The Effects of Arm Elevation on Acromiohumeral Distances: A Biplane Fluoroscopy Study with Normative Data.

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INTRODUCTION:
Narrowing of the subacromial space has been implicated in several pathologies, including subacromial impingement syndrome and rotator cuff disease. The acromiohumeral distance (AHD) has been reported to be a quantitative measurement that can be used to assess changes in the volume of the subacromial space.

The structures being impinged as a function of arm elevation angle during clinical testing have not been well defined. In addition to understanding how arm position effects AHD, normative values are necessary to serve as a reference when clinicians are trying to restore normal kinematics in patients with shoulder pathology.

The purpose of this study was to measure the AHD in vivo during abduction in the scapular plane (scaption) and forward elevation to study how arm position influenced AHD.

METHODS:
Eight healthy male subjects (average age 30) were enrolled for this IRB-approved controlled laboratory study and gave informed consent prior to participation. Each subject underwent a high-resolution CT-scan from which three-dimensional (3D) geometries were extracted (Mimics, Materialize, AnnHarbor, MI). The 3D bone poses were estimated using a contour matching algorithm (Model-Based RSA, Medis Specials BV, Leiden, The Netherlands).

All subjects then underwent a dynamic in vivo biplane fluoroscopy assessment of scaption and forward elevation. The biplane fluoroscopy system consisted of two BV Pulsera c-arms (Philips Medical Systems, Best, The Netherlands). Biplane fluoroscopy data were collected at 100Hz, but tracked at 12.5Hz, because the motions were sufficiently slow. For each frame, the 3D position and orientation of the humerus and scapula were determined (MBRSA, Medis Specials, Leiden, The Netherlands), and the acromiohumeral distance (AHD) was measured as the shortest distance between the acromion and proximal humerus (Figure 1).

A paired t-test was used to determine whether the minimum AHD and corresponding arm elevation angle were significantly different between scaption and forward flexion. In addition, a two-way repeated-measures ANOVA was performed with independent factors of motion (scaption, forward flexion) and arm elevation angle (20° to 150° in 10° increments).

RESULTS SECTION:
The AHD as a function of arm elevation angle is shown in Figure 2. The minimum AHD was 2.6 ± 0.8 mm during scaption and 1.8 ± 1.2 mm during forward flexion, at elevation angles of 83° ± 13° and 97° ± 23°, respectively. The minimum distance point was located on the articular surface of the humeral head from the neutral arm position until 34° ± 8° for scaption and 36° ± 6° for forward flexion (Figure 3).

Upon further elevation, the minimum distance point was located within the footprint of the supraspinatus muscle until 72° ± 12° of scaption and 65° ± 8° for forward flexion. At greater elevation angles, the minimum distance points were between the acromion and the proximal humeral shaft, distal from the greater tuberosity.

DISCUSSION:
The shortest acromiohumeral distance was at approximately 90° of arm elevation. The AHD was no longer measured intra-articularly or within the supraspinatus footprint above approximately 70° of arm elevation.

These findings may indicate that pain endured during subacromial impingement syndrome is not actually caused by compression of the supraspinatus footprint beyond a point of approximately 70° of arm elevation. This brings up the important question where the pain is generated at higher elevation angles. We theorize that this finding could have important implications in the diagnostic evaluation, intra-operative assessment and postoperative rehabilitation of rotator cuff pathology and other disorders of the subacromial space.

It is interesting to note that following the minimum AHD, which occurs at approximately 90° of arm elevation, the AHD increased again. This may be explained by the geometry of the proximal humerus with respect to the center of rotation. The articular surface of the humeral head is spherical and its center can be reasonably assumed to be the center of rotation. The greater tuberosity deviates from this sphericity and, therefore, reduces the distance to the acromion. Once the greater tuberosity has passed under the acromion the humeral shaft approaches the radius of the sphere and the AHD increases.

SIGNIFICANCE:
We found that subacromial space minimum distance points between the undersurface of the acromion and the humerus are distal to the rotator cuff attachment above approximately 70° of arm elevation. This may have important implications in the understanding and treatment of rotator cuff pathology and other disorders of the subacromial space.

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