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Research Article

Evaluation of Critical Shoulder Angle in Patients with Shoulder Impingement Syndrome and Rotator Cuff Tear

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Abstract

Introduction: Shoulder pain is a common orthopedic complaint, with rotator cuff tear (RCT) and impingement syndrome as prevalent causes. The critical shoulder angle (CSA), the angle between the glenoid and acromion, has been implicated in the development of RCT. However, comprehensive evaluations of CSA in Iranian patients with impingement syndrome and RCT are lacking.

Methods: This case-control study assessed CSA in patients with RCT and impingement syndrome. Patients presenting with severe shoulder pain between 2019 and 2021 were included, with CSA measurements taken from anterior-posterior radiographs. Diagnostic performance was evaluated. The control group comprised patients with other shoulder pathologies.

Results: Of 135 patients, those with RCT exhibited significantly higher CSA values (37.3) compared to the impingement syndrome group (30.25) and control group (29.9). CSA showed high sensitivity (100%) and specificity in diagnosing RCT at a cut-off value 35.1. In diagnosing impingement syndrome, CSA demonstrated a sensitivity of 60% and specificity of 66.7% at a cut-off of 30.25.

Discussion: CSA emerged as a promising diagnostic tool for RCT, with its value exceeding the critical threshold. This finding aligns with international studies, suggesting the utility of CSA in the Iranian context. The study provides valuable insights into the diagnostic potential of CSA, particularly in the differentiation of shoulder pathologies within the Iranian population.

Conclusion: As assessed through radiographs, the critical shoulder angle is a reliable diagnostic measure to identify RCT and distinguish it from impingement syndrome. This research contributes to understanding shoulder pathologies in the Iranian population, emphasizing the clinical significance of CSA as a predictor for RCT.

Keywords: Shoulder pain, Rotator cuff tear, Shoulder impingement syndrome, Critical shoulder angle, Iran.

Introduction

Shoulder pain is the third most common musculoskeletal complaint in orthopedic practice.[1] The most common cause of shoulder pain is impingement syndromes and rotator cuff tear.[1-4] Rotator cuff tear (RCT) is a disorder characterized by shoulder dysfunction and pain. The incidence of RCT in the general population is approximately 22.1%.[5] RCT is dependent on age; as it is found in 15-20%, 26-30%, and 36-50% of patients with age 60, 70, and 80 years, respectively.[5,6] The cause of RCT is multifactorial and can be classified as intrinsic factors including microtrauma, hypoperfusion, degeneration, and extrinsic factors including overuse and chronic impingement syndrome.[6,7] Furthermore, possible secondary causes of RCT are adhesive capsulitis, fatigue of scapular stabilizers, and glenohumeral instability.[7]

Shoulder impingement is a clinical syndrome in which soft tissues are painfully trapped in the shoulder joint.[1] This syndrome usually occurs following sport activities or other activities that involve repeated use of upper arm,[1-3] and affects athlete's performance.[8] Impingement syndrome is common in people during the sixth decade of life.[9] The incidence of shoulder symptoms varies from 20 to 33%,[10] and the trends are increasing in the general population.[10,11] differentiating impingement syndrome from RCT may be confusing, but the two most commonly used tests for impingement are Neer's Sign and the Hawkins–Kennedy test.[12]

The critical shoulder angle (CSA) is a key radiographic hallmark associated with RCT incidence.[13] CSA is the angle created between the superior and inferior bone margin of the glenoid and the most inferolateral border of the acromion.[6] It is suggested that increased CSA>35° leads to increased superior shear forces on the rotator cuff muscles through altered deltoid vectors and might be a risk factor for development of RCTs, while decreases CSA<30° might lead to glenohumeral arthritis through increased compressive forces on the glenohumeral joint.[14,15] Also, with larger CSA, the risk of symptomatic RCT and larger cuff tears increases.[16] Literature has showed CSA combined with age as two easily assessable variables, could predict and differentiate five common shoulder pathologies including RCT, impingement syndrome, shoulder arthropathy, glenohumeral arthropathy, and tendinitis calcarean.[17,18]

Given that the most common clinical diagnoses of pain shoulder are RCT (85%) and impingement syndromes (74%),[1] few studies have been conducted on the evaluation of CSA in patients with shoulder impingement syndrome and RCT, and no comprehensive study has been done on this topic in Iran, this study aimed to evaluate the CSA in patients with shoulder impingement syndrome and RCT.

Methods

Study design and population

With a case-control design, this study was conducted on patients with RCT and impingement syndrome who were referred with severe shoulder pain to Imam Hossein hospital, during 2019- 2021. The selection of patients was done based on physical examination and magnetic resonance imaging (MRI). Inclusion criteria were patients with lesion confirmed by MRI. Exclusion criteria were patients with radiographic tests that indicated shoulders with evidence of glenohumeral osteoarthritis, rotator cuff arthropathy, previous surgery, humeral head necrosis, calcareous tendinitis in shoulder, and history of shoulder girdle fractures. In addition, patients with traumatic causes who underwent surgery were excluded from this study. Patients with a complete rotator cuff tear of any size were categorized into the RCT group, while those with other rotator cuff lesions, such as partial tears, were categorized into the impingement group. Patients with problems other than shoulder who referred to orthopedic surgeon were considered as the control group.

Study variables

CSA was assessed on a true anterior-posterior (AP) radiography of shoulder to provide a reproducible measurement of this radiological hallmark. A vertical line which was connected the upper border of the glenoid to its lower border was drawn. Other line from the lower edge of the glenoid to the lateral portion of the acromion was drawn, forming the CSA. **Figure 1** shows the measurement of CSA. The CSA was measured by two orthopedic surgery experts, and if there was a discrepancy in CSA values, conflict was resolved by a third expert. Demographic data, including age and sex were extracted from medical records to compare the results in demographic stratifications.

Statistical analysis

Data after collection was entered to SPSS version 21 for analysis. The categorical variables were reported in frequency and percentage, and quantitative variables were reported in mean and standard deviation (±SD). ANOVA and Kruskal-Wallis tests were used to compare the findings between different study groups. Receiver operating characteristic (ROC) curve was adopted to find the cut-off distinguishing different diagnoses based on CSA value. *P-value* <0.05 was set as the level of statistical significance.

Ethical considerations

This research was approved by the ethics committee at Shahid Beheshti University of Medical Sciences (IR.SBMU.MSP.REC.1400.409). Before being enrolled in the study, all patients who were included gave their written informed consent.

Results

We investigated the study aims on a total of 135 patients, equally distributed in the rotator cuff tear group (n=45), impingement syndrome group who did not need repairing rotator cuff (n=45), and control group (n=45). Among these patients, 76 (56.3%) were male and 59 (43.9 %) were female. The mean age of patients was 47.83 (±12.57) years old. The mean age of patients in rotator cuff tear group, impingement syndrome group, and control group was 46.60 (±11.67), 51.40 (±11.72) and 45.51 (±13.70), respectively (P=0.06). The frequency of patients by sex among these groups is shown in Table 1. No significant difference in terms of sex was seen among the groups (P>0.05).

The mean CSA in different groups is shown in Table 2. There was a significant difference among the three groups regarding the mean CSA in males, females, and patients aged less or more than 50 years old (P<0.001). Moreover, a significant difference was seen among the groups in terms of total CSA (P<0.001). In addition, the mean CSA in the rotator cuff tear group was significantly higher than the impingement syndrome group (P<0.05), and the control group (P<0.05).

Figure 2 shows the ROC curve of CSA in the diagnosis of patients with rotator cuff tear, and impingement syndrome. As shown, the area under the ROC curve in the diagnosis of impingement syndrome was 0.63 with sensitivity of 60%, and specificity of 66.7% at the cut-off point of 30.25. The area under the ROC curve in the diagnosis of rotator cuff tear was 1 with sensitivity and specificity 100%, at cut of point of 35.1.

Table 1: The frequency of patients among study groups.

	Rotator cuff tear group, N (%)	Impingement syndrome group	Control group	
Male	24 (53.3)	27 (60)	25 (55.6)	0.81
Female	21 (46.7)	18(40)	20 (44.4)	
Total	45 (100)	45 (100)	45 (100)	

Table 2: The mean value of critical shoulder angle in different study groups.

Category		Impingement syndrome group	Rotator cuff tear group	Control group	P-value
Age	< 50	30.82±1.63†	36.85±0.86	29.87±1.34	0.001**
	> 50	30.62±1.63	37.73±1.69	30.07±1.17	<0.001**
Sex	Male	30.2±1.36	37.40±1.53	29.82±1.26	<0.001**
	Female	31.3±1.7	37.3±1.45	30.09±1.30	<0.001**
Total		30.74±1.61	37.3±1.48	29.9±1.27	<0.001**

ANOVA test; **Kruskal Wallis test; †standard deviation

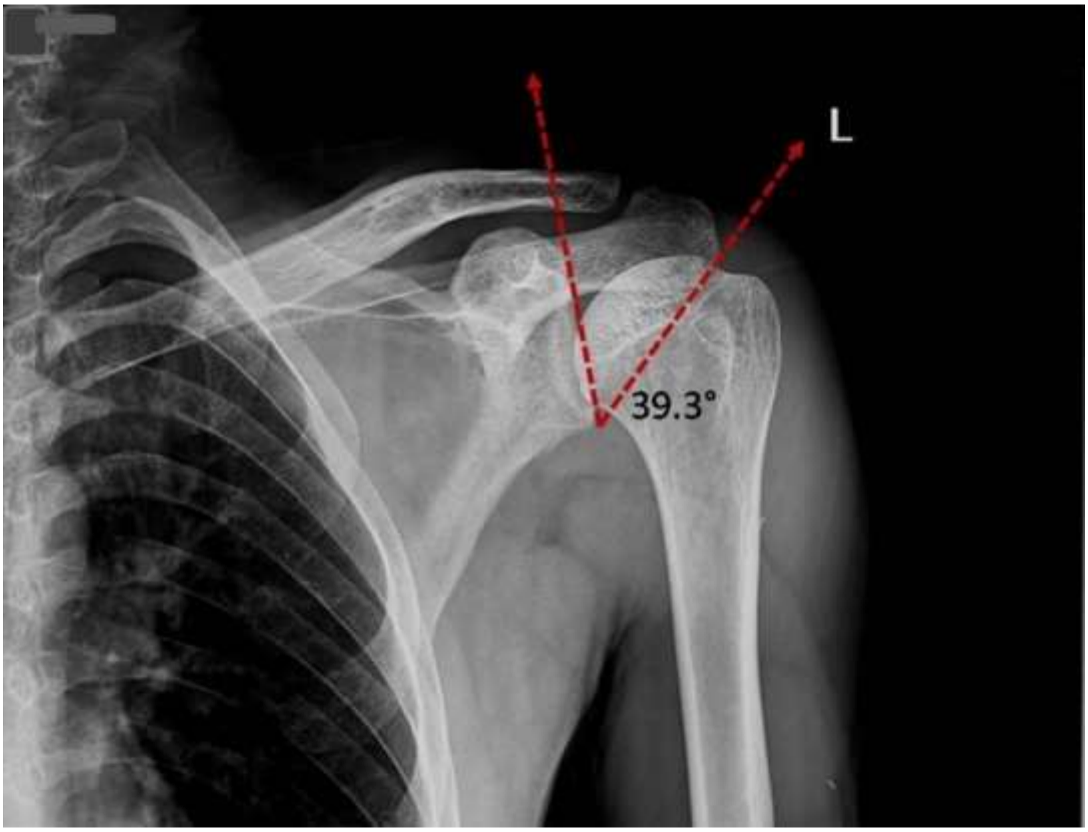

Figure 1: Measurement of critical shoulder angle.

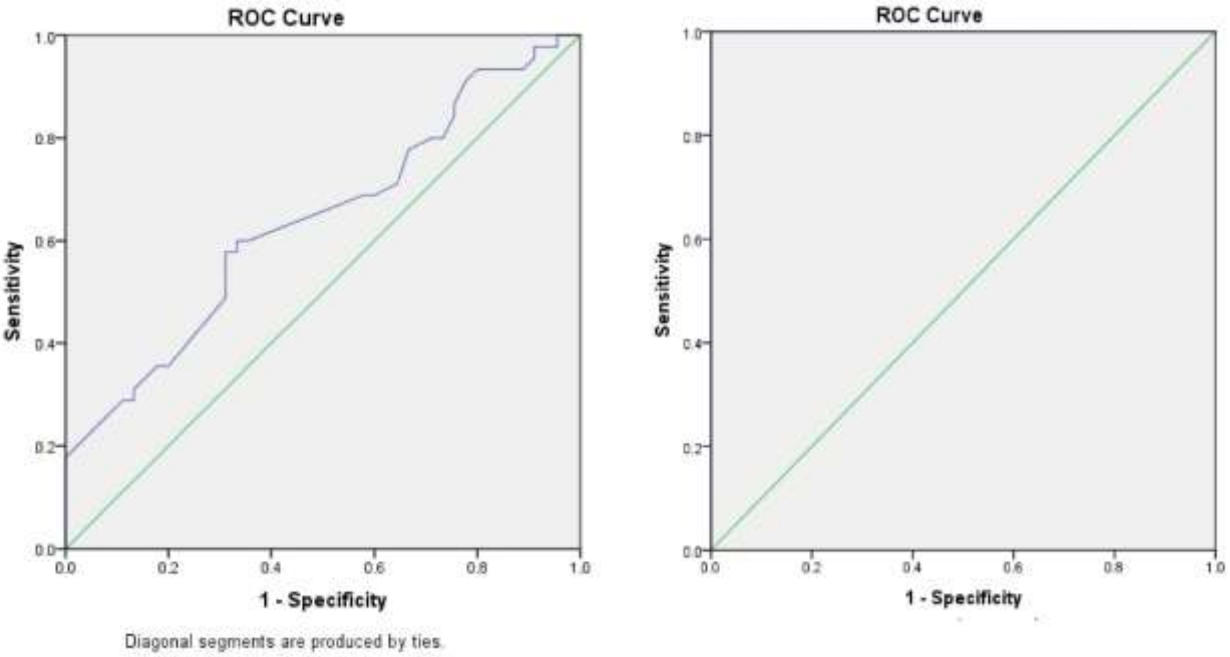

Figure 2: ROC curve of critical shoulder angle in diagnosis of patients with rotator cuff tear (left) and impingement syndrome (right).

Discussion

This study aimed to assess the CSA in patients with shoulder impingement syndrome and RCT in a referral orthopedic center in Iran, and the findings showed that the mean CSA in RCT group and control group was 37.3 (±1.48) and 29.9 (±1.27), respectively. Moreover, the comparison of these groups in terms of CSA, demonstrated the mean CSA in RCT and impingement syndrome were significantly higher than the control group. Furthermore, the mean CSA in the rotator cuff tear group was significantly higher than the impingement syndrome group. In addition, the area under the ROC curve in the diagnosis of impingement syndrome was 0.63 with sensitivity 60%, and specificity of 66.7% at cut-off point of 30.25. The area under the ROC curve in diagnosis of rotator cuff tear was 1 with sensitivity and specificity 100% at cut of point of 35.1.

Chalmers et al. assessed the correlation of CSA with RCT progression and observed that the mean CSA was higher among the cuff tear group (34°±4°) compared to the control group (32°±4°).[19] Moreover, they reported that among 1552 radiographs, only 326 had enough quality for measurement of CSA. In addition, they observed that there was no correlation between CSA with tear progression and tear size, and did not appear to change with time. Their findings also suggested that the CSA is unlikely related to rotator cuff injuries, being inconsistent with our study. The reason for this discrepancy in findings of two study may be due to differences in sampling, differences in control of the effect of confounders, and differences in the sample size.

Song et al. assessed the high performance of CSA for diagnosis of RCT and observed that the diagnostic performance of CSA on plain radiographs for RCT was acceptable (sensitivity 71%, and specificity 77%) and their findings were consistent with our study.[20] Accurate diagnosis of full-thickness RCT was seen in the cut-off value of 35°. Therefore, according to the findings of the current study, the measurement of CSA on plain radiographs may supply a readily available and reliable procedure to detect RCT in daily practice.

Cherchi et al. assessed CSA and correlation with rotator cuff tendon tear and observed that the mean CSA in RCT group was significantly higher than the labral-repair group. It is believed that the measurement of CSA on a standard radiograph using a goniometer supply reproducible assessment of this anatomical difference.[21] The finding of this study was consistent with our study. Therefore, it seems that CSA can be used as a predictor of rotator cuff tendon rupture.

Lin et al. measured the accuracy of the CSA to predict RCTs in patients with shoulder pain and observed that the CSA was an objective procedure for identifying individuals with shoulder pain who may have RCT.[6] In addition, they observed that CSA could predict RCT more accurately than the acromion index for individuals with shoulder pain. The finding of this study was consistent with our study, indicating the accuracy of CSA in rotator cuff tear was 100%.

Watanabe et al. in a study in Japan assessed the relation between rotator cuff tears and critical shoulder and observed that the mean CSA and acromion index in the RCT group was significantly greater than non-RCT group; however, no significant difference was seen between the two groups regarding lateral acromion angle.[22] The odds ratio for the CSA and acromion index was 3.1, and 2.5, respectively. They concluded that CSA was a strong predictor of RCT rather than acromion index and lateral acromion angle.[22] The difference between our study and *Watanabe et al.* study was that we evaluated CSA in RCT group, impingement syndrome, and control group, but Watanabe evaluated CSA in RCT and non-RCT group.[22] One other study found CSA alongside the acromial index, the glenoid version angle, and acromion angulation as helpful diagnostic measures in evaluation of full-thickness RCT.[23]

Gomide et al. assessed the relation between the development of rotator cuff lesions and the CSA and there was a significant relation between CSA and RCT; however, no significant relation was seen with shoulder impingement syndrome.[24] The finding of this study was consistent with our study, indicating high accuracy of CSA in the diagnosis of rotator cuff tear, but CSA in diagnosis of impingement syndrome was 60%, and could not be used to diagnose impingement syndrome. The difference between our study and this study was that CSA was also separately evaluated in terms of sex, and age; however, the mentioned study did not evaluate CSA separately in terms of sex, and age.

Although numerous publications have found associations between increased CSA and RCT risk and diagnosis, one retrospective study by *Bjarnison et al.*

conducted on 97 RCT cases and 87 cases with osteoarthritis and assessed CSA in both groups, reported no associations between CSA and RCT, while their findings indicative of significant higher risk of osteoarthritis with an odds ratio of 2.25 in CSA<30°.[25] In spite of the presented findings in the mentioned study, the authors did not suggest making CSA smaller by surgery since this intervention could increase the risk of developing osteoarthritis without decreasing risk of developing RCT.[25]

To reach a higher stability of evidence, two recent systematic reviews have reviewed the studies in field and pooled the findings on the associations between CSA and RCT risk and repair outcomes.[26,27] The first study, reviewed findings of seven comparative studies on the role of CSA on incidence of chronic full-thickness RCT and reported the positive association between greater CSA and risk RCT and higher rates of re-tear following rotator cuff repair.[26] The second study reviewed data of six studies and found higher re-tear rates in larger CSAs based on reviewed comparative, non-randomized studies; however, the high heterogeneity among studies reported by this review suggested the need for further investigations on this topic.[27]

The current study used AP radiographs to measure CSA in the included sample of participants. A similar study on the assessment of CSA in patients with RCT and shoulder osteoarthritis which measured CSA both in radiographs and MRI, found more reliable results on radiographs and their results were also suggestive association between CSA and RCT,[18] similar to our study. Another study examining CSA in radiographs and computed tomography (CT) found high correlations between CSA values obtained from the two modalities.[28] Based on the mentioned literature and findings of our investigation, using radiographs is highly suggested to assess CSA since it is widely accessible and easy to conduct and interpret besides its cost-effective nature.

Evidence suggests not only CSA could differentiate different shoulder pathologies and predict RCT effectively, but also it can efficiently predict postoperative outcomes following surgical RCT repair and risk of future re-tear in rotator cuff.[29] Another study reported no associations between CSA and postoperative functional outcomes, while larger angles was associated with an increased risk of re-tear in rotator cuff after repair.[30] However, this notion is still controversial as one study suggests against this finding and did not report CSA as a significant predictor of patient-reported outcomes after arthroscopic repair of atraumatic full-thickness RCT.[31] Therefore, the predictive role of CSA in surgical outcomes after RCT repair needs further investigations and evaluation.

This study had some limitations. As a limitation of this study, the CSA was not measured separately in terms of dominant side, and affected side. Moreover, the investigated sample was relatively small. As another limitation, this study did not record and report outcomes after surgery and study the possible correlations between CSA and outcomes in patients with different presentations.

Conclusion

This study investigated CSA in RCT and impingement syndrome and found highest mean CSA values in the RCT group. Moreover, the lowest CSA was observed in control group. The area under the ROC curve in impingement syndrome patients was 0.63 with sensitivity of 60%, and specificity of 66.7% at cut-off point 30.25. The area under the ROC curve in the RCT patients was 1 with sensitivity and specificity 100% for the cut of point 35.1. Based on the findings of our study, CSA proves to be a robust radiological parameter for predicting RCT.

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Conflict of Interest Disclosures

The authors declare that they have no competing interests.

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Authors' Contributions

RTD conceptualized and designed the study. ANB actively participated in the data collection process. SA performed the data analysis. HB took the lead in writing the initial draft of the manuscript. MB contributed significantly by revising the initial manuscript.

Ethical Statement

This research was approved by the ethics committee at Shahid Beheshti University of Medical Sciences (IR.SBMU.MSP.REC.1400.409). Before being enrolled in the study, all patients who were included gave their written informed consent.

Abbreviations

RCT: Rotator Cuff Tear

CSA: Critical Shoulder Angle

MRI: Magnetic Resonance Imaging

AP: Anterior-Posterior

SD: Standard Deviation

ROC: Receiver Operating Characteristic

CT: Computed Tomography

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