure with combined anterior and posterior approach is associated with significant trauma to the body and the stability of cervical vertebrae, especially for elderly patients with diabetes and those with major organ dysfunction. Most authors recommend a staged procedure with the posterior approach surgery performed initially, followed by a second-stage anterior decompression only if the results following posterior approach surgery are unsatisfactory after 3 months of follow-up. However, as the spinal cord blood supply flows mainly from the anterior spinal artery, performing staged surgery with a posterior approach first may result in a lost opportunity to restore blood supply in patients with anterior spinal canal encroachment exceeding 50%. This is especially true in cases with a high intramedullary MRI signal because there is no means of accurately distinguishing between high spinal cord edema or necrosis. Some authors believe in decompressing the compressed area first, especially in patients with giant ligament ossification of the posterior longitudinal ligament. Thus, this is not a wise surgical strategy for most cases. For patients with complex CSM, having severe cervical spinal cord compression, a posterior-first approach may delay recovery of spinal cord function, and increase the medical costs and psychological burden.

Strict adherence to the indications and adequate preparation for surgery can result in better outcomes with a single-stage procedure with the combined approach. In the present

study, the average patient age was 45.1 years (range 35-63) and the duration of symptoms ranged from 3 months to 6 years. Patients with CSM had several co-morbid conditions, including hypertension, chronic obstructive pulmonary disease, diabetes mellitus, among others. All patients remained stable after operation, possibly owing to the careful selection of cases.

In our study, all patients underwent posterior surgery first, followed by anterior surgery. Conventional posterior open-door surgery results in posterior displacement of the dural sac, increases the relative space, and reduces pressure on the spinal canal and venous plexus congestion. This aids in avoiding dural venous plexus injury and sudden anterior bulging of the dural sac (which may result in acute compression on the rear edge of the pressure port). Both these contribute to increasing the safety of the procedure and reducing bleeding during the anterior surgery. In our study, there were no instances of spinal cord injury, confirming the claim that the choice of operation was optimum [23-25]. However, care must be taken during the positioning of the patient and in maintaining anesthesia. It is imperative that specialists participate in each step of the procedure and care be taken to maintain the patient's head in the neutral or slightly backward position. Any carelessness during the procedure may result in serious iatrogenic injury.

Axial symptoms are an important factor affecting patient's satisfaction with posterior surgery. Since both anterior and posterior cervical spine surgery may cause axial symptoms, they may have a cumulative effect in the combined single-stage surgery. This may be attenuated by attending to the restoration of lordosis during the posterior surgery and avoiding overdistraction of the anterior column. This helps in preventing an increase in the rear facet joint stress. There are three primary ways to prevent complications with posterior surgery. First, if intraoperatively dural sac is estimated as drifting back too much, the patient presented C5 nerve root symptoms before operation and imageological examination showed a narrow nerve root canal, a 2-5 mm root canal enlarging surgery can be included in the posterior surgery, which may contribute to the prevention of postoperative cervical nerve root disease and early functional exercise. Second, the technique of open-door surgical procedures may be

improved. According to available literature, posterior cervical laminoplasty mostly involves the "small joint capsule suspension" method, "anchoring" method, "deep extensor muscle-preserving" approach, dome decompression, segmental laminectomy, and C3 laminectomy [26-29]. The "small joint capsule suspension" method was used by us in our early cases, before we started using the "anchoring" method. The "anchoring" method reduces stimulation to the internal carotid nerve collateral and joint capsule. The rigid-hinge-fixed method was favorable for early exercise. Third, adjunct procedures like administering a long-acting local anesthetic, controlling the patient's blood glucose, quitting smoking after operation, and shortening the neck collar protection time could all reduce the risk of axial symptoms. The use of analgesics and early exercise may also help reduce the occurrence and extent of axial symptoms. Some reports also found that maintaining a 15-30° opening angle and proper inward shift of the hinge during posterior surgery helped in significantly reducing the occurrence of cervical nerve root and axial symptoms [30, 31]. Despite employing these measures, three patients in our series reported axial symptoms postoperatively, indicating the need for further studies to understand the pathophysiology and prevention of axial symptoms.

In conclusion, this study suggests that a single-stage procedure with combined anterior and posterior approach achieves full decompression and good mid-term clinical efficacy for patients with complex CSM. However, caution should be exercised in opting for this surgery in patients with poor performance status as it results in significant physiological injury.

Disclosure of conflict of interest

None.

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