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ORIGINAL ARTICLE

Acromial roof in patients with concentric osteoarthritis and massive rotator cuff tears: multiplanar analysis of 115 computed tomography scans

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Background: There is evidence for differences of scapular shape between shoulders with rotator cuff tears (RCT) and osteoarthritic shoulders (OA). This study analyzed orientation and shape of the acromion in patients with massive RCT and concentric OA (COA) in a multiplanar computed tomography (CT) analysis.
Methods: CT scans of 70 shoulders with degenerative RCT and 45 shoulders with COA undergoing primary shoulder arthroplasty were analyzed. The 2 groups were compared in relation of (1) shape of the acromion, (2) its orientation in space, and (3) the anteroposterior glenoid coverage in relation to the scapular plane.
Results: Lateral acromial roof extension was an average of 4.6 mm wider and the acromial area was an average of 156 mm^2 larger in RCT than in COA ($P < .001$). Significant differences of the lateral extension of the acromion margin were limited to the anterior two-thirds. Acromial roof orientation in RCT was average of 10.8° more "externally rotated" (axial plane: $P < .001$) and an average of 7.8° more tilted downward (coronal plane: $P < .001$) than in COA. The glenoid in RCT was an average of 5.5° ($P < .001$) more covered posteriorly compared with COA.
Conclusions: A more externally rotated (axial plane), more downward tilted (coronal plane), and wider posterior covering acromion was more frequent in patients with massive RCT than COA.
Level of evidence: Anatomy Study; Imaging

Keywords: Critical shoulder angle; shape of scapula; shape of acromion; lateral acromial roof; risk factor for rotator cuff tear; risk factor for osteoarthritis

There is evidence for differences of the shape of the scapulae of shoulders with rotator cuff tears (RCTs) and with osteoarthritis (OA).[23,24,32] Clinical observations have demonstrated that especially small RCTs and OA are rarely seen together, although their pathogenesis has many probably common intrinsic (genetic) and extrinsic (anatomic) contributing factors.[24,32] Research so far has focused on describing the role of the scapular shape based on 2-dimensional (2D) radiographs in the coronal or sagittal view.

A variety of angles and indices have been introduced as parameters to demonstrate architectural differences between shoulders with RCT and OA.[2,3,15,23,28,32,34,35] However,

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anatomic differences of the scapula between healthy shoulders and RCT/OA could only recently be demonstrated with the introduction of the critical shoulder angle (CSA).[24] This angle, first introduced by Moor et al[24] in 2013, combines glenoid inclination (GI) and lateral acromial roof extension. A larger CSA (>35°-38°) is associated with RCT,[4,5,23,24,26,29,32] apparently because more supraspinatus activity is required to preserve joint stability, resulting in an overload of the supraspinatus muscle-tendon unit.[11,36] Conversely, a small CSA (<28°-30°) results in increased compressive, glenohumeral joint reaction forces[37] and is associated with OA[14,23,25,32]

Based on these findings, arthroscopic lateral acromioplasty is nowadays performed to reduce the radiologic CSA[10,16,17,21] toward "normal" values and thereby reduce an overload of the rotator cuff. Early clinical results appear to support this concept.[10] Although the first clinical research showed a lower failure rate after rotator cuff repair together with lateral acromioplasty,[9] the precise location and dimensions for an optimal lateral acromioplasty are still unknown. The CSA depends on the extent of the GI and the most lateral extension of the acromion.[7,24] Because the angle is measured on 2D images, only the part most laterally projected is used for evaluation of the lateral acromial roof extension.

This study analyzed in 3D the orientation and shape of the lateral acromion in patients with RCT and concentric OA (COA) in a multiplanar computed tomography (CT) analysis. In view of the increasingly used lateral acromioplasty, special attention was paid to the part of the lateral acromion defining the radiographic lateral margin and thereby the CSA to define the part of the acromion to be corrected during lateral acromioplasty.

Materials and methods

Patients

Clinical and imaging data of patients undergoing primary total shoulder arthroplasty (anatomic and reverse) because of massive RCT and advanced OA were retrospectively collected at our institution from January 2006 until April 2017. During this period, 743 patients (791 shoulders) underwent primary prosthetic shoulder surgery because of irreparable RCT (350 shoulders [44%]), advanced OA (159 shoulders [20%]), fracture/fracture sequelae (120 shoulders [15%]), instability OA (62 shoulders [8%]), osteonecrosis (42 shoulders [5%]), rheumatologic diseases (33 shoulders [4%]), and other reasons (28 shoulders [4%]). From the 350 shoulders with irreparable RCT and 159 shoulders with advanced OA, 115 fulfilled all inclusion and exclusion criteria.

Because our measurement methods of the acromial roof depend strongly on the glenoid orientation, we excluded glenoid versions larger than ±10°. We deliberately excluded eccentric OA (posterior/anterior humeral head subluxation of >55%/<45%,[38] Walch glenoid ≥B[38]) because of different morphologic scapular shapes between concentric and eccentric OA. Also excluded were secondary reasons and severe destruction of the glenoid (Favard ≥E1[31]) or acromion (Hamada ≥3,[13] previous acromioplasty), which make reliable measurement difficult. All inclusion and exclusion criteria are detailed for both groups in Table S1.

Methods

The Merlin PACS Imagine Software (Phönix-PACS GmbH, Freiburg im Breisgau, Germany) with its multiplane reconstruction (MPR) function was used to evaluate the acromial size, shape, and orientation. Adjustment in 3D was thus possible, and each part of interest could be highlighted individually.

Measurement of the CSA and classification after Hamada[13] and Favard[31] were performed on conventional anteroposterior radiography. The CSA was measured as an angle between a line from the upper to the lower glenoid rim and a second line from the lateral acromion extension to the lower glenoid rim, as first described by Moor et al.[24] In adjusted coronal CT images to the scapular plane (Fig. 1), the GI was measured according to the β-angle of Maurer et al[22] in relation to the supraspinous fossa. The glenoid version, posterior subluxation, and glenoid classification of Walch[38] was measured in axial CT images at the level of the glenoid center and perpendicular to the scapular plane. The glenoid center was thereby defined over a circle with best fit on the glenoid rim in sagittal images.

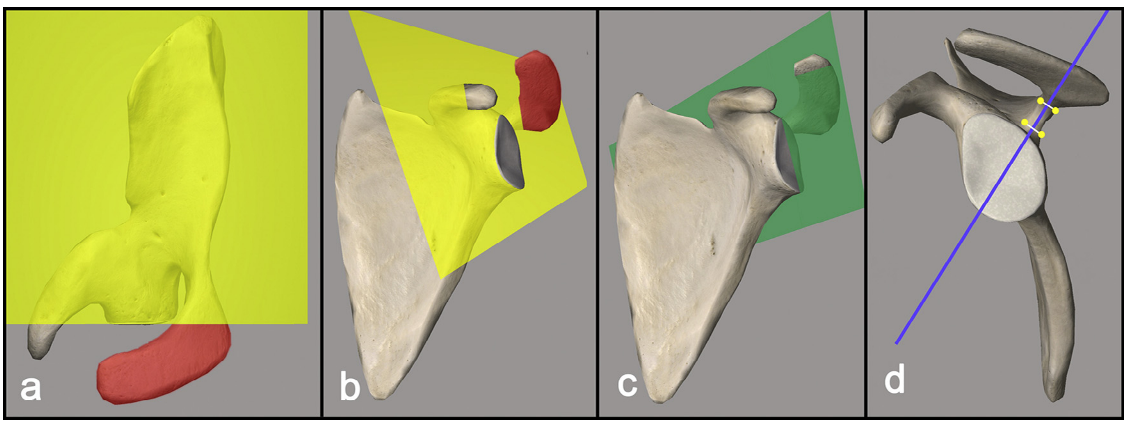

Figure 1 (**a**) Lateral acromial roof (*red*): Lateral acromial extension according to the glenoid plane. (**b**) Glenoid plane (*yellow*): Plane perpendicular to the glenoid version and tangent to the upper and lower glenoid rim. (**c**) Scapular plane (*green*): Plane parallel to the glenoid version and tangent to the upper and lower glenoid rim. (**d**) Spinal plane (*blue*): Plane centered to the scapular spine and perpendicular to the glenoid plane. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)