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ORIGINAL ARTICLE

Radiographic characterization of the B2 glenoid: is inclusion of the entirety of the scapula necessary?

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Background: Computed tomography (CT) scans are often obtained before total shoulder arthroplasty to assess glenoid deformity. To allow correction of the slice axis into the plane of the scapula, these scans have typically required inclusion of the entirety of the scapula. The purpose of this study was to determine whether inclusion of the medial border and inferior angle is necessary for accurate measurement of scapular version, inclination, and humeral subluxation.

Methods: Fourteen CT scans in preoperative total shoulder arthroplasty patients with Walch B2 type glenoids underwent a standardized measurement protocol. Glenoid version, inclination, depth, and humeral subluxation were measured on 2-dimensional CT images corrected to the plane of the scapula. These measurements were then repeated in randomized, blinded fashion after subtracting 12.5%, 25%, and 50% of the scapula from the medial border and 12.5%, 25%, and 50% of the scapula from the inferior angle.

Results: Measurement of retroversion did not significantly differ between measurement of the full scapula and measurement of any of the incomplete scapulas, with the exception of the subtraction of 50% of the scapular width, which caused retroversion to be overestimated by 4.7° ($P = .006$) and led to inaccurate measurement of subluxation and glenoid depth.

Conclusion: If at least 8 cm of scapular width is imaged on a CT scan, accurate glenoid measurements can be made. Even if 50% of scapular height is not imaged, accurate measurements can be made. Failure to include the medial border or inferior angle does not preclude accurate glenoid measurement.

Level of evidence: Anatomy Study; Imaging

Keywords: Glenoid version; glenoid inclination; scapula anatomy; computed tomography; shoulder arthroplasty; shoulder replacement

Whereas total shoulder arthroplasty provides excellent outcomes,[7,8,21] revision for glenoid loosening continues to be the most common cause of failure.[3,11,15,27] Although glenoid loosening is multifactorial, preoperative retroversion is thought to be a risk factor.[26,27] In excessive retroversion, reverse total shoulder arthroplasty may be more predictable because of accelerated loosening rates.[27] Some authors have specifically suggested that reverse total shoulder arthroplasty should be considered at 27° of retroversion.[8] Although the importance of inclination to arthroplasty outcomes is less well understood, many surgeons are also beginning to focus on this variable.[14]

Future research will require reproducible and accurate version measurement. Accurate measurement of version

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requires a computed tomography (CT) scan.[20] Reliable inclination measurements also require a CT scan.[10] Because version measurements have been suggested to be integral to determination of total shoulder arthroplasty technique and outcome,[8,26,27] future surgeons may be obtaining CT scans on large numbers of patients[17] before total shoulder arthroplasty as part of their preoperative planning.

Previously described techniques for accurate and reliable measurement of version on CT scans have required inclusion of the medial border and inferior angle.[5,6,9,16] Within these techniques, the inferior angle and medial border are necessary for correction of the axis of the CT scan into the plane of the scapula.[5,6,9,16] Within the most commonly used Friedman method for measurement of version, the medial border is also necessary.[12]

CT scans that attempt to view the thorax subject patients to substantially higher radiation doses than extremity scans because the beam must be higher energy to cross more tissue in addition to the tissue of interest.[1,4,24] Thus, CT scans that image the medial border and inferior angle are likely to have substantially more radiation than those of the more lateral and superior portions of the scapula. In addition, patients who undergo standard shoulder CT scans at outside facilities can be required to undergo repeated scanning with the entirety of the scapula included, which subjects patients to both increased radiation and increased expense. Although the increased risk is minimal on the individual patient level, the increased radiation exposure is considerable on a population-wide level. Increased medical imaging is thought to be contributing to the increasing incidence of thyroid cancer,[23] and CT scans account for almost half of all medial imaging–related radiation.[23] The purpose of this study was to determine whether inclusion of the medial border and inferior angle is necessary for accurate measurement of scapular version, inclination, depth, and humeral subluxation.

Methods

This is a retrospective diagnostic study. We included CT scans preoperative to total shoulder arthroplasty with a Walch B2 type glenoid.[26] Exclusion criteria included CT studies that do not include the entirety of the scapula and patients with poor-quality images. All total shoulder arthroplasties performed at our center were reviewed for these criteria. These CT scans were then anonymized and exported to a third-party viewer (OsiriX, Pixmeo Sarl, Bern, Switzerland).

Measurement protocol

The following protocol was developed a priori. First, coronal slices based on the plane of the scapula,[6] as defined by the inferior pole, the medial border on an axial slice at the middle of the glenoid, and the center of glenoid, were created. The axial plane was then orthogonal to this plane and parallel to a line from the middle of the glenoid to the intersection of the scapular spine and the medial border.

Measurements were then taken on these corrected images using the following protocol. The angle between a line from the anterior glenoid rim to the posterior glenoid rim and a line from the medial visible aspect of the scapula and the middle of the glenoid on the axial slice midway between the most proximal slice containing the glenoid and the most distal slice containing the glenoid was defined as retroversion, as previously described to be reliable and equivalent to 3-dimensional measurement (Fig. 1).[12,18,22] Version was also measured 5 slices proximal and 5 slices distal to the middle. The ratio of the distance from the posterior aspect of the humeral head to a line from the most medial aspect of the scapula to the middle of the glenoid along a line parallel to the face of the glenoid to the distance from the posterior aspect of the humeral head to the anterior aspect of the humeral head was defined as subluxation, with both distances measured at the widest point of the humeral head (Fig. 2). The angle between the glenoid and the scapular spine on the coronal CT slice showing the deepest aspect of the supraspinatus fossa was defined as inclination.[10,19] The distance from the middle of the glenoid at the middle cut as defined earlier to the deepest point

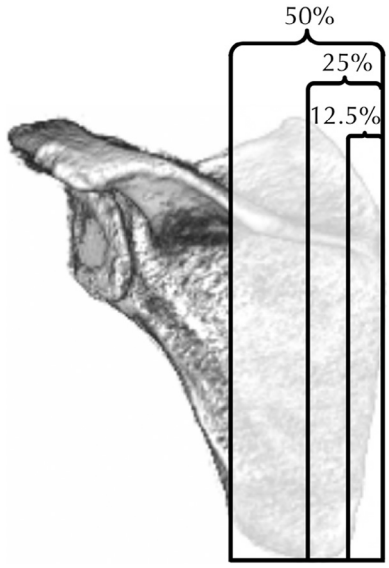

Figure 1 This 3-dimensional reconstruction of the scapula demonstrates the amount of scapula remaining when 12.5%, 25%, or 50% of the scapula starting from the medial border is digitally subtracted.

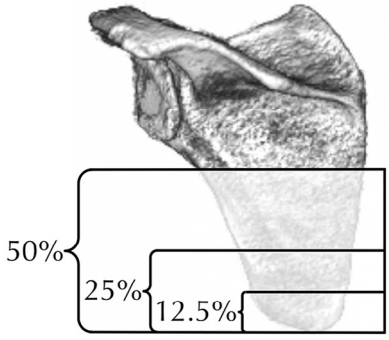

Figure 2 This 3-dimensional reconstruction of the scapula demonstrates the amount of scapula remaining when 12.5%, 25%, or 50% of the scapula starting from the inferior angle is digitally subtracted.