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Critical shoulder angle does not correlate with patient outcomes after arthroscopic rotator cuff repair

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The aim of this study was to investigate the association between the critical shoulder angle (CSA) and the clinical outcomes following arthroscopic rotator cuff repair (RCR). An ambispective study was conducted in patients who underwent arthroscopic RCR and had adequate preoperative radiological shoulder studies (type A and 1 according to Suter and Henninger). Fifty-six patients with a minimum prospective follow-up of 3 years were included: 28 with a CSA >35º and 28 with a CSA <35º prior to surgery.

At the follow-up, shoulder function was evaluated using the Constant-Murley score (CS), the Simple Shoulder Test (SST), the Quick DASH Scoring (QDS) and the Visual Analog Pain Score (VAS). The median CS showed no significant difference between groups: CSA <35º was 67.8 (IQR 27.8) and CSA ≥35º was 69.3 (IQR 39.6) (p=0.606). For the CSA <35º group, median SST, QDS and VAS scores were 75 (IQR 31.3); 6.8 (IQR 22.2) and 3.0 (IQR 4.8) respectively. In the CSA ≥35º group, the corresponding values were 75 (IQR 47.9); 11.3 (IQR 31.2) and 2.5 (IQR 7.0) respectively (all n.s.). Although scapular geometry has been implicated in the pathogenesis of rotator cuff disease, and both AI and CSA are simple radiographic tools, our results suggest that these parameters are not clinically relevant predictors of functional outcomes following arthroscopic RCR.

Keywords: Shoulder, Arthroscopy, Rotator cuff, Critical shoulder angle, Acromial Index.

INTRODUCTION

Rotator cuff tears (RCT) are common injuries in the general population, with an increasing prevalence with age, ranging from 7 to 40%[1]. The etiology of RCT has been attributed to both extrinsic and intrinsic factors.

Among the extrinsic factors, anatomic variations in bony morphology have been proposed to contribute to the development of atraumatic rotator cuff tears and to poorer surgical outcomes[2,3]. The Critical shoulder angle (CSA)[4] and the acromial index (AI)[5] have emerged as quantitative radiographic parameters that describe scapular anatomy and may influence both the development of rotator cuff tears and postoperative results.

In the original paper by Moor et al[4], a larger CSA (>35º) was associated with an increased prevalence of RCT due to altered shoulder biomechanics. Specifically, a higher CSA increases the superiorly directed deltoid force vector, generating upward shear forces against the rotator cuff and leading to tendon degeneration and tearing.

Several subsequent clinical studies have supported these findings[6-19]. However, there remains a relative lack of evidence demonstrating a relationship between increased CSA and worse clinical outcomes following rotator cuff repair. Therefore, it is still unclear whether knowledge of this anatomical parameter is clinically useful for surgeons and their patients.

The primary aim of the present study was to investigate the association between CSA and clinical outcomes following arthroscopic rotator cuff repair. The secondary objective was to assess potential correlations between the acromial index (AI) and overall postoperative outcomes.

MATERIALS AND METHODS

A cohort study was conducted including 56 patients who underwent arthroscopic RCT repair. Patients were retrospectively identified from pre-existing medical records and prospectively followed for a minimum of three years postoperatively. The cohort was divided into two groups according to the preoperative critical shoulder angle (CSA): 28 patients with CSA >35° and 28 with CSA <35° (Figure 1).

All patients underwent arthroscopic repair of full-thickness supraspinatus tears classified as small or medium (tear size <4 cm, measured from medial to lateral). Repairs were performed using suture anchors. Only patients with adequate preoperative anteroposterior (AP) radiographs of the shoulder (classified as types A and 1 according to Suter et al[20]) were included, and all provided informed consent prior to participation.

All the patients included in this study were arthroscopically treated of a full-thickness supraspinatus small or medium tears (size of the tear measured medial to lateral <4 cm) with suture anchors; adequate preoperative shoulder radiographs were performed according to Suter et al[20] (all the radiographs of the studied patients were types A and 1).

Exclusion criteria were history of prior shoulder surgery, inadequate preoperative radiographs for CSA measurement and presence of degenerative or neuromuscular disorders affecting the shoulder joint.

The CSA (Figure 2) and AI (Figure 3) were measured on standardized AP scapular radiographs by all three authors.

At the follow-up, functional outcomes were assessed using the following validated scoring systems: Constant-Murley score (CS), Simple Shoulder Test (SST), Quick DASH (Disabilities of Arm, Shoulder and Hand) Scoring (QDS) and Visual Analog Pain Score (VAS) for pain.

Statistical analysis

Descriptive statistics were used to summarize patient characteristics. The Kolmogorov–Smirnov test was applied to assess normality of continuous variables. Non-normally distributed continuous variables were expressed as median and interquartile range (IQR); while normally distributed variables were expressed as mean ± standard deviation (SD). Categorical variables were summarized as absolute frequencies and percentages. Comparisons between groups were performed using the chi-square or Fisher's exact test for categorical variables (e.g., gender, side), the Mann–Whitney U-test for non-parametric variables, and chi-square tests for qualitative data. Inter- and intra-observer reliability for CSA measurements was expressed using the Intraclass Correlation Coefficient (ICC).

All statistical analyses were performed using SPSS software, version 25, (IBM, New York, USA). Two-tailed p-values <0.05 were considered statistically significant.

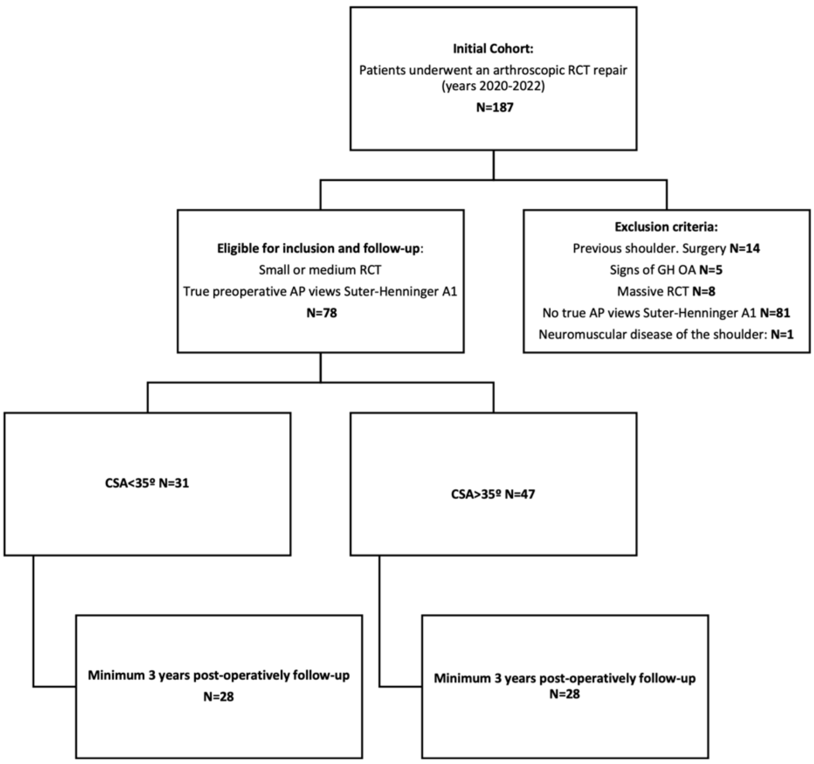

Fig. 1 — Flow chart showing the formation of the groups.

Fig. 2 — The critical shoulder angle (CSA) is formed from a line connecting the inferior and superior border of the glenoid fossa and another line connecting the inferior border of the glenoid with the inferolateral border of the acromion.

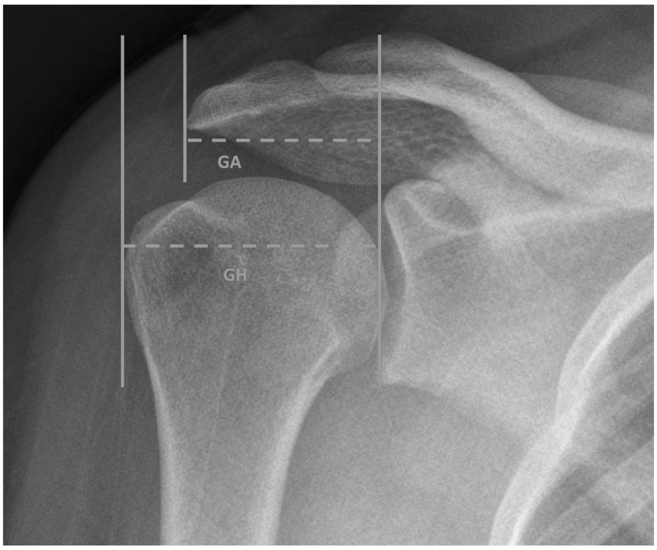

Fig. 3 — The Acromial Index (AI) is the ratio of the distance from the glenoid plane to the lateral border of the acromion (GA) to the distance from the glenoid plane to the most lateral aspect of the humeral head (GH). AI = GA/GH.

Sample size was calculated previously during the study design phase using the native power command of the Stata BE 14 statistical packages. Based on previous studies, the mean Constant score after an arthroscopic repair in patients with a medium tear and CSA <35º was 79.2±4.7 while in patients with CSA >35º it was 76.0±3.4[21]. Accordingly, a total of 56 patients (28 per group) was required to detect a statistically significant difference in Constant scores with a confidence level of 95% and a power of 80% (two-sample means test, Satterthwaite's t-test assuming unequal variances).

RESULTS

The mean age of the patients was 59.8±9 years, 22 were men (39.3%) and 34 women (60.7%). Forty-three shoulders were right-sided (76.6%) and 13 were left-sided (23.3%) (Table I).

The inter- and intra-observer reliability for CSA measurements among all examiners was excellent, with an intraclass correlation coefficient (ICC) of 0.94.

The overall mean functional outcomes were as follows: Constant-Murley Score (CS) 65.8±20.1;

Table I. — CSA: Critical Shoulder Angle; IQR: Interquartile Range.

	TOTAL	CSA < 35º (n=28)	CSA ≥ 35º (n=28)	p-value
Sex (n, %)				0.101
Female	34 (60.7%)	14 (63.6%)	8 (39.4%)	
Male	22 (39.3%)	14 (41.2%)	8 (58.8%)	
Age (median [IQR])	62 [13]	64.5 [13.0]	59.5 [10.8]	0.149
Side (n,%)				0.342
Right shoulder	43 (76.8%)	20 (71.4%)	23 (82.1%)	
Left shoulder	13 (23.2%)	8 (28.6%)	5 (17.9%)	
Tear size (n,%)				0.383
Small tears	17	7 (41.2%)	10 (56.8%)	
Medium tears	39	21 (53.8%)	18 (46.2%)	

QuickDASH 16.3±17.8; SST 78.3±16.9 and VAS 3.5±3.1.

In the group with CSA <35°, the median CS was 67.8 (IQR 27.8), compared with 69.3 (IQR 39.6) in the group with CSA ≥35°. The difference between groups was not statistically significant (p = 0.606). Similarly, for the CSA <35° group, the median SST, QuickDASH, and VAS scores were 75 (IQR 31.3), 6.8 (IQR 22.2), and 3.0 (IQR 4.8), respectively. In the CSA ≥35° group, the corresponding values were 75 (IQR 47.9), 11.3 (IQR 31.2), and 2.5 (IQR 7.0), respectively, with no statistically significant differences (p = 0.392, 0.686, and 0.947, respectively) (Table II).

Table II. — CSA: Critical Shoulder Angle; SST: Simple Shoulder Test (SST), QDS: Quick DASH Scoring; VAS: Visual Analog Pain Score; IQR: Interquartile Range.

CSA	CONSTANT/100	SST/100	QDS /100	VAS/10
≥ 35º	69.3 (IQR 39.6)	75 (IQR 47.9)	11.3 (IQR 31.2)	2.5 (IQR 7)
< 35º	67.8 (IQR 27.8)	75 (IQR 31.3)	6.8 (IQR 22.2)	3 (IQR 4.8)
	p = 0.606	p = 0.392	p = 0.686	p = 0.947

Table III. — AI: acromial index; SST: Simple Shoulder Test (SST), QDS: Quick DASH Scoring; VAS: Visual Analog Pain; Score IQR: Interquartile Range.

AI	CONSTANT/100	SST/100	QDS /100	VAS/10
≥ 0.7	69.3 (IQR 33.3)	75 (IQR 41.6)	11.3 (IQR 31.7)	2.5 (IQR 6.3)
< 0.7	67.8 (IQR 28.3)	79.2 (IQR 27.1)	4.5 (IQR 18.7)	3.5 (IQR 4.5)
	p = 0.477	p = 0.188	p = 0.266	p = 0.951

Regarding the acromial index (AI), 38 of the 56 patients (67.9%) had an AI ≥0.7, and 18 patients (32.1%) had an AI <0.7. The median CS was 69.3 (IQR 33.3) for patients with AI ≥0.7 and 67.8 (IQR 28.3) for those with AI <0.7, showing no significant difference (p = 0.477). In the AI ≥0.7 group, the median SST, QuickDASH, and VAS scores were 75 (IQR 41.6), 11.3 (IQR 31.7), and 2.5 (IQR 6.3), respectively. In the AI <0.7 group, the median SST, QuickDASH, and VAS scores were 79.2 (IQR 27.1), 4.5 (IQR 18.7), and 3.5 (IQR 4.5), respectively. None of these differences reached statistical significance (p = 0.188, 0.266, and 0.951, respectively) (Table III).

DISCUSSION

Rotator cuff disease has traditionally been described as a progressive disorder of the rotator cuff tendons, beginning with acute tendinitis and progressing to tendinosis with degeneration, partial-thickness tears, and eventually full-thickness rupture[22]. Several mechanisms have been implicated in the pathogenesis of rotator cuff disease, including both intrinsic and extrinsic factors or, most likely, a combination of the two[23].

The influence of acromial morphology on the development of rotator cuff tears remains controversial. For many years, subacromial impingement was considered the principal etiological factor, and surgical procedures were aimed at enlarging the subacromial space[2,3,22,24].

More recently, the critical shoulder angle (CSA) has emerged as a potentially important parameter affecting the incidence of rotator cuff tears and postoperative retear rates. The CSA combines the lateral acromial offset and glenoid inclination; values greater than 35° have been associated with a higher prevalence of rotator cuff tears[4].

Biomechanically, a larger CSA increases the superior shear force vector on the humeral head while reducing the compressive force component on the glenoid. In addition, a more laterally extended acromion results in more vertically oriented deltoid fibers, thereby generating a stronger superiorly directed deltoid force, particularly at low degrees of shoulder abduction (between 10° and 60º)[25]. Although several clinical studies have supported these biomechanical observations[6-19,26] the true clinical utility of the CSA remains uncertain[27-36].

Garcia et al[37] reported that a higher CSA was associated with worse patient-reported outcomes and a higher risk of retear following arthroscopic rotator cuff repair. However, in a subsequent systematic review that included that study, Docter et al[38] found no such association between greater CSA and clinical outcomes.

In agreement with these findings, our study found no correlation between CSA and postoperative outcomes at a minimum three-year follow-up. However, we did not assess retear rates, which could partially explain the differences with previous studies. It is worth noting that García et al[37] used a CSA cutoff value >38° and evaluated patients only six months after surgery. In contrast, Kirsch et al[30] reported results similar to ours when comparing patients with CSA <38° versus ≥38° at a minimum follow-up of 48 months. These discrepancies suggest that different CSA thresholds or follow-up durations may influence the observed associations, underscoring the need for further research.

Any correlations were found between CSA and overall outcomes with a minimum prospective follow-up of 3 years according to our results, but we did not study the relationship between a greater CSA and the retear rate in our patients. However, Garcia et al[37] selected a CSA cut-off value >38° and the evaluation of their patients was at 6 months after the surgery. On the other hand, Kirsch et al[30] have also reported similar results to ours comparing individuals with a CSA < 38° against patients with CSA >38° with a minimum follow-up of 48 months. This opens the possibility that with different cut-off values or postoperative timepoint we might find correlation, suggesting that more studies are needed.

Gumina et al[39] reported a mean CSA value of 33.6° in the general population, with no differences between genders or sides. In our study, we used a cutoff of 35°, in accordance with Moor et al[4], and consistent with the findings of Mantell et al[40] and Razmjou et al[41], who determined optimal CSA and AI thresholds for predicting RCT using the Youden index. Other authors, such as Hsu et al[42], found that in patients with shoulder pain, a CSA >38.11° predicted supraspinatus tendinopathy with 71.0% specificity and 71.8% sensitivity. Nevertheless, this diagnostic association was beyond the scope of our investigation, which focused exclusively on the relationship between CSA and postoperative outcomes after arthroscopic repair.

Suter et al[20] demonstrated that CSA measurements are highly sensitive to radiographic malpositioning, with deviations as small as 5° in anteversion or retroversion producing a false CSA increase of up to 2° compared with a true anteroposterior view. Therefore, careful standardization of radiographic technique is essential for reliable CSA assessment. In the present study, all radiographs were verified as types A and 1 according to Suter et al[20], ensuring measurement consistency.

The acromial index (AI) has also been associated with the development of rotator cuff tears and postoperative recovery after rotator cuff repair[5,43,44]. Lee et al[32] and Yoğun et al[35] reported that functional outcomes after arthroscopic repair were not influenced by the AI. In our cohort, there was a trend toward better outcomes among patients with AI <0.7; however, the difference was not statistically significant. Because the CSA incorporates both the AI and glenoid inclination, the CSA is likely a more comprehensive measure of scapular geometry and its potential influence on postoperative recovery.

Several researchers have reported that a higher CSA is associated with an increased risk of rotator cuff tears, higher retear rates after surgery, and poorer functional outcomes[3,9,11,24,27,30,44]. Nevertheless, our findings suggest that although a high CSA may predispose patients to the development of rotator cuff tears, this parameter does not appear to significantly affect clinical outcomes following arthroscopic repair. Suter et al[20] also reported that a CSA range between 23° and 44° did not produce any acute pathological changes in cadaveric specimens, supporting the idea that small variations in CSA may fall within the margin of measurement error. Consequently, the use of narrowly defined "normal" CSA thresholds should be interpreted with caution.

The present study has several limitations. First, the surgical procedures had been performed before the study was initiated; however, as the objective was to evaluate postoperative outcomes in relation to CSA, this limitation did not affect the validity of the findings. Although post hoc power analysis indicated that our sample size was sufficient to detect group differences, a larger sample would improve the robustness of the statistical analysis. Second, imaging studies were not performed at follow-up to assess tendon integrity. Biomechanical studies have shown that a large CSA may increase glenohumeral instability and supraspinatus tendon overload[25], potentially leading to higher retear risk. This relationship, however, was beyond the scope of the present study, and other authors have suggested that this effect may not be clinically relevant[45]. Finally, our study employed a CSA cutoff of 35° based on the original findings of Moor et al[4]; had we selected a higher cutoff (e.g., 38°), the results might have differed.

CONCLUSIONS

The CSA and AI are simple, easily obtainable radiographic parameters that may assist in preoperative assessment and surgical decision-making. However, based on our findings, these anatomical parameters do not appear to have a meaningful impact on functional outcomes after arthroscopic repair of full-thickness rotator cuff tears or on day-to-day clinical management.

Although our sample size was sufficient to demonstrate statistical validity, larger multicenter studies would be valuable to confirm these results and further clarify the true clinical role of scapular morphology in rotator cuff repair outcomes.

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