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RESEARCH ARTICLE

Prognostic Factors for Conservative Treatments of Atraumatic Rotator Cuff Tears

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Abstract:

Background:

Little consensus has been achieved on conservative treatments in patients with Rotator Cuff Tears (RCTs).

Objective:

To determine whether anatomical severities of RCTs were poor prognostic factors in conservative treatments.

Method:

This study included 102 shoulders with atraumatic RCTs diagnosed by magnetic resonance imaging. Partial-thickness tears were identified in 15 shoulders and full-thickness tears in 87 shoulders. Three patients had a concomitant subscapularis (SSC) tendon tear. All patients were treated conservatively with the administration of non-steroidal anti-inflammatory drugs and physical therapy. The visual analog scale (VAS), Constant scores, and active range of motion were evaluated as clinical outcomes. Pearson's chi-square test and Student's t test, Mann-Whitney U test, one-way analysis of variance (ANOVA), or Kruskal-Wallis test was performed to compare the participant's characteristics and clinical data. Treatment effectiveness among the tear size groups and with/without SSC tear groups was assessed using a two-factor repeated measures ANOVA.

Results:

Larger tears were associated with less improvement in VAS ($p = 0.032$). At the initial and final visits, larger tears showed lower constant scores ($p = 0.014$ and $p < 0.001$, respectively) and restricted forward elevation (FE) ($p = 0.042$ and $p = 0.013$, respectively). Shoulders with SSC tear showed higher VAS, lower constant scores, and lower FE at the final visit ($p = 0.002$, $p = 0.001$, and $p=0.019$, respectively). Patients with SSC tear underwent surgery more frequently than those without tear ($p < 0.001$).

Conclusion:

Larger RCTs and concomitant SSC tear are poor prognostic factors for the conservative treatment of atraumatic RCTs.

Keywords: Rotator cuff tears, Conservative treatment, Tear size, Tear pattern, Shoulder disorder, Anatomical severities.

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1. INTRODUCTION

Rotator Cuff Tears (RCTs) are a common shoulder disorder mainly affecting people older than 50 years and has a prevalence of approximately 20% in the general population [1 - 3]. Treatment options for symptomatic RCTs are operative intervention and conservative treatments including administration of Nonsteroidal Anti-Inflammatory Drugs (NSAIDs), corticosteroid injections to the glenohumeral joint or sub-

acromial bursa, and physical therapy. Although the benefit of surgical treatments for patients with symptomatic RCTs has been proposed, other treatment options remain controversial [4, 5]. Numerous factors that affect clinical outcomes of RCTs have been described [5, 6], including anatomical severities, such as tear size and quality of torn cuff muscles, a history of trauma, duration of symptoms, and duration and/or failure of conservative treatments [5, 6].

Many researchers have reported various outcomes with regard to conservative treatments for symptomatic full-thickness RCTs. Success rates of conservative treatments vary widely. Some investigators described a rate of approximately 50% or less [7 - 9], whereas others reported over 70% [10 - 13]. This variation is attributed to the difference in the participants' characteristics (*e.g.*, a history of trauma and anatomical features, such as tear size, with or without subscapularis [SSC] tendon tear) and types of conservative treatments (*e.g.*, home exercise program, physical therapy by physical therapists) [8 - 10, 12, 14 - 19].

Progression of tear size is one of the most important factors from asymptomatic to symptomatic tears [20, 21]. The anatomical severities of RCTs are associated with a failure rate of conservative treatments [9, 10, 15]. However, recent studies have indicated that symptomatic RCTs are not associated with anatomical features, pain, or functions [18, 22, 23]. Curry *et al*. stated that pain and functional status in patients with RCTs with operative and conservative treatments were not associated with tear size or thickness, fatty infiltration, or muscle atrophy [22]. The MOON Shoulder Group demonstrated that shoulder pain and activity level were not associated with anatomical severities of atraumatic RCTs [18, 23]. Correlations between anatomical severities and conservative treatments of atraumatic RCTs are still controversial. In the present study, we aimed to determine whether anatomical severities, such as tear size and patterns at the initial visit, could be prognostic factors in conservative treatments for atraumatic RCTs.

2. MATERIALS AND METHODS

2.1. Participants

This study included 102 shoulders in 101 patients (50 men and 51 women; mean age, 70.1 ± 8.5 years) who met the inclusion criteria and visited the senior author's clinic between April 2010 and August 2014. The inclusion criteria were as follows: shoulder pain at rest and/or during motion, 50 years or older, positive supraspinatus test [24], and RCTs diagnosed by magnetic resonance imaging. The exclusion criteria were the history of trauma or previous surgery on the affected shoulder joint or girdle; history of chronic arthritis involving the shoulder joint, such as osteoarthritis and rheumatoid arthritis; systemic disorders, such as diabetes mellitus and thyroid disorder; neurological disorders, such as cervical myelopathy, radiculopathy, and stroke; or a recent intra-articular corticosteroid injection. All patients were followed up closely, and the median duration of conservative treatment was 3.1 months (Interquartile Range [IQR], 2.2-5.9 months).

Partial-thickness tears were identified in 15 shoulders and full-thickness tears in 87. Shoulders with full-thickness tears were classified by their greatest diameter using the system of DeOrio and Cofield [25]. Twenty-two shoulders were classified as small tears (<1 cm), 41 as medium (1-3 cm), 19 as large (3-5 cm), and 5 as massive tears (≥5 cm). The partial, small, medium, and large and massive tear groups were categorized as the study groups.

2.2. Conservative Treatments

All patients were treated with physical therapy such as mobilization of the sternoclavicular and sternocostal joints, restoration of thoracic spine and rib motion, static and dynamic exercises for the scapula and glenohumeral movement, and stretching the periscapular and rotator cuff muscles. NSAIDs were administered to patients with severe pain. As abnormal posture and scapular kinema tics were associated with patients with RCTs, the motion of the scapula, clavicle, and thoracic spine was intensified [26 - 28]. Physical therapy was performed twice a week by physical therapists specializing in shoulder problems, and they provided the patients with a daily home-exercise program [29]. The two senior doctors (J.H. and Y.H.) assessed the range of motion, and scapular motion, and evaluated Visual Analog Scale (VAS).

2.3. Outcome Assessment and Goal Setting

VAS and Constant scores [30] were used for clinical outcomes. Active Range of Motion (AROM) including Forward Elevation (FE), External Rotation with the arm at side (ER), and Internal Rotation (IR) as the hand behind the back was also evaluated. In seven patients who underwent arthroscopic rotator cuff repairs, the condition of the torn cuff and intra-articular findings were recorded to reveal the reason for recalcitrance to conservative treatment. The goal of the conservative treatment for responders was set as follows: significant improvement in pain during daily living, work, and sports activities. For non- or weak responders, limitation of the conservative treatment was set as follows: restriction of their daily living, work, and sports activities with pain even after the conservative treatment.

2.4. Statistical Analysis

Categorical variables were summarized as percentages and continuous variables as means with standard deviation or medians with IQR. Participant's characteristics and clinical data were compared using Pearson's chi-square test for categorical variables, and using Student's t-test, Mann-Whitney U test, one-way analysis of variance (ANOVA), or Kruskal-Wallis test for continuous variables. Treatment effectiveness with regard to the study's continuous dependent variables (*e.g.*, VAS, Constant scores, AROM [FE and ER]) among the anatomical feature groups (*e.g.*, four tear size groups, with /without SSC tear groups) was assessed using a two-factor repeated measures ANOVA (RMANOVA). The generalized estimating equations for repeated measures were used to analyze the change of IR in AROM among the groups, since IR

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was an ordinal variable. All statistical tests were conducted at a significance level of 0.05. Statistical analyses were performed with SPSS for Windows version 23.0 (SPSS Inc., Chicago, IL, USA).

3. RESULTS

Basic characteristics among the partial, small, medium, and large and massive tear groups at the initial visit are summarized in Table **1**. SSC tendon tear was concomitant in three shoulders. Significant differences were not found among the four groups in age (p = 0.13), sex (p = 0.58), affected shoulder (p = 0.88), or presence of SSC tendon tear (p = 0.31).

The clinical characteristics of the four groups at the initial and final visits are listed in Table **2**. After the conservative treatment, the clinical outcomes greatly improved in 95 shoulders, whereas little improvement was noted in 7 shoulders. Seven patients (1 in the partial, 3 in the medium, and 3 in the large and massive tear groups) underwent arthroscopic rotator cuff repairs. The duration of the treatment and the number of operated shoulders were not statistically significant among the groups (p = 0.82 and p = 0.42, respectively). Larger tears showed less improvement in VAS (group * time interaction by RMANOVA: p = 0.032). Significant differences in effectiveness of conservative treatment were not observed for the Constant scores or AROM (FE, ER, and IR) among the four groups (group * time interaction: Constant score, p = 0.33; FE, p = 0.54; ER, p = 0.68; IR, p = 0.65). At both the initial and final visits, larger tears showed lower Constant scores (p = 0.014 and p < 0.001, respectively) and restriction of FE (p = 0.042 and p = 0.013, respectively). No significant differences were found in ER or IR among the four groups.

Table 1. Basic characteristics of study participants.

-	Tear size				p Value
-	Partial (n = 15)	Small (n = 22)	Medium (n = 41)	Large and massive (n = 24)	
Age, years	69.7 ± 8.6	68.7 ± 7.1	68.9 ± 8.8	73.7 ± 8.1	0.13[a]
Sex, females	9 (60)	13 (59)	20 (49)	10 (42)	0.58[b]
Affected side, right	9 (60)	16 (73)	28 (68)	16 (67)	0.88[b]
SSC tear	0	0	1 (2)	2 (8)	0.31[a]

Age is presented as mean ± standard deviation; sex, affected side, and combined SSC tear are presented as n (%).
Partial, partial tear group; Small, small tear group; Medium, medium tear group; Large and massive, large and massive tear group; SSC, subscapularis.
[a]One-way analysis of variance; [b]Pearson's chi-square test.

Table 2. Clinical characteristics among the four tear size groups.

-	Tear size				p Value	
-	Partial (n = 15)	Small (n = 22)	Medium (n = 41)	Large and massive (n = 24)		
VAS						
Initial visit	6.5 ± 1.7	5.2 ± 1.6	6.1 ± 2.0	5.8 ± 2.0	0.032[a]	0.20[b]
Final visit	1.2 ± 1.3	0.8 ± 1.6	1.3 ± 1.4	2.4 ± 2.1		0.011[b]
Constant score						
Initial visit	50.8 ± 15.4	60.0 ± 12.5	54.5 ± 15.4	46.2 ± 13.7	0.33[a]	0.014[b]
Final visit	77.1 ± 10.9	79.2 ± 7.7	77.1 ± 9.0	66.7 ± 13.4		<0.001[b]
FE						
Initial visit	125.0 ± 24.5	138.2 ± 19.5	131.5 ± 25.7	116.6 ± 33.9	0.54[a]	0.042[b]
Final visit	145.9 ± 10.9	152.0 ± 12.2	147.0 ± 10.9	139.4 ± 17.3		0.013[b]
ER						
Initial visit	37.0 ± 17.0	44.6 ± 17.7	42.5 ± 14.4	35.5 ± 18.0	0.68[a]	0.18[b]
Final visit	49.6 ± 14.2	53.9 ± 14.6	50.3 ± 12.8	45.6 ± 15.6		0.27[b]
IR						
Initial visit	T12 [T8, L2]	T10 [T8, T12]	T12 [T8, L2]	T12 [T10, L1]	0.65[c]	0.29[d]
Final visit	T7 [T6, T12]	T8 [T6, T10]	T8 [T7, T10]	T9 [T8, T10]		0.28[d]
Duration (months)	3.1 [1.8, 7.3]	4.1 [2.2, 7.0]	3.0 [2.0, 5.3]	3.0 [2.5, 5.3]	0.82[d]	
Operated shoulders	1 (7)	0	3 (7)	3 (13)	0.42[e]	

VAS, Constant score, FE, and ER are presented as mean ± standard deviation; IR and treatment duration as median [interquartile range]; operated shoulders as n (%).
Partial, partial tear group; Small, small tear group; Medium, medium tear group; Large and massive, large and massive tear group; VAS, visual analogue scale; FE, forward elevation; ER, external rotation; IR, internal rotation.
[a]Repeated measures analysis of variance (ANOVA) for group * time interaction; [b]one-way ANOVA; [c]generalized estimating equations for group * time interaction; [d]Kruskal-Wallis test; [e]Pearson's chi-square test.

Table 3. Clinical characteristics of the groups with and without SSC tears.

-	SSC tear		p Value	
	Absent (n = 99	Present (n = 3)		
VAS				
Initial visit	5.9 ± 1.9	6.7 ± 0.2	0.09[a]	0.44[b]
Final visit	1.3 ± 1.6	4.4 ± 4.0		0.002[b]
Constant score				
Initial visit	53.5 ± 15.1	42.7 ± 11.8	0.17[a]	0.22[b]
Final visit	75.7 ± 10.3	55.0 ± 21.5		0.001[b]
FE				
Initial visit	128.6 ± 27.3	125.0 ± 31.2	0.30[a]	0.83[b]
Final visit	146.7 ± 12.4	128.3 ± 34.0		0.019[b]
ER				
Initial visit	40.2 ± 31.2	50.0 ± 26.5	0.059[a]	0.32[b]
Final visit	50.0 ± 14.2	45.0 ± 13.2		0.55[b]
IR				
Initial visit	T12 [T8, L1]	T12 [T10, −]	0.36[c]	0.71[d]
Final visit	T8 [T7, T10]	T9 [T7, −]		0.45[d]
Duration (months)	3.3 [2.2, 6.1]	1.9 [0.9, −]	0.064[d]	
Operated shoulders	5 (5.1)	2 (66.7)	<0.001[e]	

VAS, Constant score, FE, and ER are presented as mean ± standard deviation; IR and treatment duration as median [IQR]; operated shoulders as n (%).
SSC, subscapularis; VAS, visual analogue scale; FE, forward elevation; ER, external rotation; IR, internal rotation.
[a]Repeated measures analysis of variance (ANOVA) for group * time interaction; [b]Student's t-test; [c]generalized estimating equations for group * time interaction; [d]Mann-Whitney U test; [e]Pearson's chi-square test.

Significant differences were not observed in the effectiveness of conservative treatment between the two groups with or without SSC tendon tears (Table **3**). Significant differences in VAS, Constant scores, and FE at the initial visit were not identified. However, the group with SSC tear showed higher VAS, lower Constant scores, and smaller range of FE at the final visit ($p = 0.002$, $p = 0.001$, and $p = 0.019$, respectively). Patients with SSC tendon tear had a tendency to have surgery than those without ($p < 0.001$).

4. DISCUSSION

The important findings of this study were as follows. First, larger RCTs tended to be recalcitrant to the conservative treatment. Second, the presence of SSC tendon tear had poor outcomes for the conservative treatment.

Although the anatomical features of RCTs have been speculated to be one of the most important factors for surgical repairs, the association between the anatomical severities of RCTs (*e.g.*, tear size, quality of the torn rotator cuff muscle) and pain, function, and effectiveness of conservative treatments is controversial [9, 10, 15, 18, 22, 23]. Recent studies have indicated that symptomatic RCTs are not associated with anatomical features on pain or function [18, 22, 23]. Dunn *et al*. reported that anatomical severities, such as tear size, superior migration of the humeral head, and fatty infiltration of rotator cuff muscles, were not related to pain severity [18]. Curry *et al*. also described that pain and functional status did not correspond with anatomical features (*e.g.*, tear size and thickness, fatty infiltration, muscle atrophy) [22]. Brophy *et al*. documented that the activity levels of patients with atraumatic RCTs were not associated with tear size, but with age, sex, and occupation [23]. However, in this study, relieving pain from larger RCTs was difficult by conservative treatment and these RCTs exhibited lower function and FE. In addition, RCTs with SSC tendon tear showed higher VAS, lower Constant scores and FE at the final visit, and more shoulder surgeries than those without. The rotator cuff muscles can stabilize the humeral head centered in the glenoid cavity and move the humerus in multiple directions. Throughout the shoulder motion, the compressive joint force in the transverse plane contributes to joint stability [31]. Patients with larger RCTs might present with the instability of the humeral head in the glenoid cavity and limited shoulder motion due to loss of the transverse plane force couple [32]. Therefore, larger RCTs and the combination of an SSC tendon tear appear to decrease the stability of the humerus and would be recalcitrant to the conservative treatment, which corresponded well with some reports [9, 10, 15]. Although surgical procedure should be recommended to such patients, this category of RCTs has a higher rate of re-rupture [33, 34]. To provide an appropriate treatment protocol, further high quality research would be needed on the treatment of symptomatic RCTs.

The success rate of conservative treatments varies from less than 50% to 80% [7 - 13]. In this study, seven patients had poor improvement in their clinical symptoms and poor satisfaction after the conservative treatment, which meant a success rate of 93%. This result is better than those in previous studies because of the following reasons. First, a small number of massive RCTs and SSC tendon tear were included. This may lead to overestimation of the effectiveness of the conservative treatment. Second, we excluded patients with traumatic episodes and/or systemic disorders, such as diabetes mellitus, in this study. Complications of diabetes mellitus have a worse

effect on shoulder pain in frozen shoulder [35]. Finally, the frequency of physical therapy in this study was higher than that in other studies [11], and all therapies were performed by physical therapists specializing in shoulder problems. This physical therapy program might result in a high success rate in conservative treatments [36].

We have to consider short-term follow-up (the median duration of conservative treatment was 3.1 months). Kuhn *et al*. conservatively treated 452 patients with atraumatic full-thickness RCTs using physical therapy protocol. They found that patient-reported outcomes improved significantly at 6 and 12 weeks and most failures occur within the first 12 weeks [11]. However, deterioration after the completion of conservative treatments remains a possibility [16, 37].

Yamamoto *et al*. reported that RCTs were present in 20.7% of a rural population in Japan, in which 35% was painful and 65% was asymptomatic RCTs [2]. Tempelhof *et al*. stated that the rate of RCTs increasing with age was a normal condition, but the reasons for changing asymptomatic to symptomatic RCTs are unclear [3]. This suggested that the presence of RCTs themselves was not only a substantial cause. However, other factors, such as extra-articular factors (*i.e.*, scapular dyskinesis, scapular dysfunction, stiffness of the sterno-clavicular joint, and weakness of the shoulder muscles), intra-articular factors (*i.e.*, thickened glenohumeral ligaments and coracohumeral ligament), and factors related to RCTs (*i.e.*, tear size and patterns or muscle weakness due to large or massive tears), might influence the phenomenon. Physical therapy is a treatment option targeting the extra-articular factors, but it shows little efficacy to the intra-articular factors and the factors related to RCTs are unknown. Arthroscopic findings in the seven patients demonstrated attachment of torn supraspinatus tendons to the deltoid muscle in one patient, large or massive tears and combined SSC tendon tear in three patients, and decreased mobility of SSC, supraspinatus, and infraspinatus tendons by the thickened coracohumeral ligament and superomedial capsule in three patients. From these findings, surgical treatment was recommended for patients with intra-articular factors and/or factors related to RCTs [38]. Further study is needed with regard to the three factors to choose appropriate treatment options.

This study has several limitations. The first limitation is the small number of massive tears, a combination of SSC tendon tears, and operated shoulders included. The second limitation is the short-term follow-up. Deterioration after the completion of conservative treatment is possible and may lead to over-estimation of the effectiveness of the treatment [16, 37]. The third limitation is that we could not evaluate the function of the extra-articular factors. Finally, our study was performed at a single center hospital. Furthermore, as there was no information about the demand level of the shoulder, such as work and sports activities, ruling out information bias would be difficult.

CONCLUSION

Larger RCTs and a combination of SSC tendon tears are predisposing factors for recalcitrant conservative treatment.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for the studies that are basis of this research.

CONSENT FOR PUBLICATION

Informed consent was obtained from all the participants prior to publication.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

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