

# Evaluation of Anterior Decompression Surgical Outcomes of Proximal-type Cervical Spondylotic Amyotrophy, a Retrospective Study

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## Research article

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# Abstract

**Background** To investigate the effect of anterior decompression on cervical spondylotic amyotrophy patients with cervical radiculopathy. **Methods** From January 2012 to December 2016, 21 patients with proximal-type cervical spondylotic amyotrophy(CSA) underwent anterior decompression were included. There were 15 males and 6 females, aged 35-73 years with an average of 51.62 years. All underwent surgery of anterior decompression (ACDF or ACCF). Among them, 12 patients underwent C4/5 single level ACDF, 8 patients underwent C4/5 and C5/6 double level ACDF, and one patient underwent C5 anterior cervical corpectomy decompression and fusion surgery. Preoperative and postoperative clinical and radiologic results were assessed. The evaluation items include muscle strength, visual analog scale (VAS) score, neck disability index (NDI) score, Japanese Orthopedic Association (JOA) score, and improvement rate at the last follow-up. Neurological and radiological follow-up averaged 13.2 months. **Results** Severe preoperative muscle atrophy was observed in the deltoid or biceps muscles of 21 patients before surgeries. At the final follow-up, all patients showed statistically improvements in muscle strength, VAS scores, and NDI scores ( $P<0.05$ ,  $P<0.05$ ,  $P<0.05$ ), especially for the deltoid muscles force and JOA scores ( $P<0.01$ ,  $P<0.01$ ), of which the average improvement rates were  $66.49\pm 10.04\%$  and  $62.23\pm 9.23\%$ , respectively. **Conclusions** For CSA patients, especially resulted from cervical radiculopathy, anterior decompression surgery can improve patient's muscle strength and nerve root compression symptoms and generally achieve satisfactory curative effects

## Background

Cervical spondylotic amyotrophy (CSA) is an uncommon clinical syndrome which is characterized by muscle atrophy in the upper extremities with no or minimal sensation deficits. The first clinical case of CSA was reported by Keegan in 1965 as "dissociated motor loss in the upper extremities with cervical spondylosis." [1, 2]. Clinically, CSA is classified into two subtypes according to most predominantly affected muscle groups: proximal amyotrophy (deltoid and biceps) and distal amyotrophy (triceps, forearm, and hand muscles). Most cases are reported as unilateral disorder and occasionally presents as bilateral symmetric disorder [3]. Conservative treatment has once been suggested at the onset of neurological symptom and subsequent surgical intervention is indicated if conservative treatment has not been successful [4, 5]. However, several recent studies have found positive correlations between the long symptoms duration and the poor surgical outcome [6-8] and early surgical intervention is recommended once diagnosed [9]. Indeed, the underlying pathogenesis of CSA is still a controversy, of which the focus lies in whether CSA is the result of selective damage to the ventral root or to anterior horn [10]. Thus, a number of issues involving correlations between surgical procedure and surgical outcome remain controversial until now.

Studies by Chang et al. reported that surgical decompression significantly improves the degree of deltoid palsy in patients with CSA [11]. However, clinical study on the effects of anterior decompression surgery on muscles strength restoration of CSA patients with cervical radiculopathy caused by cervical disc herniation have not been fully investigated. Since clinical patients diagnosed with CSA often manifests

with either the myelopathy or radiculopathy[1, 12]. To clarify the effects of anterior approach for CSA patients with radiculopathy, we reviewed CSA patients especially caused by cervical radiculopathy who underwent anterior decompression surgery in our hospital, between January 2012 and December 2016, with an average 13.2 months follow-up. In our study, we retrospectively studied a total of 21 patients with proximal type CSA and evaluated the surgical outcomes of anterior decompression surgery.

## **Materials And Methods**

### **Patients**

From January 2012 to December 2016, 21 cases subjects in our department who had proximal CSA were enrolled in our study. All patients complained of radicular pain or numbness in unilateral scapular area, shoulder or upper arm which last for 8.8 weeks (2-17 weeks) on average. Patients diagnosed as CSA must meet the following criteria:(1).the presence of unilateral muscle atrophy or impairment of the shoulder girdle muscles; (2) mild or no sensory disturbance in the upper extremity; (3)magnetic resonance imaging indicating cervical spinal cord compression and/or foraminal stenosis with a varying degree of bulging disc; (4) no gait disturbance. Additionally, strict physical examination and the upper extremity Electromyography (EMG) was performed at the entry to rule out patients with brachial plexus and peripheral nerve injury (carpal tunnel syndrome, cubital tunnel syndrome, biceps tendonitis, thoracic outlet Syndrome, etc.), cervical flexion myelopathy multifocal motor neuropathy and amyotrophic lateral sclerosis.

We collected data on patients' sex, age, surgical approaches, preoperative manual muscle test (MMT) results, JOA scores, VAS score, NDI score, duration of symptoms, levels of spinal canal stenosis, etiological diagnosis, and presence of high-intensity zones (HIZ) on T2-weighted magnetic resonance imaging (MRI).

### **Surgical procedure**

All operations were performed in our hospital. 13 patients underwent C4/5 single-segment ACDF surgery, 7 patients underwent C4/5 and C5/6 dual-segment ACDF surgery, and one C5 vertebral ACCF surgery. During the surgery, a complete decompression was performed to the luschka joint especially in the affected side. Additional osteophyctomy was performed to enlarge the intervertebral foramen, and the spinal canal or nerve root canal was carefully explored to see whether there is broken nucleus pulposus tissue. Finally, cages or titanium mash filled with autologous bone grains was placed into the intervertebral space and anterior titanium plate fixation was performed obtain firm interfusion.

### **Assessment of surgical outcome**

For these patients, we collected the basic information including operative procedure, operation time, blood loss during the cervical operation, and postoperative hospital stay. All imaging studies include plain radiographs (neutral, flexion, and extension views), CT and MRI examinations were performed to identify the presence of impingement of the ventral nerve root and corresponding intervertebral levels in each patients. To evaluate the effect of surgical treatment, we used manual muscle testing (MMT): muscle strength improvement rate = (last follow-up muscle strength - preoperative muscle strength) / (5 - preoperative muscle strength), and improvements in muscle strength of the most atrophic muscle strength. Improvements in muscle power of the most severely atrophic muscle were classified as 4 grades: excellent (more than 2 grades of recovery on manual muscle testing), good (1 grade of improvement on manual muscle testing), fair (no improvement on manual muscle testing), and poor (worsening on manual muscle testing). Additional clinical outcomes include scoring system proposed by neck disability index (NDI), visual analogue scale (VAS) and the Japanese Orthopedic Association for the cervical spine (C-JOA score): the recovery rate for the C-JOA score = [(postoperative score – preoperative score)/(17-preoperative score)]\*100%.

## Statistical analysis

The statistical analysis of the clinical data was performed with software SPSS verion24.0 (SPSS, Inc., Chicago,IL). Measured data were expressed as mean±standard deviation ( $\bar{x}\pm s$ ). Variations of postoperative follow-up were analyzed by Wilcoxon signed-rank test, of which  $P<0.05$  was considered significant difference.

## Results

All participants were treated with anterior cervical discectomy and fusion (ACDF) or anterior cervical corpectomy and fusion (ACCF). All the surgery operations were performed by the same surgeon to ensure the consistence in variables. After an average follow-up of 13.2 months (10-32 months), 4 individuals were lost to follow-up. Eventually, 21 subjects (15 males and 6 females) aged 35-73 years old were included in this study, with an average age of 52.9 years.

The patients' characteristics and operation approaches are shown in Table 1. Of the 21 patients diagnosed as CSA, the average operation time was 136.7 minutes, the average intraoperative blood loss was 111.9 ml, and the postoperative hospital stay was 4.63 days on average. In 13 patients underwent C4/5 ACDF, prolapse intervertebral disc can be found in the spinal canal, resulting in foramen stenosis or oppression of ipsilateral nerve root (Figure 1); In 7 patients underwent C4 /5, C5 / 6 two-stage ACDF patients, different degrees of ipsilateral intervertebral disc protrusion in intervertebral space and nerve root compression can be found (Figure 2); It should also be noted that in one case of C5 ACCF, aside from a huge deviation of the contralateral disc herniation, intervertebral space and spinal canal stenosis were found during the procedure (Figure 3).

For all patients, no significant complications occurred at the latest follow-up,. Reviewing the cervical X-ray and lateral three-dimensional reconstruction of CT showed that all surgical segments achieved bony fusion.

At the final follow-up, the deltoid muscle strength of all participants was  $4.09\pm 0.55$  on average, which was significantly higher than the preoperative level of  $2.29\pm 0.78$  ( $P<0.01$ ). The recovery rate was  $66.49\pm 10.04\%$ . The biceps brachii muscle strength was  $4.21\pm 0.62$  on average at follow-up, which was statistically significant improved ( $P<0.05$ ) compared with the preoperative  $3.16\pm 0.94$ . Postoperative muscle power improvement in proximal-type patients was superior to that in distal-type patients ( $P<0.05$ ). The recovery rate was  $57.12\pm 12.37\%$ . VAS and NDI scores were  $3.37\pm 0.88$  and  $12.50\pm 2.42$ , respectively at the final follow-up, which were significantly improved compared with preoperative status( $P<0.05$ ,  $P<0.05$ ). The preoperative JOA score was  $6.02\pm 2.11$  on average, while the average score of follow-up was  $12.91\pm 3.82$  ( $P<0.01$ ). The average recovery rate was  $62.23\pm 9.23\%$ . (Table 2) Regarding improvement of the most atrophic muscle on manual muscle testing, 12 proximal-type patients were graded excellent, 6 were good, and 3 were fair, the improvement rate was 85.7%.(Table 3)

## Discussion

Syndromes of CSA has been documented since 60 years ago. However, the underlying pathogenesis is still unclear. Based on autopsy findings, some researchers proposed that the impingements are mainly concentrated in ventral nerve root[1]. Alternatively, others attribute it to impingement against the anterior horn. Studies by Fujiwara et al and Shinomiya et al. proposed that the impingement against both the ventral nerve root and the anterior horn might cause disease[7, 13]. In our study, we selected proximal-type CSA patients with cervical radiculopathy based on MRI imaging data.

As with surgical options for patient with CSA, there is still controversy in previous literatures. Previously, posterior laminoplasty with or without foraminotomy was reported to have comparable results with anterior decompression and fusion, but clinical evidence on the point is poor. Recent study by Yu Chen et al. recommend anterior decompression as first choice regardless of the number of spinal canal stenosis considering pathogenic lesion leading to CSA comes from the ventral side of the nerve root or anterior horn. In consistent with this point, we select anterior approach as surgical procedure for CSA patients especially with cervical radiculopathy. Anterior cervical discectomy and fusion is a widely accepted surgery approach recommended for CSA caused by CDH[14]. Several previous literatures have reported techniques, outcomes, complications, and prognosis of the surgery in treatment for cervical radiculopathy[15, 16]. However, there are few studies exploring correlations between pathology of compression sites and the outcomes of surgical treatment.

It is also worth noting that during one decompression surgical procedure, disc tissue was absent in the C4/5 intervertebral space and a rupture was found in the posterior longitudinal ligament. After further intraoperative exploration, multiple broken nucleus pulposus was found at the outlet of C5 nerve root and a complete decompression was performed to the affected nerve roots. Therefore, in the actual surgical

procedures of anterior decompression surgery, it is necessary to carefully explore in the spinal canal and ipsilateral nerve root canal and remove the hyperplastic osteophytes. When necessary, the cervical vertebral joint should be decompressed accompanied by enlarging the intervertebral foramen to achieve a complete decompression of the affected nerve roots.

It is generally accepted that upper limb muscles are innervated by several nerve roots[17]. C5 nerve roots mainly innervate the deltoid muscle, as well as part of biceps muscle. Damage to C5 nerve root compression often resulting in restricted motion of shoulder and/or elbow, which has been reported to occur in C4/5 segment disc herniation. However, some scholars have proposed that deltoid muscle spasm may also occur in patients with C3/4 or C5/6 single-segment CDH[18, 19]. Han et al. reported a total of 14 patients with deltoid muscle paralysis caused by single-segment cervical disc herniation and cervical spondylosis of the nerve root ranging from C3 to C6 levels[11]. After anterior decompression surgery, all the patients gain satisfying results. Nevertheless, in some cases, the pathogenesis of decreased deltoid or biceps brachii muscle strength in the C3/4 or C5/6 segment of the CDH or CDH cannot be interpreted solely by clinical studies. In our study, 8 of 21 with C5 nerve root paralysis were found to be involved with C4/5 and C5/6 double-segmental lesions. Two-stage decompression and fusion surgery were conducted, and all patients achieved satisfactory results after the second surgery. For this type of patients, it is advisable to make a comprehensive surgical plan according to involved levels so as to achieve a complete decompression.

Several limitations of our study must be acknowledged. First, the number of cases is small and therefore insufficient for statistically evaluating the surgical outcomes. This is mainly because CSA patients of this type are rare and loss of contact with patients in the follow-up. Secondly, short follow-up time. The shortest follow-up of the study was 10 months, with an average of 13.2 months, which is less persuasive compared with the long-term clinical follow-up study reported in previous literatures. Nonetheless, we added the JOA scores, Neck Disability Index and VAS score to assess the surgical outcomes to make this study more valuable.

In conclusion, we demonstrated clinical features of CSA specifically with cervical radiculopathy and evaluated the surgical outcomes of anterior approaches. We concluded that anterior decompression is effective and can achieve satisfying clinical improvement in both clinical syndrome and muscle strength of atrophic muscles in proximal type CSA patients with cervical radiculopathy. However, the longer-term effect of the surgery remains to be determined, which calls for longer follow-up and further research.

## List Of Abbreviations

CSA:cervical spondylotic amyotrophy, ACDF:anterior cervical discectomy and fusion, ACCF:anterior cervical corpectomy and fusion, MMT>manual muscle test, VAS:visual analog scale, NDI:neck disability index, JOA:Japanese Orthopedic Association, CDH: cervical radiculopathy.

## Declarations

## Ethics approval and consent to participate

The study was approved by the Ethics Committee of Xi Jing Hospital, Xi'an, China.

## Consent for publication

Written informed consent was obtained from each patient in the study.

## Availability of data and material

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

## Competing interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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## Authors' contributions

Changbo Lu and Zhen-sheng Ma contributed equally to the paper.

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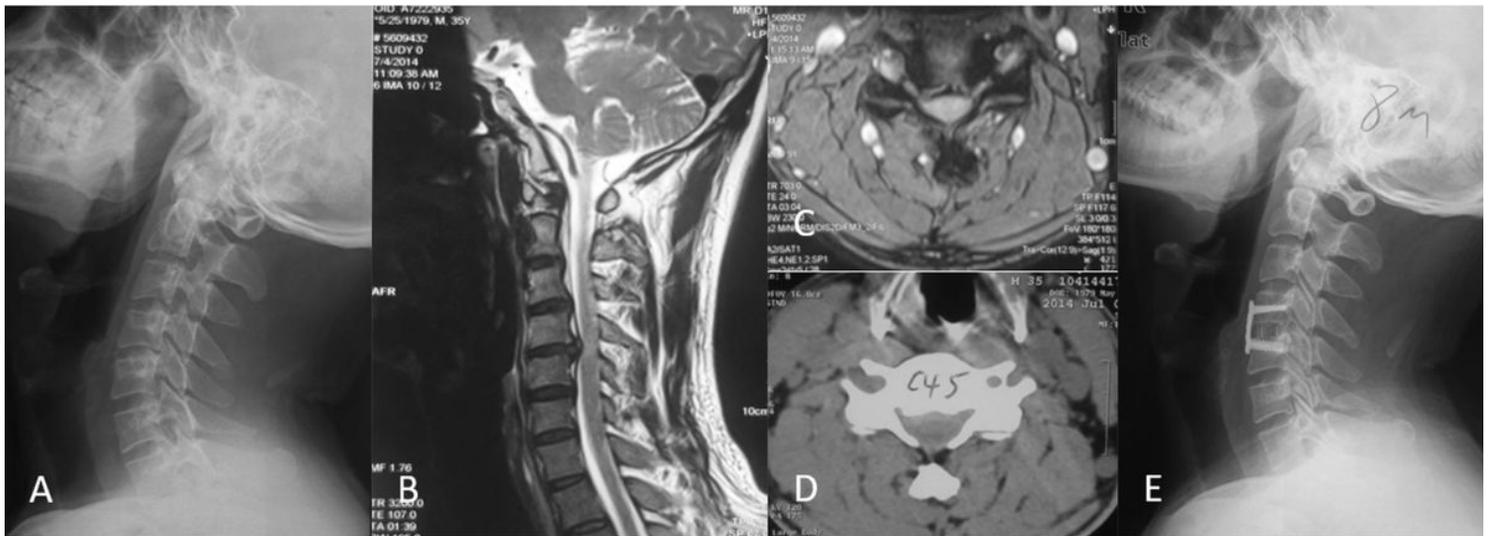
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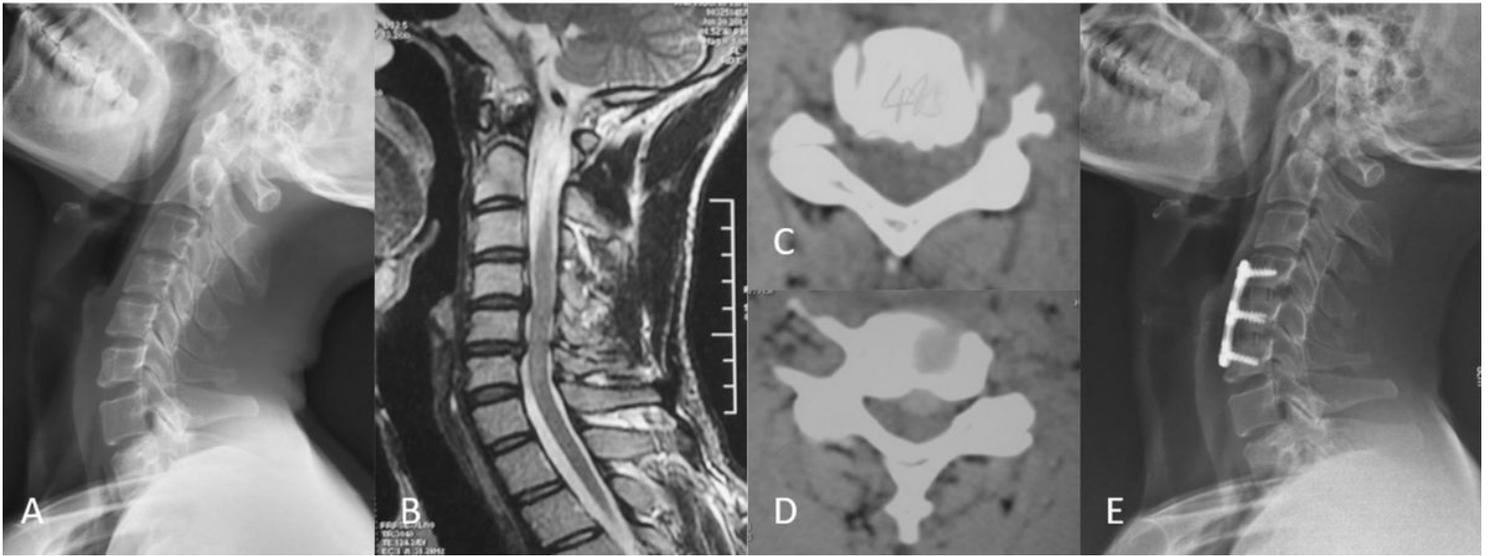
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## Figures



**Figure 1**

A: The pre-operative X-rays of the cervical spine showing narrowed intervertebral space of the C4/5 in a 35-year-old man with right deltoid muscle atrophy. B: Sagittal T2-weighted magnetic resonance image showing cord compression at the C4-C5 space; C: Axial T2-weighted magnetic resonance image at the C4-C5 space showing impingement against the right ventral nerve root and anterior horn, with no abnormal signal intensity in the spinal cord. D: CT of the cervical spine show that the center of the C4/5 disc protrudes to the right, the outlet of the right nerve root is narrowed. E: postoperative lateral X-ray of the cervical spine showing that the internal fixation is firm and the bony fusion is formed.



**Figure 2**

A: The pre-operative X-rays of the cervical spine showing narrowed intervertebral space of the C4/5 and C5/6 in a 41-year-old man with left deltoid and biceps muscle atrophy. B: Sagittal T2-weighted magnetic resonance image showing cord compression at the C4-C6 space. C: CT image at the C4-C5 space showing impingement against C4/5 intervertebral disc on the left side. (An intraoperative exploration confirmed that multiple nucleus pulposus broke into the spinal canal and the nerve root outlet (black arrow)). D: CT image at the C5-C6 space showing that the central C5/6 disc protruded to the left and the outlet of the left nerve root narrowed. E: postoperative lateral X-ray of the cervical spine showing that the internal fixation is firm and the bone fusion is formed.



**Figure 3**

A: The pre-operative X-rays of the cervical spine showing cervical hyperplasia bone hyperplasia, narrowed C4/5, C5/6 intervertebral space in a 48-year-old man with left deltoid and biceps muscle atrophy. B, Sagittal T2-weighted magnetic resonance image showing cord compression at the C4-C6 space. C: Axial

T2-weighted magnetic resonance image at the C4-C5 space showing impingement against the left ventral nerve root and anterior horn, with no abnormal signal intensity in the spinal cord. D: Axial T2-weighted magnetic resonance image at the C5-C6 space showing narrowed segmental spinal canal and impingement against the left anterior horn nerve roots (white arrows). E: Postoperative lateral X-ray of the cervical spine showing that the internal fixation and the titanium cage were in appropriate position.

## Supplementary Files

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