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Original article

The acromiohumeral distance and the subacromial clearance are correlated to the glenoid version

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ABSTRACT

Background: The acromiohumeral distance (ACHD) is a radiographic parameter for evaluating the presence of a rotator cuff rupture. Previous investigations have demonstrated that several factors may influence the magnitude of the acromiohumeral distance, but glenoid version has not yet been considered.
Hypothesis: Our hypothesis was that there is a direct correlation between glenoid version and acromiohumeral distance as well as subacromial clearance.
Methods: Four right glenohumeral joints from adult fresh cadavers were anatomically dissected to the level of the rotator cuff. After fixation to a board and positioning of the humeral head in neutral position, an osteotomy of the glenoid neck was carried out and the version was altered in steps of 5°. The ACHD as well as the subacromial clearance (SAC) were measured for every degree of glenoid version.
Results: The ACHD increased with increased anteversion and consistently decreased with increased retroversion of the glenoid. The SAC also depended on glenoid version. Neutral version was associated with a minimal clearance under the anterior third of the acromion, retroversion transferred the minimal SAC posteriorly and anteversion transferred minimal SAC under the coracoacromial ligament.
Conclusion: Our results indicate that glenoid version correlates directly with the magnitude of ACHD and SAC. Therefore, variations of glenoid version can lead to false interpretations of cuff integrity.
Type of study: Biomechanical investigation.
Level of evidence: Not possible to define.

1. Introduction

The acromiohumeral distance (ACHD) is defined as the shortest distance between the inferior cortex of the acromion and the top of the humeral head. It is measured on plain anterior-posterior radiographs of the shoulder [1–3]. It is a well-accepted and highly specific anatomical measure for evaluating the presence of a postero-superior full-thickness rotator cuff rupture and subacromial impingement syndrome [4–8]. The normal value lies between 7 and 13 mm [3,6,7,9]. A distance smaller than 7 mm is considered proof of a full-thickness RCR and is associated with a poor prognosis for rotator cuff repair [10–12].

However, several studies investigated parameters influencing the magnitude of the ACHD. Some postulated that the size of the subacromial space and consequently the ACHD might depend not only upon variations in the anatomical shape of the acromion itself, but also upon the acromial and scapula–spine angle [13]. Others demonstrated a correlation between the arm position and decreased ACHD values in antero-medial elevation between 60° and 120° [1,14]. A further decrease of the ACHD value could be observed in cases with primary omarthritis due to a posterior translation of the humeral head.

Besides these factors, no previous investigations up to this day have investigated the influence of different variations of the glenoid and its spatial position on magnitude on the ACHD. Especially glenoid version is very variable and is subject to change in chronic glenohumeral disease, such as osteoarthritis.

The aim of the present study was to assess the influence of glenoid version on the ACHD and to examine the effect of different degrees of version on clearance in the subacromial space. Subacromial clearance was the space, defined by the humeral head inferiorly, the anterior edge and under surface of the anterior third of the acromion, coracoacromial ligament and the acromioclavicular joint superiorly.

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We hypothesized that the ACHD as well as the subacromial clearance (SAC) correlates directly with degree of glenoid version.

2. Material and methods

Four right glenohumeral joints were harvested from fresh cadavers and dissected to the level of the rotator cuff. Only shoulders without morphological cartilage lesions, fractures or other abnormalities were used. Specimens were stored in gauze moistened with "Mercuryl" (*Phenyhydroargyrum boricum*) solution containing a bactericide to stunt specimen dehydration and degradation. Each shoulder was freed of all soft tissue, leaving intact only the tendons of the rotator cuff and the coracoacromial ligaments.

In order to simulate the anatomical situation as far as possible, we fixed each scapula parallel to a board on a bone cement bed with the spine parallel to the upper border of the board. In this position, dimensional parameters, such as native glenoid version, glenoid width and length as well as the three dimensional position of the glenoid were determined. Beside this, morphological differences between the different joints could be evaluated and wider variations be excluded. Next, the humerus was secured in a centered position to the scapula by attaching Ethibond # 3 to the tendons of the infraspinatus and subscapularis and pulling with springs hooked to wires fixed on the board. Several anatomical landmarks of the proximal humerus can be used as reference points, including the humeral head margin, the bicipital groove, the medial margin of the greater tuberosity, and the lateral margin of lesser tuberosity. The bicipital groove is an easy displayable landmark on images. Therefore, we used this structure as a reference point to define the neutral position of the humerus. All X-rays were evaluated concerning this matter for correct positioning. Once this was done, we placed a Kirschner wire as a reference for the humeral shaft rotation. Finally, the humeral shaft was brought parallel to the medial border of the scapula.

To secure the distance between board and the lateral position of the glenoid after a total osteotomy of the neck of the scapula, we mounted an external fixator, which allowed only horizontal version of the glenoid. One part of this fixator was fixed parallel to its medial margin perpendicularly to the board. The other part was introduced in the lateral part of the glenoid neck. Both parts were parallel to each other, whether seen from caudal (horizontal version), or seen from lateral (vertical tilt).

To alter the version, we used the anterior rim of the glenoid as axis of rotation for the retroversion, and the posterior rim of the glenoid cavity as axis of rotation for anteversion (Fig. 1).

Thereafter, the version of the glenoid cavity was gradually changed in steps of 5° from –20° to 20°. For each new version, an anterior-posterior radiograph was performed to determine the ACHD and a CT scan (Siemens SOMATOM CT Scanner, Siemens, Erlangen, Germany) for the glenoid version.

For measurement of the glenoid version, the shoulders were positioned in supine position with the humerus at side and in neutral rotation. Three lines were drawn on the first CT-slice under

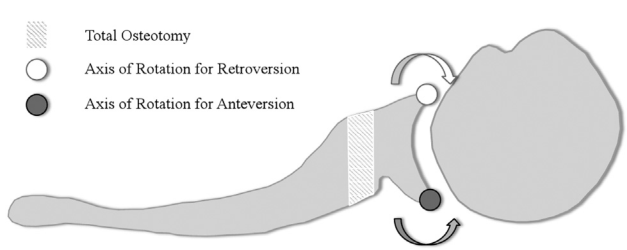

Fig. 1. The anterior glenoid rim was used as the axis for retroversion and the posterior rim was used for anteversion.

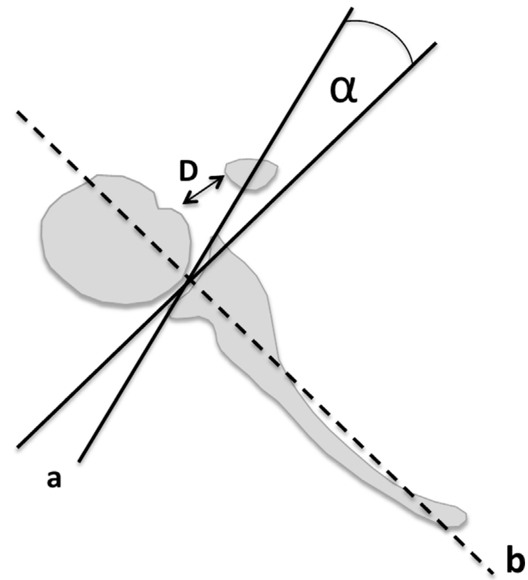

Fig. 2. Glenoid version was measured on the first CT-slice under the tip of the coracoid.

the tip of the coracoid, as previously described [15,16] (Fig. 2). The degree of version was defined as the angle (α) measured between the line of the plane of the glenoid fossa (a) and the line representing neutral version (c).

The ACHD was evaluated on standard plain anterior-posterior radiographs with the shoulder parallel to the board, a cranio-caudal tilt of 20°, the same film-focus distance for each image (150 cm), and with the arm in zero degrees of abduction and neutral rotation. The distance was measured between a radio-dense line on the inferior acromial cortex and a line parallel to it tangent to the humeral head. Although the first afore-mentioned line is only a radiological artefact, the use as a reference mark is well described [1].

To measure the subacromial clearance, it was filled with uncured silicon rubber after removal of all remaining soft tissue. The thickness of the cured silicon was then measured with a dial gauge on several defined points arranged in a Cartesian system. In order to take the different size and shape of the acromion into account, the mean acromion length and width was used as a reference to always position the points at the same place.

Due to the study design, no Ethical Committee Approval was necessary.

3. Results

In all shoulders, a consistent variation of the ACHD in dependence with the grade of version could be observed. Every shoulder showed a progressive increment of its ACHD with increase of anteversion, as well as a progressive decrease with progressive retroversion (Fig. 3). The smallest value with a mean of 6.2 mm was observed in 20° of retroversion. By contrast, in 20° anteversion, the value was the highest with a mean of 14.4 mm. In neutral position, the mean ACHD was 11.2 mm. Between –15° and +15° of version, the slope of the curve was linear, so that a change of 2.75° of glenoid version led to a change of the ACHD by 1 mm. Depending on the glenoid version, the ACHD standard deviation ranged from 1.7 mm up to 2.9 mm.

During the evaluation of the SAC, we identified three different zones under the acromial arch with different trends (Fig. 4).

Under the middle and posterior third of the acromion, retroversion leads to a decrease of the SAC whereas anteversion increases it. In this area, the mean thickness of the silicon spacer measured in