The Association Between the Rotator Cuff Status and the Severity and Recovery of Weakness in the Shoulder Abductor Strength in a Case of Proximal Type Cervical Spondylotic Amyotrophy

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Abstract

Study Design: Case series study.

Objective: We aimed to clarify the prevalence of rotator cuff tear (RCT), and the association between RCT and the severity and prognosis in patients with proximal type cervical spondylotic amyotrophy (CSA).

Methods: We retrospectively analyzed 35 proximal type CSA patients who were treated conservatively. The following data was collected: age, rotator cuff status on MRI, manual muscle test (MMT) score of shoulder abductor and biceps brachii muscles both at the first visit and final follow-up. We investigated the prevalence of RCT and the association between the rotator cuff status, and the severity and recovery of upper extremity weakness in patients with proximal type CSA.

Results: Of the 35 patients, 21 had an RCT on MRI, indicating that the prevalence of RCT in patients with proximal type CSA was 60%. An age-adjusted analysis showed that the presence of RCT was significantly associated with the MMT score of the shoulder abductor muscles both at the first visit and at the final follow-up. The presence of RCT was significantly associated with the recovery of the shoulder abductor muscles. The size of the RCT was negatively correlated with the MMT score of the shoulder abductor muscles at the final follow-up. The size of the RCT was independently correlated with the change of the MMT score of the shoulder abductor muscles.

Conclusion: RCT was detected in >50% in patients with proximal type CSA, and the presence and severity of RCT can be used as prognostic factors for proximal type CSA patients who are treated conservatively.

Keywords
cervical spondylotic amyotrophy, rotator cuff tear, conservative treatment, shoulder abductor strength

Introduction

Cervical spondylosis, a degenerative change of the cervical spine, is asymptomatic in most people; however, it sometimes induces neurological symptoms. Although cervical spondylotic myelopathy and radiculopathy are well-known diseases, weakness and atrophy of the upper extremity muscles, without significant sensory deficits, rarely occur in association with cervical spondylosis.

Brian et al.¹ first described cases of upper extremity atrophy associated with cervical spondylosis, without sensory disturbance or pyramidal signs, in 1952. Keegan² reported cases with a dissociated loss of the upper extremity motor function.
with cervical spondylosis in 1965. Moreover, Sobue et al.\(^3\) established the clinical entity of cervical spondylotic amyotrophy (CSA), and also indicated that its main clinical symptoms are muscular atrophy or weakness of the upper extremities, without sensory deficits.\(^3,4\) Although several researchers have discussed hypotheses regarding the etiology of CSA, including selective damage to the ventral nerve root\(^5\) and the anterior horn of the spinal cord,\(^6\) the precise etiology of the entity remains unclear to date. CSA is generally classified into 2 subgroups: proximal type CSA is characterized by weakness of the shoulder abductor and biceps brachii muscles, which can cause dropped shoulder syndrome; distal type CSA is characterized by triceps, forearm and hand intrinsic muscle impairment.

The rotator cuff includes the supraspinatus, infraspinatus, subscapularis and teres minor muscles.\(^9\) Among these, the supraspinatus assists in shoulder abduction with the deltoid muscle, whereas the infraspinatus and teres minor are external rotators of the glenohumeral joint, and the subscapularis is an internal rotator. A subset of patients with rotator cuff tear (RCT) are severely debilitated by pseudoparalysis of the shoulder, which is defined by the inability to actively raise the affected arm above shoulder level.\(^10\) Thus, it is difficult to differentiate between proximal type CSA and RCT in the clinical setting. Nevertheless, there have been no reports about the prevalence of RCT and the influence of RCT on the severity and recovery of upper extremity weakness in CSA patients.

We conducted a retrospective analysis to clarify the prevalence of RCT, and the association between the rotator cuff status and the severity and recovery of upper extremity weakness in proximal type CSA patients who were treated conservatively.

**Materials and Methods**

After receiving institutional review board approval, we retrospectively reviewed the medical records of 61 consecutive patients with proximal type CSA who were managed at our university hospital between January 2012 and May 2019. In the present study, proximal type CSA was defined by the following criteria: (1) degenerative change identified by X-ray of the cervical spine; (2) unilateral muscular weakness with a score of 0-4 on the manual muscle test (MMT) of the shoulder abductor and biceps brachii muscles; and (3) no or insignificant sensory disturbance. Proximal type CSA was diagnosed on the basis of these criteria by a board-certified spine surgeon. From a total of 61 patients, 44 patients underwent 1.5-T magnetic resonance imaging (MRI) of the shoulder of the affected side, and were available for the analysis. Among them, we included 35 conservatively treated patients. We did not include patients who had ossification of the posterior longitudinal ligament of the cervical spine, a history of cervical spine surgery, or a diagnosis of motor neuron disease made by a neurologist.

The following data was collected from these patients with proximal type CSA: age, sex, affected side, presence or absence of RCT, size of RCT, and the MMT score of the shoulder abductor and biceps brachii muscles at the first visit and final follow-up. The size of RCT was classified into 4 grades: “Small,” 0-1 cm cuff tear; “Medium,” 1-3 cm cuff tear; “Large,” 3-5 cm cuff tear; and “Massive,” >5 cm cuff tear, using the classification introduced by Cofield.\(^11\) The assessment of the rotator cuff status was made by an experienced shoulder surgeon who showed high intra-observer and inter-observer reliability in previous RCT studies.\(^12,13\)

The recovery of the shoulder muscle strength was defined as follows: an improvement of at least 2 MMT grades or recovery to grade 5 was defined as “Good recovery”; and recovery of one grade without MMT score of 5, or no improvement, was defined as “Poor recovery.”

We investigated the prevalence of RCT and the association between the rotator cuff status and the severity and recovery of upper extremity weakness in patients with proximal type CSA.

**Statistical Analysis**

The data was expressed as the mean ± S.D. The statistical analysis was performed using Fisher’s exact probability test, the Mann-Whitney U-test, and linear regression and logistic regression analyses. All of the analyses were conducted using the IBM SPSS Statistics 26 software program (IBM Japan, Tokyo, Japan). P values of <0.05 were considered to indicate statistical significance.

**Results**

**The Prevalence of RCT in Proximal Type CSA**

The characteristics of the 35 patients are summarized in Table 1. The average age of the patients at the first visit was 68.5 years (range, 42-82 years). There were 26 men and 9 women. The average follow-up period was 34.2 months (range, 6-103 months). Of the 35 patients, 21 had RCT; thus the prevalence of RCT in patients with proximal type CSA was 60% in

### Table 1. Characteristics and Clinical Findings of Patients with Proximal Type CSA.

| Characteristic                        | Value                      |
|-------------------------------------|----------------------------|
| No. of patients                     | 35                         |
| Age (yrs)                           | Mean 68.5 ± 10.6           |
|                                     | Range 42-82                |
| Sex (men/women)                     | 26/9                       |
| Affected side (right/left)          | 22/13                      |
| RCT (+/-)                           | 21/14                      |
| MMT at first visit                  |                            |
| Shoulder abductor                   | 2.14 ± 0.81                |
| Biceps brachii                      | 3.40 ± 0.91                |
| MMT at final follow up              |                            |
| Shoulder abductor                   | 3.37 ± 1.33                |
| Biceps brachii                      | 4.11 ± 1.11                |
| Duration of FU (mos)                |                            |
| Mean                                | 34.2 ± 34.0                |
| Range                               | 6-103                      |

RCT indicates rotator cuff tear; MMT, manual muscle test.
Association Between the Presence and Severity of RCT and the Prognosis of CSA

The patients with RCT were significantly older (71.9 ± 10.0 vs. 63.4 ± 9.5, p = 0.016), and the MMT scores of their shoulder abductor muscles were lower both at the first visit (1.76 ± 0.63 vs. 2.71 ± 0.73, p = 0.001) and at the final follow-up (2.76 ± 1.30 vs. 4.29 ± 0.73, p = 0.001). In addition, the proportion of patients with a “Good recovery” status among patients with RCT was significantly lower than that in patients without RCT (6/21 vs. 10/14, p = 0.018). There were no significant differences between the 2 groups in sex, affected side, duration of follow-up, or the MMT scores of the biceps brachii muscle at the first visit and final follow-up (Table 2).

After adjusting for age, the presence of RCT was significantly associated with recovery of the shoulder abductor muscles (odds ratio, 0.200; 95% CI, 0.041-0.978, P = 0.047) (Table 4). The sizes of RCT were as follows: “No” tear (n = 14), “Small” tear (n = 10), “Medium” tear (n = 4), “Large” tear (n = 2), and “Massive” tear (n = 5). After adjusting for age, the RCT size was significantly correlated with the MMT score of the shoulder abductor muscles at the final follow-up (β, −0.424, 95% CI, −0.691 to −0.158, P = 0.003), while it was not correlated with that at the first visit. Furthermore, the RCT size was independently correlated with the change in the MMT score of the shoulder abductor muscles (β, −0.307; 95% CI, −0.576 to −0.038, P = 0.027) (Table 5).

Discussion

The present study had 3 main findings. First, we showed the prevalence of RCT in patients with proximal type CSA. The prevalence of RCT on MRI of the shoulder in patients with proximal type CSA was 60% in this study. Second, the presence of RCT on MRI was associated with the severity and recovery of the shoulder abductor muscles in patients with proximal type CSA. Finally, we further found that the severity of RCT, as assessed by MRI, was also correlated with the severity and recovery of the shoulder abductor muscles in these patients.

Proximal type CSA is likely to be misdiagnosed as RCT because patients with either condition can present difficulty in shoulder abduction. In addition, CSA generally affects patients after their 50s.14 Similarly, it has been reported that the mean age of subjects with RCT, approximately 60% of whom were asymptomatic, was in the 60s.15 However, previous studies paid little attention to the association between CSA and RCT.

Some researchers discussed the differentiation between proximal type CSA and RCT. Tauchi et al. reported that the assessment of weakness of the biceps brachii and supinator muscles was useful for differentiating an RCT from proximal type CSA.16 Furthermore, Iwata et al reported that the shoulder provocation test can also help to differentiate an RCT from proximal type CSA, in addition to the assessment of weakness of the biceps brachii.17,18 However, to the best of our

Table 2. Demographics and Clinical Findings of Patients with and without RCT.

| RCT+ | RCT− | P Value |
|------|------|---------|
| No. of patients | 21 | 14 |
| Age (yrs) | 71.9 ± 10.0 | 63.4 ± 9.5 | 0.016 |
| Sex (men/women) | 15/6 | 11/3 | 0.642 |
| Affected side (right/left) | 13/8 | 8/6 | 0.587 |
| MMT at first visit | | | |
| Shoulder abductor | 1.76 ± 0.63 | 2.71 ± 0.73 | 0.001 |
| Biceps brachii | 3.24 ± 1.00 | 3.64 ± 0.75 | 0.359 |
| MMT at final follow up | | | |
| Shoulder abductor | 2.76 ± 1.30 | 4.29 ± 0.73 | 0.001 |
| Biceps brachii | 3.95 ± 1.33 | 4.36 ± 0.63 | 0.678 |
| Recovery (good/poor) | 6/21 | 10/14 | 0.018 |
| Duration of FU (mos) | 44.7 ± 52.0 | 39.0 ± 54.0 | 0.516 |

RCT indicates rotator cuff tear; MMT, manual muscle test. Continuous variables were compared using Mann-Whitney’s U-test; categorical data was analyzed using Fisher’s exact probability test.

Table 3. The Adjusted Linear Regression Analysis of the Association Between MMT of the Shoulder Abductor and the Presence of RCT by Age.

| MMT of shoulder abductor at first visit | β (95% CI) | P value |
|---------------------------------------|------------|---------|
| RCT+                                  | −0.761 (−1.251, −0.270) | 0.003 |
| RCT−                                  | 0 (Reference) | |

| MMT of shoulder abductor at final follow up | β (95% CI) | P value |
|---------------------------------------------|------------|---------|
| RCT+                                        | −1.175 (−1.982, −0.369) | 0.006 |
| RCT−                                        | 0 (Reference) | |

RCT indicates rotator cuff tear; MMT, manual muscle test.

among patients with RCT was significantly lower than that in patients without RCT (621 vs. 10/14, P = 0.018). There were no significant differences between the 2 groups in sex, affected side, duration of follow-up, or the MMT scores of the biceps brachii muscle at the first visit and final follow-up (Table 2). After adjusting for age, the presence of RCT was significantly associated with the MMT score of the shoulder abductor muscles both at the first visit (β, −0.761; 95% CI, −1.251 to −0.270, P = 0.003) and at the final follow-up (β, −1.175; 95% CI, −1.982 to −0.369, P = 0.006) (Table 3). Furthermore, the presence of RCT was significantly associated with recovery of the shoulder abductor muscles (odds ratio, 0.200; 95% CI, 0.041-0.978, P = 0.047) (Table 4). The sizes of RCT were as follows: “No” tear (n = 14), “Small” tear (n = 10), “Medium” tear (n = 4), “Large” tear (n = 2), and “Massive” tear (n = 5). After adjusting for age, the RCT size was significantly correlated with the MMT score of the shoulder abductor muscles at the final follow-up (β, −0.424, 95% CI, −0.691 to −0.158, P = 0.003), while it was not correlated with that at the first visit. Furthermore, the RCT size was independently correlated with the change in the MMT score of the shoulder abductor muscles (β, −0.307; 95% CI, −0.576 to −0.038, P = 0.027) (Table 5).

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knowledge, there have been no reports on the coexistence or prevalence of RCT in patients with CSA.

Milgrom et al. studied the presence of RCT in asymptomatic adults of $\geq 30$ years of age using ultrasonography and found that the prevalence was $>50\%$ in the 7th decade of life, and approximately $80\%$ in individuals of $>80$ years of age. On the other hand, Yamamoto et al. showed that the prevalence of RCT in individuals of $\geq 40$ years of age in the Japanese general population was 22.6% using ultrasonography; this prevalence increased with age, but did not exceed $50\%$. In the present study, the average ages of patients with proximal type CSA was 68.5 years (range, 42 to 82 years), and the prevalence of RCT in these Japanese patients was 60%. Even though ultrasonographic examination yielded more false negatives in comparison to MRI, this prevalence may be higher than the actual prevalence in the Japanese general population.

No studies have focused on the influence of RCT on the severity and recovery of shoulder abductor muscles weakness in patients with proximal type CSA. In the present study, we found that the presence of RCT on MRI was associated with both the severity of the shoulder abductor muscles weakness at the first visit and the recovery of the muscles in patients with proximal type CSA who were managed conservatively. Dyrma et al. previously reported that shoulders with rotator cuff tears require a considerable compensatory deltoid function to maintain shoulder abduction strength. Therefore, it seems reasonable to assume that the deltoid muscle weakness associated with the onset of proximal type CSA affects not only its own function—as the prime mover of shoulder abduction—but also the compensation for the deficient rotator cuff, resulting in precipitous decrease and a poor recovery of shoulder abduction in patients with RCT.

We also found that the size of RCT assessed using MRI was correlated with the severity and recovery of shoulder abductor muscle weakness in patients with proximal type CSA who were managed conservatively. McCabe et al. previously reported that shoulder abductor strength was associated with the size of RCT assessed using the Cofield classification. Thus, it is possible that residual rotator cuff musculature is also independently attributed to the severity and recovery of weakness in the shoulder abduction in proximal type CSA. However, although the supraspinatus and deltoid muscles are innervated by the supraspinatus and axillary nerves respectively, both nerves receive fibers from the C5 and C6 spinal cord segments/nerve roots. Thus, both the supraspinatus and deltoid muscles can be impaired in proximal type CSA. Probably for this reason, the extent of impairment in the residual supraspinatus fibers associated with the proximal type CSA may also affect the severity and recovery of weakness in shoulder abduction.

Although it has been reported that several factors, including older age, lower manual muscle grade, multi-segmental compression, longer duration of symptoms, the presence of high signal intensity change on T2-weighted MR imaging, and pyramidal sign can be prognostic factors in the proximal type CSA, our data suggests that the presence and severity of RCT can also be a poor prognostic factor in patients with proximal type CSA, at least in those who are managed conservatively.

The present study was associated with some limitations. First, there was a selection bias because this was a retrospective study and not all patients with proximal type CSA underwent shoulder MRI of the affected side. Second, the follow-up period was relatively short. Although several significant associations between CSA and RCT were observed in patients over a period of 6 months, long-term follow-up studies may yield additional information. Third, MRI examinations of the shoulder were not performed just after the onset of CSA-associated weakness of the shoulder abductor and biceps brachii muscles in most of cases. Weakness and paralysis of the shoulder in itself is reported to be a risk factor for rotator cuff tears; thus, the MRI finding of RCT might be influenced by long-standing proximal type CSA. Fourth, the sample size was relatively small. As a result, the statistical power might have been insufficient for some of the investigated items. Despite these limitations, we believe that this study contains information that is of clinical importance and provides a basis for further studies regarding the diagnosis and treatment of proximal type CSA.

**Conclusion**

In conclusion, our data indicate that the presence of RCT is $>50\%$ in patients with proximal type CSA, and the presence

| Table 5. The Crude and Age-adjusted Linear Regression Analyses of the Correlation between MMT of the Shoulder Abductor and the Severity of RCT. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | Crude           | Age adjusted    |                 |
|                 | $\beta$ (95% CI)| $P$ value       | $\beta$ (95% CI)| $P$ value       |
| MMT of shoulder abductor at first visit |                 |                 |                 |
| Per one grade increased in size of RCT | $-0.193$ ($-0.383$ to $-0.004$) | 0.046 | $-0.120$ ($-0.304$ to $0.065$) | 0.195 |
| MMT of shoulder abductor at final follow-up |                 |                 |                 |
| Per one grade increased in size of RCT | $-0.529$ ($-0.803$ to $-0.256$) | <0.001 | $-0.424$ ($-0.691$ to $-0.158$) | 0.003 |
| $\Delta$ MMT of shoulder abductor |                 |                 |                 |
| Per one grade increased in size of RCT | $-0.354$ ($-0.611$ to $-0.097$) | 0.008 | $-0.307$ ($-0.576$ to $-0.038$) | 0.027 |

RCT indicates rotator cuff tear; MMT, manual muscle test.
and severity of RCT can be used as prognostic factors for patients with proximal type CSA, at least those who are managed conservatively.

Authors’ Note
All data analyzed during this study is included in this article. Each participant provided an informed consent for participation. Each participant provided an informed consent for publication. Ethics approval was provided by the local ethics committee.

Declaration of Conflicting Interests
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