

A Review of the Critical Shoulder Angle



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Submission: 📅 January 29, 2018; Published: 📅 February 07, 2019

Introduction

Rotator cuff tears (RCT) are a complex pathology of the shoulder which may result from trauma or chronic degeneration and are often multifactorial in nature. The concept of mechanical impingement of the supraspinatus tendon underneath the acromion was first introduced by Armstrong [1] in 1949 and was later verified and popularized by Neer [2]. In 1986, Bigliani et al. [3], identified three distinct acromial shapes and found the hooked type acromion to be the most strongly associated with rotator cuff pathology. By Banas et al. [4] described an increase in RCTs and subacromial disease with a decreasing lateral inclination angle of the acromion.

Nyffeler et al. [5] introduced the concept of the acromion index in 2006 when they found that patients with a larger lateral extension of the acromion had a significantly increased incidence

of full-thickness RCT. The Critical Shoulder Angle (CSA) was introduced by Moor et al. [6] as a reliable method to measure the lateral projection of the acromion and was associated with both glenohumeral osteoarthritis and RCTs.

Critical shoulder angle radiographic parameters

Moor et al. [6] described the CSA as the measurement of an angle created by the inclination of the glenoid and the most lateral extension of the acromion on an AP radiograph. The CSA is formed with a line connecting the superior to the inferior most aspect of the glenoid and a second line extending from the inferior glenoid to the inferolateral aspect of the acromion. A true AP is captured with the arm in neutral position and a visible glenohumeral joint space with little to no overlap of the anterior and posterior glenoid rim (Figure 1).

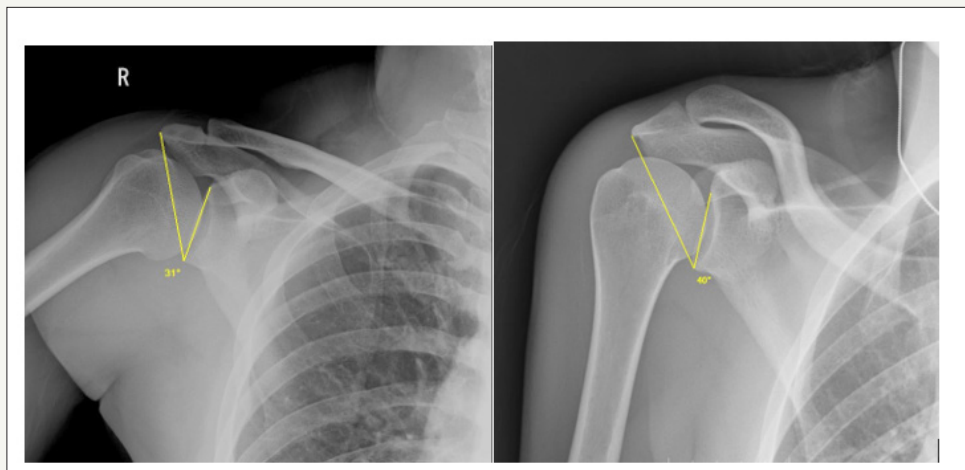


Figure 1: Critical Shoulder Angle: the angle formed by the line connecting the superior to the inferior most aspect of the glenoid and a second line extending from the inferior glenoid to the inferolateral aspect of the acromion.

Numerous studies have found that radiographic CSA measurements have a very high interobserver and inter-observer reliability [7-9], as high as 96.7% interobserver and 95.5% inter-observer reproducibility [9]. Bouaicha et al. [10] compared CSA angle measurements between radiographs and computerized

topography (CT). They measured the CSA on radiographs as originally defined by Moor et al. [6] and compared these to the measurements produced by 64-slice CT with three-dimensional reconstruction of the scapula. It was shown that AP radiographs and CT measurements of the CSA do not differ significantly and were

both reliable methods of evaluating the CSA. In the measurement of the CSA, comparing radiographs to magnetic resonance imaging, radiographs have been shown to be more reliable than MRI [11].

Scapular position has been shown to affect the CSA measurement enough to potentially alter the clinical interpretation and its reproducibility [6,12,13]. Moor [6] determined that CSA measurements deviated $<2^\circ$ with scapular malrotation up to 20° in internal rotation/extension and 20° in external rotation/flexion. These tolerances were modified by Suter et al. [13] with the addition of scapular version, indicating that 5° anteversion, 8° retroversion, $>15^\circ$ flexion, and $>26^\circ$ extension led to a 2° or greater change in the CSA and should be avoided. This led to the development of the Suter-Henninger (SH) scapular classification system [13], which reliably measures and detects mispositioning of the scapula on the AP radiograph. This system classifies the glenoid rim overlap as Type A-D, where Type A has no overlap and Type D has a double contour of the glenoid rim $>50\%$ of the glenoid height. It further classifies coracoglenoid overlap as Type 1-3 coracoid overlap with the upper glenoid rim is classified as Type 1 while no coracoid overlap with upper rim of glenoid because the coracoid projection is inferior to the upper glenoid rim is classified as Type 3. Radiographs with Type B (inverted tear drop at the upper glenoid rim) or Type D (any glenoid double contour $>50\%$ of glenoid height) rotation were determined to be malpositioned enough to distort the CSA measurement in a clinically relevant way and should not be used to calculate the CSA [13].

CSA, glenohumeral arthritis and rotator cuff tears

Moor et al. [6] originally described the CSA in three groups. They had found that shoulders with a CSA $<30^\circ$ had an increased prevalence of glenohumeral arthritis, those with a CSA $>35^\circ$ had a higher prevalence of RCT, and those with a CSA $30\text{--}35^\circ$ had significantly lower rates of both glenohumeral arthritis and RCT. Similar findings were produced by several other authors [14-16] and an elevated CSA has also been found to be an independent risk factor for full-thickness RCT [17].

The biomechanical association between CSA and shoulder pathology involves the force vector generated by the deltoid during contraction and the impact of this vector on adjacent shoulder structures. Gerber et al. [18] showed that when the CSA increased from 33° to 38° , there was a 13-33% (15-23N) increase in supraspinatus strain during thoracohumeral abduction; max strain was reached during 33° to 37° of abduction. The more lateral deltoid origin seen with an elevated CSA increases the shear forces on the supraspinatus tendon, thus increasing its strain. This increase in shear forces also results in glenohumeral instability (higher shear forces, lower compressive forces), requiring more force from the rotator cuff muscles to maintain stability of the joint [19-23], which in turn leads to rotator cuff pathology as well as eccentric wear of the glenoid articular surface [24].

Furthermore, Mantell et al. [25] found a significant increase in concurrent OA and RCT in shoulders with CSA $>35^\circ$ (90% specific, 52% sensitive) and recommended using this measurement as a screening tool, directing the need for MRI when managing patients with osteoarthritis. Cherchia et al. [9] not only found an association

with RTC pathology and CSA but were also able correlate increased CSA with labral tears requiring repair. Blonna et al. [12] correlated a CSA of $\geq 36^\circ$ with an increased risk for RCT, increased size of the tear and eccentric glenohumeral arthritis while a CSA of $\leq 28^\circ$ was correlated with concentric glenohumeral arthritis.

Several studies have failed to show an association between increased CSA and rotator cuff pathology. Bjarnison et al. [26] found a positive association between OA and CSA below 30° , but did not find a strongly positive association with elevated CSA and RCT. Similarly, Chalmers et al [27] did not find a correlation between elevated CSA and rotator cuff pathology, however both Chalmers and Bjarnison were unable to achieve a mean CSA $>35^\circ$ (Bjarnison RCT group mean CSA 33.6° , Chalmers RCT group mean CSA 34°) [26,27] as originally described by Moor et al. [6].

Acromioplasty and the CSA

In cadaver studies, the CSA was able to be altered without violation of the deltoid insertion. Alitnta et al. [28] were able to arthroscopically resect 1cm of the lateral acromion, reducing the mean CSA from 35.0° to 25.1° , without any evidence of deltoid violation. Katthagen et al. [29] used an arthroscopic anterolateral acromioplasty to reduce the CSA by a mean of 1.4° and were able to achieve a 2.8° reduction in CSA when combined with a 5mm lateral acromion resection. They determined combined arthroscopic acromioplasty with lateral acromial resection to be a feasible procedure capable of reducing the CSA without damage to the deltoid origin. Furthermore, Milano recommended lateral acromioplasty as a safe and effective procedure to reduce the CSA without violating the acromial deltoid origin this is a potentially useful procedure to prevent progression of RCT or to protect a cuff repair from re-tear [30]. However, there is currently not much literature pertaining to the intermediate and long-term outcomes of lateral acromioplasty and the complications following over-resection.

In the current literature, it is unknown whether a reduction of the CSA with lateral acromioplasty to within the normal accepted range of $30\text{--}35^\circ$ decreases the incidences of primary RCTs or retears after RCT repair. Of note, it has been shown that patients with impingement who underwent arthroscopic subacromial decompression with acromioplasty had a decreased long-term prevalence of rotator cuff tears [31]. However, this study did not include data on the change in CSA, while Familiari et al. [32] in a systematic literature review found no difference in short-term clinical outcomes in patients undergoing rotator cuff repair with and without acromioplasty and did not recommend routine acromioplasty during rotator cuff repairs.

Outcomes

Preoperative CSA has been shown to be a risk factor complicating arthroscopic rotator cuff repair. A retrospective study conducted by Garcia et al. [33] found high preoperative CSA ($\geq 38^\circ$) to be associated with a 14-fold increased risk in full thickness retear after RCT repair as well as worse postoperative American Shoulder and Elbow Surgeons scores at short-term follow-up. Furthermore, Gerber et al. [34] determined that smaller CSAs

were associated with better long-term postoperative clinical and functional outcomes after irreparable posterosuperior RCTs which were treated with latissimus dorsi tendon transfers. On the other hand, Lee et al. [35] found patients with lower CSAs to have better functional scores at 6 months but found no difference in functional outcome scores at 24 month follow-up. Kirsch et al. [36] concluded in their study of 53 patients that those with a CSA >38 degrees showed no significant difference in postoperative functional or pain scores.

Following hemiarthroplasty, Cerciello et al. [37] found no association between CSA and symptomatic glenoid erosion at 105 month follow-up. In another study, CSA was not associated with late rotator cuff failure following anatomic shoulder replacement with a mean follow-up of 45 months [38]. Hemiarthroplasty following fracture [39], however, has been shown to impart poorer functional outcomes and pain scores at long-term follow-up 53 months in patients with CSA >38°.

Summary

As described by Moor et al. [6] the CSA is a reliable measurement of the extent of acromial lateral projection which has high intraobserver and inter-observer reproducibility. While a true scapular anterior posterior radiograph is the gold standard for this measurement a 3D reconstructed CT¹⁰ may also be used with similar reliability. Several studies have repeated and confirmed that Moor's original clinical implications of this radiographic measure are accurate a low CSA (<30°) is associated with glenohumeral concentric osteoarthritis and a high CSA (>35°) is associated with full-thickness RCTs, eccentric glenohumeral osteoarthritis and is an independent risk factor for rotator cuff pathology [6,14-16].

Lateral acromioplasty has been shown to be capable of reducing a high CSA below the 35° threshold without disrupting the deltoid insertion [29], which may be useful preventing progression or recurrence of rotator cuff pathology. There is, however, very little literature examining the clinical and functional outcomes following a lateral acromioplasty and debate still exists on whether this procedure's benefit is clinically relevant or merely theoretical.

Future research may look to address the gaps in literature surrounding effectiveness of lateral acromioplasty in preventing repeat rotator cuff pathology and the need for revision surgery. There may also be a place for research related to the impact of CSA on the outcomes of reverse total shoulder arthroplasty.

Disclosures

This review article was produced by members of the Department of Orthopedics at Nassau University Medical Center, East Meadow NY. There are no conflicts of interest or financial disclosures to report. There were no external sources of funding for this project.

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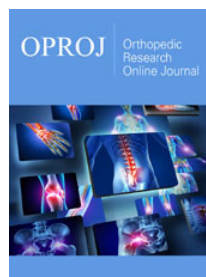
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