Are differences in shoulder morphology and hand dominance risk factors for rotator cuff tears?

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Abstract. – **OBJECTIVE:** The purpose of this study was to evaluate whether there was a difference in shoulder morphology and hand dominance between a healthy shoulder and a shoulder with rotator cuff tear (RCT) in the same patient.

PATIENTS AND METHODS: Between 2015 and 2020, 120 shoulders from 60 patients with complete RCT and contralateral intact rotator cuffs were enrolled in this retrospective analysis. Physical examinations, shoulder radiographs, and magnetic resonance imaging (MRI) pictures of the patients were reviewed. On radiographs, the AT, CSA, LAA, and AI values were compared between shoulders with complete RCT and contralateral healthy shoulders from the same individuals. Additionally, the association between hand dominance and RCT was evaluated.

RESULTS: This study enrolled 60 patients. 59.17% of the participants are female, and 40.83% are male. The mean age of the patients was 54.5±7.1 years. There were statistically significant differences in AI, CSA, and LAA measurements between the study group (RCT group) and the control group. There was no significant difference in AT between the two groups.

CONCLUSIONS: There are morphological differences between a healthy shoulder and a shoulder with an RCT in the same patient, and these differences (LAA/CSA/AI/AT) may have an effect on the prevalence of RCT.

Key Words:

Acromial angles, Acromion index, Acromion type, Critical shoulder angle, Rotator cuff tears.

Introduction

Rotator cuff tears (RCT), the primary leading cause of shoulder pathology, increased to 22.1% in the general population with age[1]. Rotator cuff pathologies are multifactorial and are caused by the interaction of biological and biomechanical factors[2]. A complete understanding of joint biomechanics is required to ensure that those shoulder injuries are properly treated[3-5].

Numerous radiological measurements that reveal morphological changes have been identified to help identifying risk factors for RCT. Researchers have typically used radiographs to define various morphological characteristics. Bigliani et al[6] first described the acromion type (AT) concerning shoulder pathologies in 1986, Banas et al[7] first described the lateral acromion angle (LAA) in 1995. On the other hand, the critical shoulder angle (CSA)[8] and the acromion index (AI)[9] were first described in recent decades. Bigliani et al[6] reported high incidence RCT with hooked (Type-III) acromions, Moor et al[8] with high critical shoulder angle, Banas et al[7] with lower lateral acromion angle (LAA), and Nyffeler et al[9] with high acromial index (AI)[9].

Based on the above-mentioned reports, we evaluated bilateral AT, CSA, LAA, and AI measurements on true AP radiographs in patients with a complete RCT side and a contralateral intact side. Thus, we aimed to minimize error values that could result from age, sex, and associated disorders between the patient and control groups. The purpose of this study was to evaluate whether there was a difference in shoulder morphology and hand dominance between a healthy shoulder and a shoulder with RCT in the same patient. We hypothesized that a patient may have anatomical differences between both shoulders and these differences could be a contributing factor for RCT.

Patients and Methods

Institutional Research Ethics Committee approval was obtained before the initiation of this

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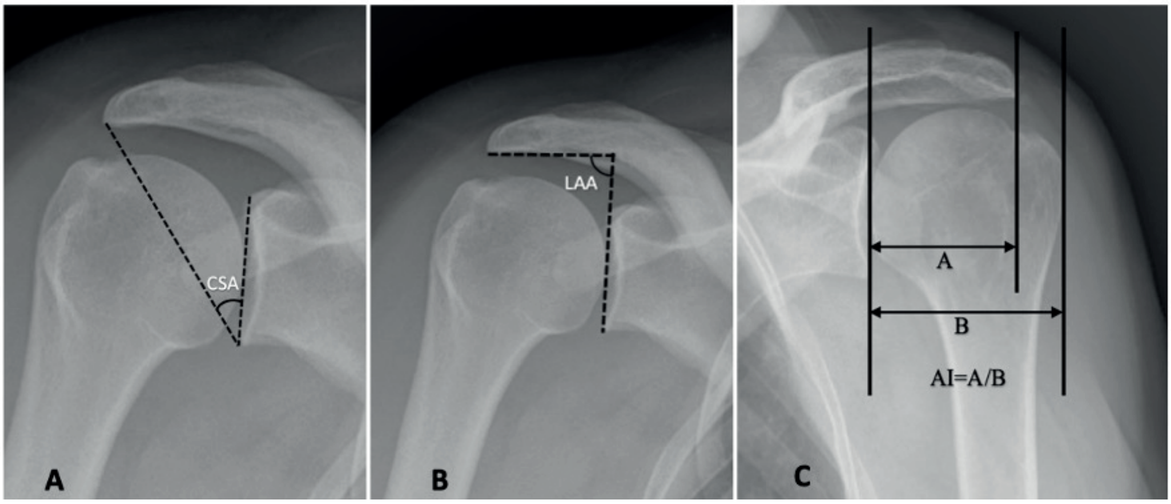

Figure 1. Determining acromial morphology and measurements on radiographs.

study. In this retrospective study, from 2015-2020, 120 shoulders from 60 patients diagnosed with complete RCT and contralateral intact rotator cuffs were enrolled. Retrospectively, physical examination, shoulder radiographs, and MR images of the patients were evaluated. The study included participants with bilateral shoulder radiographs and a diagnosis of unilateral RCT confirmed by MRI. 230 patients' files were reviewed, and only 60 of them met the criteria. Shoulders with complete RCT were included in the patient group. Opposite shoulders without RCT were used as the control group in the same patients.

ATs were determined on outlet radiographs. CSA, LAA, and AI values were measured on true AP radiographs between shoulders with complete RCT and the opposite healthy shoulders of the same patients. Patients with, rheumatologic disease, prior shoulder surgery, fractures and/or dislocation, and shoulder osteoarthritis were excluded.

Measurements were made using the Infinitt PACS system to view radiographs. The values on the radiograph were measured by two experienced orthopedic surgeons. Two weeks later, the same surgeons repeated the measurements. Inter- and intraobserver reliability were measured for radiographic measurements using intraclass correlation coefficients (ICC) calculated from two sets of repeat measurements on a sample of 60 radiographs. The following scores were used: ICC greater than 0.80 indicates excellent; 0.70-0.80 indicates very good; 0.60-0.70 indicates good; 0.40-0.60 indicates fair; and 0.40 indicates poor.

The ATs were determined on outlet view radiographs[6]. A line was drawn from the supraglenoid tubercle to the infraglenoid tubercle, and then, from the infraglenoid tubercle to the acromion's farthest lateral edge to determine the CSA. The CSA angle is determined by the intersection of these two lines (Figure 1A). LAA was determined by drawing a vertical line parallel to the acromion undersurface and a horizontal line parallel to the glenoid (Figure 1B). The AI (A/B) was determined by dividing the distance between the glenoid plane and the acromion's lateral border (A) by the distance between the glenoid plane and the proximal humerus's farthest lateral part (B) (Figure 1C).

There are descriptive statistics for the quantitative variables acquired and frequency analyses for the qualitative variables. The Kolmogrov-Smirnov test was used to determine the data's conformity to the normal distribution, and it was determined that the data was suitable for the normal distribution. Chi-square analysis was used to analyze the association between the dominant and torn sides. The *t*-test was used to determine the significance of the difference between the measurers and between the averages of the measurements. A Chi-square analysis was used to investigate the correlations between the factors. SPSS 20 (Armonk, NY, USA) software was used to perform analyses with a 95% confidence level.

Results

This study involved sixty individuals with 120 shoulders. 59.17% of the participants are female, and 40.83% are male. The mean age of the patients was

Table I. Association between dominant hand and rotator cuff tear.

		RCT		
		Right	Left	Total
Dominant	Right	32	14	46
	Left	5	9	14
Total		37	23	60

RCT: Rotator cuff tear.

Table II. Acromion types in two groups.

	Intact Side	RCT Side
Type I (Flat)	14	15
Type II (Curved)	21	19
Type III (Hooked)	24	25
Type IV (Convex)	1	1

54.5±7.1 years (range, 40-69 years), and the mean body mass index (BMI) was 29.1±4 kg/m^2 (range, 18-37 kg/m^2). The rate of those with a tear on the right side is 61.67%, while the rate of those with a tear on the left side is 38.33%. While 69.57% of individuals with the dominant side on the right had a tear on that side, 64.28% of those with the dominant side on the left had a tear on that side (Table I).

There was no significant difference in acromion types (AT) between the two groups, and no significant difference between the RCT and the acromion type was observed (p = 0.464). On the intact side, 35% of the ATs are Type II acromion and 40% of the Type III acromion. On the torn side, Type II acromion accounts for 31.67%, and Type III acromion accounts for 41.67% (Table II).

The mean critical shoulder angle, the lateral acromial angle, and the acromial index of both groups are shown in Table III.

Three measurements (AI, CSA, and LAA) demonstrated statistically significant differences between the study group (RCT group) and the control group. Table III summarizes the findings obtained for each parameter. Similarly, AI and CSA mean values were significantly higher in the RCT group than in the control group (AI: 0.69 *vs.* 0.76, p<0.05; CSA: 31.97 *vs.* 35.13, p<0.05). LAA was significantly lower in the RCT group than in the control group (77.3 *vs.* 73.5, p< 0.001).

When we analyzed intraobserver and interobserver correlations, we discovered that angle measurements had an almost perfect interobserver agreement (ICC, 0.97; confidence interval [CI], 0.96-0.99) and intraobserver agreement (ICC, 0.97; CI, 0.96-0.99) (ICC, 0.94; CI, 0.89-0.96).

Discussion

In this study, we found statistically significant changes in bone morphometric measurements between shoulders with and without rotator cuff tears. On the RCT side, we found that CSA and AI values were high, whereas LAA measurements were low. Additionally, we observed an increase in the prevalence of type III acromion in patients with rotator cuff injuries. When we analyzed the results of this study, the most significant difference from prior studies was that it demonstrated the possibility of anatomical changes between the two shoulders of the same patient.

According to some studies, there was a correlation between acromion type and RCT, and a strong correlation exists between type III acromion and RCT[10-12]. On the contrary, several studies[13-15] have found no correlation between acromion type and RCT. Although we found a higher incidence of type III acromion on the torn side in this study, we did not observe a difference in the acromion types when compared to the intact side.

We compared a healthy shoulder to one with an RCT in the same patient, reducing the number of variables to two (dominant side and anatomical variance). The relationship between hand dominance and RCT remains debatable. Although some studies[16-18] have found an association between hand dominance and RCT, others[19,20] have found no association. We observed that RCT was

Table III. The mean measurement values of two groups.

	Intact Side Mean±SD	RCT Side Mean±SD	*p*-value
Critical shoulder angle (CSA)	31.97±2.64	35.13±3.12	< 0.05
Lateral acromial angle (LAA)	77.3±4.11	73.5±3.10	< 0.001
Acromion index	0.69±0.03	0.76±0.02	< 0.05

more likely on the dominant side of individuals. The prevalence of RCT on the dominant side was determined to be 68.33%.

When we evaluated the bone morphometric measurements, it was reported that there was a significant correlation between a higher CSA and RCT, and a CSA ≥35° was indicative of a high risk of RCT[8,21-24]. Also, a high AI has been associated with an increased risk of RCT[9,25-28]. Additionally, an LAA was associated with RCT[10,25,29]. We observed a significant association between high CSA, high AI, and low LAA and RCT in this study, which is consistent with the literature.

This study has some limitations. The effect of morphological changes on the tear type could not be examined, and the study sample was small. A prospective, randomized-controlled study with a larger sample size should be designed. The strength of this study is that we used the same patient as the control group to minimize the patient's age, gender, and associated disorders.

Conclusions

This study demonstrated that there are morphological differences between a healthy shoulder and a shoulder with an RCT in the same patient and that these differences (LAA/CSA/AI) may affect the RCT incidence.

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Conflicts of interest

The authors declare no conflicts of interest.

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