



# Clinical Features and Long-Term Surgical Outcomes of Patients with Cervical Spondylotic Amyotrophy

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**BACKGROUND:** Cervical spondylotic amyotrophy (CSA) is not common. The clinical features and long-term surgical outcomes of patients with CSA are also unclear. We sought to summarize clinical features, assess long-term surgical outcomes, and determine the prognostic factors relevant for patients with CSA.

**METHODS:** A total of 136 patients with CSA who underwent anterior or posterior decompression during January 2001 to December 2012 were included. Their clinical and radiologic data were collected. The surgical outcome was evaluated using manual muscle test and improvements in the muscle strength. Correlations between the surgical outcome and various factors also were analyzed.

**RESULTS:** In total, 128 patients underwent anterior decompression and 8 patients underwent posterior decompression. At the final follow-up, the surgical outcome was significantly better after anterior decompression compared with that after posterior decompression. Statistical analyses showed the type of CSA, duration of symptoms, and association with ossification of the posterior longitudinal ligament were associated with a poor outcome after anterior surgery ( $P < 0.05$ ).

**CONCLUSIONS:** Besides significant muscular atrophy in one upper extremity, CSA also occasionally presents with mild atrophy in the other upper extremity, sensory disturbance

in the upper extremities, or hyperflexia in the lower extremities. Anterior decompression is generally effective in the treatment of patients with CSA. Preoperative duration of symptoms, type of CSA, and ossification of the posterior longitudinal ligament are important predictors for the surgical outcome.

## INTRODUCTION

Patients with cervical spondylotic myelopathy (CSM) sometimes present with muscle atrophy in the upper extremities, with minimal or no sensory symptoms, which is called “cervical spondylotic amyotrophy (CSA).”<sup>1-3</sup> Crandall et al.<sup>4</sup> indicated this subgroup accounted for somewhat less than 7% of patients with CSM. However, the clinical features and long-term surgical outcomes of the patients with CSA have never been clarified.

In 1952, Brain et al.<sup>5</sup> first described a case of cervical spondylosis with muscle atrophy of the upper limbs without sensory disturbance or pyramidal signs. The dissociated motor loss syndrome in cervical spondylosis was reported by Keegan.<sup>6</sup> The characteristic of this syndrome was that the patients complained of difficulty in raising their upper extremities due to severe muscle atrophy of deltoid muscle (Delt), biceps muscle (Bicep), and supinator muscles, with little sensory deficit in the upper limbs and without any long tract sign.<sup>6</sup> Then, Ebara et al.<sup>2</sup> described an amyotrophic type of hand myelopathy as wasting and weakness of the extrinsic and

### Key words

- Anterior decompression
- Cervical spondylotic amyotrophy
- Follow up
- Long-term
- Prognostic factor

### Abbreviations and Acronyms

- APB:** Abductor pollicis brevis
- Biceps:** Biceps muscle
- Bra:** Brachioradialis
- CSA:** Cervical spondylotic amyotrophy
- CSM:** Cervical spondylotic myelopathy
- Delt:** Deltoid muscle
- HIZ:** High-intensity zone
- MMT:** Manual muscle test

**MRI:** Magnetic resonance imaging

**OPLL:** Ossification of the posterior longitudinal ligament

**Tri:** Triceps muscle

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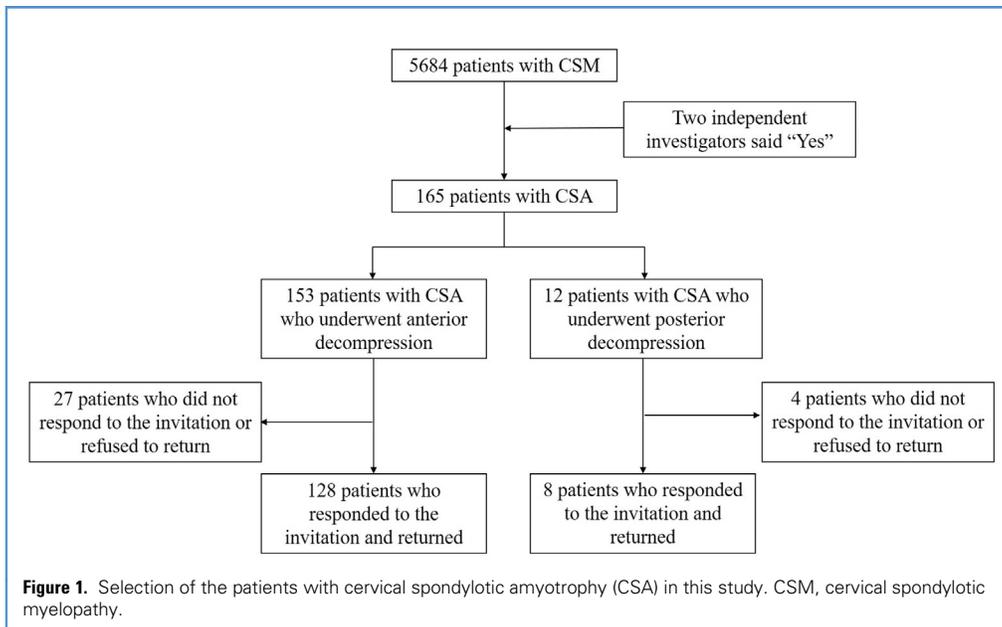
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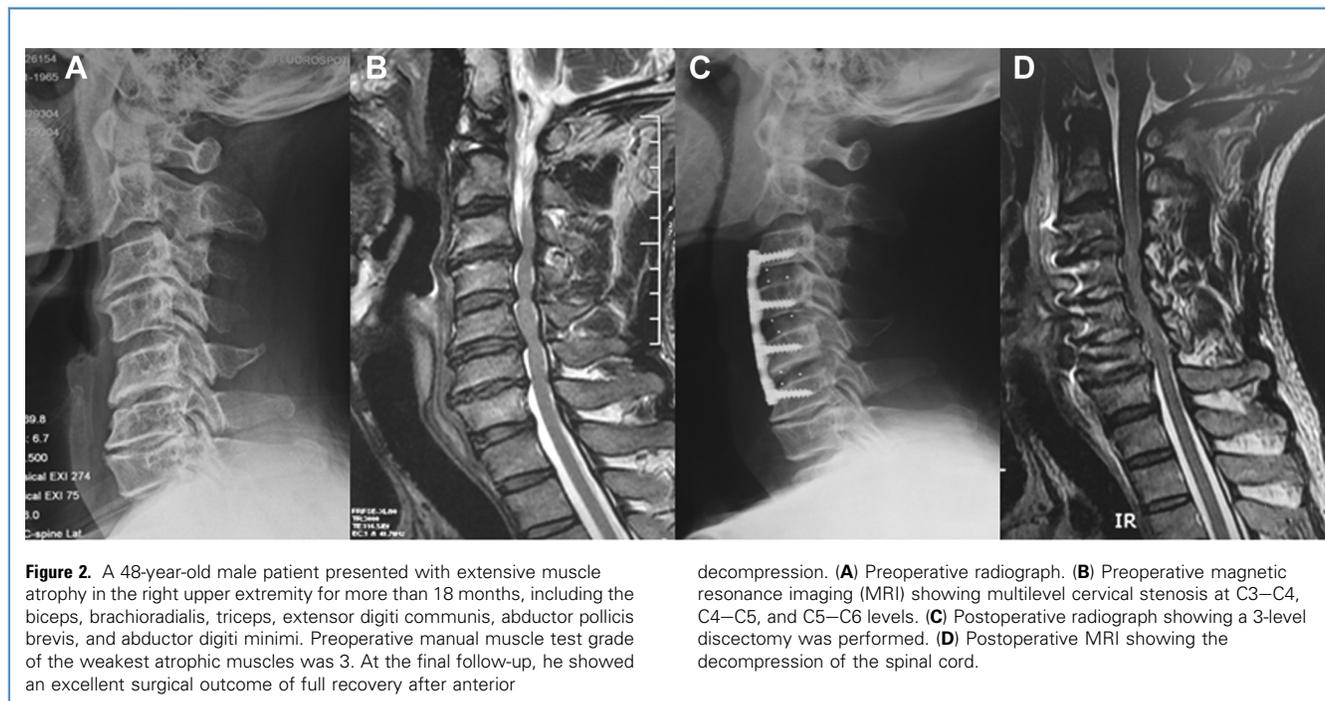
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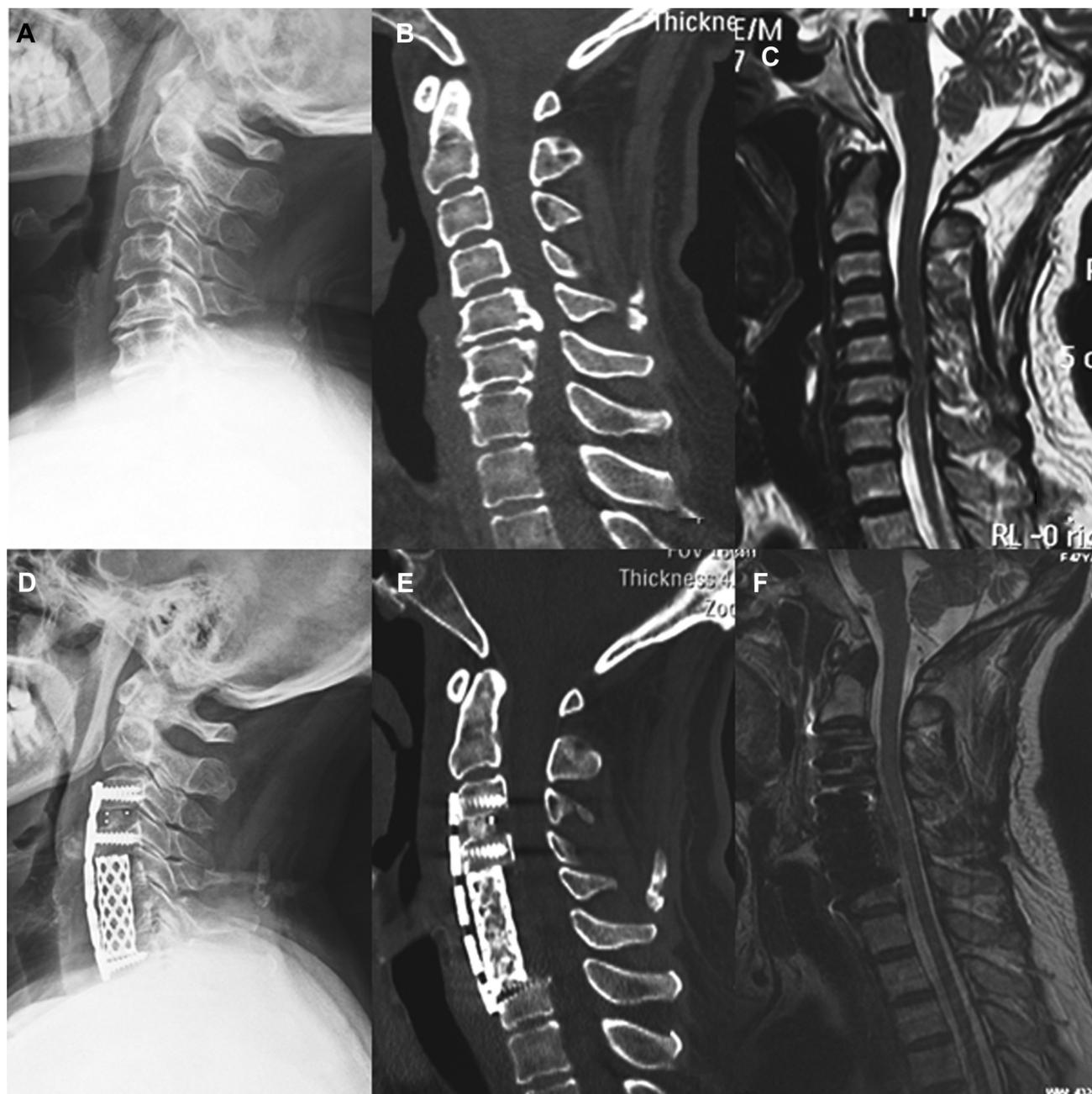
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intrinsic hand muscles with neither sensory loss nor spastic quadriparesis. However, after studying the clinical characteristics of CSA, Sobue et al.<sup>7</sup> suggested a broad definition of CSA. The main subjective symptoms were dissociated motor loss with no, or insignificant, sensory disturbance and radicular pain in the upper limbs, albeit mostly transient. The presence of objective signs of hyperreflexia in the lower limbs also was acceptable.

To summarize the clinical features and assess the long-term surgical outcome of these patients with CSA, we reviewed patients with CSA who underwent anterior or posterior surgery in our hospital between January 2001 and December 2012, with an average 8.5-year follow-up (range from 60 to 176 months). We collected clinical and radiologic data on these patients and examined potential prognostic factors related to poor outcomes.





**Figure 3.** A 49-year-old female patient presented a distal-type cervical spondylotic amyotrophy cervical spondylotic amyotrophy in the right upper extremity for more than 2 years. The atrophic muscles included extensor digiti communis, abductor pollicis brevis, and abductor digiti minimi. Preoperative manual muscle test grade of the weakest atrophic muscles was 2. At the final follow-up, she showed a fair surgical outcome of no significant improvement, although a completed decompression of the spinal cord was confirmed by radiologic examinations. **(A)** Preoperative

radiograph. **(B)** Preoperative computed tomography (CT) scan showing ossification of the posterior longitudinal ligament (OPLL) at C5–C6 levels. **(C)** Preoperative magnetic resonance imaging (MRI) showing multilevel cervical stenosis. **(D)** Postoperative radiograph showing a combined discectomy and corpectomy was performed for this patient. **(E)** Postoperative CT scan showing OPLL was removed. **(F)** Postoperative MRI showing full decompression of the spinal cord.

**Table 1.** Demographic Data of Patients with CSA

	Anterior Approach			Posterior Approach			All Patients (n = 136)
	Proximal-Type (n = 45)	Distal-Type (n = 51)	Combined-Type (n = 32)	Proximal-Type (n = 1)	Distal-Type (n = 3)	Combined-Type (n = 4)	
Male/female	28/17	32/19	23/9	1/0	2/1	3/1	89/47
Mean age, years	46.5 ± 7.3	48.9 ± 6.7	49.8 ± 7.6	53	54.3	51.3	48.6 ± 6.8
Preoperative MMT grade	2.3 ± 0.2	2.2 ± 0.2	2.0 ± 0.2	1	2	2.3	2.2 ± 0.2
Duration of symptoms, months	17.1 ± 5.9	17.5 ± 5.6	24.5 ± 6.8	22	19.3	26.8	19.4 ± 4.8*
Bilateral involvement (+/−)	10/35	14/37	7/25	0/1	1/3	2/2	34/102
Sensory disturbance (+/−)	27/18	30/21	18/14	1/0	3/0	3/1	82/54
Hyperreflexia in lower extremities (+/−)	16/29	19/32	11/21	1/0	2/1	3/1	52/84
Cervical canal stenosis							
1-level	16	18	0	0	0	0	34*
2-level	24	27	0	0	0	0	51*
3-level	4	3	22	1	1	1	32*
4-level	1	3	10	0	2	3	19*
Kyphosis (+/−)	8/37	10/41	18/14	0/1	0/3	0/4	36/100*
OPLL (+/−)	9/36	10/41	6/26	1/0	3/0	4/0	33/103
HIZ on T2-weighted MRI (+/−)	29/16	38/23	30/2	1/0	3/0	4/0	105/31*

CSA, cervical spondylotic amyotrophy; MMT, manual muscle test; OPLL, ossification of the posterior longitudinal ligament; HIZ, high-intensity zone.  
\*P < 0.05 when compared between proximal-type, distal-type, and combined-type subgroup patients.

## MATERIALS AND METHODS

### Patient Selection

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was reviewed and approved by the Ethics Committee of Changzheng Hospital, Shanghai, China. Written informed consent was obtained from each patient. This consent procedure also was approved by the Ethics Committee.

Two independent investigators reviewed our patients who underwent surgery operation for CSM between January 2001 and December 2012. We identified patients with CSA according to the criteria of Sobue et al.<sup>7</sup> as follows: 1) the presence of cervical spondylosis or ossification of the posterior longitudinal ligament (OPLL), 2) the presence of diffuse or localized muscle atrophy of the upper extremity, 3) mild or no sensory disturbance in the upper extremity, 4) either the presence or absence of hyperreflexia in the lower extremities, and 5) the absence of gait disturbance. Only the patients for whom 2 independent investigators said “yes” were enrolled in this study. Eventually, 128 patients who underwent anterior decompression and 8 patients who underwent posterior decompression for CSA responded to the invitation and made return visits (Figure 1).

We collected data on patients’ sex, age, type of CSA, preoperative manual muscle test (MMT) results, duration of symptoms,

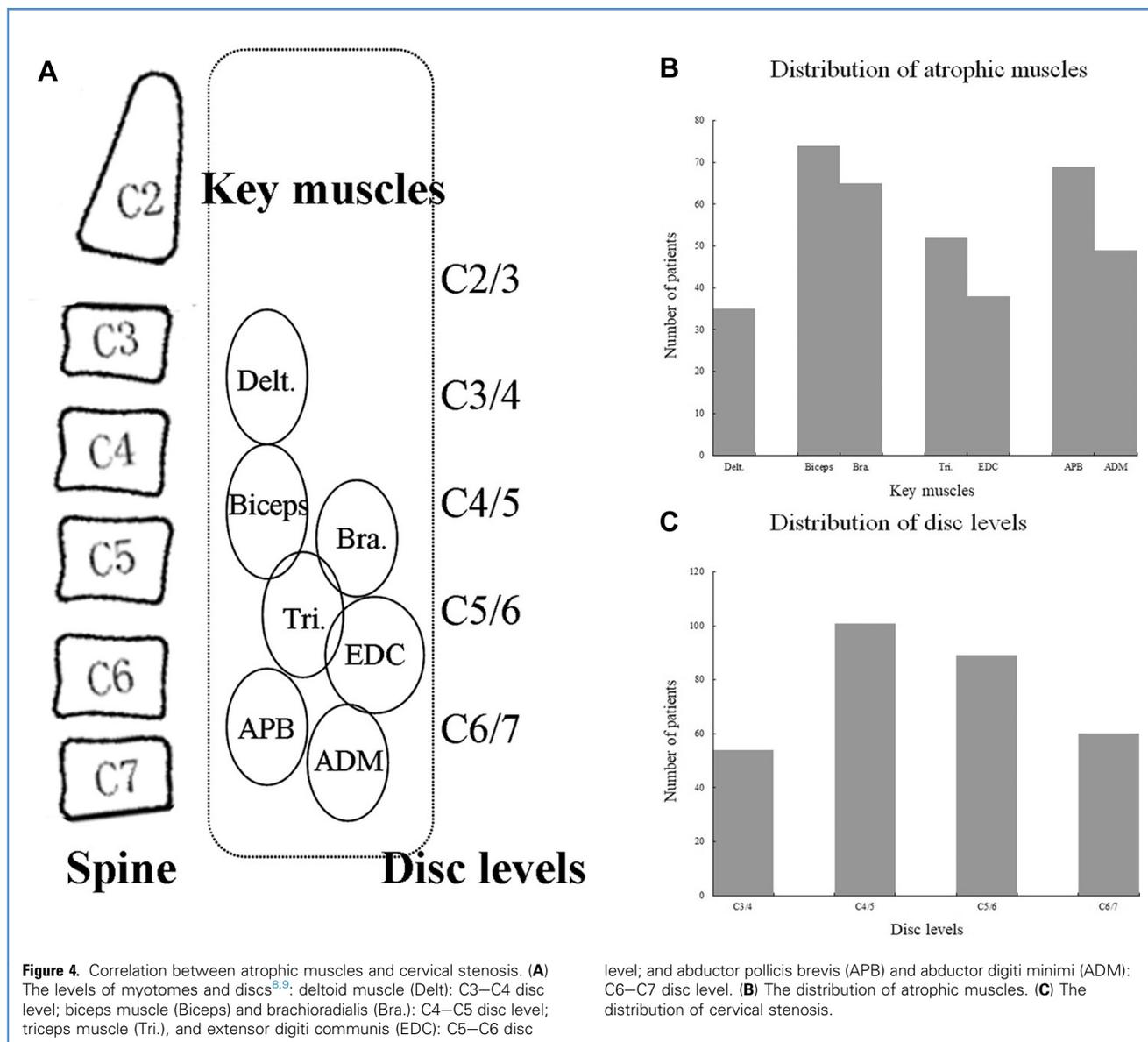
bilateral involvement, sensory deficit, hyperreflexia in lower extremities, levels of spinal canal stenosis, presence of cervical kyphosis, association with OPLL, and presence of high-intensity zones (HIZ) on T2-weighted magnetic resonance imaging (MRI).

To determine the type of CSA, we examined 7 key muscles in the upper extremity, including Delt, Biceps, brachioradialis (Bra.), triceps muscle (Tri.), extensor digiti communis, abductor pollicis brevis (APB), and abductor digiti minimi. The patients were classified into 3 subgroups according to the distribution of atrophic muscles: proximal type (impairment of Delt, Biceps, and Bra.), distal type (impairment of Tri., extensor digiti communis, APB, and abductor digiti minimi), and combined type.

### Surgical Approach

All operations were performed in our hospital. The cervical anterior approach has been described in detailed in previous reports. To summarize in brief, the affected discs were exposed via a right-sided anterior approach. We preferred to perform discectomy for cervical spondylosis and corpectomy also was used when the disease extended behind the bodies as in the patients with OPLL. For the patients with CSA, decompression of the von Luschka joint must be performed.

The superior and inferior uncinata processes were bluntly drilled with a high-speed diamond bur and then resected using a micro-Kerrison rongeur. During partial resection of the uncinata processes, we carefully ensured that the tip of the micro-Kerrison



rongeur always slid along the posterolateral vertebral corners to clip a very small amount of the compressive osseous lesion and did not excessively introduce this tip far laterally to avoid injury to the affected nerve root and vertebral artery (Figures 2 and 3). For the posterior approach, open-door C3–C7 laminoplasty was performed in selected cases with multilevel OPLL. After laminoplasty, the suspected nerve roots were further decompressed using foraminotomy technique. A 5- to 7-mm length of the foraminotomy from the medial border of the facet joint to the lateral end of the bony resection was pursued, and the nerve roots were completely exposed.

#### Outcome Assessment

To evaluate the effect of surgical treatment, we used MMT, and improvements in the muscle strength of the most atrophic and

impaired muscles were classified into 4 grades: 1) excellent, full recovery, or recovery to an MMT grade of 2; 2) good, 1 grade of recovery; 3) fair no improvement; 4) poor, worsening effect. Taken together, we created 2 groups, a good outcome group including excellent and good outcomes and a poor outcome group including fair and poor outcomes.

#### Statistical Analysis

The paired *t* test was used to detect changes in results of MMT before surgery and at the last follow-up. The Mann–Whitney *U* test for independent samples was used to compare continuous variables such as age, preoperative MMT results, and duration of symptoms. The  $\chi^2$  test was used to compare nominal variables, such as sex, type of CSA, levels of spinal canal stenosis, bilateral involvement, sensory deficit, hyperreflexia in lower extremities,

**Table 2.** Surgical Outcomes After Anterior and Posterior Decompression for Patients with CSA

	Anterior Approach (n = 128)	Posterior Approach (n = 8)	P Value
Preoperative MMT grade	2.2 ± 0.2	2.1 ± 0.6	0.648
Postoperative MMT grade	3.4 ± 0.3	2.3 ± 0.6	<0.001
Surgical outcome			
Excellent	40	0	<0.001
Good	32	2	
Fair	37	5	
Poor	18	1	

CSA, cervical spondylotic amyotrophy; MMT, manual muscle test.

presence of cervical kyphosis, association with OPLL, and presence of HIZ on T2-weighted MRI. Furthermore, logistic regression analysis was conducted to determine the factors best correlating to clinical results. Analysis was performed using SPSS for Windows, Version 16.0 (SPSS, Chicago, Illinois, USA), and a P value of less than 0.05 was considered significant.

## RESULTS

### Clinical Features

There were 89 men and 47 women (men: women 1.9:1), with a mean age of  $48.6 \pm 6.8$  years during operation. The duration of symptoms averaged  $19.4 \pm 4.8$  months. Forty-six patients had proximal-type CSA, 54 patients had distal-type CSA, and 36 patients had combined-type CSA. For all the patients, preoperative MMT grade of the most atrophic muscles averaged  $2.2 \pm 0.2$ . Among these patients, 34 (25.0%) patients had mild muscular atrophy in the other upper extremities; 82 (60.3%) patients had or ever had sensory disturbance in the upper extremities; and 52 (38.2%) patients presented hyperflexia in the lower extremities. Cervical canal stenosis ranged from 1 to 4 intervertebral levels. Thirty-four (25.0%) patients had 1-level stenosis, 51 (37.5%) patients had 2-level stenosis, 32 (23.5%) patients had 3-level stenosis, and 19 (14.0%) patients had 4-level stenosis. Cervical kyphosis was preoperatively found in 36 (26.5%) patients. Preoperative computed tomography scan revealed that 33 (24.3%) patients had OPLL. HIZ on T2-weighted MRI was confirmed in 105 (77.2%) patients (Table 1). Statistical analyses among the subgroup patients with different type CSA showed the combined-type patients had longer duration of symptoms, greater number of cervical kyphosis, spinal canal stenosis, and HIZ on T2-weighted MRI.

According to previous reports and our anatomic knowledge, we defined levels of segmental motor innervation and localization of the reflex center.<sup>8,9</sup> Biceps, Bra., and APB were mostly involved in muscle atrophy, but cervical stenosis was mostly observed at C4–C5 and C5–C6 levels. There was no significant consistency between the levels of muscle atrophy and cervical stenosis in our patients (Figure 4).

### Surgical Outcomes and Prognostic Factors

At the final follow-up, the surgical outcome was significantly better after anterior decompression compared with that after posterior decompression. The mean MMT grade of the weakest muscles improved from  $2.2 \pm 0.2$  preoperatively to  $3.4 \pm 0.3$  postoperatively in anterior group ( $P < 0.01$ ), and from  $2.1 \pm 0.6$  preoperatively to  $2.3 \pm 0.6$  postoperatively in posterior group ( $P = 0.549$ ), respectively. Improvement of MMT after anterior surgery was excellent in 40 cases, good in 32 cases, fair in 7 cases fair, and poor in 18 cases. However, it was good in 2 cases, fair in 5 cases, and poor in 1 case after posterior surgery (Table 2).

We also performed univariate analyses and multivariate logistic regression analyses in the patients who underwent anterior decompression to study other potential prognostic factors besides surgical approach. Those patients who underwent posterior decompression were not included because limited number of cases. Thus, 72 patients were grouped into Group 1 with good outcome, and other 56 patients into Group 2 with poor outcome. On univariate analyses of surgical outcomes, the type of CSA, duration of symptoms, and association with OPLL were statistically associated with a poor outcome after surgery ( $P < 0.05$ ). The combined-type CSA patients had a poorer surgical outcome compared with the proximal-type or distal-type patients, but there was no significant difference between proximal-type and distal-type patients (Table 3). Furthermore, the multivariate logistic regression analyses also showed the same results (combined type of CSA: odds ratio 1.347,  $P < 0.001$ ; Duration of symptoms: odds ratio 1.836,  $P = 0.028$ ; OPLL: odds ratio 4.238,  $P < 0.001$ ) (Table 4).

## DISCUSSION

CSA was first reported more than 60 years, but several issues related to this disease remain unsolved, which means that diagnosis is difficult and treatment is delayed in clinical practice.<sup>10</sup> This is a relatively large-sample (136 cases), retrospective study of anterior or postoperative decompression for CSA with an average 8.5-year follow-up. The strengths of this study are that the clinical and imaging data provide insights into the clinical features of CSA, and nearly all known factors were included in the analysis to determine which factor influenced surgical outcome.

In the traditional concept, CSA presented with progressive muscular atrophy of the upper extremity without any preceding symptoms or sensory disturbance, in contrast to the typical features of spastic paralysis caused by cervical spondylosis or OPLL.<sup>1,2,5,6</sup> The signs and symptoms of CSA usually showed an insidious onset. However, more than one-half of our patients presented with minimal or temple sensory disturbance. Most of them presented with transient or lasting needling pain in the upper extremities. In addition, more than one third patients presented with exaggerated deep tendon reflexes in lower extremities without gait disturbance.

Previous reports only described the proximal-type or distal-type of CSA, and the atrophy is generally divided into 2 subgroups according to the most severely atrophic muscle: proximal-type (deltoid and biceps) and distal-type (triceps, forearm, and hand muscles).<sup>10-12</sup> However, very few authors have described the combined-type CSA, and actually various muscles of the upper extremities can be affected in this disease, resulting from multilevel spinal stenosis (more than

**Table 3.** Univariate Analysis of Surgical Outcome in 128 Patients Who Underwent Anterior Decompression for CSA

	Group 1 Good (n = 72)	Group 2 Poor (n = 56)	P Value
Sex			
Male	47	36	0.325
Female	25	20	
Mean age, years	47.5 ± 7.8	49.3 ± 8.4	0.237
Type of CSA			
Proximal	28	17	<0.001
Distal	32	19	
Combined	12	20	
Preoperative MMT grade	2.3 ± 0.2	2.1 ± 0.3	0.065
Duration of symptoms, months	15.8 ± 6.4	23.5 ± 7.5	0.032
Bilateral involvement			
+	17	14	0.354
-	55	42	
Sensory disturbance			
+	43	32	0.280
-	29	24	
Hyperreflexia in lower extremities			
+	27	19	0.125
-	55	37	
Cervical canal stenosis			
1-level	19	15	0.199
2-level	29	22	
3-level	16	13	
4-level	8	6	
Kyphosis			
+	20	16	0.319
-	52	40	
OPLL			
+	9	16	<0.001
-	63	40	
HIZ on T2-weighted MRI			
+	54	43	0.295
-	18	13	

CSA, cervical spondylotic amyotrophy; MMT, manual muscle test; OPLL, ossification of the posterior longitudinal ligament; HIZ, high-intensity zone; MRI, magnetic resonance imaging.

one-quarter of our patients). Another feature we noted in our patients was bilateral involvement.<sup>13</sup> Although most of our patients complained of symptoms in 1 upper extremity, careful neurologic examination revealed mild deterioration of muscle power in the

**Table 4.** Multiple Logistic Regression Analysis for the Risk Factors of Poor Postoperative Outcome After Anterior Decompression

Variables	OR	P Value	95% CI
Age (≥50 years)	2.534	0.184	1.073–1.865
Combined type of CSA	1.347	<0.001	1.387–24.458
Preoperative MMT grade (≥3 grade)	0.628	0.053	0.145–0.722
Duration of symptoms (≥12 months)	1.836	0.028	1.065–6.038
Cervical canal stenosis (≥3 levels)	1.439	0.084	0.082–14.582
OPLL	4.238	<0.001	2.458–8.342
HIZ on T2-weighted MRI	1.638	0.358	1.823–3.483

OR, odds ratio; CI, confidence interval; CSA, cervical spondylotic amyotrophy; MMT, manual muscle test; OPLL, ossification of the posterior longitudinal ligament; HIZ, high-intensity zone; MRI, magnetic resonance imaging.

other extremity in 25% of our patients, which exceeded our expectations. Thus, we considered CSA was closely related to subclinical cervical myelopathy, or an atypical presentation of CSM.

There have been several studies addressing the mechanism of CSA caused by cervical degenerative disease, but there are still some controversies. Keegan<sup>6</sup> demonstrated from autopsy findings that selective impingements against the ventral nerve root caused this disease. However, others considered that impingement of the anterior horn caused this disease based on a T2 high-signal intensity area on MRI and delayed enhanced computed tomography.<sup>11,14</sup> According to electrophysiologic findings, Shinomiya et al.<sup>15</sup> proposed that both mechanisms might cause it.

In our patients, we found it was very difficult to distinguish clearly between them from MRI, especially in those patients with multilevel spinal stenosis. The presence of sensory symptoms in the upper limbs indicates involvement of the spinal cord in the root canal rather than the ventral motor root alone, and the presence of pyramidal signs in the lower limbs indicates damage to the lateral corticospinal tracts. Although proximal muscular atrophy could be caused by either root or anterior horn compression, distal muscular atrophy was more likely to be caused by anterior horn compression. Furthermore, our results also revealed the dissociation between the levels of atrophic muscles and levels of spinal stenosis. Thus, all clinical findings in patients with CSA cannot be explained solely by one mechanism.

There is still much controversy on the surgical options for patient with CSA in the literature; most authors have selected surgical approaches according to their clinical experiences (Table 5).<sup>2,11-13,16-22</sup> Posterior laminoplasty with or without foraminotomy was reported to have comparable results with anterior decompression and fusion, but there were no studies on surgical approaches based on a similar patient population. Some authors agreed that the anterior approach was indicated for a patient with lesions ventral to the cord at 1–2 intervertebral levels, whereas in the presence of a narrow spinal canal, posterior decompression was the choice for a lesion involving more than 2 intervertebral levels.<sup>19-21</sup> However, in our view, anterior decompression is the

**Table 5.** Summary of Literature on Treatment and Outcome in Patients with CSA

Authors	No. of Patients	Type of CSA	Treatments	Follow-up	Outcome
Ebara et al., 1988 <sup>2</sup>	7	Distal-type: 7	ADF: 1 LAM: 6	N/A	6 (85.7%) improved
Matsunaga et al., 1993 <sup>16</sup>	2	N/A	ADF: 2	N/A	1 (50%) improved
Kaneko et al., 2004 <sup>12</sup>	6	Distal-type: 6	LAM: 6	2 years	4 (66.7%) improved
Fujiwara et al., 2006 <sup>17</sup>	32	Proximal-type: 24 Distal-type: 8	LAM: 32	78 months	22 (92%) of proximal-type improved 3 (38%) of distal-type improved
Uchida et al., 2009 <sup>11</sup>	51	Proximal-type: 37 Distal-type: 14	ADF: 51	2.6 years	23 (62%) of proximal-type improved 5 (35.7%) of distal-type improved
Srinivasa Rao et al., 2009 <sup>13</sup>	7	Distal-type: 7	ADF: 7	46.5 months	6 (85.7%) improved
Inui et al., 2011 <sup>18</sup>	90	Proximal-type: 59 Distal-type: 25 Combined-type: 6	Conservative: 56 Surgery: 34	5.0 ± 2.6 years	22 (40%) of conservative treatment improved 28 (82%) of surgery improved
Imajo et al., 2012 <sup>19</sup>	24	Proximal-type: 24	ADF: 11 LAM: 13	50 months	14 (58.3%) improved
Tauchi et al., 2013 <sup>20</sup>	59	Proximal-type: 41 Distal-type: 18	ADF: 8 LAM: 45 PDF: 6	2.7 years	41 (69.5%) improved
Zhang et al., 2016 <sup>21</sup>	88	Proximal-type: 52 Distal-type: 36	ADF: 69 LAM: 19	5.2 years	50 (56.8%) improved
Wang et al., 2014 <sup>22</sup>	28	Proximal-type: 12 Distal-type: 16	ADF: 28	26.6 months	11 (91.7%) of proximal-type improved 6 (37.5%) of distal-type improved

Improved means patients who gained 1 or more grades of muscle power improvement determined by MMT (excellent or good outcome).

CSA, cervical spondylotic amyotrophy; ADF, anterior decompression and fusion; LAM, laminoplasty with or without foraminotomy; N/A, not available; PDF, posterior decompression and fusion; MMT, manual muscle test.

first choice regardless of the number of spinal canal stenosis, because pathogenic lesion leading to CSA comes from the ventral side of the nerve root or anterior horn. Posterior decompression is an alternative option for the cases with multilevel OPLL, on which anterior decompression is impossible or very difficult.

Several prognostic factors of CSA have been reported in previous studies.<sup>11,15,16,23</sup> The analyses in our study showed the patients with longer duration of symptoms, combined-type CSA, and association with OPLL had a poorer surgical outcome. A close association between disease history and recovery of muscle power in the patients with CSA has been proven in many studies.<sup>11,16</sup> It generally is believed that a lengthy period of cord compression causes irreversible injury to the spinal cord. Thus, Uchida et al.<sup>23</sup> suggested that surgical treatment of CSA required urgent action.

Most studies reported that the surgical outcome for distal-type CSA was inferior to the outcome for proximal-type CSA. One possible reason is that the distal type basically involves impingement against the anterior horn, which has less ability than the ventral nerve roots to regenerate. Other reason may be the longer distance from the spinal cord to muscle in the distal type than in the proximal type.<sup>11,16,24</sup> However, our study showed the combined-type CSA patients had the poorer surgical outcome compared with proximal or distal-type CSA, which was characterized by longer duration of symptoms, greater number of cervical kyphosis, spinal canal stenosis, and HIZ on T2-weighted MRI.

In fact, clinical observation found combined-type CSA always began from proximal or distal-type CSA. We think it is the late stage of progression of CSA disease.

In addition, our results showed that OPLL was a new prognostic factor related to poor surgical outcome. This condition could be more common in Chinese and other Asian patients, and the morbidity reached 24.3% in our patients with CSA. The hard compression lesion means longer disease history and more serious damage to the neurologic elements.

One weakness of this retrospective study is that our patients did not have the results of electrophysiology examinations, which contribute to investigate the pathophysiology of different type of CSA. The results of electrophysiology examination also help us to distinguish CSA from amyotrophic lateral sclerosis and other motor neuron diseases.<sup>10,15</sup> Another weakness of this study is that most of our patients were treated by anterior decompression; thus, we could not perform a direct comparison of surgical outcome between anterior and posterior approach on a similar patient population.

## CONCLUSIONS

CSA is not very common in clinical practice. This study focuses on the clinical features and surgical outcomes of the patients with CSA. Besides significant muscular atrophy in one upper extremity,

it also occasionally presents with mild atrophy in the other upper extremity, sensory disturbance in the upper extremities, or hyperflexia in the lower extremities. There is no significant correlation between the levels of muscle atrophy and the levels of

cervical stenosis. Anterior decompression is generally effective in the treatment of patients with CSA regardless of the numbers of cervical stenosis. Preoperative duration of symptoms, type of CSA and OPLL are important predictors for the surgical outcome.

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