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ORIGINAL ARTICLE

Interest in the glenoid hull method for analyzing humeral subluxation in primary glenohumeral osteoarthritis

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Background: Posterior humeral subluxation is the main cause of failure of total shoulder arthroplasty. We aimed to compare humeral head subluxation in various reference planes and to search for a correlation with retroversion, inclination, and glenoid wear.
Materials and methods: We included 109 computed tomography scans of primary glenohumeral osteoarthritis and 97 of shoulder problems unrelated to shoulder osteoarthritis (controls); all computed tomography scans were reconstructed in the anatomic scapular plane and the glenoid hull plane that we defined. In both planes, we measured retroversion, inclination, glenohumeral offset (Walch index), and scapulohumeral offset.
Results: Retroversion in the scapular plane (Friedman method) was lower than that in the glenoid hull plane for controls and for arthritic shoulders. The threshold of scapulohumeral subluxation was 60% and 65% in the scapular plane and glenoid hull plane, respectively. The mean upward inclination was lower in the scapular plane (Churchill method) than in the glenoid hull plane (Maurer method). In the glenoid hull plane, 35% of type A2 glenoids showed glenohumeral offset greater than 75%, with mean retroversion of $25.6° \pm 6°$ as compared with $7.5° \pm 7.2°$ for the "centered" type A2 glenoids ($P < .0001$) and an upward inclination of $-1.4° \pm 8°$ and $6.3° \pm 7°$ ($P = .03$), respectively. The correlation between retroversion and scapulohumeral offset was $r = 0.64$ in the glenoid hull plane and $r = 0.59$ in the scapular plane ($P < .05$).
Conclusion: Measurement in the glenoid hull plane may be more accurate than in the scapular plane. Thus, the glenoid hull method allows for better understanding type B3 of the modified Walch classification.
Level of evidence: Basic Science; Anatomy Study; Imaging

Keywords: Humeral subluxation; shoulder arthritis; glenoid retroversion; glenoid inclination; shoulder arthroplasty; glenoid hull

Static posterior subluxation of the humeral head, initially described by Neer,[19] is an important parameter for evaluating glenohumeral arthritis. This humeral subluxation may be responsible for posterior erosion of the glenoid, which may lead to prosthetic instability,[9,12,20] glenoid polyethylene wear,[7] or early loosening of the glenoid implant,[4,11] in turn leading to

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failure or poor results. Several studies have shown preoperative posterior humeral subluxation as the main cause of failure of total shoulder arthroplasty.[3,31] Gerber et al[10] showed that posterior subluxation could be corrected by resurfacing; however, there was no statistical correlation between preoperative retroversion and correction of subluxation as concerns functional score results. Recent studies have emphasized the complexity of humeral subluxation,[10,11,17,22,29] but further studies are needed to understand and improve the treatment of shoulder arthritis associated with posterior subluxation of the humeral head.

Two main methods are used to measure subluxation of the humeral head: one method, described by Walch et al,[30] measures the alignment of the humerus relative to the glenoid surface, and the other method measures the alignment of the humerus relative to the axis of the scapula.[1,21,24] Few studies have studied the relationship between these methods and the effect of biometry of the glenoid on humeral subluxation.[15,25] Bryce et al[5] showed that the degree of posterior subluxation of the humeral head was directly related to the degree of posterior wear of the glenoid, which suggested greater variability than what is described in the Walch classification. Walch and colleagues[2] have recently modified the Walch classification of glenoid wear by adding a B3 type, which is monoconcave and posteriorly worn, with at least 15° of retroversion or at least 70% posterior humeral head subluxation, or both; however, this type was based on computed tomography (CT) scan observations and literature data and not on biometric measurements.

We aimed to compare humeral head subluxation in various reference planes—the glenoid plane as described by Walch et al,[30] the 2-dimensional (2D)–corrected anatomic plane of the scapula, and the 2D-corrected glenoid hull plane—and to examine any correlation with retroversion, inclination, and glenoid wear. The secondary aim was to identify and precisely define the B3 type of glenoid wear of the modified Walch classification.

Materials and methods

Population

We included 206 shoulder CT scans: 109 were from patients undergoing consultations for primary glenohumeral osteoarthritis in the orthopedics department at Lapeyronie University Hospital, Montpellier, France, and 97 were from patients undergoing consultations for shoulder problems unrelated to shoulder osteoarthritis in the orthopedics department at l'Archet 2 University Hospital, Nice, France. For the 97 nonarthritic shoulder CT scans, the disorder was of the long head of the biceps ($n = 62$) or traumatic instability with no damage to the glenoid ($n = 35$). The exclusion criteria were a history of fracture of the glenoid or proximal humerus, a history of shoulder instability with fracture of the glenoid or humeral head, inflammatory arthritis, or a glenohumeral joint tumor. The 109 shoulders with primary glenohumeral osteoarthritis were classified according to the Walch classification[30] as follows: type A1 in 36 (33%); A2, 21 (19%); B1, 20 (18%); B2, 28 (26.5%); and C2, 4 (3.5%). All the CT scans were carried out according to the standard protocol of our institutions; the arm was in a neutral position with the elbow extended and the palm of the hand against the thigh, with 2-mm-thick continuous slices (16-slice Somatom Sensation; Siemens, Forchheim, Germany).

Methods

For each CT scan, we extracted the native Digital Imaging and Communications in Medicine images and then analyzed them by using OsiriX[23] with multiplanar reconstruction to reconstruct the images in the 3 spatial planes and therefore eliminate the biases related to the rotation and inclination of the scapula in the scanner. We compared 2 reference planes: the 2D-corrected anatomic plane of the scapula and the 2D-corrected glenoid hull plane.

The anatomic plane of the scapula (Fig. 1) as defined by Kwon et al[16] goes through the lower angle of the scapula, the center of the glenoid surface, and the medial angle of the scapula. Thus the frontal plane of the scapula is defined to allow for measuring glenoid inclination. Then, we reconstructed the axial plane consisting of the center of the glenoid and the medial angle of the scapula, perpendicular to the scapular plane; this plane allows for measuring glenoid version as well as glenohumeral and scapulohumeral alignment used to define subluxation of the humeral head.

The glenoid hull plane (Fig. 2) that we defined and for which we found excellent reliability and reproducibility, with an intraclass correlation coefficient for intrarater and inter-rater reproducibility between 0.89 and 0.94, does not account for the body of the scapula, and therefore the biometry of the glenoid relative to the glenoid hull can be easily measured. The frontal plane goes through the Saller line,[26] connecting the upper and lower rims of the glenoid and the tip of the triangle formed by the meeting point of the anterior and posterior cortical regions in the axial plane. The axial plane is defined by the plane passing perpendicularly through the middle of the Saller line in the sagittal plane and parallel to the floor of the supraspinous fossa in the frontal plane. The middle of the Saller line represents the center of the glenoid.

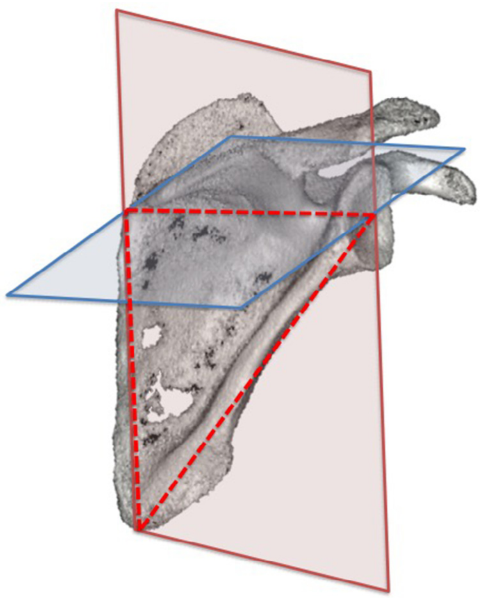

Figure 1 Section planes defining the anatomic plane of the scapula.