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The effect of sagittal rotation of the glenoid on axial glenoid width and glenoid version in computed tomography scan imaging

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Background: Computed tomography (CT) scans of the shoulder are often not well aligned to the axis of the scapula and glenoid. The purpose of this paper was to determine the effect of sagittal rotation of the glenoid on axial measurements of anterior-posterior (AP) glenoid width and glenoid version attained by standard CT scan. In addition, we sought to define the angle of rotation required to correct the CT scan to optimal positioning.

Methods: A total of 30 CT scans of the shoulder were reformatted using OsiriX software multiplanar reconstruction. The uncorrected (UNCORR) and corrected (CORR) CT scans were compared for measurements of both (1) axial AP glenoid width and (2) glenoid version at 5 standardized axial cuts.

Results: The mean difference in glenoid version was 2.6% ($2^\circ \pm 0.1^\circ$; $P = .0222$) and the mean difference in AP glenoid width was 5.2% (1.2 ± 0.42 mm; $P = .0026$) in comparing the CORR and UNCORR scans. The mean angle of correction required to align the sagittal plane was 20.1° of rotation (range, 9°-39°; standard error of mean, 1.2°).

Conclusion: These findings demonstrate that UNCORR CT scans of the glenohumeral joint do not correct for the sagittal rotation of the glenoid, and this affects the characteristics of the axial images. Failure to align the sagittal image to the 12-o'clock to 6-o'clock axis results in measurement error in both glenoid version and AP glenoid width. Use of UNCORR CT images may have notable implications for decision-making and surgical treatment.

Level of evidence: Level IV, Diagnostic Study.

Keywords: Computed tomography; shoulder; glenohumeral; glenoid; version; scapula; 3D

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Radiographic evaluation of the shoulder can be challenging because of the complex anatomy of the glenohumeral joint (GHJ). The Grashey view, originally described in 1923, was the first to provide a true anterior-posterior (AP) view of the GHJ by orienting the gantry angle of the x-ray beam perpendicular to the plane of the scapula as opposed to the coronal plane of the body.[10] Since then, numerous authors have described tailored orientations of the x-ray beam gantry angle to produce unique projections of the GHJ that are useful in elucidating difficult pathologic processes.[8,9,13,22,25,26,28] The one element that unites all of these planar x-ray techniques is that they are oriented to account for the angle of the scapula in the axial and coronal planes and the unique anatomy of the GHJ. The scapular angle is defined as the angle between the scapular axis (the line between the tip of the medial border of the scapula and the center of the glenoid fossa[11]) and the horizontal (axial) plane.

Standard 2-dimensional (2D) computed tomography (CT) scans may misrepresent the actual 3-dimensional (3D) glenohumeral anatomy in terms of AP width and version when measurements are made in the planes of the 2D scans.[2-5,15,19,21] The 3D anatomy and ability to attain an en face view of the glenoid may be further distorted when 2D CT scans are aligned to the body as opposed to the plane of the glenoid and scapula.[3,4]

Neutral or ideal position of the scapula within a CT scanner should align the glenoid articular surface to be perpendicular to the axis of the CT gantry angle.[3,16] Standard protocols for shoulder CT scans often fail to account for the anterior sagittal rotation of the scapula and glenoid. This results in axial cuts through the glenoid at angles that are not in line with the longitudinal axis of the glenoid (Fig. 1). In this sense, they are not ''optimized'' glenohumeral images.

Among the advantages of 3D CT reconstructions of the shoulder are the elimination of the effect of gantry angles[12,16,19] and the ability to manipulate the orientation of the GHJ to the plane of the scapula. For this reason, the use of 3D CT reconstructions of the GHJ with the humeral head digitally subtracted to achieve a true en face view has become the ''gold standard'' for accuracy in assessing glenoid disease.[19,23,27,29,30] However, 3D CT scans are often cost prohibitive and may not always be available or warranted, so the ability to interpret morphologic variables of the glenoid and scapula on 2D CT remains important.

The accuracy of glenoid version and axial AP width measurements can be improved by aligning the CT image to the plane of the glenoid and scapula in the axial and coronal planes. To our knowledge, analysis of sagittal rotation of the scapula in 2D CT scans and the effect of that rotation on AP width and version measurements made in the corresponding axial image has not been previously performed.

Subtle variations of these measurements have the potential to lead to changes in patient management. In the management of glenohumeral instability, the determining factor between various reconstruction procedures is often the recognition of glenoid bone loss and its accurate measurement. Arthroscopic soft tissue capsulolabral repair has increased failure rates in patients with elevated levels of glenoid bone loss.[1,7,23,31] In a patient with >20% to 25% anterior bone loss, bone reconstruction procedures, such as coracoid transfer, iliac crest bone graft, or osteochondral allograft to the anterior glenoid, may be necessary.[6]

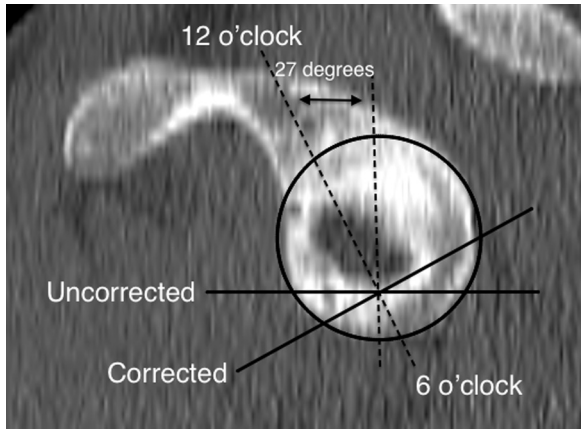

Figure 1 Sagittal view of an uncorrected (UNCORR) computed tomography (CT) scan showing the difference in angle of axial cuts through the glenoid in both UNCORR and corrected (CORR) alignments. CORR scans align the glenoid to the 12-o'clock to 6-o'clock axis in the sagittal plane.

The purpose of this paper was to compare the axial AP glenoid width and glenoid version measurements of standard 2D CT scans of the GHJ done with standard methods as opposed to methods that align the axial CT scan to the scapula and glenoid anatomically. By using the function of 3D multiplanar reconstruction (MPR), this paper intends to illustrate how the sagittal orientation of 2D CT scans alters the resulting axial image and that the subsequent changes in orientation result in substantial variation in glenoid width and version measurements on the axial image. In addition, we sought to define the angle required to correct the CT scan to optimal positioning.

Materials and methods

Study cohort

Thirty patients were selected from a database of normative CT shoulder imaging studies. The inclusion criterion to qualify a glenohumeral CT scan for this study was no evidence of glenoid bone loss or degenerative changes.

The default orientation of the CT scans was defined as uncorrected (UNCORR). In the UNCORR scans, the axial, sagittal, and coronal planes were relative to the scanner gantry table as opposed to the anatomy of the glenoid. Corrected (CORR) CT scans aligned all 3 planes to the face of the glenoid, resulting in axial cuts that were perpendicular to the long axis of the glenoid.