Glenoid Version Measurement when the Medial Scapula Is Not in the Cross-Sectional Imaging Field of View

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Introduction: Glenoid version, glenoid surface orientation in the axial plane, has an important role in the passive stabilization of the articular components of the glenohumeral joint. Glenoid shape and version has been associated with glenohumeral instability, arthritis, and rotator cuff tears. Cross-sectional computed tomography (CT) and magnetic resonance (MR) imaging have been demonstrated to be more accurate than radiography for measuring glenoid version. Glenoid version calculation requires a transverse scapular axis, often defined as a line connecting the glenoid fossa midpoint with the scapular spine medial endpoint. Other transverse axis definitions include a line perpendicular to the glenoid surface midpoint or a line tangent to either the posterior or anterior glenoid rim. Prior studies require identification of scapula’s medial border to measure glenoid version. Clinical shoulder joint cross-sectional imaging frequently uses a reduced field of view (FOV) without visualizing scapula’s medial border. Thus preventing replication of the published methods. No method is currently available to measure glenoid version in routine shoulder cross-sectional imaging studies where the medial scapular border is not in the FOV.

The purpose of this study was to design and validate a method to accurately measure glenoid version on cross sectional clinical CT shoulder images, where the FOV does not include the entire scapula.

Materials and Methods: Forty unembalmed, fresh scapulae cadavers (20 pairs, 10 male, 10 female, mean age: 52±18 years, mean height: 171±12 cm). Exclusion criteria were moderate or severe arthritis, or bony radiographic abnormalities in any one of the pair. None of the included donors had any surgical procedure performed on their scapulae or humeri. This study was approved by the University of Pittsburgh’s Institutional Review Board.

All scapulae were radiographed anteroposteriorly and laterally. Each scapula was placed in a custom fixture replicating a neutral supine position and adjusted to minimize/eliminate version measurement inaccuracies due to scapula rotation. CT was used to validate the new cross-sectional glenoid version measurement methodology, although the results can be directly applied to MR imaging as well. The middle third of the medial edge of the scapula was positioned parallel to the long axis of the CT table such that the slices were approximately perpendicular to the glenoid articular surface (Fig. 1). High-resolution volumetric CT axial images (slice thickness: 1 mm, FOV: 20x20 cm²) were obtained producing a “patient supine clinical simulation” CT image study.

Results: Overall, males were more retroverted (-3°±3°; p=0.02) than females (0°±3°). Glenoid version in rights and lefts was approximately equal (-2°±4°; p = 0.95). “Full-scapula” glenoid version (-0.4°±3°) was less retroverted than that from the “partial-scapula” image (-7.5°±3°; p=0.01). “Partial-scapula” glenoid version measurements were reliable. Table 1 gives ICC and SEM results. Glenoid version measurement accuracy was 7.1°±4.0°. Adding a 7° correction factor to “partial-scapula” glenoid version measurements yielded values not significantly different than truth (-0.5°±3°; p=0.995).

Table 1. ICC and SEM results.

<table>
<thead>
<tr>
<th>Observer</th>
<th>Intra-Observer</th>
</tr>
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<tbody>
<tr>
<td>ICC</td>
<td>0.7233 0.6349 0.8953 0.9175</td>
</tr>
<tr>
<td>SEM</td>
<td>1.6° 2.2° 0.9° 0.9°</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.0001 0.0111 0.0001 0.0001</td>
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</tbody>
</table>

Discussion: This study described and validated a new method for accurately measuring glenoid version on “partial-scapula” axial cross-sectional images. Scapular positioning to obtain accurate glenoid version measurement was optimized. As per literature this was needed whether the FOV includes the full scapula or not. Glenoid version varies from superior to inferior glenoid. Clinical utilization has chosen the midpoint for measuring. This is the position we selected to test and validate. As all tested scapulae were “normal”, this technique was not demonstrated for use in dysplastic or deformed scapulae. CT was more accessible for our research. Nevertheless, the principles validated here are applicable to MR imaging. This study demonstrated that true glenoid version is different than “partial-scapula” glenoid version. However, the inaccuracy of the partial scapula view version measurements can be reduced if not completely eliminated by a correction factor.

Significance: To improve spatial resolution and examination of shoulder structure clinical CT and MR imaging studies frequently exclude the entire scapula preventing replication of previously published glenoid version measurements. A novel method is presented to enable version measurements on “partial-scapula” cross-sectional imaging studies.