Anterior Acromial Anatomy: Relevance to Arthroscopic Acromioplasty

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Purpose: To evaluate the effect of arthroscopic acromioplasty on the anterior deltoid origin. **Type of Study:** In vitro cadaveric histologic study. **Methods:** We performed a histologic evaluation of the anterior aspect of 15 acromions, the parameters of the anatomy of the anterior acromion, including the deltoid origin, and the morphology of the acromion. A simulated arthroscopic acromioplasty was performed and the effect on the anterior deltoid origin was determined. **Results:** Resection of 4 mm of bone from the underside of the acromion resulted in release of 56% (± 11%), and resection of 5.5 mm of bone resulted in 77% (±15%) release of the deltoid origin. The amount of deltoid released correlated statistically with both the thickness of the acromion and the acromial angle ($P < .0001$ and $P = .04$). **Conclusions:** These findings show that arthroscopic acromioplasty can cause substantial injury to the deltoid origin, that this effect is related to acromial anatomy, and that preoperative planning may help to reduce the risk of excessive deltoid origin release. **Clinical Relevance:** Consideration of acromial anatomy is required to avoid deltoid detachment when performing arthroscopic acromioplasty. **Key Words:** Acromion—Acromioplasty—Impingement syndrome—Shoulder arthroscopy.

Impingement syndrome and rotator cuff tearing are common causes of shoulder pain and disability.[1-3] Codman[4] described the relevant subacromial pathology in the 1930s and theorized that the "supraspinatus syndrome" was chronic supraspinatus tendinitis and subdeltoid bursitis caused by compression of the tendon and bursa against the acromion during mid-range abduction. The belief that the entire acromion was involved led to recommendations of lateral and radical acromionectomy as definitive surgical treatment for the supraspinatus syndrome.[5,6]

In 1972, Neer[2] emphasized the role of the anterior acromion in rotator cuff disorders and described anterior acromioplasty as a surgical treatment for chronic impingement syndrome.[2,3] Subsequently, open anterior acromioplasty became the treatment of choice for chronic impingement syndrome and is a major component of rotator cuff repair procedures.[3,7-9] Numerous studies report the successful results of open anterior acromioplasty.[2,3,7-9]

Several studies reported correlations between acromial morphology and the extent of rotator cuff tearing. Bigliani et al.[10] first described 3 types of acromion (Fig 1). Subsequently, Morrison and Bigliani[11] reported a clinical correlation between acromial type and rotator cuff tearing. In later studies, Toivonen et al.[12] defined the acromial angle (Fig 2) and reported a positive correlation between increased acromial angle and rotator cuff tearing. In addition, Banas et al.[13] described the lateral acromion angle determined from magnetic resonance images of the shoulder and reported a strong correlation with the extent of rotator cuff tearing.

More recently, arthroscopic acromioplasty has replaced open acromioplasty as the preferred treatment for impingement syndrome.[14-21] Ellman[15] presented the first clinical results of arthroscopic acromioplasty in 1985. Variations of his original technique have been developed and popularized.[22,23] The goal of arthroscopic acromioplasty is to remove bone from the undersurface of the

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0749-8063/04/2010-3316$30.00/0

doi:10.1016/j.arthro.2004.08.014

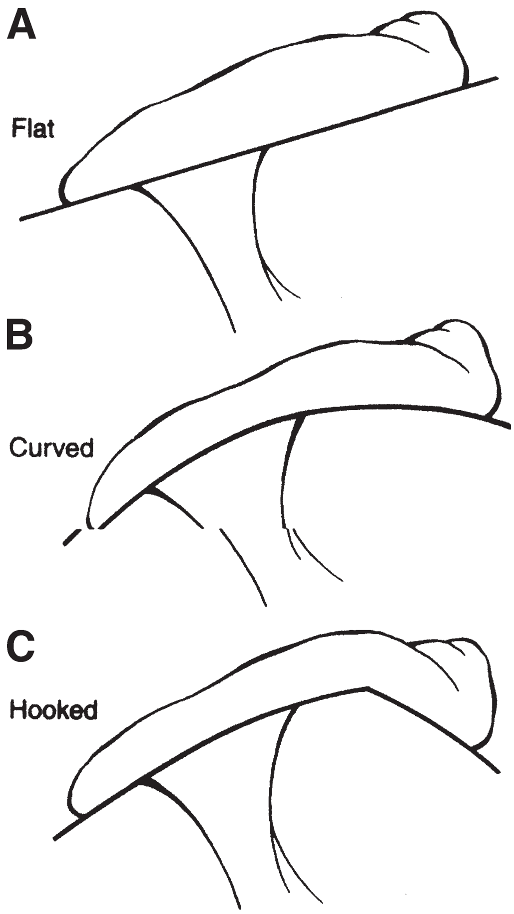

FIGURE 1. Diagram of acromial types: (A) type I, (B) type II, and (C) type III.

anterior acromion so as to decompress the subacromial space and reduce contact of the acromion against the rotator cuff.[24]

Among the several advantages of arthroscopic acromioplasty are enhanced visualization of the glenohumeral joint and subacromial space, reduced surgical morbidity, and accelerated rehabilitation. Arthroscopic acromioplasty theoretically preserves the integrity of the deltoid origin. Neer and Marberry[25] previously highlighted the problems of excessive acromioplasty or total acromionectomy including deltoid dehiscence and shoulder weakness. Nevertheless, few studies have examined the effect of arthroscopic acromioplasty on the deltoid origin. Recently, Torpey et al.[26] found that a substantial portion of the deltoid origin is released by arthroscopic acromioplasty but did not find a correlation with acromial morphology.

The goal of our study was to evaluate the effect of arthroscopic acromioplasty on the deltoid origin and to determine if parameters of acromial anatomy contribute to this effect. We hypothesized that the size and shape of the acromion has an effect on the extent of detachment of the deltoid origin that might occur as a result of arthroscopic acromioplasty.

METHODS

Fifteen embalmed cadaver shoulders from elderly individuals, 7 pairs and 1 single shoulder, were obtained for this study. The scapular spine was osteotomized at the spinoglenoid notch and the acromion was harvested with all attached soft tissue, including the deltoid muscle and coracoacromial ligament. Plain radiographs of the acromion were obtained in an axial projection and tangential to the plane of the acromion (a simulated outlet view).[3,27] The gross anatomy of the rotator cuff, on the bursal and articular sides, was assessed visually and any tearing was documented. None of the shoulders had glenohumeral osteoarthritis or an os acromiale.

Excess soft tissue was trimmed from the specimens. The origin of the deltoid and the attachment of the coracoacromial ligament were preserved. The specimens were decalcified in 50% formic acid solution and sodium citrate and then embedded in paraffin. The

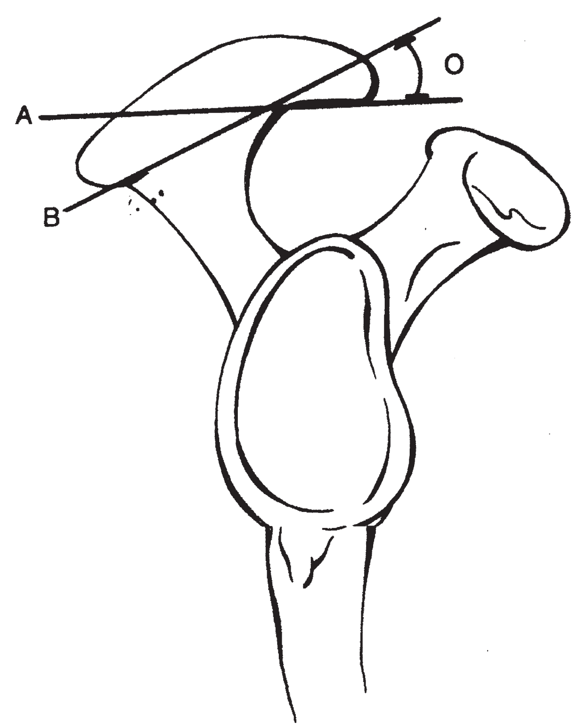

FIGURE 2. Diagram of acromial angle O.

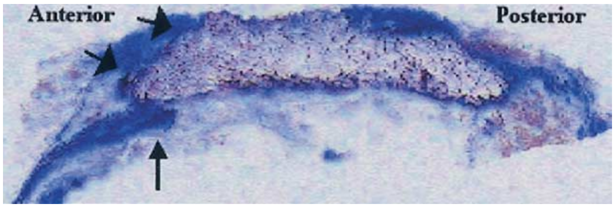

FIGURE 3. Histologic specimen of midsagittal section of an acromion. The deltoid muscle is stained brownish red and the deltoid origin is blue (short arrows). The coracoacromial ligament is stained blue (long arrow).

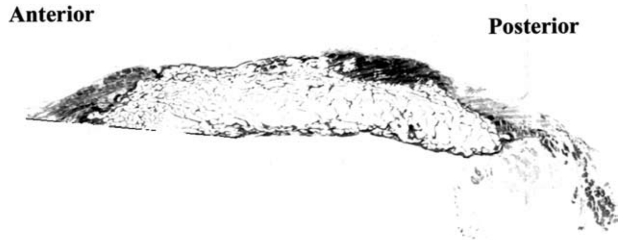

FIGURE 5. Simulated arthroscopic acromioplasty with 5.5 mm of bone resection.

acromion were cut atraumatically along the midsagittal axis. Serial microtome sections were made along the midsagittal axis, mounted on slides, and stained with Trichrome blue (Fig 3). The sections were scanned using a color video camera and light microscope. The captured images were then visualized and analyzed using NIH Image software (National Institutes of Health, Bethseda, MD).

Anatomic and geometric parameters of the histologic specimens were evaluated (Fig 4). The origin of the anterior deltoid and the attachment of the coracoacromial ligament were determined by analyzing the histologic specimens. Acromial angles were determined as described by Bigliani et al.[27] Also assessed were acromial thickness, length of the arc of the anterior deltoid origin, and the linear thicknesses of the deltoid origin and coracoacromial ligament insertion.

Arthroscopic acromioplasty was simulated on the computer-captured images with acromial resection of 4.0 and 5.5 mm and was based on standard surgical techniques[15,16,22] (Fig 5). The deltoid muscle detachment produced by the acromioplasty was assessed both as a percentage of the length of the arc of the origin and as a percentage of the thickness of the deltoid origin.

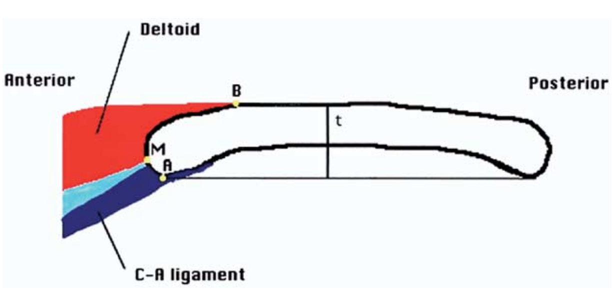

FIGURE 4. Schematic representation of histologic specimen of an acromion (AM, coracoacromial ligament attachment; MB, deltoid origin arc; AB, anterior acromial thickness; t, thickness of peak of undersurface concavity).

Rationale for Experimental Design

Acromial resection of 4.0 and 5.5 mm was selected because these are typical diameters of commercially available arthroscopic burs. This amount of bone resection was also chosen because it approximates the amount of bone removal required to flatten the undersurface of the anterior acromion. Colman et al.[24] previously determined that flattening of the anterior acromial undersurface occurs with removal of 5.4 mm of acromial bone.

Statistical Methods

The correlations between the amount of deltoid detachment and the parameters of acromial morphology were determined using linear regression analysis. The paired *t* test showed that the measured parameters of paired specimens were not statistically similar, and were thus considered as individual specimens; $P < .05$ was considered statistically significant.

RESULTS

Rotator cuff tearing was identified in 12 shoulders (80%); 6 (40%) had full-thickness tearing and 6 (40%) had partial-thickness tearing. The mean acromial angle was 20° (range, 5.3° to 31°). This corresponded to 2 type I, 12 type II, and 1 type III acromion. Based on the radiographic analysis, there were no type I, 11 type II, and 4 type III acromion. Using the available data, we could not show a statistically significant correlation between acromial type and the presence or extent of rotator cuff tearing.

The average thickness of the acromion at the peak of the undersurface concavity (t in Fig 4) was 5.5 mm (range, 3.4 to 6.6 mm) and the average thickness at the anterior aspect (vertical distance between A and B in Fig 4) was 7.4 mm (range, 4.7 to 9.4 mm). The ratio of this thickness was 0.75 (0.64 to 1.09).

The average linear thickness of the deltoid origin (vertical distance between M and B in Fig 4) was 5.4 mm (range, 3.8 to 6.8 mm). This represented 74% (range, 43% to 88%) of the anterior acromion. The length of the arc of the deltoid origin (MB in Fig 4) attachment was 8.8 mm (range, 5.9 to 11.5 mm). On average, the thickness of the coracoacromial ligament attachment to the anterior acromion (vertical distance between A and M in Fig 4) was 2.0 mm (range, 0.8 to 5.1 mm).

There was considerable variation in the extent of deltoid detachment that occurred with the simulated acromioplasty. When 4 mm of bone was resected, a mean of 55.9% (±11%) of the deltoid origin was detached. When 5.5 mm of bone was resected, a mean of 75.7% (±15%) of the deltoid origin was detached.

The extent of deltoid detachment was highly correlated with the anterior acromial thickness ($P < .0001$). The extent of deltoid detachment was inversely related to the acromial angle ($P = .04$). That is, when the acromial angle is larger, presumably due to greater spurring, a smaller percentage of the deltoid origin is detached. The worst-case scenario would be a thin, flat acromion, and the best case (least deltoid detachment) occurs when the acromion is thick and curved (type II or III).

DISCUSSION

Current surgical treatment of impingement syndrome (and rotator cuff tear if present) is arthroscopic subacromial decompression (and open, mini-open, or arthroscopic rotator cuff tear when indicated). In theory, a properly performed arthroscopic acromioplasty should preserve the deltoid origin. This would presumably allow an accelerated rehabilitation program and earlier return to functional activities.

These advantages of arthroscopic acromioplasty, however, do not preclude potential problems. In this study we analyzed the effect of a simulated arthroscopic acromioplasty on the deltoid origin. Torpey et al. recently addressed this issue.[26] In their study, they found that a 4-mm resection released 41% of the direct deltoid origin and that a 6-mm resection released 69%. However, their study did not find a correlation between acromial size and morphology with the extent of deltoid detachment.

Similarly, our study found that a simulation of the standard arthroscopic acromioplasty can detach a large portion of the deltoid origin. However, in contrast to Torpey et al., when using a simulation of the recommended technique of arthroscopic acromioplasty, we were able to show a significant correlation between the anatomic parameters of acromial thickness and acromial angle with the extent of deltoid detachment. The latter finding is consistent with our clinical experience and belief that acromial spurring often accounts for increased anterior acromial thickness, occurs within the coracoacromial ligament, and does not originate along the deltoid origin.

The clinical relevance of anterior deltoid detachment resulting from arthroscopic acromioplasty has not been determined. Based on our clinical experience and the findings of this study, we hypothesize that a shoulder with a thick, angled, and spurred acromion would be more likely to develop impingement syndrome and rotator cuff pathology. Assuming that spurring of the anterior edge of the acromion would lead to an increased acromial angle, a smaller percentage of the deltoid origin would be detached from an acromion with true primary outlet impingement from degenerative acromial spurring. This type of acromion should be more representative of the typical case of impingement that undergoes surgery. Shoulders with a thin and flat acromion would be unlikely to develop true coracoacromial outlet impingement syndrome and thus would not warrant treatment with a subacromial decompression. In this case, a cause for secondary impingement should be sought and treated accordingly.

Extensive deltoid detachment may significantly affect deltoid strength and could lead to deltoid avulsion. Although relevant in all cases, our finding may be most relevant when subacromial debridement and decompression are performed to treat massive rotator cuff tearing. Patients with rotator cuff deficiency are more dependent on deltoid function and thus would be at greater risk of loss of function if the deltoid origin were excessively detached.

Our study does have limitations. We do not know the effect of aging on acromial morphology. If acromial morphology changes with advancing age, then the findings derived from our study of elderly shoulders might not be relevant to patients who tend to be younger. If advancing age is associated with more severe undersurface anterior acromial prominence, as would be found in the type II and III acromion and in the acromion with a greater acromial angle, then extrapolation of our findings to a younger population might indicate an even more severe effect on the deltoid origin.

The present study shows that the effect of arthroscopic acromioplasty on the integrity of the deltoid origin can be extensive. Our results contradict those of Torpey et al.,[26] who did not find a correlation between deltoid detachment and acromial morphology. The effect of performing an arthroscopic subacromial decompression on an acromion that does not show significant degenerative spurring should be considered carefully in the treatment of impingement syndrome and should not be used if the pathology leading to impingement is secondary, such as that seen with posterior capsular tightness or other causes of secondary impingement. Preoperative planning with an adequate outlet radiograph is essential to avoiding complications of the deltoid origin and to ensure that the pathology being addressed is true primary impingement.

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