

Original Article

Significance of critical shoulder angle as predictor in rotator cuff tear

Girish Gadekar¹, Monika Verma¹, Dineysh Dhytadak¹

¹Department of Orthopaedics, Mahatma Gandhi Mission Medical College and Hospital, Aurangabad, Maharashtra, India.

ABSTRACT

Objectives: A critical shoulder angle (CSA) is the angle between the line drawn from the Glenoid's superior and inferior margins and a line drawn from the inferior glenoid margin to the lateral border of acromion. The study aims to establish the significance of CSA as a predictor in RCT.

Materials and Methods: Data points were collected retrospectively from 196 patients with shoulder pain who visited out-patient department or were in an inpatient orthopedics ward. The diagnosis of those patients of either a RCT or a normal shoulder was confirmed using ultrasonography or magnetic resonance imaging. Then, two investigators, unaware of the status of RCT or non-RCT (NRCT), calculated the CSA. Later, these data points were compared using an unpaired *t*-test, which helped to determine the accuracy of CSA in diagnosing RCT and the optimal cutoff.

Results: We included 196 patients in our studies, out of which 101 patients had RCTs, that is, in the RCT group and 95 in the NRCT group. The CSA was higher in the RCT group ($P < 0.01$) than in the NRCT group.

Conclusion: At the end of the study, we concluded that there is a significant correlation between CSA and RCT that CSA is significantly greater in patients with RCT.

Keywords: Critical shoulder angle, Rotator cuff tear, Shoulder pain

INTRODUCTION

During the evolution of human beings, the upper limb needed more mobility to accommodate a wide variety of tasks, which became possible due to the larger humeral head compared to the Glenoid, which creates a mismatch in size, that is, there is a trade-off of stability for mobility. Hence, the stability of this joint depends on two types of stabilizers: Static and Dynamic. Static stabilizers are capsule, labrum, and dynamic stabilizers are rotator cuffs.

The rotator cuff is formed by the tendinous confluence of four muscles, supraspinatus muscle, infraspinatus, teres minor, and subscapularis. They help in shoulder movements, abduction, external rotation, and internal rotation. They also prevent superior translocation of the humerus.

Most rotator cuff tears (RCTs) occur in a previously diseased cuff, like degeneration of the rotator cuff.^[1] These degenerated rotator cuff progresses to partial or full-thickness tears. Most commonly, the supraspinatus tendon is involved. Among the patients who undergo rotator cuff repair, only 8% of them are due to trauma.^[2]

When we speak about partial thickness tears of a rotator cuff, we refer to tendon involvement <50% of the thickness, which

does not lead to muscle retraction.^[1] These partial tears of RCT can be intra-substance, bursal-sided, or articular-sided (under the surface). The latter constitute ~90% of partial tears.^[3] These generally do not present with weakness but cause pain, which is generally more significant than a complete tear.

On the other hand, total thickness tear involves complete disruption of the rotator cuff fiber, which causes communication of both articular and bursal spaces.

The extent of the lesion is assessed in radiographs AP and mediolateral direction. It is classified as a small lesion (1–3 cm), medium (3–5 cm), and large (>5 cm). The involvement of 2 or more tendons is termed massive, and the reconstruction procedure is more complex than the small or medium lesions.^[4] If the tears are significantly larger, they might get retracted and undergo fatty degeneration, which becomes an irreversible change over time.^[5]

RCTs are prevalent, and it has shown a gradually increasing trend, primarily due to the advent of investigations like magnetic resonance imaging (MRI). However, despite this intervention, most patients with RCT remain undetected as many are asymptomatic.

*Corresponding author: Monika Verma, Department of Orthopaedics, Mahatma Gandhi Mission Medical College and Hospital, Aurangabad, Maharashtra, India. doctormonikaverma@gmail.com

Received: 05 November 2023 Accepted: 08 February 2024 Published: 29 March 2024 DOI: 10.25259/JASSM_18_2023

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RCT can present a spectrum of symptoms, from shoulder pain and restricted movements to hardly any symptoms. RCTs are very prevalent, and this prevalence differs in different age groups; approximately 15–20% in 60-year-old patients, 30% in 70-year-old patients, and 36–50% in people aged 80 years old. The prevalence of RCT increases with an increase in age. Moreover, the prevalence of RCT in the general population is about 22.1%.^[6,7] Regarding its contribution to shoulder pain, RCT accounts for approximately 30–70% of shoulder pain.^[6] The etiology of RCT is of two types intrinsic and extrinsic. Intrinsic being microtrauma, degeneration, and hyperperfusion, and the latter include overuse of the cuff and chronic impingement syndrome.^[8]

Recent studies have shown anatomical factors like critical shoulder angle (CSA) are related to RCT.^[9] Before establishing this relationship, let us become familiar with CSA. This angle is between the line of the superior to the inferior bony margin of the glenoid and the inferior bony margin of the glenoid to the lateral margin of the acromion. The CSA can indicate glenoid inclination and lateral extension of the acromion.^[10] Studies like^[11–13] have also reported the significance of CSA in patients with RCT. Among the studies mentioned earlier, study^[12] also reported similar results for degenerative RCT, which is CSA being higher in them than in the normal population.

Although several studies have associated radiographic assessment measures like CSA with RCT, there has yet to be a study that can determine the accuracy of these parameters in predicting RCT.^[11–13]

Studies like^[11–13] have also reported the significance of CSA in patients with RCT. Among the earlier studies, study^[12] also reported similar results for degenerative RCT, with CSA higher than the average population.

Some studies have mentioned the diagnostic value of the CSA in RCTs, but its prognostic value still needs to be determined. In the study by Docter *et al.*,^[14] which is a review of 12 studies, Docter *et al.* found a variation of this angle among age groups. Although the incidence of re-tear is higher in the group, who were found to have CSA >38° but clinically, they had the same outcome.^[14]

In a retrospective study conducted by Gumina *et al.*, no significant variation in CSA was observed among genders or sides. However, the study did find a linear correlation between CSA and age.^[15]

According to a meta-analysis by Docter *et al.*, there is an association between the higher value of CSA and chronic, full-thickness RCT. The study also demonstrated a greater risk of re-tear in cases with higher CSA values, but interestingly, no significant association was found between CSA and the functional outcome of RCR.^[14]

MATERIALS AND METHODS

We conducted a retrospective record-based study at a medical hospital from 2022 to 2023. We included participants in this

study from the inpatient and outpatient departments of orthopedics. This study is approved by the Ethics Committee for Research on Human Subjects, MGM, Maharashtra.

Inclusion criteria

The following criteria were included in the study:

1. Patients between the ages of 40–60
2. Patients complaining of shoulder pain and restricted shoulder joint movement
3. Patients consented to undergo investigations such as shoulder X-ray, ultrasonography (USG), and MRI
4. Patients with X-ray shoulder AP were taken with standard protocol.

Exclusion criteria

The following criteria were excluded from the study:

1. Patients previously operated on the same shoulder
2. Patients with glenohumeral osteoarthritis or acromioclavicular arthritis, which could influence CSA
3. Patient not giving consent
4. Patients with shoulder X-rays which are not with standard protocol.

The MRI or USG reports of one hundred and ninety six patients were studied, and confirmation of RCT or normal shoulder was made. One hundred and fifty patients underwent MRI, and forty six patients underwent USG. Out of these, ninety patients were reported normal through MRI, and five patients were reported normal through USG.

Then, radiographs of those patients were collected, and three independent investigators who were orthopedic surgeons-assessed radiographs and calculated CSA by drawing the line from the superior to the inferior bony margin of the glenoid and the inferior bony margin of the Glenoid to the lateral margin of the acromion and the angle between them is recorded as CSA. This is demonstrated in Figure 1. After calculating CSA, the patients were distributed into RCT and non-RCT (NRCT). After this CSA of both groups is compared using an unpaired *t*-test. We have summarized the method of our study in flow chart 1.

Radiographic evaluation of CSA

After MRI or USG confirmation of the RCT X-ray of the patients was examined. This X-ray is taken initially before MRI or USG is advised. This X-ray is taken in a standing position with a beam descending and tilted to 20° depressed to ensure an accurate assessment of radiological features. AP shoulder was taken as per protocol. Moreover, CSA was measured as described by Blonna *et al.*^[16]

According to the Suter-Henninger criteria,^[17] an A1 view shows the glenoid in profile with the coracoid overlapping the superior rim of the glenoid. Hence, the transverse glenoid measures 0 mm; the RTL equals 0 in this case. The CSA, for example, is 30.7° (normal range of 30°–35°).

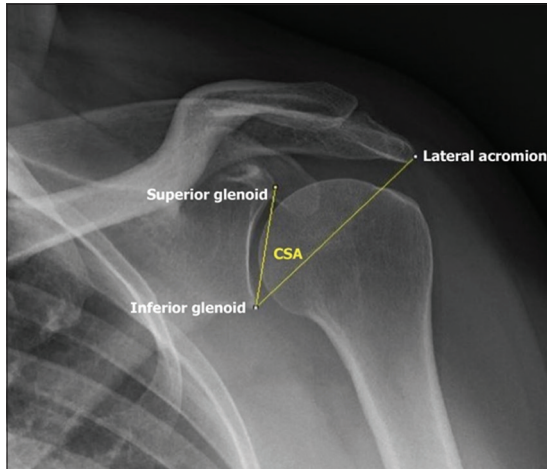
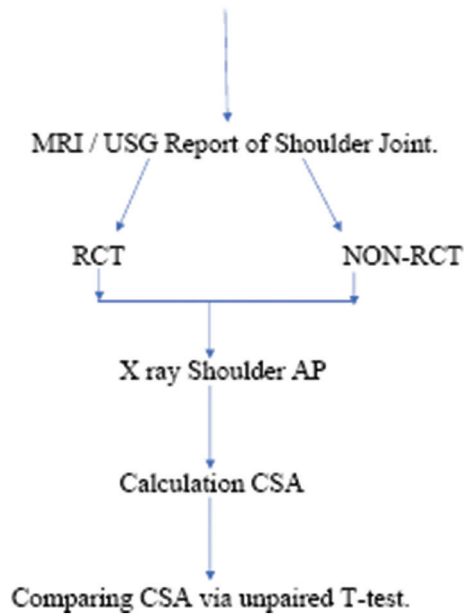


Figure 1: Demonstrating, the calculation of critical shoulder angle (CSA).

Patients with shoulder pain who met the inclusion criteria



Flow chart: Study flow chart. RCT: Rotator cuff tear, AP: Antero-posterior view, CSA: Critical shoulder angle.

The same scapula as in the previous case, with no flexion or extension, but the shoulder is rotated to 10° of anteversion, which will yield a D1 view, on which the glenoid cup is now visible. The RTL equals 0.18, which is below the 0.25 cutoff proposed by Hou *et al.*^[18] The CSA deviates by 1.5° , which is below the 2° allowable error but still in the normal range.

(C) The scapula is now rotated into 20° of anteversion, and the RTL equals 0.32, which exceeds the cutoff value of 0.25. The measured CSA is 37.8° , which aberrantly errs into the range indicative of a RCT, which leads to a change in the clinical interpretation of this scapula.

According to Hou *et al.*,^[16] RTL is ratio of the transverse to longitudinal projected length of the glenoid (diameter of the lateral glenoid outline), and the RTL is quite specific and sensitive for identifying an image that is adequate for accurate measurement of CSA. Scapula from patients with RCT shows a higher correlation between the RTL and error in CSA prediction than the general population, but as the RTL increases, an error in CSA prediction longitudinal projected length of the glenoid.^[18]

For the sake of accuracy, we have used only A1 views in our study. That is, the X-rays had minimal overlapping of the anterior and posterior edges of the glenoid cavity.

Furthermore, CSA was calculated between the line from joining the superior and inferior glenoid to the line from the most lateral border of the acromion. To ensure the accuracy of measurement of CSA, independent observers measured in two different incidences,^[19] each image was measured 3 times, and the mean value was calculated and used in this study. An experienced and capable physician performed radiological investigations such as USG and MRI as routine practice and was unaware of the study and radiographic CSA measurement due to the nature of the study, which is retrospective. The previous studies^[20] have estimated that diagnostic accuracy of USG for full-thickness RCT was more than 0.90 for sensitivity and specificity. For partial thickness RCTs, specificity was more than 0.9.

Statistical analysis

After calculating CSA for each group, we subdivided all participants into the RCT and NRCT groups based on ultrasound or MRI findings. Then, baseline 1:1 matching for demographic data was done from records. After this step, the CSA of both groups was done using an unpaired *t*-test.

RESULTS

P-value for this study is <0.01 that sensitivity and specificity were calculated to be 73.2% and 70.5%, respectively, in predicting SS tendinopathy.

DISCUSSION

In a study by Gerber *et al.*,^[19] a comparison was made of the joint reaction force of CSA of more than 38 for more than 33 patients with RCT.

They also reported that an increased CSA could result in a decrease in the stability of the joint, and this instability leads to increased work for the supraspinatus tendon, which can lead to tearing after repetitive use.

Docter *et al.*: carried out meta-analysis to demonstrate the association of higher value of CSA and RCT. In his study, he found that CSA was not efficient in predicting the outcome of rotator cuff repair.^[14]

There was another meta-analysis by Tashjian that is worth mentioning; in this study, he included 70 papers; and noticed that as the age increased, the CSA also increased. Smoking and genetics also increase the risk of RCT.^[21]

Viehöfer *et al.*, in their retrospective study, observed that the shoulder X-ray of normal patients had a comparatively smaller value of CSA than patients with RCT. They hypothesized an increase in the ratio of glenohumeral joint shear to joint compression forces as the value of CSA increases. This will cause increase stress on supraspinatus loads to stabilize the shoulder joint in abduction.^[7]

Blonna *et al.*, in their cohort study, concluded that raised CSA value is associated with an increased risk of RCT, larger cuff tear, and osteoarthritis of the shoulder joint.^[16]

While other authors like Gumina *et al.*, in their retrospective study, observed that the CSA does not vary significantly with gender or side. Though it does have a linear correlation between CSA and age.^[15] While Kim *et al.* found no relationship between CSA and RCT and mentioned that higher CSA in RCT can signify a preexisting osteophyte.^[11]

Kirsch *et al.* conducted a cohort study and observed that CSA stand-alone could predict the patient outcome after arthroscopic repair.^[22]

Bjarnison *et al.* this study was a retrospective case – control study. It comprised 184 patients, 97 with RCT and 87 with OA. No causal relationship between CSA and RCT was found; however, there was a 2.25 OR of developing OA, given that the patient had a CSA <30°.^[23]

In our study, we have included patients who visited us with shoulder pain and routinely advised shoulder AP and axial for these patients. However, many institutes do not have these facilities; hence, it is crucial that we have some radiological parameters available to screen for the RCT.

A high CSA can be a guiding light in this situation. A high CSA indicated high acromial coverage and glenoid inclination, contributing to vulnerability to RCTs from impingement.

We conducted this study on the Indian population and found that CSA can be considered an objective assessment tool for predicting whether the patient has RCT. However, we had limitations because we enrolled only those patients who consented to a USG or MRI. Hence, patients without any symptoms of RCT were omitted. Hence, more extensive research is required.

The cause of RCT is multi-factorial; it includes extrinsic and intrinsic factors; studies have shown an association of CSA with impingement, which is an extrinsic factor of RCTs.

The mean age of the patient in the RCT group is 54.34, and in the NRCT group is 51.87. For elaborate age distribution refer to Table 1. The age range for the RCT group is 40–60 years and the mean age of the NRCT group is 40–60 years. Considering the gender distribution of both the groups, we found that the RCT group had a sex ratio of 0.6833 which is 683.33 females per 1000 males, whereas the sex ratio for the NRCT group is 0.9, which is 900 females per 1000 males [Table 2].

The CSA was significantly higher in the RCT group than in the NRCT group. The mean CSA for the RCT group is

Table 1: Demographic profile of patients in groups.

Age	Group A (case)	Group B (normal)
40–45 years	23	10
45–50 years	20	21
50–55 years	22	25
55–60 years	36	39
Total	101	95

Table 2: Gender distribution.

Gender	Group A	Group B
Male	60	50
Female	41	45
	101	95

Table 3: Comparison of mean CSA in the group.

CSA	Group A	Group B
Mean CSA	42.19	33.89

CSA: Critical shoulder angle

Table 4: Mean CSA. SD and SEM.

Group	RCT group	NRCT group
Mean CSA	42.19	33.89
SD	5.09	3.33
SEM	0.51	0.34

CSA: Critical shoulder angle, SD: Standard deviation, SEM: Standard error of mean, RCT: Rotator cuff tear, NRCT: Non-rotator cuff tear

42.19, and for the NRCT group was calculated to be 33.89. The typical CSA range is 30–35, and the RCT group has a mean value above 35 [Tables 3 and 4]. That signifies that it can function as a predictor of RCT.

The confidence interval was calculated to be 8.3 ± 1.22 (Mean CSA of the RCT group – Mean CSA of the NRCT group)-95% of this confidence interval of this difference from 7.08 to 9.52.

CONCLUSION

1. Mean CSA for the RCT group is 42.19, and for the NRCT group was calculated to be 33.88; with this, we can conclude that the mean CSA was above the normal range of 30–35° in patients with RCTs.
2. In cases of RCT, the observed angle was found to be significantly increased as indicated by $P < 0.01$ in this study
3. It is predictive of RCT even in the absence of osteoarthritis of the shoulder joint, as in this study, we have excluded patients with glenohumeral osteoarthritis or acromioclavicular arthritis, which could influence CSA

4. We observed that the number of patients with RCT increased with age, showing a positive correlation with this demographic value.

Limitations of the study

We do acknowledge that our study has its own set of limitations. Particularly, the sample size, which is relatively small and was collected from a single tertiary care center, including only the Indian population, prevented the generalization of the study. Another drawback of this study is that it only includes patients with shoulder pain and does not include those without symptoms of RCT.

Hence, further study with a larger sample size, including different ethnicity, is required as well.

Ethical approval

This study is approved by Ethics Committee for Research on Human Subjects, MGM, Maharashtra. Approval number 2023/03. Approval date 1/01/2023.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that they have not used artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript or image creations.

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How to cite this article: Gadekar G, Verma M, Dhytadak D. Significance of critical shoulder angle as predictor in rotator cuff tear. *J Arthrosc Surg Sports Med.* 2023;4:43-7. doi: 10.25259/JASSM_18_2023