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Correlation of acromial shape and rotator cuff tears using magnetic resonance imaging

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Abstract

We investigated the relationship between four acromial shapes by magnetic resonance imaging (MRI), and the characteristics and occurrence of rotator cuff tears (RCTs). This retrospective study included 621 patients aged 18-90 years who underwent shoulder imaging in the Turgut Ozal University, Training and Research Hospital, Department of Radiology from April 2022 to May 2022. The study reviewed a total of 621 patients, including 377 (60.7%) female, and 244 (39.3%) male patients. Of the total 621 MRI imagines of the patients, 344 (55.4%) were MRIs of the right shoulder, and 277 (44.6%) were MRIs of the left shoulder. No tears were detected in 20.7% of them, and various grades of tears were detected in 79.3% of them. Of the total, 43% had the full thickness and complete tears, and 36.3% had partial tears. A correlation was found between the RCTs and females ($p<0.001$). No statistically significant relationship was found for left or right shoulder ($p<0.065$) and acromion type and tear ($p=0.465$). A correlation was found between the mean acromio-humeral distance of acromion type I, II, and III (mean of three acromion types) and type IV ($p<0.001$). There were statistical differences between impingement and acromion hypertrophy (ACH) ($p<0.001$), between tear and impingement ($p<0.001$), and between tear and ACH ($p<0.001$). There was no relationship between acromial shape and gender. However, from the point of view of acromial shape, supraspinatus injury and gender were significantly related, namely; right-sided partial tear injuries are more common in females ≥50 years of age with type II acromion shape than with other RCTs.

Keywords: Acromion, MRI, supraspinatus injury, rotator cuff tears

Introduction

Rotator cuff disease and impingement syndrome are the most common causes of shoulder pain and disability. The rotator cuff consists of four muscles, the supraspinatus, infraspinatus, subscapularis, and teres minor. The rotator cuff maintains the stability and strength of the shoulder joint. The supraspinatus tendon is the most frequently injured of these four muscles [1].

There are numerous risk factors listed for the pathogenesis of rotator cuff tear (RCT), classified as intrinsic or extrinsic. Subacromial impingement, the formation of acromial spurs, the shape of the acromion, and stretch overload can be included among the external factors. Collagen fiber abnormalities, hypovascularity, and degenerative changes are also intrinsic factors [2]. According to the Bigliani classification, acromial shapes are three types (Figure 1, 2): straight shape (Type I), curved shape (Type II), and hooked shape (Type III) [3]. Gageyet al. added a fourth type, convex inferior surface shape (Type IV) to this classification [4].

Rotator cuff tear (RCT) is one of the most common causes of shoulder pain found in the middle-aged population [5]. Although there have been many studies on the RCTs according to acromion type, there have been no large-scale studies using magnetic resonance imaging (MRI) to confirm the tears. Most studies confirmed only the existence of complete tears using arthroscopy.

It aims to reveal the possible pathophysiological relationship of RCT by examining shoulder MRI images and comparing the relationship between age, gender, acromion hypertrophy, shoulder side, impingement, acromio-humeral distance, and the severity of the four types of acromion with the severity of the supraspinatus tear.

Material and Methods

This study was designed as a retrospective, open-label, single-center, non-randomized clinical study. This study was approved by the Institutional Ethics Committee of Malatya Turgut Ozal University Medicine Faculty Training and Research Hospital

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(document date: 04/18/2022 and number: 2022/83). The protocol of the present study complies with the ethical principles of the World Medical Association Declaration of Helsinki.

The data will be collected through the hospital information system. The age, gender, and shoulder MRI of the patients were examined from the patient files. The information system and picture archiving and communicating system (PACS) of the University Training and Research Hospital were used to evaluate the RCT and the other structures of the shoulder.

Patients' selection

We studied 621 MRI scans of the shoulder performed in our institution between April 2022 and May 2022.

Bone tumors, post-traumatic shoulder pain (fractures, etc.), osteoarthritis of the shoulder joint, another shoulder surgery, congenital deformity, inflammatory arthritis, septic shoulder, unstable or frozen shoulder, and calcified tendonitis were exclusion criteria.

MRI protocol

All the scans were performed on two 1.5-T magnets (MAGNETOM Amira, Material Number 10836777, Serial number 174075 Siemens Healthcare, Erlangen, Germany 2019) with a dedicated shoulder coil.

The parameters of the routinely used sequences are given in Table 1.

MRI analyses

Evaluation of all sequences was done in a predetermined order. First, acromial shape and acromio-humeral diameter were investigated from the sagittal images. Second, the degree of acromioclavicular hypertrophy, enthesopathy, and impingement degree was evaluated from PD FS coronal and T1 coronal images. Third, the rotator cuff was evaluated. Finally, the classification and evaluation of tears in the supraspinatus predominantly supra/infraspinatus muscle- tendinous localization were performed.

Statistical analysis

Statistical analysis was performed by Statistical Program in Social Sciences 25 program. The Shapiro Wilk test was used to check whether the data included in the study fit the normal distribution. The significance level (p) for comparison tests was taken as 0.05. Since the variables did not have a normal distribution ($p>0.05$), the analysis was continued with parametric test methods. Comparisons in independent pairs; Since the assumption of normality was not provided, the Mann-Whitney test was used. In the analysis of categorical data, chi-square analysis was performed by creating cross tables. Correlation coefficients are criteria that give information about the degree and direction of the relationship between the variables. The correlation coefficients range from -1 to+1. The signs show the direction of the relationship. The strength of the relationship increases as it approaches -1 and +1, and decreases as it approaches 0. Values that are frequently used in the evaluation of the findings; 0.00–0.19 no relevance, 0.20–0.39 weak relevance, 0.40–0.69 moderate relevance, 0.70–0.89 strong relevance, and 0.90–1.00 is interpreted as a very strong relevance. Since the variables included in the study showed normal distribution, the spearman rank correlation coefficient was used.

Results

Between April 2022 and May 2022, 621 patients who had an MRI of the shoulders due to pain and were diagnosed with RCT were included in the study.

The study reviewed a total of 621 patients, including 377 (60.7%) female, and 244 (39.3%) male patients. The mean age of patients was 53.56±13.17 years (range, 18-90). The mod of the patients' age is 60 (28 times (4.6%)). The mean age of male patients was 52±14.12 (range, 18-87) years. The mean age of female patients was 54.57±12.41 (range, 19-90) years.

Of the total 621 MRI imagines of the patients, 344 (55.4%) were MRIs of the right shoulder, and 277 (44.6%) were MRIs of the left shoulder. The mean acromio-humeral distance (AHD) was 7.56±2.08 (range, 1.05-16.20) millimeters.

A comparison of tears, impingement, edema and acromio-humeral distances of patients over 50 years old and under 50 years old are represented in Table 2.

The distribution of shoulder tear types, acromion type, impingement, acromion hypertrophy, edema, and AHD are represented in Table 3.

The distribution of acromion types, gender, shoulder side, and acromio-humeral distance is represented in Table 4.

A statistically significant difference was found between the tear and females ($p<0.001$). In terms of left or right shoulder, a statistically significant difference was not found ($p<0.065$). No correlation was found between the acromion type and tear ($p=0.465$)

A statistically significant difference was found between the mean acromio-humeral distance of acromion type I, II, and III (mean of three acromion types) and type IV ($p<0.001$).

It was investigated whether there was a statistically significant relationship between the acromio-humeral distances of the 4 groups (acromion type I, II, III, and IV). A statistically significant difference was not found between I to III ($p=0.603$). It was detected between I and II ($p=0.005$), I to IV ($p<0.001$), II to III ($p=0.006$), II to IV ($p< 0.001$), III to IV ($p<0.001$).

Table 1. The parameters of the routinely used sequences are given

	TR	TE	FOV read	Slice	Slice thickness	BW	Average	Phase
PD TSE FS TRA	2380	36	190mm	23	3mm	155	2	100
PD TSE FS COR	1870	36	150mm	18	3.5mm	151	2	100
T1 TSE COR	635	9.3	180mm	18	3.5mm	153	2	100
PD TSE FS SAG	1970	36	180mm	19	4mm	151	2	100

(FOV = field of view, RT = repetition time, TE = echo time)

Table 2. Comparison of tears, impingement, edema, and acromio-humeral distances of patients over 50 years old and under 50 years old

Variables		<50 years		≥50 years		p-value
		No	Yes	No	Yes	
Tear		96 (15.5%)	128 (20.6%)	33(5.3%)	364(58.6%)	<0.001
Impingement		83 (13.4%)	141 (22.7%)	34(5.5%)	363(58%)	<0.001
Edema		188 (30.3)	36 (5.8%)	275(44.3)	122(19.6%)	0.001
Acromion hypertrophy		120 (%19.3)	104 (16.7%)	64(10.3%)	333(53.6%)	<0.001
Acromion types	I Flat	95 (15.3%)		116(18.6%)		0.246
	II Curved	87 (14.0%)		211(33.9%)		0.016
	III Hook	13 (2.1%)		40(6.4%)		0.156
	IV Concave	29 (4.6%)		30(4.8%)		0.985
Acromio-humeral distance mm (mean±SD)		8.01±1.92		<50 years		0.029

(n: Number of individuals, SD: Standard deviation, %: Incidence rate)

Table 3. Distribution of shoulder tear types, acromion type, impingement, acromion hypertrophy, edema, the acromio-humeral distance (AHD)

Variables, [n (%)]		No tear	Partial Articular tear	Partial Bursal tear	Full-thickness tear	Complete rupture	Total
		41.82±12.60	52.11±11.05	53.39±12.30	57.87±9.71	63.70±9.86	53.56±13.17
Gender	**Male**	62(9.9%)	37(5.9%)	63(10.1%)	66(10.6%)	16(2.5%)	244(39.3%)
	Female	67(10.7%)	31(4.9%)	92(14.8%)	121(19.5%)	66(10.6%)	377(60.7%)
Shoulder	**Right**	68(10.9%)	40(6.4%)	70(11.3%)	116(18.7%)	50(8.1%)	344(55.4%)
	Left	61(9.8%)	28(4.5%)	85(13.7%)	71(11.4%)	32(5.2%)	277(44.6%)
Acromion types	**Flat**	53(8.5%)	27(4.3%)	50(8.1%)	63(10.1%)	18(2.9%)	211(33.9%)
	Curved	43(6.9%)	31(4.9%)	77(12.4%)	93(14.9%)	54(8.7%)	298(47.9%)
	Hook	10(1.6%)	7(1.1%)	13(2.1%)	16(2.6%)	7(1.1%)	53(8.5%)
	Concave	23(3.7%)	3(0.5%)	15(2.4%)	15(2.4%)	3(0.5%)	59(9.5%)
	Total	129(20.7%)	68(10.9%)	155(24.9%)	187(30.1%)	82(13.2%)	621(100%)
Acromion types Impingement	**None**	64(10.3%)	10(1.6%)	29(4.7%)	12(1.9%)	2(0.3%)	117(18.8%)
	Mild	52(8.3%)	41(6.6%)	87(14%)	85(13.7%)	23(3.7%)	288(46.3%)
	Moderate	13(2.1%)	17(2.7%)	39(6.2%)	87(14%)	49(7.9%)	39(6.2%)
	Hard	0(0%)	0(0%)	0(0%)	3(0.5%)	8(1.28%)	11(1.7%)
Acromion hypertrophy	**None**	102(16.4%)	20(3.2%)	43(6.9%)	15(2.4%)	4(0.6%)	184(29.6%)
	Mild	20(3.2%)	36(5.8%)	96(15.4%)	116(18.6%)	34(5.4%)	302(48.6%)
	Moderate	7(1.1%)	12(1.9%)	15(2.4%)	49(7.9%)	39(6.2%)	122(18%)
	Hard	0(0%)	0(0%)	1(0.2%)	7(1.1%)	5(0.8%)	13(2.1%)
Entesopathies/ Edema	**Yes**	11(1.7%)	17(2.7%)	36(5.8%)	70(11.2%)	24(3.8%)	158(25.4%)
	No	118(19%)	51(8.2%)	119(19.1%)	117(18.8%)	58(9.3%)	463(74.5%)
Acromio-humeral distance mm (mean±SD)		8.32±2.16	7.95±1.29	7.98±1.78	7.46±1.71	5.44±2.37	7.56±2.08

(n: Number of individuals, SD: Standard deviation, %: Incidence rate)

Table 4. Distribution of acromion types, gender, shoulder side, and acromio-humeral distance

Variables, n (%)	Distribution	Gender		Shoulder		Acromio-humeral distance (millimeter) (mean ±SD)
		Male	Female	Right	Left	
Acromion types	211(33.9%)	85(13.6%)	126(13.7%)	128(20.6%)	83(13.3%)	7.51±1.65
	298(47.9%)	114(18.3%)	184(29.6%)	169(27.2%)	129(20.7%)	6.96±1.81
	53(8.5%)	20(3.2%)	33(5.3%)	26(4.1%)	27(4.3%)	7.86±2.21
	59(9.5%)	25(4%)	34(5.4%)	21(3.3%)	38(6.1%)	10.49±2.10
Total	621(100%)	244(%)	377(60.7%)	344(%)	277(44.6%)	7.56±2.08

(n: Number of individuals, SD: Standard deviation, %: Incidence rate)

There are statistical differences between impingement and ACH ($p<0.001$), between tear and impingement ($p<0.001$), and between tear and ACH ($p<0.001$).

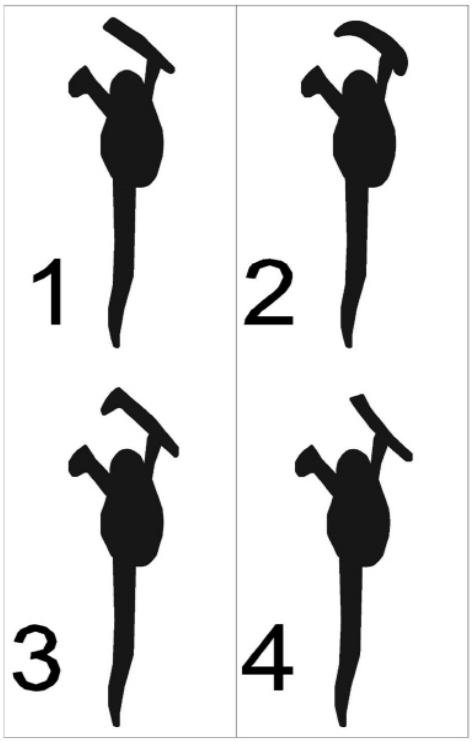

Figure 1. Acromion types are shown schematically. 1) Flat, 2) Curved, 3) Hook, 4) Concave

Figure 2. Acromion types in PD sagittal oblique plane. a) Flat type, b) Curved type, c) Hook type, d) Concave type

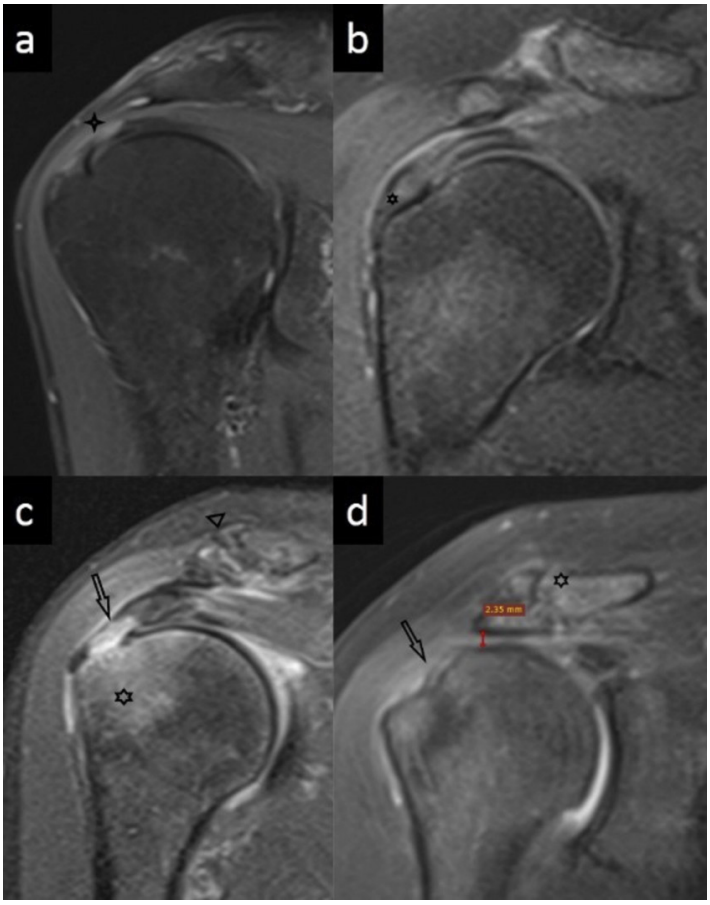

Figure 3. PD coronal plane RCT types a) Articular side partial RCTs (star) b) Bursal side partial RCTs (star) c) Full-thickness RCTs (arrow) and caput humerus contusion (star) and acromioclavicular hypertrophy (arrowhead) d) Complete RCT's (arrow) and reduction in the acromio-humeral distance (AHD) (2.35 mm) and acromioclavicular hypertrophy (star)

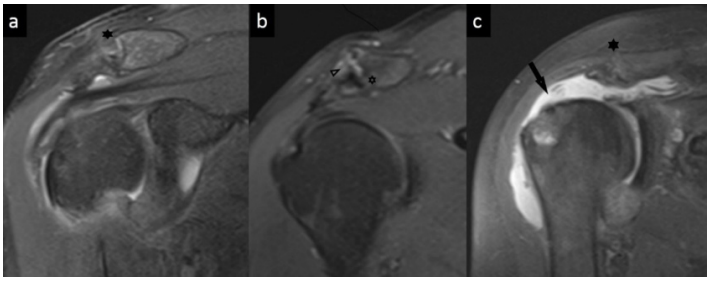

Figure 4. a) Mild (grade 1) impingement (star), b) Moderate (grade 2) impingement (star), enthesopathy and edema (arrowhead), c) Hard (grade 3) impingement (star) and complete RCTs and musculotendinous regression (arrow)

Discussion

Rotator cuff tears (RCTs) are a common shoulder disease among older people. In addition to known risk factors such as systemic diseases, age, and dominant arm, there are studies reporting associations between the acromion types and RCTs [4,6–8].

Morphological features of acromial shapes may be valuable in the diagnosis and treatment of subacromial pathologies. Using T2W MRI coronal oblique images, measurements of acromio-humeral distance, acromial index, and lateral acromial angle can be a valuable aid in the evaluation of patients with suspected rotator cuff disease [9].

Acromion type distribution has been investigated in various studies. The prevalence of acromion types at different rates has been reported in different populations. In the literature review by Natsis et al., the prevalence of acromion types was found to be 5.4-67.7% for type I, 24.2-83% for type II, and 0-42.4% for type III [10].

In Polat et al. found that of total 516 patients, 116 patients (22.5%) had flatted shape acromion (type I), 352 (68.2%) curved shape acromion (type II), 10 (1.9%) hooked shape acromion (type III), and 38 (7.4%) convex shape acromion (type IV) [11].

Ranie et al. [9] found that the least common acromion types in the patient and control groups were type IV (3.6% and 10%, respectively), and the most common type was type II acromion (44.6% and 43.3%, respectively). In the studies of Kogantiet al., they found type I acromion in 14% (7), type II in 52%, and type III and type IV acromion in 34% [12]. Ahmed Hasan et al. showed that type III was seen in 43.8% and type IV was 6.3% of patients [13]. This rate was quite high compared to the literature and was not compatible with our rates.

In our study, it was found in type I 211 (33.9%), type II 298 (47.9%), type III 53 (8.5%), type IV 59 (9.5%) patients, as indicated in Table 4, with the data obtained from sagittal oblique plane images. It is consistent with the studies mentioned above. While type III was 1.9% in the article examining the population in our country, this rate was found to be higher (33.9%) in our study. Type II was reported higher (68.2%) and type I (22.5%) lower than ours.

Paraskevaset al. found that flatted type (type I) was more frequently seen in females (56.5%) and type III was more frequently seen in the male group (56.2%) [14]. Muhammed et al. represented that type III was more frequently seen in the male group [15]. In our study, type II acromion is observed more frequently in women. Acromion type III was found in 20 (3.2%) patients in males and 33 (5.3%) in females, and no significant difference was found.

In the present study, when tears under the age of 50 were evaluated, no tears were detected in 96 (15.5%) cases, and RCTs (Figure 3) of varying degrees were present in 128 (20.6%) cases. While no tears were detected in 33 (5.3%) cases at the age of 50 and above, RCTs were detected in 364 (58.6%) cases, which was statistically significant ($p<0.001$). In this study, type III under 50 years of age was 13 (2.1%), and type III was 40 (6.4%) at age 50 and older and was evaluated as compatible.

Rotator cuff tears increase with age and peak in the fifth and sixth decades. Uhthoff et al. [16] and Ozaki et al. [17] reported that the pathogenesis of rotator cuff diseases is an intrinsic process. They reported that rotator cuff dysfunction increases with age. Various microvascular studies have found that vascularity in the rotator cuff tissue decreases as people age [12,16]. Over the age of 50, a complete RCT is most commonly detected in their study [12,16].

In this study, RCT was observed in 128 (20.6%) patients under the age of 50 in all tear types, while this number was found to be 364 (58.6%) in patients aged 50 and over. Due to intrinsic and extrinsic degenerative changes and age, tears were found to be 2.8 times more common in patients aged 50 years and older than those under 50 years of age. Our findings were evaluated following the literature.

Neer et al., Biglianiet al., Ahmed Hassan et al. ($p = 0.06$), and Balke et al. represented associations between type III acromion and RCT [3,6,8,13]. On lateral radiographs, Bigliani et al and Hirano et al examined the shape of the attraction. They found that patients with type III acromion shapes had a higher incidence of RCTs than patients with type II or type I acromion shapes [6,18]. Hirano et al. reported that acromial shape affects RCT size [18]. Rania et al. also reported that type III acromion was significantly associated with full-thickness RCT ($p=0.016$) [9].

On the contrary, there are articles reporting that there is no association between acromion type III and RCT. Kim et al. [19] found no association between severity of RCTs and acromion types and left or right joint side. In addition, gender and the side of the affected shoulder were investigated and no relationship was found between them ($p=0.709$). In the study of Hirano et al., when looking at patients with and without RCTs, no association was reported between type III acromion shape and RCT [18]. These findings show us that type III acromion is not always associated with RCT formation.

Koganti et al. reported a statistically significant relationship between type II and RCTs. [12]. In this study, although the number of type III acromion increased in the age of 50 and over, no statistically significant relationship was found between the RCT, and a statistically significant relationship was found between type II and RCTs.

We think that the differences between the findings of the studies mentioned above may be related to the genetic, osteological factors, age groups, mechanical irritation of the rotator cuff tendons, microvascular circulation, and secondary diseases affecting them, and the possibility of originating from the coracoacromial ligament due to degeneration. There is a need for studies with larger series and examining these issues.

An association was found between RCTs and females ($p<0.001$). When the RCTs were evaluated, it was determined to male 182 (37%) and females 310 (67%), which differs from previous publications [5,15,21]. We think that this is because our females are more delicate as stated in the literature [7,12].

When all RCTs were evaluated, the right side was detected in 276 (56%) and the left side in 244 (44%) patients. In terms of left or right shoulder, a statistically significant correlation was not found ($p<0.065$) in this study. This has been evaluated as compatible with the literature [5,15,21]. When evaluated in terms of subacromial distance, Polatet al. [11] showed that there was no significant difference between male and female patients and right and left shoulders ($p=0.309$, $p=0.454$, respectively).

Examining the relationship between full-thickness rotator cuff ruptures (FTRCT) and AHD, Saupe et al. reported a significant association between a shorter AHD and RCT [20]. Goutallier et al. demonstrated that an AHD of less than 6 mm was statistically significantly associated with FTRCTs [21]. Contrary to this study, Polat et al. [11] reported that no significant difference was observed in the AHD between patients with and without os acromiale ($p = 0.306$).

In our study, it was 8.32±2.16 mm in AHD without tears, 7.95±1.29 mm in A type partial tear, 7.98±1.78mm in B type partial tears, 7.46±1.71mm in FT tears, 5.44±2.37mm in C type tears, and 7.56±2.08mm in total. It was evaluated following the literature because it was less than 6 mm, especially in C-type tears.

When investigating the relationship between the types of acromion, impingement syndrome, and rotator cuff tears, Bigliani et al., Neer et al., and Nyfeller et al. found a statistically significant relationship [6-8]. In our study, regardless of the type of acromion, impingement (Figure 4) is more prominent at the age of 50 and above [no impingement under 50 years of age 83 (13.4%), there is 141 (22.7%); We found a statistically significant relationship between the age of 50 and older, no impingement 34 (5.5%), present 363 (58%)] and RCT's ($p< 0.001$). This was consistent with the literature.

This study has some limitations. Our study is a cross-sectional study and retrospective analysis. Therefore, limited clinical information is available. Moreover, no comparison was made with the control group. The prevalence of the dominant hand in our study is unknown. This can affect the factor related to the right or left side of the RCTs.

Conclusion

There was no relationship between acromial shape and gender. However, from the point of view of acromial shape, supraspinatus injury and gender were significantly related, namely; right-sided partial tear injuries are more common in females ≥50 years of age with type II acromion shape than with other RCTs.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
Ethics Committee of Malatya Turgut Ozal University Medicine Faculty Training and Research Hospital (document date: 04/18/2022 and number: 2022/83).

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