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The relationship between the shape of rotator cuff tears and shoulder anatomical parameters

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Abstract

Background The aim of this study is to investigate the potential relationship between shoulder anatomical parameters and the shape of rotator cuff tears (L-shaped, U-shaped, and crescent-shaped).

Materials and methods The study included 160 (n:160) patients. Patients were divided into four groups: crescent type, u type and L type tears and control group. There were 40 cases in each group. The operated patients were divided into three groups based on the shape of the tears in arthroscopic images. Measurements of Critical Shoulder Angle (CSA), Greater Tuberosity Angle (GTA), Acromion Index (AI), Lateral Acromion Angle (LAA), and Humerus Footprint width (coronal width and sagittal width) were taken in each group and compared.

Results Patients were divided into four different groups: Crescent type group (n:40), L type group (n:40), U type group (n:40) and control group (n:40). Upon assessing the coronal and sagittal width measurements, The mean coranal width measurement of the L-type tear group was 12.62 ± 0.29 mm, which was significantly higher than all other groups ($p < 0.05$). The mean sagittal width of the L-type tear group was 34.95 ± 0.29 mm, which was significantly higher than all other groups ($p < 0.05$). When the groups were evaluated based on GTA, CSA, and AI data, the mean GTA measurement of the L-type tear group was 73.03 ± 0.95 degrees, which was significantly higher than all other groups ($p < 0.05$). The mean CSA measurement of the L-type tear group was 34.77 ± 0.66 degrees, which was significantly higher than all other groups ($p < 0.05$). The mean AI measurement of the L-type tear group was 0.77 ± 0.02, which was significantly higher than all other groups ($p < 0.05$). When the groups were evaluated based on LAA data, the mean LAA measurement of the L-type tear group was 76.98 ± 1.04 degrees, which was significantly lower than all other groups ($p < 0.05$).

Conclusion In our study, especially in L-shaped tears, measurements of GTA, CSA, AI, LAA, coronal and sagittal width were found to be different compared to the control group. These results suggest that shoulder anatomy affects the mechanisms of rotator cuff tear formation and that these parameters play a more significant role in L-shaped tears.

Keywords Rotator Cuff tears, Shoulder arthroscopy, Shoulder anatomy

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Introduction

Full-thickness rotator cuff tears (RCT) are one of the most common causes of chronic shoulder pain, and arthroscopic rotator cuff repair is one of the most frequently performed surgeries in orthopedics [1]. Many classifications have been made in the literature to describe full-thickness RCT. One of the most common used classifications separates tears based on their geometric appearance in shoulder arthroscopy. According to this classification, tears are divided into L-shaped, U-shaped, and crescent-shaped. According to the tear shape, crescent-type tears are those with smooth edges, high mobility, and a length in the anterior-posterior plane greater than the medio-lateral length. U-shaped tears consist of two symmetrical edges. Generally, both edges of the tear are mobile. After the tear is minimized using intratendinous sutures, repair is applied to the bone. L-type tears have two asymmetric edges. One edge is mobile and the other is more rigid. For the L-shaped tear, the surgical procedure often refers to the identification of the apex of the "L" and the side-to-side suturing of the longitudinal split. Because the repair of this L-shaped tear was supposed to be easier than those massive contracted tears [2].

There are a series of studies examining the relationship between RCT and shoulder anatomical parameters. These parameters include the coronal and sagittal dimensions of the footprint, Greater Tuberosity Angle (GTA), Critical Shoulder Angle (CSA), Lateral Acromial Angle (LAA), and Acromion Index (AI). Quinlan et al., in their study using Magnetic Resonance Imaging (MRI) images to examine the relationship between humerus footprint measurements and RCT, showed that footprint measurements were not directly related to RCT, but wider coronal width of footprint indicated better healing after RCT repair [3]. Cunningham et al., in their MRI study, revealed that GTA and CSA were associated with degenerative RCT [4]. Another study demonstrated that CSA and GTA are independent risk factors in partial bursal tears [5]. However, Seo et al., investigating the relationship between CSA and GTA with partial bursal and articular-side rotator cuff tear types, indicated that GTA was only associated with articular-side partial tears, while CSA was only associated with bursal-side tears [6]. Additionally, the relationship between GTA and CSA with RCT delamination has also been examined [7]. A series of studies have shown that high AI and low LAA values are associated with full-thickness RCT [8, 9]. Although there are studies in the literature on the comparison of MR, X-ray and USG in rotator cuff tears, there are no studies investigating the relationship between tear shape and anatomical parameters [10].

The primary aim of this study is to investigate the potential relationship between anatomical parameters such as the sagittal and coronal width of the footprint, GTA, CSA, LAA, and AI, and the geometry of RCT (L-shaped, U-shaped, and crescent-shaped).

Materials and methods

Our study is a retrospective study and has been approved by a local ethics committee. A total of 160 (n:160) patients who underwent arthroscopic repair for RCT between 2018 and 2023 were included in the study. Informed consent was obtained from all patients. Operated patients were divided into three groups based on the shape of the tears in their arthroscopic images (classification). In the crescent type group (n:40), those with crescent-shaped tears in the rotator cuff in arthroscopic images, in the L-type group (n:40), those with L-shaped tears, and in the U-type group (n:40), those with U-shaped tears were included (figure). The control group included patients who had shoulder MRI but were not diagnosed with RCT (n:40). A power analysis was conducted before the study, and the sample size for each group was found to be n:32. Therefore, after applying exclusion criteria, 40 patients with the least common type, L-type tear, were taken as the base. 40 patients with U-type and crescent-type tears were included in the study. In the control group, 40 patients who had shoulder MRI but were not diagnosed with RCT were included in the study.

Inclusion criteria in our study were; L-type, U-type and crescent-type tears can be clearly visualized with the arthroscope, patients without glenohumeral degeneration, patients with x-ray and mr radiologic examinations, patients without rheumatologic joint disease, patients with follow-up.

Exclusion criteria in our study were; Absence of preoperative radiological images of the patients in the system, patients with massive retracted rotator cuff tears, the arthroscopically determined RCT type not fitting one of the L, U, or crescent types, the patient having undergone previous surgery on the same shoulder, the patient having significant deformity in the humerus and/or glenoid, presence of humeral avascular necrosis, diagnosis of neurovascular disease, shoulder instability, diagnosis of partial thickness tear.

Measurements

A medical imaging program (DataMed, Ankara, Turkey) was used for radiological measurements. All measurements were conducted by two authors together in a single session. CSA, GTA, AI, and LAA were measured on true shoulder anteroposterior radiographs [5].

The CSA was measured as described by Moor et al.; the angle between the line passing through the superior and inferior points of the glenoid and the line passing through the inferior point of the glenoid and the most lateral point of the acromion was recorded as CSA [11]. GTA, as described by Cunningham et al., was recorded as the angle between a line parallel to the diaphysis axis passing through the rotational center of the humeral head and another line connecting the superior edge of the humeral head and the superolateral edge of the greater tuberosity [12]. AI, as described by Nyffeler et al., was calculated as the ratio of the distance from the glenoid to the most lateral point of the acromion to the distance from the glenoid to the most lateral point of the humeral head [13]. LAA, as shown by Banas et al., was recorded as the angle between the line connecting the superior and inferior edges of the glenoid and the extension of the inferior surface of the acromion [14] (Fig. 1).

Humerus footprint measurements were taken during shoulder arthroscopy as sagittal width and coronal width. The coronal width was measured and recorded as the distance from the lateral bone edge to the area where the cartilage surface begins at the midpoint of the humerus footprint in arthroscopic images obtained from the posterior portal. Then, moving to the lateral viewing portal, the distance between the anterior edge and the posterior edge at the midpoint of the greater tuberosity was measured and recorded as the sagittal width (Fig. 2).

Surgical procedure

All patients were operated on by the same surgeon. All cases were performed under general anesthesia in the beach-chair position. First, the arthroscopic examination of the glenohumeral joint was performed by entering through the posterior portal. Then, the subacromial space was entered to make the rotator cuff tear visible. The tear shape is made visible by the examination probe. The shape was decided by looking at the mobility on each edge of the tear. If the mobility of both edges of the tear was different, it was considered as L-type tear, and if it was the same, it was considered as U-type tear. In crescent type tears, the crescent shape was seen and classified. The type of tear was determined, and side-to-side suture technique was used for U- and L-shaped tears. Subsequently, the footprint was identified, a double row repair was performed with the help of 4.5 mm titanium anchor and push lock (Arthroline, Arthrotek, Adana/Turkey). Subacromial decompression was performed in all cases.

Post-operative patient follow-up protocol was applied the same for all groups. All patients started passive shoulder movement one day after surgery. An abduction support shoulder-arm sling was provided for 6 weeks, and active shoulder movement was restricted for 6 weeks. After 6 weeks, the shoulder-arm sling was removed, and

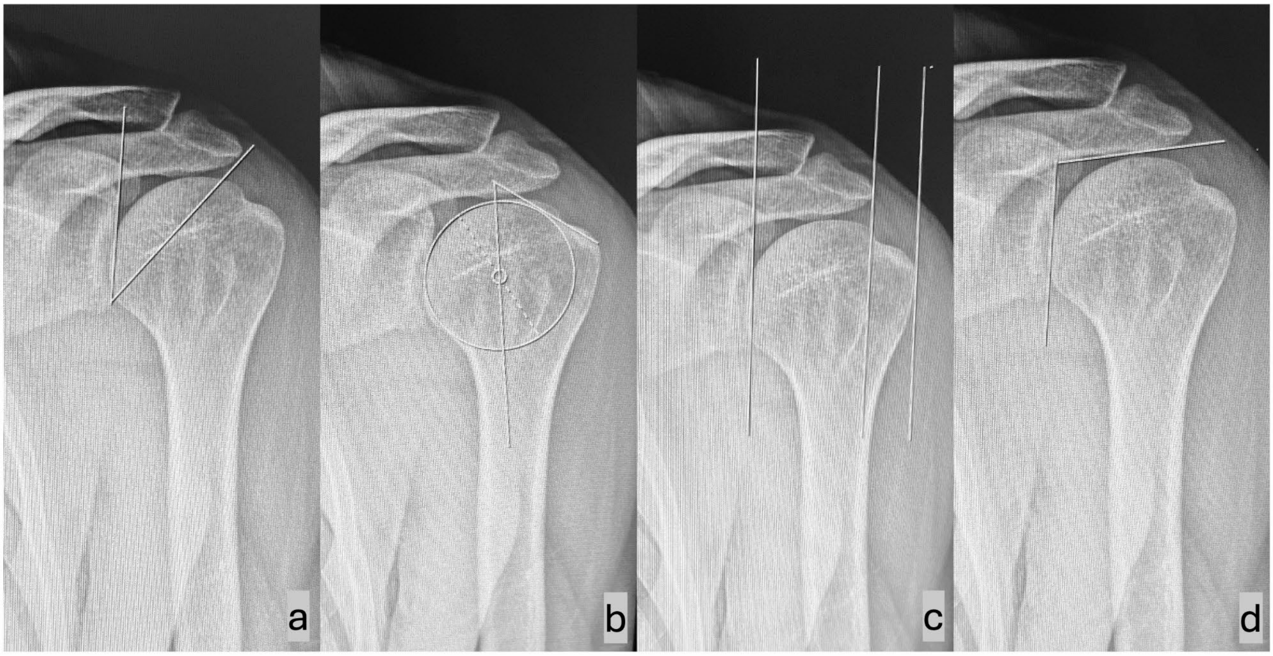

Fig. 1 Parameters evaluated on direct radiographs; **(a)** Critical Shoulder Angle: the angle between the line passing through the superior and inferior points of the glenoid and the line passing through the inferior point of the glenoid and the most lateral point of the acromion, **(b)** Greater Tuberosity Angle: the angle between a line parallel to the diaphysis axis passing through the rotational center of the humeral head and another line connecting the superior edge of the humeral head and the superolateral edge of the greater tuberosity **(c)** Acromion Index: the ratio of the distance from the glenoid to the most lateral point of the acromion to the distance from the glenoid to the most lateral point of the humeral head **(d)** Lateral Acromion Angle: the angle between the line connecting the superior and inferior edges of the glenoid and the extension of the inferior surface of the acromion

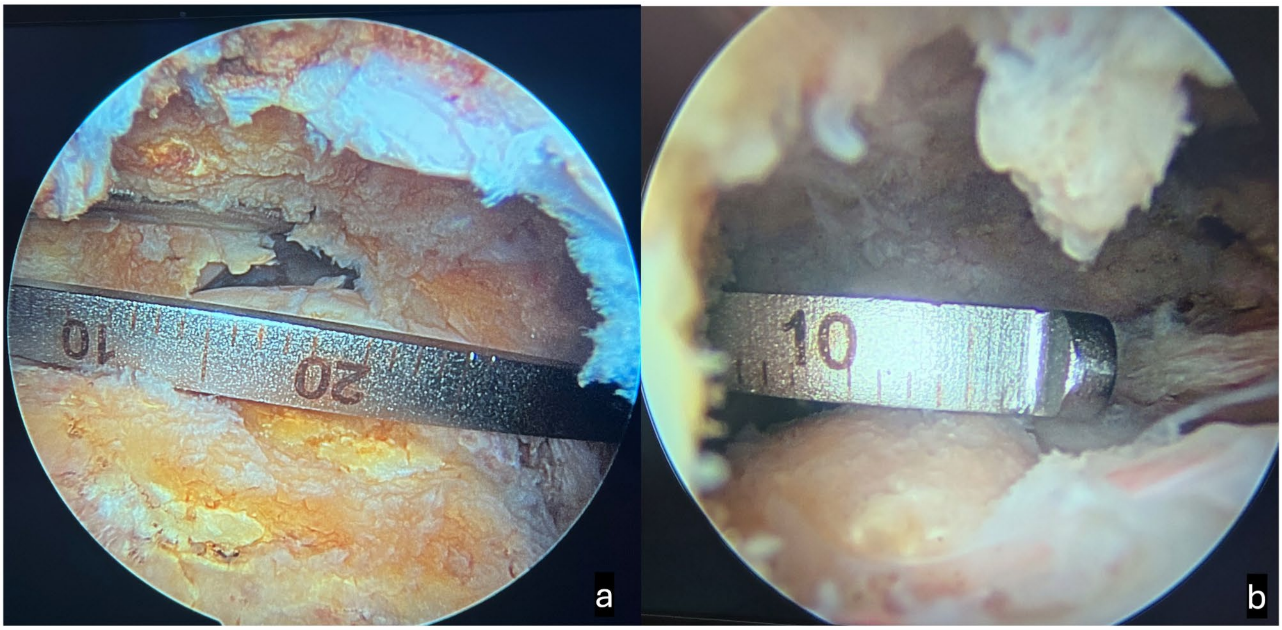

Fig. 2 Humerus Footprint measurements **(a)** sagittal width: the distance between the anterior edge and the posterior edge at the midpoint of the greater tuberosity **(b)** coronal width: the distance from the lateral bone edge to the area where the cartilage surface begins at the midpoint of the humerus footprint

all patients underwent a physical therapy program focusing on active shoulder movements for 2 months. No complications were observed in any patients during postoperative follow-up.

Statistical analysis

For statistical analyses, the NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used. Descriptive statistical methods (mean, standard deviation, median, frequency, percentage, minimum, maximum) were used when evaluating the study data. For comparisons of three or more groups of variables with normal distribution, the Oneway Anova test and Bonferroni test for pairwise comparisons were used. The Pearson Chi-Square test was used for comparing qualitative data. Diagnostic screening tests (specificity, sensitivity, etc.) and ROC analysis were used to determine the cut-off point. Logistic regression analysis was used to evaluate the risk factors affecting the groups. Statistical significance was accepted as $p<0.05$.

Results

Of the 160 patients included in our study, 60% ($n=96$) were female, and 40% ($n=64$) were male. The mean age of the cases was 66.53±6.76 years (range, 50–88 years). The shoulders included in the study consisted of 61.9% ($n=99$) right and 38.1% ($n=61$) left shoulders.

In the evaluation of demographic data, a statistically significant difference was found only in the average ages ($p=0.001$; $p<0.01$); the average age of the L-type group was 70,35±6,90 and was significantly higher than in the other patient groups ($p=0.001$). It was higher than that of the crescent type group ($p=0.001$), the U-type group ($p=0.010$), and the control group ($p=0.010$) ($p<0.05$). No statistically significant difference was found in other pairwise comparisons ($p>0.05$). During the assessment of the coronal and sagittal width measurements, The mean coranal width measurement of the L-type tear group was 12.62±0.29 mm, which was significantly higher than all other groups ($p<0.05$). The mean sagittal width of the L-type tear group was 34.95±0.29 mm, which was significantly higher than all other groups ($p<0.05$). The measurements in the L-type group were found to be higher than those in the crescent type group ($p=0.001$, $p=0.002$), the U-type group ($p=0.001$, $p=0.001$), and the control group ($p=0.001$, $p=0.023$). No statistically significant difference was found in other pairwise comparisons ($p>0.05$).

When the groups were evaluated based on GTA, CSA, and AI data, The mean GTA measurement of the L-type tear group was 73.03±0.95 degrees, which was significantly higher than all other groups ($p<0.05$). The mean CSA measurement of the L-type tear group was 34.77±0.66 degrees, which was significantly higher than all other groups ($p<0.05$). The mean AI measurement of the L-type tear group was 0.77±0.02, which was significantly higher than all other groups ($p<0.05$). The measurements in the L-type group were found to be higher than those in the crescent type group ($p=0.001$), ($p=0.001$), ($p=0.001$), the U-type group ($p=0.001$),

Table 1 Anatomical and radiological measurements by groups

		Total(*n* = 160)	**Crescentic (*n* = 40)**	**Type U (*n* = 40)**	**Type L (*n* = 40)**	**Control (*n* = 40)**
Coronal width	*Mean ± Sd*	12,28 ± 0,29	12,17 ± 0,20	12,20 ± 0,18	12,62 ± 0,29	12,15 ± 0,18
	Med (Min-Max)	12,3 (11,5–13,2)	12,2 (11,5–12,4)	12,2 (11,8–12,7)	12,7 (12,1–13,2)	12,2 (11,5–12,4)
Sagital width	*Mean ± Sd*	34,78 ± 0,29	34,72 ± 0,27	34,68 ± 0,26	34,95 ± 0,29	34,77 ± 0,26
	Med (Min-Max)	34,8 (34–35,6)	34,8 (34–35,1)	34,7 (34,2–35,1)	34,9 (34,3–35,6)	34,8 (34,2–35,2)
Greater tuberosity angle	*Mean ± Sd*	71,05 ± 1,30	70,35 ± 0,52	70,45 ± 0,43	73,03 ± 0,95	70,38 ± 0,45
	Med (Min-Max)	70,6 (68,8–74,6)	70,5 (68,8–71)	70,5 (68,9–71)	73,2 (70,9–74,6)	70,4 (68,8–71)
Critical shoulder angle	*Mean ± Sd*	33,62 ± 0,89	33,21 ± 0,61	33,31 ± 0,54	34,77 ± 0,66	33,20 ± 0,60
	Med (Min-Max)	33,6 (31,4–35,8)	33,3 (31,5–34,1)	33,5 (32,4–34,1)	34,8 (33,5–35,8)	33,3 (31,4–34,2)
Lateral acromial angle	*Mean ± Sd*	78,85 ± 1,39	79,20 ± 0,69	79,26 ± 0,67	76,98 ± 1,04	79,96 ± 0,81
	Med (Min-Max)	79,2 (75,2–81,2)	79,3 (77,5–80,5)	79,3 (77,9–80,6)	76,7 (75,2–80,2)	79,9 (78,4–81,2)
Acromial index	*Mean ± Sd*	0,76 ± 0,02	0,75 ± 0,02	0,75 ± 0,02	0,77 ± 0,02	0,74 ± 0,02
	Med (Min-Max)	0,8 (0,7 – 0,8)	0,8 (0,7 – 0,8)	0,8 (0,7 – 0,8)	0,8 (0,7 – 0,8)	0,7 (0,7 – 0,8)

Table 2 Comparison of evaluated parameters between groups

	p	***p*(Crescentic-Type U)**	***p*(Crescentic-Type L)**	***p* (Cresentic-Control)**	***p* (Type U-Type L)**	***p* (Type U-Control)**	***p* (Type L-Control)**
Coronal width	*^{a}0,001***	*^{b}0,808*	*^{b}0,001***	*^{b}0,976*	*^{b}0,001***	*^{b}0,528*	*^{b}0,001***
Sagittal width	*^{a}0,001***	*^{b}1,000*	*^{b}0,002***	*^{b}1,000*	*^{b}0,001***	*^{b}0,835*	*^{b}0,023**
Greater tuberosity angle	*^{a}0,001***	*^{b}0,787*	*^{b}0,001***	*^{b}0,994*	*^{b}0,001***	*^{b}0,883*	*^{b}0,001***
Critical shoulder angle	*^{a}0,001***	*^{b}1,000*	*^{b}0,001***	*^{b}1,000*	*^{b}0,001***	*^{b}1,000*	*^{b}0,001***
Lateral acromial angle	*^{a}0,001***	*^{b}1,000*	*^{b}0,001***	*^{b}0,001***	*^{b}0,001***	*^{b}0,001***	*^{b}0,001***
Acromial index	*^{a}0,001***	*^{b}1,000*	*^{b}0,001***	*^{b}0,058*	*^{b}0,004***	*^{b}0,067*	*^{b}0,001***

[a] Oneway ANOVA Test

[b] Bonferroni Test

*$p<0{,}05$

**$p<0{,}01$

(p=0.001), (p=0.004), and the control group (p=0.001), (p=0.001), (p=0.001). No statistically significant difference was found in other pairwise comparisons (p>0.05).

When the groups were evaluated based on LAA data, The mean LAA measurement of the L-type tear group was 76.98±1.04 degrees, which was significantly lower than all other groups (p<0.05). The measurements in the L-type group were found to be lower than those in the crescent type group (p=0.001), the U-type group (p=0.001), and the control group (p=0.001) (p<0.01). The measurements in the crescent type group (p=0.001) and the U-type group (p=0.001) were found to be lower than those in the control group (p<0.01) (Tables 1 and 2).

According to the presence of crescent tear, the cut-off point for LAA was determined as 79.3 and below. In cases with LAA levels of 79.3 and below, the risk of seeing a crescent tear is 4.5 times higher (OR:4.500; 95% CI:1.731–11.696). According to the presence of U-type tear, the cut-off point for LAA was determined as 79.3 and below. In cases with LAA levels of 79.3 and below, the risk of seeing a U-type tear is 4.5 times higher (OR:4.500; 95% CI:1.731–11.696). According to the presence of L-type tear, the cut-off point for coronal width was determined as 12.4 and above; the cut-off point for sagittal width was determined as 35 and above; the cut-off point for GTA was determined as 71.4 and above; the cut-off point for CSA was determined as 33.9 and above; the cut-off point for LAA was determined as 78.3 and below; and the cut-off point for AI was determined as 0.77 and above. In cases with coronal width levels of 12.4 and above, the risk of seeing an L-type tear is 31 times higher (OR:31.000; 95% CI:8.689–110.600). In cases with sagittal width levels of 35 and above, the risk of seeing an L-type tear is approximately 4 times higher (OR:3.857; 95% CI:1.382–10.764). In cases with GTA levels of 71.4 and above, the risk of seeing an L-type tear is 1500 times higher (OR:1521.000; 95% CI:91.836-25190.999). In cases with CSA levels of 33.9 and above, the risk of seeing an L-type tear is 86 times higher (OR:86.333; 95% CI:19.184-388.514). In cases with LAA levels of 78.3 and below, the risk of seeing an L-type tear is 481 times higher (OR:481.000; 95% CI:47.867-4833.396). In cases with AI levels of 0.77 and above, the risk of seeing an L-type tear is approximately 12 times higher (OR:11.769; 95% CI:3.952–35.051) (Table 3) (Figs. 3 and 4).

Based on the logistic regression analyses, various risk factors were evaluated for different groups according to the determined cut-off values. For the crescentic group

Table 3 Diagnostic screening tests and ROC curve results for anatomical measurements

	Diagnostic Scan					ROC Curve			*p*
	Cut off	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Accuracy	Area	95% Confidence Interval	
Crescentic- Control									
Lateral acromial angle	***≤ 79,3***	60,00	75,00	70,59	65,22	67,50	**0,747**	0,641-0,852	***0,001****
Type U- Control									
Lateral acromial angle	***≤ 79,3***	60,00	75,00	70,59	65,22	67,50	**0,733**	0,624-0,841	***0,001****
Type L- Control									
Coronal Width	***≥ 12,4***	77,50	90,00	88,57	80,00	83,75	**0,910**	0,847-0,973	***0,001****
Sagittal Width	***≥ 35***	45,00	82,50	72,00	60,00	63,75	**0,682**	0,566-0,799	***0,005****
Greater Tuberosity angle	***≥ 71,4***	97,50	100	100	97,56	98,75	**0,998**	0,993-1,000	***0,001****
Critical Shoulder Angle	***≥ 33,9***	92,50	87,50	88,10	92,11	90,00	**0,968**	0,937-0,999	***0,001****
Lateral acromial angle	***≤ 78,3***	92,50	100	100	93,02	96,25	**0,972**	0,934-1,000	***0,001****
Acromion Index	***≥ 0,77***	67,50	85,00	81,82	72,34	76,25	**0,846**	0,763-0,930	***0,001****

$^{**}p<0,01$

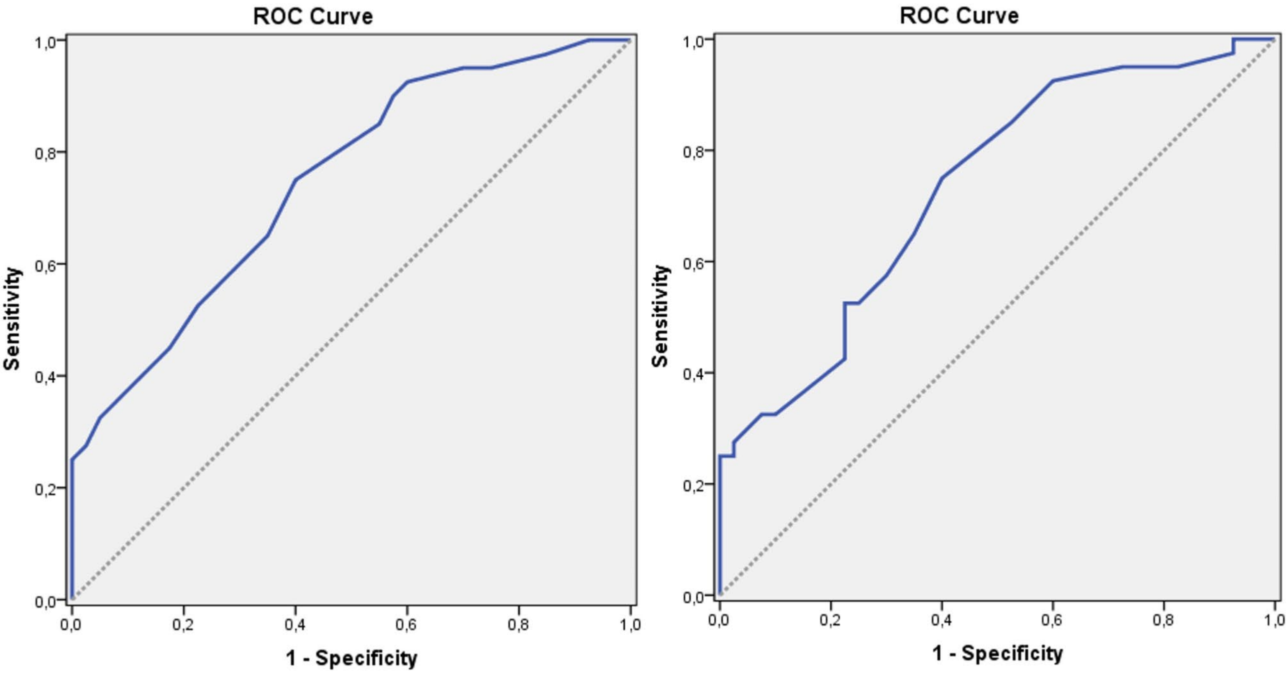

Fig. 3 ROC curve for Lateral Acromion Angle. On the left between the crescent group and the control group, on the right between the U-type group and the control group

and U-type group, age and LAA measurements were analyzed. When the logistic regression analysis was performed for the crescentic group, the model was found to be significant (F=22.210; p=0.004), with the explanatory power of the model being at a good level (%72.6). In this model, the ODDS ratio for having an LAA level below 79.3 was found to be 6.400 (95% CI: 2.03–20.19), and this was determined to be significant. The age variable did not show a significant effect.

Similarly, in the U-type group, when logistic regression analysis was performed, the model was found to be significant (F=10.409; p=0.005), with the explanatory power of the model being at a good level (%67.5). In this model, the ODDS ratio for having an LAA level below 79.3 was calculated as 4.604 (95% CI: 1.75–12.09), and this was found to be significant. The age variable also did not show a significant effect in the U-type group.

In the L-type group, when logistic regression analysis was performed, the model was found to be significant (F=81.862; p=0.000), with the explanatory power of the model being at a very good level (%92.5). In this model, coronal width, CSA, and age variables were found to be significant. The ODDS ratio for having a coronal width above 12.4 was found to be 43.613 (95% CI: 3.51–541),

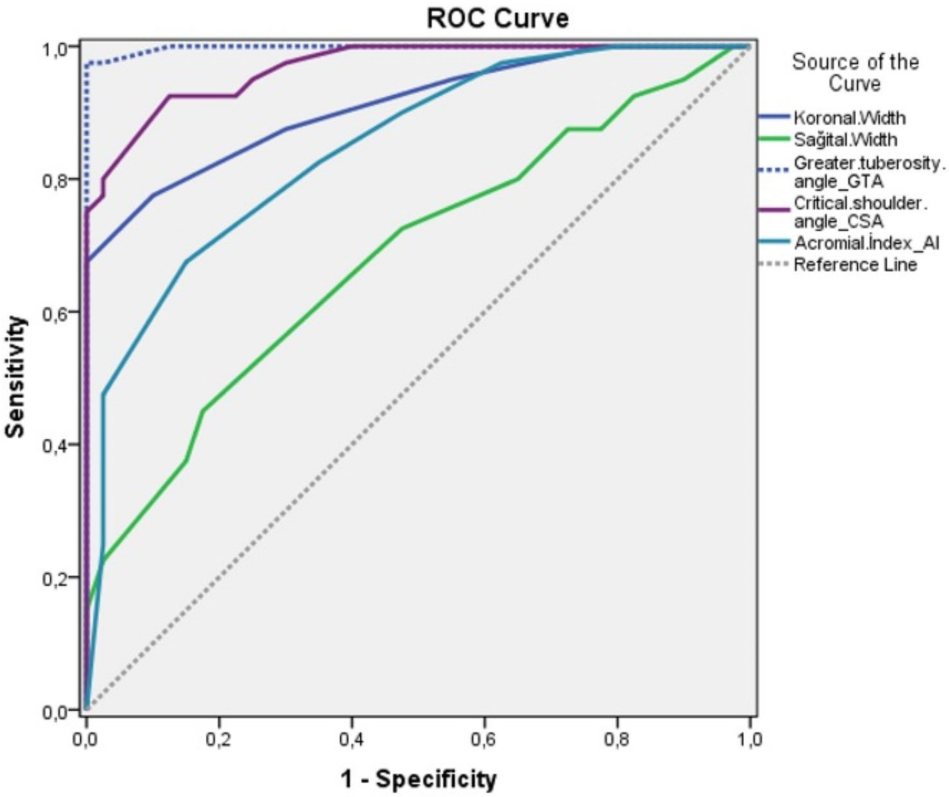

Fig. 4 ROC curve for the evaluated parameters between the L-type tear and the control group

Table 4 Logistic regression analysis of risk factors for the L-Type Group

	B	*P*	ODDS	%95 CI	
				Lower	Upper
Coronal Width (≥ *12,4*)	3,775	***0,003*****	43,613	3,510	541,835
Sagittal Width (≥ *35*)	1,784	***0,118***	5,953	0,636	55,755
Critical Shoulder Angle (≥ *33,9*)	4,710	***0,001*****	111,050	7,761	1589,054
Age (year)	0,283	***0,019****	1,327	1,048	1,680

**p* < 0,05

***p* < 0,*01*

and the ODDS ratio for having a CSA level above 33.9 was found to be 111.05 (95% CI: 7.76–1589). Additionally, the ODDS ratio for an increase of one unit in age was determined to be 1.327 (95% CI: 1.05–1.68), which was also significant. However, the sagittal width variable was not found to be significant in the multivariate analysis. Additionally, the measurements of GTA, LAA, and AI were highly discriminative for the L-type group, which distorted the model and did not produce a significant result (Table 4).

Discussion

This study is the first to investigate the relationship between anatomical parameters of the shoulder joint and the shapes of rotator cuff tears. The most important finding of our study is that in L-type tears, GTA, CSA, AI, coronal, and sagittal width measurements were higher and LAA values were lower compared to other tear types and the control group. The analyses determined that certain anatomical parameters significantly increased the risk of L-type tears: cases with a coronal width level of 12.4 and above had a 31- times increase, cases with a sagittal width level of 35 and above had an approximately 4-times increase, cases with a GTA level of 71.4 and above had a 1500-times increase, cases with a CSA level of 33.9 and above had an 86-times increase, cases with an LAA level of 78.3 and below had a 481-times increase, and cases with an AI level of 0.77 and above had a 12-times increase.

Many studies have examined the relationship between the shoulder joint and RCT [3, 4, 6, 15]. These anatomical parameters have been extensively investigated in relation to different RCT shapes. Liu et al. found that an increased AI was an independent risk factor for bursal-sided rotator cuff tears [5]. Seo et al. examined partial thickness RCTs and showed that a higher CSA was more strongly associated with articular-sided tears, while a higher GTA was more strongly associated with bursal-sided tears

[6]. Yoo et al. indicated that higher GTA and CSA values were associated with RCT but not with tear delamination [7]. Our study also found that increased GTA, CSA, and AI values were risk factors particularly for L-type tears.

Footprint measurements have previously been investigated by Quinlan et al. and no relationship was found between the size of coronal and sagittal measurements and RCT. However, it was found that especially as coronal width increased, the healing rates were higher [3]. In our study, it was found that both high coronal and high sagittal measurements were associated only with L-type tears. Particularly, in cases with a coronal diameter above 12.4, the risk of L-type tear was found to be 31 times higher. In other tear types, these measurements were not identified as risk factors. This interesting result should be investigated through biomechanical studies.

The relationship between low LAA values and RCT has been previously proven [14]. Additionally, Balke et al. demonstrated that LAA is more highly associated with degenerative tears compared to traumatic RCTs [8]. In our study, low LAA was found to be associated with all tear types. In cases of crescent and U-type tears, those with an LAA below 78.3 were found to be 4.5 times more at risk, while in L-type tears, this situation reached a very high value of 481 times. The age of the L-type tear group was found to be higher than all other groups and considering that the risk of degenerative tears increases with age, this result is consistent with the literature. However, the very high difference indicates that further studies are needed to investigate this situation.

Apart from low LAA values, other parameters (GTA, CSA, AI, and footprint measurements) were not found to be risk factors in U-type and crescent-type tears compared to the control group. However, all the parameters examined were considered risk factors for L-type tears. Although the results of studies conducted with these parameters vary, there are many studies showing their association with RCT [6, 7, 16]. However, none of these studies made this association without distinguishing based on the shape of the tears. Since the proportion of L-type tears in the patients used in studies in the literature is unknown, the situation in our study where these anatomical parameters are not risk factors for tear types other than L-type may not contradict the literature.

When rotator cuff tears are classified by shape, L-type tears are less common compared to U-type and crescent-type tears. Studies examining the impact of tear shapes on clinical outcomes have found no difference between tear shapes and functional outcomes [17, 18]. Additionally, different repair techniques for different tear shapes have been researched, and no difference has been found in their clinical outcomes [17–19]. It can be considered that different mechanisms are involved in the formation of these different tear shapes, but there are no studies in the literature examining these mechanisms. The results of our study, where the examined anatomical parameters were found to be more significant, especially in the relatively rare L-type tears, suggest that shoulder anatomy affects the mechanisms of tear formation.

When examining L-type tears, it was found that GTA, CSA, AI, coronal and sagittal width measurements were higher and LAA values were lower compared to other tear types and the control group. The reason for the high GTA values in L-type tears may be related to the lateralization of the joint rotation center as a result of increased coronal width measurements in these patients. In our study, the average age of the group with L-type tears was high. Additionally, osteophytes on the greater tuberosity may have influenced the results. The high CSA might be attributed to the increased acromial length due to acromial spur. The decrease in LAA could be related to the reduced subacromial space in these patients. When all these angle and length measurements are generally considered, it appears that the moment arm of the shoulder joint has increased, and the load on the rotator cuff has naturally increased. Therefore, we think that when the rotator cuff tears, it appears as both a tear separating from the bone and an intratendinous tear towards the joint rotation center. We believe the reason for the formation of L-type tears, i.e., the length difference in the legs of the tear, is due to this increased moment arm. This study has revealed extremely important results by examining the correlation between humerus morphology and rotator cuff tear shapes. However, it needs to be supported by further biomechanical studies.

In our study, arthroscopic images were used for humerus footprint measurements. Quinlan et al. used MR images for footprint measurements [3]. It is a fact that measurements can change with the patient's position in MR images. Quinlan et al. used an imaging program to prevent positional changes and tried to standardize their measurements [3]. In our study, using direct arthroscopic images, we completely avoided potential errors that could occur in the program despite all precautions. Thus, we believe that more meaningful results were obtained. However, Quinlan et al. found the average coronal width value in the RCT group to be approximately 12 mm and the sagittal width to be approximately 35 mm [3]. These measurements were also found to be approximate values in our study.

Preoperatively, the presence of a tear can be determined according to the results of x-ray and radiologic imaging of the patients, but it is difficult to make any comment on the shape of the tear. In our study, information about the shape of the tear can be obtained according to these measured angles during pre-op planning. The advantage of this situation is that L-type tears require more experience to repair because of their shape. During pre-op planning, the number of anchors and sutures to be used can be predetermined if the presence of an L-type tear is suspected. Also, one of the edges of the tear should be mobilized. This increases the possibility of bleeding. The surgeon is informed preoperatively about the possibility of increased surgical time and complications that may develop.

Our study has some limitations. Primarily, this is a retrospective study and includes all the limitations associated with this type of study. Although our control group did not have RCT, MRI imaging was taken in patients with shoulder pain and complaints, which may have included small tears and other pathologies that could be missed in the control group. The age group in L-type tears was found to be higher than in other tears, and this may have the potential to influence the results.

Conclusion

The findings of this study demonstrate that L-type rotator cuff tears are significantly associated with shoulder anatomical parameters. L-type tears were found to be associated with high GTA, CSA, AI, and wide coronal and sagittal width measurements, while low LAA values were identified as a significant risk factor for this tear type. These anatomical parameters did not stand out as risk factors for other tear types. These results suggest that shoulder anatomy affects the mechanisms of rotator cuff tear formation, and these parameters play a more pronounced role in L-type tears. It is very important to have preoperative information about the shape of the tear in order to prevent complications that may develop. These findings need to be supported by further biomechanical studies.

Abbreviations

CSA	Critical Shoulder Angle
GTA	Greater Tuberosity Angle
AI	Acromion Index
LAA	Lateral Acromion Angle
RCT	Rotator cuff tears
MRI	Magnetic Resonance Imaging
USG	Ultrasonography

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Author contributions

OK, AO participated in the design of the study and performed the statistical analysis. OK, conceived of the study, and participated in its design and coordination and helped to draft the manuscript. OK, AO writing and collecting data.All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval and consent to participate

In accordance with the Declaration of Helsinki Ethical approval was obtained by T.R. University of Health Sciences Turkey, Balıkesir Ataturk City Hospital Internal Review Board 2023/9/58 No:58. Consent to participate was obtained from the participants. Informed consent was obtained from all participants.

Consent for publication

Written informed consent for publication of their clinical details and/or clinical images was obtained from the patient. A copy of the consent form is available for review by the Editor of this journal.

Competing interests

The authors declare no competing interests.

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