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Case Control Study

Role of shoulder gradient in the pathogenesis of rotator cuff tears

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Abstract

BACKGROUND

Shoulder gradient has been associated with shoulder pathologies such as shoulder impingement syndrome.

AIM

To investigate if there is an association between shoulder gradient and incidence of rotator cuff tear (RCT).

METHODS

A total of 61 patients with a confirmed diagnosis of RCT were included in this retrospective study. The anteroposterior radiograph of the shoulder was used to measure shoulder gradient in adduction and neutral rotation positions. The pain level was assessed with the visual analog scale for pain.

RESULTS

The mean age of the patients was 55.7 ± 12.3 years. The mean visual analog scale of the patients was 4.1 ± 1.2 . The mean shoulder gradient was $14.11^\circ \pm 2.65^\circ$ for the affected shoulder and $15.8^\circ \pm 2.2^\circ$ for the unaffected shoulders. This difference was not statistically significant ($P = 0.41$). A difference of $1.15^\circ \pm 1.82^\circ$ was found between the injured and non-injured shoulder. No significant association was found between the gradient difference of the shoulder and demographic and clinical characteristics of the patients.

CONCLUSION

Shoulder gradient is not associated with the pathology of RCT. Yet, future studies with more standardization and a larger sample size are needed to investigate the role of shoulder gradient in RCT pathogenesis further.

Key words: Shoulder; Shoulder gradient; Rotator cuff tear; Pathogenesis; Anatomy

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Core tip: Shoulder anatomical characteristics have been associated with several shoulder

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pathologies. We hypothesized that the shoulder gradient might be regarded as an anatomic factor affecting the occurrence of rotator cuff pathologies. Our analysis revealed no association between shoulder gradient and incidence of rotator cuff tear.

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INTRODUCTION

Rotator cuff tear (RCT) is one of the most common causes of shoulder pain and disability among the adult population the prevalence of which increases with age. In this respect, either a partial or a complete RCT has been identified in the magnetic resonance imaging (MRI) of 54% of the asymptomatic patients aged 60 years and older^[1]. According to the study of Rincón-Hurtado *et al*^[2], 72% of patients with rotator cuff injuries reported poor quality of life in the physical health component and 60% in the mental health component. The high prevalence of RCT also imposes a considerable financial burden on both the patients and health-care systems^[3]. In this dilemma, the identification of RCT risk factors could be considered as a preventive intervention capable of reducing the health and financial burden of RCT^[4].

To date, many investigations have focused on the predictors of RCT, and several risk factors have been introduced. In this regard, older age, hand dominance, and a history of trauma have been frequently associated with the risk of rotator cuff tear^[5,6]. Yet, more studies are required for further identification of RCT risk factors^[6].

Schamberger stated that the spine malalignment could weaken the passive support for the humerus, thereby increasing the gravity traction force on the capsule and rotator cuff muscles and causing shoulder injuries such as supraspinatus tendinitis and the shoulder impingement syndrome^[7].

The height of both shoulders in the standing position generally reveals slight differences, known as shoulder gradient. Kim *et al*^[8] aimed to find an association between the shoulder gradient and shoulder impingement syndrome. Based on their results, a significantly higher frequency of shoulder impingement syndrome was observed on the side of the relatively lower shoulder^[8].

Based on the earlier evidence, we hypothesized that the shoulder gradient might also predispose the incidence of RCT and be regarded as an RCT risk factor. In this study, we aimed to find how the shoulder gradient is associated with the frequency of RCT.

MATERIALS AND METHODS

This study was approved by the institutional review board of Iran University of Medical Sciences, and written consent was obtained from the patients before their participation. In a cross-sectional study, 61 patients, who were referred to our orthopedic clinic from March 2017 to March 2018 in order to confirm their RCT, were included. The most eligible criteria were the diagnosis of small complete rotator cuff tear based on the MRI findings of the affected side. The MRI of the other side was intact. Patients with over 70 years of age and history of operative treatment of either side of the shoulder were excluded from the study. Associated injury, tumoral lesion, shoulder instability, and patient with a history of shoulder dislocation were excluded from the study, as well. Finally, a total number of 61 patients (total; 462 patients) were identified as eligible for the study.

With the position of the patient in 10 cm apart between the both of the medial malleoli, their heels placed in a neutral position and the knees in full extension, the anteroposterior radiograph of the shoulder was used to measure shoulder gradient in adduction and neutral rotation position of both shoulders. Both shoulders were imaged on one cassette. The gradient difference between affected and unaffected shoulders was measured at the angle between the vertical line and a line connecting a superior angle with an inferior angle of the scapula (Figure 1). The shoulder gradient was independently assessed by a musculoskeletal radiologist and an orthopedist. In

case of a discrepancy between the two observers, a consensus was achieved with the help of a third observer (an orthopedist).

Demographic characteristics of the patients such as age, gender, and body mass index and clinical characteristics of the patients such as the level of pain, etiology of injury and duration of symptoms were recorded. The pain level was assessed with the visual analog scale for pain.

Statistical analysis

SPSS for Windows, version 16, was used for statistical evaluations. Descriptive statistics were presented as mean \pm SD or number and percentage. A Kolmogorov-Smirnov test was implemented to test the normality of variables. A paired *t* or its nonparametric counterpart (Wilcoxon signed-rank test) was used to compare the gradient of the shoulders. A χ^2 was used for testing the association between categorical variables. Pearson's correlation coefficient test was used for the evaluation of potential correlations. A median split approach was used for the categorization of quantitative variables. $P < 0.05$ was considered a significant statistical value.

RESULTS

The study population included 31 females and 30 males with a mean age of 55.7 ± 12.3 years. The injury was dominant in 39 (64%) of the patients. Trauma was the most frequent etiology of the RCT in our patients. The mean visual analog scale of the patients was 4.1 ± 1.2 . The mean symptom duration was 4.57 ± 1.88 mo. The clinic demographic characteristics of the patients are demonstrated in detail in Table 1.

The mean shoulder gradient was $14.95^\circ \pm 2.1^\circ$. The mean shoulder gradient was $14.11^\circ \pm 2.65^\circ$ for the affected shoulder and $15.8^\circ \pm 2.2^\circ$ for the unaffected shoulders. Accordingly, a difference of $1.15^\circ \pm 1.82^\circ$ was found between the injured and non-injured shoulder. This difference was not statistically significant, by the way ($P = 0.41$). The median shoulder gradient was 14.1. The median shoulder gradient was 13.94° affected shoulders and in 14.6° in unaffected shoulders. This difference was not statistically significant, as well ($P = 0.12$).

No significant association was found between the difference of shoulder gradient and demographic characteristics of the patients such as age, gender, and body mass index. Moreover, no significant association was found between the difference of shoulder gradient and clinical variables such as etiology and symptom duration (Table 2). The shoulder gradient was not correlated with the pain level of the patients ($r = 0.109$, $P = 0.071$). The shoulder gradient was not correlated with other clinical and demographic characteristics of the patients, as well.

DISCUSSION

In this study, we aimed to find how the shoulder gradient is associated with the incidence of RCT. According to our results, the mean shoulder gradient was not significantly different between the affected and unaffected shoulder of RCT patients. Moreover, the distribution of shoulder gradient was not significantly different between the injured and non-injured shoulder. No significant association was also found between the clinicodemographic characteristics of the patients and the shoulder gradient difference, as well.

RCTs are amongst the most frequent shoulder pathologies that might significantly reduce the quality of life of the affected patients. Thus, considerable interest has been focused on the optimization of its therapeutic approaches and the identification of its risk factors as well^[5,9].

Traditionally, the normal population is known to have balanced shoulders, and any disturbance in this balance is considered pathologic like the scapular tumoral lesion^[10]. However, recent studies reveal that contrary to popular belief, shoulder balance often does not exist in a healthy population. Akel *et al.*^[11] found an average height difference of 7.5 ± 5.8 mm between the shoulders of the normal population. In addition, the average coracoid height difference was 6.9 ± 5.8 mm. The clavicular angle, the clavicle-rib cage intersection, and clavicular tilt angle were also different between the shoulders of healthy individuals^[11]. Acromial morphology has also been associated with rotator cuff tear pathology in several investigations^[12-14]. The study of Cherchi *et al.*^[15] also revealed that the critical shoulder angle is significantly greater RCT patients. According to these findings, they suggested that an anatomical difference seems to exist between RCT patients and the general population^[15]. We hypothesized that the

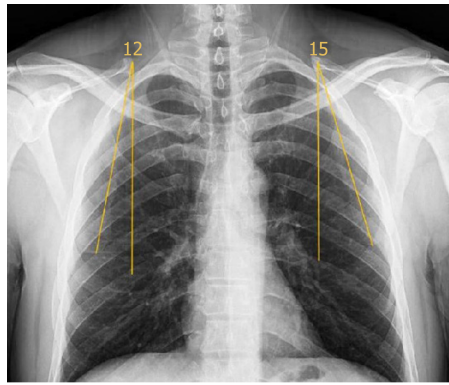


Figure 1 The gradient difference between affected and unaffected shoulders.

shoulder gradient might also be regarded as an anatomic factor affecting the occurrence of rotator cuff pathologies.

Naidoo *et al*^[16] evaluated the shoulder slope in 260 posterior radiographs of the shoulder to provide an appropriate definition of the shoulder slope with standardized anatomical landmarks. Based on their results, the mean shoulder slope was approximately $13.56^{\circ} \pm 3.70^{\circ}$. They also found a significant association between the age and shoulder slope, that is to say larger slopes were observed in older ages^[16]. By contrast, we did not find any significant association between the shoulder gradient and clinicodemographic characteristics of the patients. Yet, it should be noted that their method of slope evaluation was different from ours.

Although different industries such as the textile and aviation industries have reported the shoulder gradient in accordance with the specific occupational activities, the association of shoulder slope with shoulder pathologies has been merely investigated^[16-18].

In one of the few articles in this field, Kim *et al*^[8] investigated the association of shoulder gradient with acromiohumeral interval of both shoulders in patients with unilateral shoulder impingement syndrome. They used an angulometer to measure the shoulder gradient. According to their results, the frequency of shoulder impingement syndrome was considerably more on the side of the relatively lower shoulder (76.2%). This study was the first and only study suggesting the role of shoulder gradient in shoulder pathologies^[8].

We did not find a significant association between the shoulder gradient and RCT. Yet, the results of this study might be adversely affected by several confounding factors. We did not take into account factors that might play a role in shoulder levels, such as the lengths of the lower extremities and the level of the pelvic bone. Moreover, the sample size of this study was not large enough to perform a multivariate analysis and reduce the effect of confounding factors. Thus, future standardized studies with larger sample sizes are recommended to fully untie the role of shoulder gradient in shoulder pathologies such as RCT.

Table 1 Clinical and demographic characteristics of the patients with rotator cuff problems

Variable	mean \pm SD /n (%) (n = 61)
Age (yr)	55.7 \pm 12.3
Gender	
Female	31 (50.8)
Male	30 (49.2)
BMI (kg/m ²)	27.3 \pm 4.9
Dominancy	
Dominant	39 (64)
Non-dominant	22 (36)
Etiology	
Trauma	33 (54.1)
Rheumatologic disorders	18 (25.5)
Unspecified	10 (16.4)
Type of RCT	
Supraspinatus	27 (43.5)
Supraspinatus and infraspinatus	21 (34.5)
Subscapularis	5 (8.5)
Supraspinatus and subscapularis	8 (13.5)
Symptom duration (mo)	4.57 \pm 1.88
VAS pain	4.1 \pm 1.2

BMI: Body mass index; VAS pain: Visual analogue scale for pain; RCT: Rotator cuff tear.

Table 2 The statistical association of shoulder gradient with the clinical and demographic characteristics of the patients with rotator cuff problems

Variable	Shoulder gradient difference (n = 61)	P value
Age (yr)		0.089
< 60	-1.48 \pm 1.08	
> 60	-1.03 \pm 0.96	
Gender		0.12
Female	-1.1 \pm 0.77	
Male	-1.21 \pm 0.97	
BMI (kg/m ²)		0.11
< 26	-1.53 \pm 0.89	
> 26	-1.27 \pm 1.07	
Dominancy		0.092
Dominant	-1.25 \pm 1.09	
Non-dominant	-1.27 \pm 1.11	
Etiology		0.068
Trauma	-1.47 \pm 1.21	
Rheumatologic disorders	-1.12 \pm 1.28	
Unspecified	-1.52 \pm 1.03	
Type of RCT		0.51
Supraspinatus	-1.13 \pm 1.4	
Supraspinatus and infraspinatus	-1.28 \pm 1.33	
Subscapularis	-1.09 \pm 1.1	
Supraspinatus and subscapularis	-1.22 \pm 1.39	
Symptom duration (mo)		0.77
< 3	-1.61 \pm 1.12	
> 3	-1.16 \pm 1.09	
VAS pain		0.14
< 3	-1.52 \pm 1.02	

> 3

-1.24 ± 0.95

BMI: Body mass index; VAS pain: Visual analogue scale for pain.

ARTICLE HIGHLIGHTS

Research background

Rotator cuff tear (RCT) is referred to the injury of one or more of the tendons or muscles of the rotator cuff and is known as one of the most common causes of shoulder pain and disability among the adult population. Identification of risk factors, which predisposes the incidence of RCT, is of considerable importance in the prevention of such injuries.

Research motivation

Earlier investigations have revealed an association between shoulder gradient and shoulder pathologies, such as shoulder impingement syndrome. We hypothesized that the shoulder gradient might also predispose the occurrence of RCT.

Research objectives

In this study, we evaluated the association between the shoulder gradient and RCT incidence to find whether the shoulder gradient could be regarded as a risk factor for RCT or not.

Research methods

Sixty-one patients with a confirmed diagnosis of RCT were identified as eligible for the study. On the anteroposterior radiograph of the shoulder, we evaluated the gradient of both shoulders in adduction and neutral rotation positions. The gradient difference between affected and unaffected shoulders was also calculated.

Research results

The mean shoulder gradient was $14.11^\circ \pm 2.65^\circ$ for the affected shoulder and $15.8^\circ \pm 2.2^\circ$ for the unaffected shoulders. Based on these results, a gradient difference of $1.15^\circ \pm 1.82^\circ$ was found between the injured and non-injured shoulders. This difference was not statistically significant ($P = 0.41$). The shoulder gradient was not correlated with the pain level of the patients ($r = 0.109$, $P = 0.071$), as well as with other clinical and demographic characteristics of the patients.

Research conclusions

Based on the results of this study, there is no association between the shoulder gradient and incidence of RCT. Moreover, the shoulder gradient is not associated with the pain level of RCT patients.

Research perspectives

Future large-scale studies allowing the elimination of confounding factors in a multivariate analysis will shed more light on the role of shoulder gradient in the incidence of RCT.

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