The Scapuloacromial Angle: Impact on Shoulder Impingement and Rotator Cuff Tear

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Introduction: Although there are many studies analyzing the angular relationship between the acromion and scapula most have involved a 2-D approach on radiographs or single MR or CT slices and usually qualitative assessment[1,2]. Such methods are susceptible to projectional differences and misregistration depending on the orientation of the 2-D imaging planes. We propose a quantitative 3-D asessment which allows intrinsic angle measurement, independent of imaging orientation or projection. We define the scapuloacromial (SA) angle as the angle between the unit normal vectors of planes of best fit through the posterior surface of the blade of the scapula and the undersurface of the acromion.

Methods: Retrospective analysis of MR shoulder examinations was performed after approval by the hospital Institutional Review Board. Patients were imaged with shoulder coils using a 1.5 T MRI scanner (Seimens, Erlangen, Germany). The patient populations included those diagnosed with glenohumeral instability (27 patients), shoulder impingement without tear (18 patients) and rotator cuff tear (21 patients) proven at surgery (50 males and 16 females with a mean age 41 years). For each patient the DICOM images were converted to JPEG format using a DICOM viewer (DicomWorks, 2002, Inviweb, Philippe PUECH and Loic BOUSSEL) and then imported into AutoCAD 2005 (Autodesk, San Rafael, CA) as seen in Figure 1. The acromial undersurface (up to the spine of the scapula) and posterior surface of the scapular blade were outlined manually with points (between 150-200 per series). Using DICOM header information (e.g. slice orientation and field of view) the set of points (x_{image}, y_{image}) for each series were projected into $\mathbf{R}^3$ consistently to maintain true spatial relationship. The acromion data was acquired from sagittal images, the scapula from axial images, and rotation corrections for the different scan orientations were made when both were projected into $\mathbf{R}^3$. After this correction, angular but not spatial consistency was maintained between series. This resulted in a set of points, $(x,y,z) \in \mathbf{R}^3$, for each surface. Each slice was resampled to contain the same number of points (20) as seen in Figure 2 so that a plane of best fit could be constructed consistently between different subjects. This plane was fitted by minimizing the least squares difference of each sampled point to its surface. Normal vectors ($n_{acromion}$, $n_{scapula}$) were constructed for each plane. Using the dot product the scapuloacromial angle, $SA = \cos^{-1}(n_{acromion} \cdot n_{scapula})$, was then computed (Figure 3). By calculating the relevant components of each normal on the x-, y-, and z-axes, the angular projections in sagittal (SA_s), coronal (SA_c), and transverse (SA_t) planes were obtained.

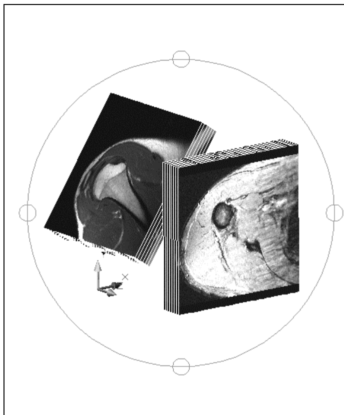


Figure 1: MR images imported into space while maintaining angular, but not spatial consistency.

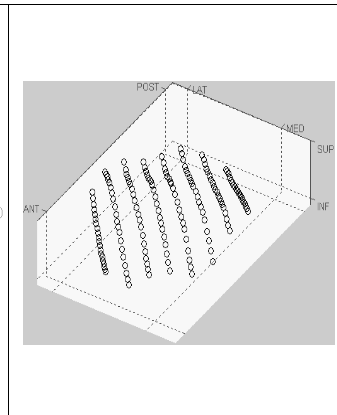


Figure 2: Resampled points of acromial undersurface.

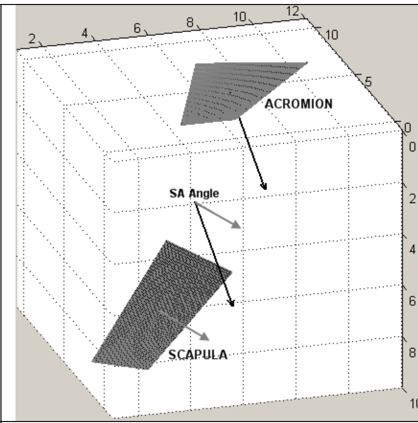
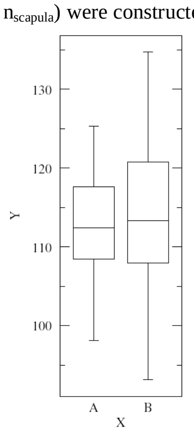


Figure 3: Plane of best fit through acromial undersurface and scapular blade with calculated normal vectors demonstrating the scapuloacromial (SA) angle.

Results:
The mean and standard deviation of the scapuloacromial angle and the derived projectional angles are displayed in Table 1. After splitting the sample into no impingement (glenohumeral instability) and impingement (impingement with no tear and impingement with tear) a Student's t-test was applied. The 95% confidence interval for the mean in the no impingement and impingement groups were 109.2–115.9 and 110.0–116.5, respectively (Graph 1). The standard deviation for no impingement and impingement groups were 6.26 and 10.0, respectively. The t-value was -0.524, with a SD of 8.67. The number of degrees of freedom was 64, and if we assume a normal distribution and a null hypothesis the probability of these results is 60%.

Table 1: Scapuloacromial and Projectional Angles

Group	Glenohumeral Instability	Impingement with no tear	Rotator Cuff Tear
SA (Mean±SD)	112.6°±6.3°	114.1°±11.6°	113.3°±8.7°
SA_t	42.5°±10.2°	36.8°±11.5°	43.8°±12.3°
SA_c	58.4°±7.0°	58.7°±6.7°	59.2°±5.9°
SA_s	29.3°±6.6°	25.8°±9.2°	29.9°±8.7°



Graph 1: Plot showing 95% confidence intervals for the no impingement (A) and impingement (B) group.

Discussion:
The scapuloacromial angle is comparable in theory to the acromial slope previously described.[1,2] In contrast to previous findings, utilizing our objective method we found no significant difference in the mean scapuloacromial angle of patients with and without impingement. Further, there was no statistically significant difference between the derived projectional angles, raising the possibility that the prior concept of acromial orientation may be flawed.

References:
1. Kitay SK, Ianotti JP, Williams GR, Haygood T, Kneeland BJ, Jerlin J. Roentgenographic assessment of acromial morphologic condition in rotator cuff impingement syndrome. J Shoulder Elbow Surg. 4(6) 441 – 448. 1995.
2. Edelson JG, Taitz C. Anatomy of the coraco-acromial arch. Relation to degeneration of the acromion. *J Bone Joint Surg Br.* 1992;74:589-94.