Original Article

Subacromial volume and rotator cuff tears
Does an association exist?

Anthony Yi, Ioannis A Avramis, Evan H Argintar, Eric R White[1], Diego C Villacis, George F Rick Hatch III

Abstract

Background: Rotator cuff pathology occurs commonly and its cause is likely multifocal in origin. The development and progression of rotator cuff injury, especially in relation to extrinsic shoulder compression, remain unclear. Traditionally, certain acromial morphologies have been thought to contribute to rotator cuff injury by physically decreasing the subacromial space. The relationship between subacromial space volume and rotator cuff tears (RCT) has, however, never been experimentally confirmed. In this study, we retrospectively compared a control patient population to patients with partial or complete RCTs in an attempt to quantify the relationship between subacromial volume and tear type.

Materials and Methods: We retrospectively identified a total of 46 eligible patients who each had shoulder magnetic resonance imaging (MRI) performed from January to December of 2008. These patients were stratified into control, partial RCT, and full-thickness RCT groups. Subacromial volume was estimated for each patient by averaging five sequential MRI measurements of subacromial cross-sectional areas. These volumes were compared between control and experimental groups using the Student's *t*-test.

Results: With the numbers available, there was no statistically significant difference in subacromial volume measured between: the control group and patients diagnosed partial RCT ($P > 0.339$), the control group and patients with complete RCTs ($P > 0.431$).

Conclusion: We conclude that subacromial volumes cannot be reliably used to predict RCT type.

Key words: Magnetic resonance imaging, rotator cuff tear, subacromial volume
MeSH terms: Shoulder, rotator cuff, magnetic resonance imaging

Introduction

Rotator cuff pathology occurs commonly and its cause is likely multifocal in origin.[1] The development and progression of rotator cuff injury, especially in relation to extrinsic shoulder compression, remain unclear.[1] Traditionally, certain acromial morphologies have been thought to contribute to rotator cuff injury by physically decreasing the subacromial space.[2-4] However, the relationship between subacromial volume and the progression of rotator cuff tears remains poorly understood; this relationship has never been experimentally confirmed.

Departments of Orthopedic Surgery and [1]Radiology, Keck School of Medicine, University of Southern California, Los Angeles, California, USA

Address for correspondence: Mr. Anthony Yi, 1200 N. State Street, GNH 3900, Los Angeles, CA 90033, California, USA.
E-mail: yi.anthony.m@gmail.com

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In an effort to clarify the relationship between subacromial space volume and specific shoulder pathology, we retrospectively compared magnetic resonance imaging (MRI) based estimations of subacromial volumes in control patients to patients with partial or complete rotator cuff tears (RCTs). In this study, we retrospectively compared a control patient population to patients with partial or complete RCTs in an attempt to quantify the relationship between subacromial volume and tear type.

Materials and Methods

46 patients who had shoulder MRI's performed from January to December of 2008 were identified using ICD-9 codes, generated by three fellowship trained shoulder surgeons and were included in the study. One control and two experimental groups of patients (partial and complete RCTs) were identified. Patients were retrospectively identified for potential inclusion in our investigation after obtaining institutional review board approval from our institution.

Our control group consisted of patients with clinically diagnosed anterior or posterior gleno-humeral instability. Patients with instability were selected as we do not routinely image healthy shoulders. Our controls had focal intraarticular, not subacromial pathology, thus allowing for their nonpathologic subacromial space to serve as a healthy control. Instability was diagnosed clinically with positive apprehension and/or jerk tests. In addition, all patients included in the control group had full passive range of shoulder motion in all planes and demonstrated no clinical signs of cervical spine, proximal biceps or acromioclavicular (AC) joint pathology. The control group patients also had negative impingement examinations, symmetric rotator cuff strength and negative Jobe and belly press examinations.[5,6] Furthermore, all patients had a MRI-diagnosed labral injury. Specific exclusion criteria for the control group included: previous shoulder surgery, known history of shoulder trauma, incomplete imaging (MRI and X-ray), or a diagnosis of shoulder pain attributed to a diagnosis other than gleno-humeral instability. A thorough chart review was conducted to confirm eligibility for inclusion in the control group.

Inclusion criteria for our experimental group included a diagnosis of partial or complete RCT. This was determined clinically by an isolated weak supraspinatus on physical examination (positive Jobe test) and confirmed via MRI evaluation by a musculoskeletal-trained radiologist. All subjects included in this group demonstrated either full thickness or partial thickness supraspinatus and/or infraspinatus tears. Additionally, individuals in this group had full range of passive motion and no clinical cervical neck, AC joint or focal proximal biceps pathology. Specific exclusion criteria for the experimental group included: previous shoulder surgery, incomplete imaging, subscapularis RCT (positive belly press examination or MRI read), or diagnosis of shoulder pain attributed to any diagnosis other than partial or complete RCT. A thorough chart review was conducted to confirm eligibility for inclusion in the experimental study group.

The subacromial space volume was estimated by averaging cross-sectional areas by using Synapse© (2010 FUJIFILM Medical Systems USA, Inc., IL, USA) software. The cross-sectional area of the supraspinatus fossa was measured at five sections imaged along the course of the supraspinatus muscle on each MRI using the "freehand" tool in millimeters squared [Figure 1]. The cross-sections analyzed were as follows: one at the acromial central midpoint as determined by the axial images, two cuts medial (referred to as "far medial" and "medial"), and two cuts lateral (referred to as "far lateral" and "lateral") [Figure 2]. The 5 supraspinatus cross sectional areas were multiplied by the depth of the measured subacromial space to establish supraspinatus fossa volumes (mm^3). The average of these 5 supraspinatus fossa volumes was used for statistical analysis. A musculoskeletal trained radiologist performed all MRI measurements.

Once collected, the data generated for all groups was analyzed using the Student's *t*-test with two tails and unequal variance as the different groups had different sizes.

Results

A total of 13 patients were deemed eligible for inclusion in our control group. Five of these patients were female and 8 patients were male. The average age for the control group was 44 years (range 19-73 years; standard deviation [SD]: 17). The average subacromial space volume was 2589 mm^3 (SD: 760) [Table 1].

Of the 33 patients included in our experimental group of RCTs, 18 patients were female and 15 patients were male. The average age of patients with RCTs was 64 years (range 24-88 years; SD: 13). The average subacromial volume for patients with partial or full RCTs was 2350 mm^3 (SD: 787) [Table 1].

A total of 8 patients had a partial RCT. Five of these patients were female and the remaining 3 patients were male. The average age of patients with partial RCTs was 56 years (range 24-71 years; SD: 15). The average subacromial volume for patients with partial RCTs was 2275 mm^3 (SD: 678) [Table 1 and Figure 3]. With the numbers available, the Student's *t*-test revealed that there was no statistically significant difference between subacromial volumes of the control and partial RCT groups ($P > 0.339$).

Table 1: Demographic details of patients

Injury type	*n*	Female	Male	Average age (years)	Subacromial volume (mm^3)
Partial tears	8	5	3	55.5 (SD: 15.2)	2274.50 (SD: 677.78)
Complete tears	25	13	12	66.4 (SD: 12.0)	2374.32 (SD: 830.33)
All RCTs	33	18	15	63.8 (SD: 13.5)	2350.12 (SD: 787.06)

SD=Standard deviation, RCT=Rotator cuff tear

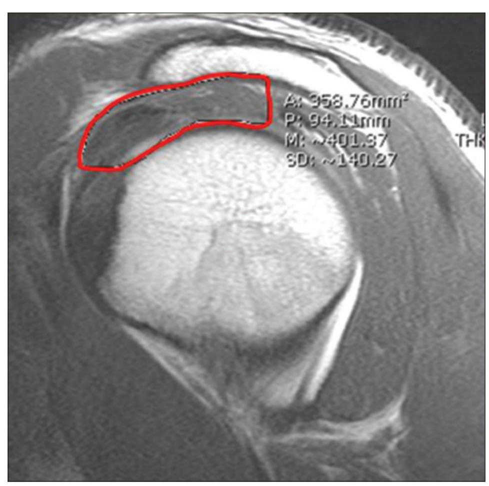

Figure 1: A magnetic resonance imaging-based cross-sectional area showing measurements of subacromial volume

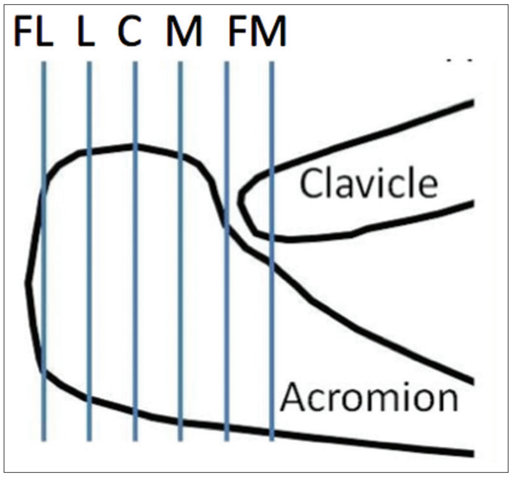

Figure 2: Axial diagram of the five measured cross-sectional planes (FL: Far lateral, L: Lateral, C: Central, M: Medial, FM: Far medial)

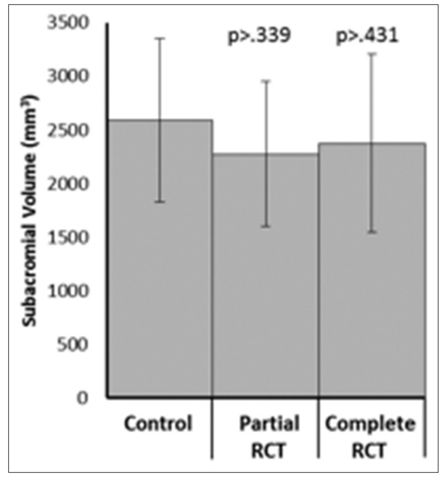

Figure 3: A bar diagram showing subacromial volume and rotator cuff tear (RCT): Comparison of subacromial volumes between control, partial RCT and complete RCT groups with Student's *t*-test P values illustrated to show differences relative to control group

Of the 25 patients with a complete RCT, 13 patients were female and the remaining 12 patients were male. The average age of patients with complete RCTs was 66 years (range 28-88 years; SD: 12). The complete RCT group had an average subacromial volume of 2374 mm^3 (SD: 830) [Table 1 and Figure 3]. With the numbers available, the Student's *t*-test revealed that there was no statistically significant difference between subacromial volumes of the control and complete RCTs groups ($P > 0.431$).

Discussion

Rotator cuff injury has been associated with specific acromial morphologies such as hooked[2] and sloped[3,4] acromia. Through extrinsic compression, the presence of these more constraining bony geometries has been thought to contribute to or serve as a predictor of decreased subacromial space volumes. However, there exists a paucity of research investigating the possible association between subacromial space volume itself and rotator cuff pathology. Our study investigated the utility of using MRI based subacromial space volumes to predict rotator cuff pathology. Our results demonstrate that MRI based subacromial volume measurements do not reliably predict RCT type.

In fact, recent literature has challenged the original notion that particular acromial morphologies are associated with RCTs. The original findings of Toivonen *et al*.[3] that identified an association between acromial slopes and shoulder pathology have been challenged.[7,8] Similarly, the original findings of Bigliani *et al*.,[2] supporting an association between RCTs and hooked acromion shapes, have come into question.[9-11] Clinical studies have even demonstrated improvement in patients who underwent subacromial decompression in addition to rotator cuff repair compared to patients who underwent rotator cuff repair alone.[13-17]

These results suggest that extrinsic compression may not contribute to rotator cuff injury to the degree that was previously postulated.

Although there may be narrowing of the interval space between the acromion and proximal humerus during forward flexion,[18] RCTs seem to be most commonly caused by tensile failure,[19-21] beginning on the articular side[22] of the rotator cuff tendon. This concept has been supported by biomechanical studies that have shown higher tensile forces and strain on the articular side of the supraspinatus tendon with shoulder abduction.[23]

Traditionally, radiographs have served as the mainstay for investigation of possible bony contribution to rotator cuff disease. Two dimensional imaging is extrapolated to reflect changes in a three dimensional volume. Although prior MRI based three dimensional analysis has been used to evaluate acromial morphology,[24] we used a more simplified, novel method to measure the subacromial space volume. We acknowledge that the subacromial volumes used in this study represent estimations. We believe, however that our MRI based measurement still better reflects three dimensional volumes relative to traditional radiographic interpretation.

MRI is a static imaging modality and does not reflect the dynamic compression that may be generated with various degrees of abduction, flexion/extension, and/or rotation. Modalities incorporating three dimensional evaluation could have generated results more reflective of actual mechanical impingement.[24,25] These modalities, however, are not available at most centers. We chose an imaging modality that is more accessible to practicing orthopedic surgeons.

There are limitations to our study. We do not routinely image normal shoulders and, therefore, we could not produce a true control group that was free of all shoulder pathology. We attempted, however, to create a control group that reflected patients with focal gleno humeral and not subacromial pathology. Further, we acknowledge that decreases in subacromial volume likely contribute to bursal sided rotator cuff pathology. We did not stratify our partial RCT cohort to reflect this subset due to our limited study cohort number. Also, MRI is performed in the supine position. Although extrinsic compression could occur in this position, especially nocturnally, supine imaging may not truly reflect external impingement experienced during normal standing. Finally, we were unable to determine if the tear started on the bursal or articular side for our complete RCT cohort.

In summary, we found that MRI based subacromial volume measurements cannot be used reliably to predict partial or complete RCTs. Although anatomical abnormalities may exist that could conceivably act as an extrinsic source of compression to the rotator cuff, estimated subacromial volumes alone do not predict rotator cuff injury type.

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