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Relationship of individual scapular anatomy and degenerative rotator cuff tears

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Background: The etiology of rotator cuff disease is age related, as documented by prevalence data. Despite conflicting results, growing evidence suggests that distinct scapular morphologies may accelerate the underlying degenerative process. The purpose of the present study was to evaluate the predictive power of 5 commonly used radiologic parameters of scapular morphology to discriminate between patients with intact rotator cuff tendons and those with torn rotator cuff tendons.
Methods: A pre hoc power analysis was performed to determine the sample size. Two independent readers measured the acromion index, lateral acromion angle, and critical shoulder angle on standardized anteroposterior radiographs. In addition, the acromial morphology according to Bigliani and the acromial slope were determined on true outlet views. Measurements were performed in 51 consecutive patients with documented degenerative rotator cuff tears and in an age- and sex-matched control group of 51 patients with intact rotator cuff tendons. Receiver operating characteristic analyses were performed to determine cutoff values and to assess the sensitivity and specificity of each parameter.
Results: Patients with degenerative rotator cuff tears demonstrated significantly higher acromion indices, smaller lateral acromion angles, and larger critical shoulder angles than patients with intact rotator cuffs. However, no difference was found between the acromial morphology according to Bigliani and the acromial slope. With an area under the receiver operating characteristic curve of 0.855 and an odds ratio of 10.8, the critical shoulder angle represented the strongest predictor for the presence of a rotator cuff tear.
Conclusion: The acromion index, lateral acromion angle, and critical shoulder angle accurately predict the presence of degenerative rotator cuff tears.
Level of evidence: Level IV, Case-Control Design, Diagnostic Study.

Keywords: Rotator cuff disease; scapular anatomy; acromial morphology; critical shoulder angle; acromion index; lateral acromion angle; acromial slope

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IRB: This study was conducted at the Balgrist University Hospital, Zürich, according to medical-ethical guidelines after informed consent was obtained from all of the individuals studied for retrospective data analysis.

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Distinct anatomic variants of the scapula have been found to be associated with degenerative rotator cuff tears (RCTs). Neer[14,15] described a bone spur at the anteroinferior acromion and attributed 95% of all RCTs to a mechanical conflict between the rotator cuff insertion and coracoacromial arch. Accordingly, Bigliani et al[5] classified the shape of the acromion into 3 patterns that were more or less prone to rotator cuff disease. An increased prevalence of RCTs was then found in relation to a flatter slope of the acromion and a decreased lateral acromion angle.[1,3]

Other authors focused on the inclination of the glenoid and hypothesized that an upward-facing glenoid would less efficiently resist the cranial pull of the deltoid muscle and therefore favor secondary impingement.[8,22] A similar concept was introduced with the acromion index.[18] Nyffeler et al postulated that a large lateral extension of the acromion results in a more vertical orientation of the force vector of the middle deltoid, necessitating higher loads of the rotator cuff to maintain the humeral head centered on the glenoid. More recently, the critical shoulder angle was introduced, and a strong association between large angles and degenerative RCTs was demonstrated.[12]

The aims of the present study were to assess the inter-rater reliability of different radiologic parameters of scapular morphology and to determine their individual predictive power for the presence of degenerative rotator cuff disease. Because the critical shoulder angle represents the combination of glenoid inclination and acromial coverage, we hypothesized that this parameter is the most valuable measure to discriminate between patients with intact rotator cuff tendons and those with torn rotator cuff tendons.

Materials and methods

Patient selection

On the basis of data from previously published series, pre hoc power analysis was performed for each of the outcome measures.[1-3,9,11,12,18,23] This analysis determined that for a significance level (type I error) of 5%, a sample size of 51 patients in each group was sufficient to provide a desired power of 95%.

The RCT group consisted of 51 consecutive patients who underwent arthroscopic rotator cuff surgery between January 2012 and October 2012 for a degenerative full-thickness tear involving at least the supraspinatus tendon. RCTs were diagnosed by magnetic resonance imaging and were corroborated at surgery. Only patients with available preoperative true anteroposterior and standardized lateral (outlet) views were included.[10,20] Patients with inflammatory disease or a history of trauma or previous surgery were excluded, as were those with an acromiohumeral distance <7 mm. The average age of these 17 women and 34 men was 58.2 years (standard deviation [SD], 8.0; range, 42-76 years).

On the basis of the demographics of the RCT group, an age- and sex-matched control group was formed. These subjects were retrieved from a data registry of a consecutive series of patients treated for isolated osteoarthritis of the acromioclavicular joint or idiopathic frozen shoulder between January 2011 and December 2011. In all of these patients, the integrity of the rotator cuff was confirmed by gadolinium-enhanced magnetic resonance arthrography. Regarding the RCT group, only patients with available true anteroposterior and standardized lateral (outlet) views were included, whereas individuals with previous surgery were excluded. The average age of these 17 women and 34 men was 58.1 years (SD, 8.4; range, 41-76 years).

Radiologic assessment

Two independent readers (K.W. and S.B.), who were both blinded to the patients' diagnosis, assessed all radiographs. Standardized, true anteroposterior radiographs with the arm in the neutral position were used to assess the acromion index (AI) as described by Nyffeler et al[18] (Fig. 1, *A*), the lateral acromion angle (LAA) according to Banas et al[3] (Fig. 1, *B*), and the recently introduced critical shoulder angle (CSA; Fig. 1, *C*).[12] On standardized outlet views, the acromion morphology was classified according to Bigliani and Morrison into type I (flat), type II (curved), and type III (hooked).[5] In addition, the acromial slope (AS), as described by Aoki et al,[1] was determined (Fig. 1, *D*). All radiologic data were stored on a picture archiving and communication system (Cerner Corp, Kansas City, MO, USA) workstation, and the provider's image analysis software was used for review and measurement of images.

Statistics

In the first step, we tested data for normality with the Kolmogorov-Smirnov test and performed quantile-quantile plots of dependent variables. Descriptive analysis was used to report medians and the interquartile range of the continuous variables as well as means and standard deviations, if appropriate. We compared groups by the univariate linear analysis as well as by logistic regression analysis. An adjustment for possible confounders was not performed because an age- and sex-matched control group was already formed a priori. Unadjusted differences and odds ratios between groups were presented with 95% confidence intervals (CIs). To assess the inter-rater reliability of the ratings, the intraclass correlation coefficients (ICC) of the different parameters were calculated. We considered ICCs of 0.7 or higher to be sufficient for the reliability. The Spearman ρ correlation coefficient was calculated to determine the correlation among the different parameters. Receiver operating characteristic (ROC) analyses were performed to determine cutoff values and to assess the sensitivity and specificity of each individual parameter. Statistical significance was defined as a *P* value <.05. Statistical analysis was performed with the SPSS statistical software (SPSS Inc, Chicago, IL, USA) and STATA (version 11, Stata Corp, College Station, TX, USA).

Results

The data for all parameters (median and interquartile range) are summarized in Table I.

ICCs were good to excellent for all parameters studied, with an ICC_{AI} and ICC_{CSA} of 0.98, ICC_{LAA} of 0.94, $ICC_{Bigliani}$ of 0.79, and ICC_{AS} of 0.95.