Editorial Commentary: Is Your Critical Shoulder Angle Accurate? Only If You Can Verify That You Have the Correct Images

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Abstract: The critical shoulder angle (CSA) has been the focus of significant research related to the etiology and prognosis of rotator cuff tears in recent years, but the accuracy of CSA measurements on plain anteroposterior (Grashey) radiographs has been questioned. Research to better understand what qualifies as a "tolerable" radiograph for reliable measurement of the CSA can inform best practices for obtaining plain radiographs. Optimal measurements rely on optimal images, and knowing how much room for error there is regarding malrotation provides surgeons with unbiased criteria to rule out inadequate images.

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The plain radiograph is one of the primary clinical diagnostic tools in orthopaedics because of its availability, low cost, and reasonable radiation exposure. However, plain radiographs remain shadows of the underlying 3-dimensional (3D) osseous structures, and thus, measurements on these radiographs are inherently affected by the relative positioning of the anatomy, x-ray beam, and receiver. The reliability as well as accuracy of linear and angular measurements on plain radiographs has been a subject of renewed interest recently, specifically in discussion of the critical shoulder angle (CSA).

Moor et al.[1] defined the CSA and noted that malrotation of the viewing perspective up to 20° did not affect the CSA beyond a threshold of 2°, where unacceptable views were "easily identified by the oval shape of the glenoid." Digging deeper, our team determined that anteverted and retroverted viewing perspectives were highly sensitive to 5° to 8° of malrotation, and stricter criteria were needed to identify optimal images.[2] The true anteroposterior radiographic view of the glenoid is elusive because body habitus, posture, and resting scapulothoracic orientation confound the radiologist's ability to pinpoint the imaging plane(s). Multiple studies have shown that over 70% of retrospective imaging falls into a D1 classification,[3,4] in which the glenoid oval is visible (anteverted view) and the coracoid overlaps the superior glenoid (neutral flexion-extension view). But do these D1 images preclude accurate assessment of the CSA?

We appreciate how the article "The Ratio of the Transverse to Longitudinal Diameter of the Glenoid Projection Is of Good Predictive Value for Defining the Reliability of Critical Shoulder Angle in Nonstandard Anteroposterior Radiographs" by Hou, Li, Zhang, Zhang, Yang, Tang, and Yang[5] answers this question by identifying how "off the mark" a D1 image can be while still presenting a reliable estimate of the CSA. Similarly to the Suter-Henninger criteria,[2] Huo et al. define the "RTL" as the ratio of the transverse to longitudinal projected length of the glenoid. The utility of the RTL is based in its simplicity: Use what is visible to assess what is unseen. The RTL has high sensitivity and specificity for identifying an image that is adequate for accurate measurement of CSA, and it can be measured with excellent reliability. Scapulae from patients with rotator cuff tears showed a higher correlation between the RTL and error in CSA prediction than the general population, but in both groups, as the RTL increased, the error in CSA

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measurement also increased. If the RTL remains below 0.25 (or, more strictly, 0.22 in patients with a rotator cuff tear), the error in the CSA measurement is likely below the commonly used 2° threshold for accuracy.

This study advances our understanding of when the CSA measurement can be made accurately, and it calls into question prior studies on CSA performed without rigorous definitions of radiographic quality, as it clearly shows that deviations in CSA increase with the RTL. Although we still stress the importance of the A1 image to our radiologic team, we now have criteria to assess D1 images as they appear commonly in the patient record (Fig 1). But one must be cautious when using a D1 image. As Hou et al.[5] show in Figure 4 of their article, even the RTL is not bulletproof—an RTL below the 0.22 to 0.25 cutoff level can still result in up to 13° of error in the CSA. It also remains to be seen what proportion of retrospective D1 images fall below the RTL cutoff in a typical clinical record (which is a broad measure of applicability) or contain more than 10° to 15° of viewing-perspective malrotation. Larger malrotations could be limited to controlled research studies, which ultimately affects the sensitivity and specificity of the RTL.

These concepts of reliability and viewing-perspective malrotation are not unfamiliar in other shoulder diagnostic criteria. Our group has also quantified these effects on glenoid inclination[6] and the glenopolar angle[7] and proposed viewing-perspective criteria for lateral-view radiographs.[8] Similar viewing-perspective criteria were proposed for anteroposterior radiographs of the scapula.[9] From the underlying 3D morphology, the "true" angles can be quantified to identify the relations between 2-dimensional and 3D measures such as glenoid inclination and the glenopolar angle.[6,7] Regarding CSA, the 3D measures must be evaluated in the context of the critical acromial point to determine where on the

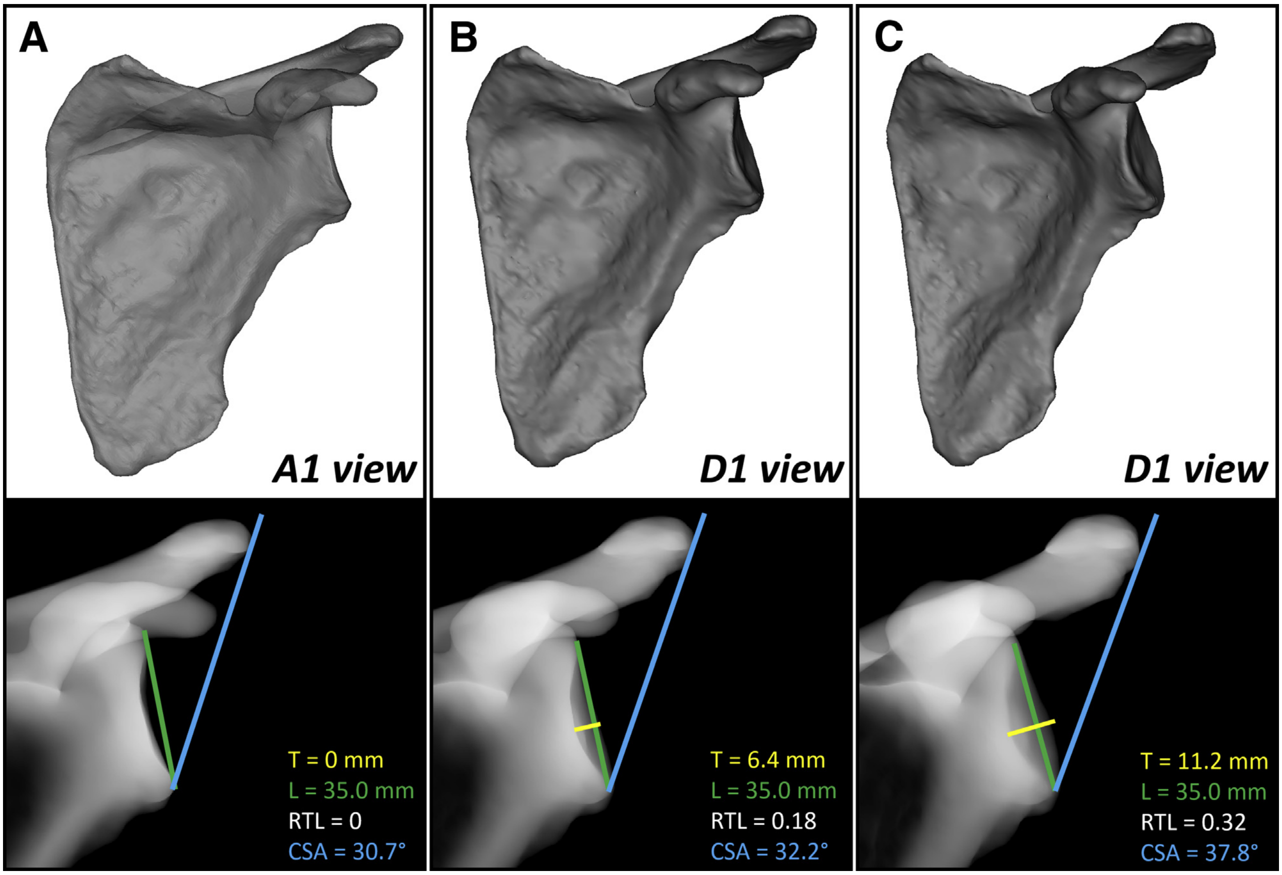

Fig 1. The ratio of the transverse (T) to longitudinal (L) diameter of the glenoid projection (RTL) is shown on a scapula at varied viewing perspectives. (A) Per the Suter-Henninger criteria,[2] an A1 view shows the glenoid in profile with the coracoid overlapping the superior rim of the glenoid. This results in a transverse glenoid measure of 0 mm; the RTL consequently equals 0. The critical shoulder angle (CSA) is 30.7°, which is in the normal range of 30° to 35°.[1] (B) The same scapula as in A, with no flexion-extension but with rotation into 10° of anteversion, yields 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.[5] The CSA deviates by 1.5°, which is below the 2° allowable error but still in the normal range. (C) With the same scapula now rotated into 20° of anteversion, the RTL equals 0.32 and exceeds the 0.25 cutoff. The measured CSA is 37.8°, which aberrantly errs into the range indicative of a rotator cuff tear, changing the clinical interpretation of this scapula.

lateral acromion the CSA is being referenced if acromioplasty is in consideration.[10] The contrasting value of 2-dimensional and 3D measures is still up for debate, but as more groups gain access to high-fidelity morphometric data, we expect that 3D measures will gain more traction as the universal methodology.

Although the subject of this study may, at a glance, appear esoteric—the influence of one newly invented measurement on another controversial measure ment—the underlying concepts presented will be of use to any doctor who regularly evaluates shoulder radiographs. If more room for error in visualization is allowed, this would decrease the need for unnecessary repetitive images, which directly lowers costs and exposure to ionizing radiation. An RTL of less than 0.25 provides an easy and unbiased criterion to evaluate when a D1 anteroposterior Grashey radiograph is worth consideration for measurement of the CSA.

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