


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

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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 root⁵ and the anterior horn of the spinal cord,⁶⁻⁸ 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 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

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

	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.

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

this study population. The supraspinatus muscle was involved in all 21 patients.

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

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.

	β (95% CI)	P value
MMT of shoulder abductor at first visit		
RCT+	$-0.761 (-1.251, -0.270)$	0.003
RCT–	0 (Reference)	
MMT of shoulder abductor at final follow-up		
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 (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 the MMT score of the shoulder abductor muscles both at the first visit (β , -0.761 ; 95% CI, -1.251 to

Table 4. The Age-adjusted Logistic Regression Analysis of the Association Between MMT of the Shoulder Abductor and the Presence of RCT.

	OR (95% CI)	P value
Recovery of shoulder abductor (Good/Poor)		
RCT+	0.200 (0.041-0.978)	0.047
RCT–	1.0 (Reference)	

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

-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).

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 50 s.¹⁴ Similarly, it has been reported that the mean age of subjects with RCT, approximately 60% of whom were asymptomatic, was in the 60 s.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 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	
	β (95% CI)	P value	β (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
Δ 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.

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 ≥ 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.¹⁹ On the other hand, Yamamoto et al. showed that the prevalence of RCT in individuals of ≥ 40 years of age in the Japanese general population was 22.6% using ultrasonography; this prevalence increased with age, but did not exceed 50% .¹⁵ 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. Dyrna et al. previously reported that shoulders with rotator cuff tears require a considerable compensatory deltoid function to maintain shoulder abduction strength.²⁰ 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.^{11,21} 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.²² 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,^{5,16,23,24} 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 tears²⁵; 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

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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References

- Brian WR, Northfield D, Wilkinson M. The neurological manifestations of cervical spondylosis. *Brain*. 1952;75(2):187-225.
- Keegan JJ. The cause of dissociated motor loss in the upper extremity with cervical spondylosis, a case report. *J Neurosurg*. 1965;23(5):528-536.
- Sobue I, Kato H, Yanagi T. Clinical characteristics of cervical spondylotic amyotrophy. *Rinsho seikeigeka*. 1965;10(7):999-1006.
- Yanagi T, Kato H, Sobue I. Clinical characteristics of cervical spondylotic amyotrophy. *Rinsho Seikeigeka*. 1976;16(7):520-528.
- Imajo Y, Kato Y, Kanchiku T, Suzuki H, Taguchi T. Pathology and prognosis of proximal-type cervical spondylotic amyotrophy: new assessment using compound muscle action potentials of deltoid and biceps brachii muscles. *Spine (Phila Pa)*. 1976;36(7):E476-E481.
- Asaka T, Satake R, Takamori M, Matsushima A. Dissociated motor loss syndrome with cavities in the anterior horns. *Intern Med*. 1995;34(10):1027-1029.
- Kameyama T, Ando T, Yanagi T, Yasui K, Sobue G. Cervical spondylotic amyotrophy. Magnetic resonance imaging demonstration of intrinsic cord pathology. *Spine (Phila Pa 1976)*. 1998;23(4):448-452.
- Srinivasa Rao NV, Rajshekhar V. Distal-type cervical spondylotic amyotrophy: incidence and outcome after central corpectomy. *J Neurosurg Spine*. 2009;10(4):374-379.
- Clark JM, Harryman DT II. Tendons, ligaments, and capsule of the rotator cuff. Gross and microscopic anatomy. *J Bone Joint Surg Am*. 1992;74(5):713-725.
- Tokish JM, Alexander TC, Kissenberth MJ, Hawkins RJ. Pseudoparalysis: a systematic review of term definitions, treatment approaches, and outcomes of management techniques. *J Shoulder Elbow Surg*. 2017;26(6):e177-e187.
- Cofield RH. Subscapular muscle transposition for repair of chronic rotator cuff tears. *Surg Gynecol Obstet*. 1982;154(5):667-672.
- Hamano N, Yamamoto A, Shitara H, et al. Does successful rotator cuff repair improve muscle atrophy and fatty infiltration of the rotator cuff? A retrospective magnetic resonance imaging study performed shortly after surgery as a reference. *J Shoulder Elbow Surg*. 2017;26(6):967-974.
- Sasaki T, Shitara H, Yamamoto A, et al. What is the appropriate reference for evaluating the recovery of supraspinatus muscle atrophy after arthroscopic rotator cuff repair? The occupation ratio of the supraspinatus may change after rotator cuff repair without volumetric improvement. *Am J Sports Med*. 2018;46(6):1416-1423.
- Tauchi R, Imagama S, Inoh S, et al. Risk factors for a poor outcome following surgical treatment of cervical spondylotic amyotrophy: a multicenter study. *Eur Spine J*. 2013;22(1):156-161.
- Yamamoto A, Takagishi K, Osawa T, et al. Prevalence and risk factors of a rotator cuff tear in the general population. *J Shoulder Elbow Surg*. 2010;19(1):116-120.
- Tauchi R, Imagama S, Inoh H, et al. Appropriate timing of surgical intervention for the proximal type of cervical spondylotic amyotrophy. *Eur J Orthop Surg Traumatol*. 2015;25(Suppl1):S107-S113.
- Iwata E, Shigematsu H, Inoue K, Egawa T, Sakamoto Y, Tanaka Y. Muscle weakness in the empty and full can tests cannot differentiate rotator cuff tear from cervical spondylotic amyotrophy: pain provocation is a useful finding. *Open Orthop J*. 2017;30(11):1081-1086.
- Iwata E, Shigematsu H, Inoue K, et al. Biceps-related physical findings are useful to prevent misdiagnosis of cervical spondylotic amyotrophy as a rotator cuff tear. *Asian Spine J*. 2018;12(1):69-73.
- Milgrom C, Schaffler M, Gilbert S, van Holsbeeck M. Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. *J Bone Joint Surg Br*. 1995;77(2):296-298.
- Dyrna F, Kumar NS, Obopilwe E, et al. Relationship between deltoid and rotator cuff muscles during dynamic shoulder abduction: a biomechanical study of rotator cuff tear progression. *Am J Sports Med*. 2018;46(8):1919-1926.
- McCabe RA, Nicholas SJ, Montgomery KD, Finneran JJ, McHugh MP. The effect of rotator cuff tear size on shoulder strength and range of motion. *J Orthop Sports Phys Ther*. 2005;35(3):130-135.
- Hattrup SJ, Cofield RH. Rotator cuff tears with cervical radiculopathy. *J Shoulder Elbow Surg*. 2010;19(6):937-943.
- Asaka T, Satake R, Takamori M, Matsushima A. Dissociated motor loss syndrome with cavities in the anterior horns. *Intern Med*. 1995;34(10):1027-1029.
- Iizuka Y, Iizuka H, Mieda T, et al. Prognostic factors for cervical spondylotic amyotrophy: are signs of spinal cord involvement associated with the neurological prognosis? *Spinal Cord*. 2014;2(5):364-367.
- Yi Y, Shim JS, Kim K, et al. Prevalence of the rotator cuff tear increases with weakness in hemiplegic shoulder. *Ann Rehabil Med*. 2013;37(4):471.