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Grade of coracoacromial ligament degeneration as a predictive factor for impingement syndrome and type of partial rotator cuff tear

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Background: The purpose of this study was to investigate the role of coracoacromial ligament degeneration and specific anatomic parameters in the etiology of partial-thickness rotator cuff tears.
Materials and Methods: This study retrospectively assessed 96 patients (mean age, 50.1 years [17-76]; 34 men, 62 women) diagnosed with bursal-side and articular-side rotator cuff tears with a history of failed conservative treatment and persistent shoulder pain who underwent arthroscopic surgery. Video records of the surgery were used to evaluate the type of cuff tear, grade of coracoacromial ligament degeneration, and associated pathologic changes; preoperative magnetic resonance images were used to measure acromioglenoid angle, supraspinatus glenoid angle, and subacromial distance.
Results: Most of the patients with articular-side tears demonstrated grade 0 and grade 1 coracoacromial ligament degeneration, whereas patients with bursal-side tears had grade 1 and grade 2. There was a significant positive correlation between the grade of coracoacromial ligament degeneration and bursal-side partial rotator cuff tears, whereas no correlation was observed with articular-side tears. There was no significant difference between bursal-side and articular-side partial cuff tears regarding acromioglenoid angle, supraspinatus glenoid angle, and subacromial distance.
Conclusions: Grade 1 and grade 2 coracoacromial ligament degeneration is a strong predictive factor for impingement syndrome in the etiology of bursal-side partial cuff tears and can guide the surgeon to consider ligament release and débridement or acromioplasty in these patients.
Level of evidence: Level IV; Case Series; Prognosis Study

Keywords: Bursal-side partial rotator cuff tears; articular-side partial rotator cuff tears; coracoacromial ligament degeneration; arthroscopy; subacromial impingement; magnetic resonance imaging

Partial-thickness rotator cuff tears are a common source of shoulder pain and dysfunction. Compared with full-thickness tears, the incidence is reported to be higher, and interestingly, they tend to be more painful than full-thickness tears. Lohr and Uhthoff examined the

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supraspinatus tendons of 306 cadaveric shoulders and found an incidence of 19% for full-thickness tears and 32% for partial-thickness tears.[13] Symptoms resulting from partial tears are thought be a consequence of nonphysiologic tension created within the remaining intact rotator cuff fibers.[4,7]

This subject is particularly important because the estimated prevalence of partial-thickness rotator cuff tears is significant with apparent clinical symptoms, and it can be expected to increase because there is a correlation between increasing age and rotator cuff disease. According to the study of Sher et al, magnetic resonance imaging in 96 shoulders revealed a nearly 7-fold increase in partial rotator cuff tear prevalence in patients younger than 40 years compared with patients older than 60 years.[20]

According to different structural characteristics, partial rotator cuff tears can be divided into 3 subgroups: bursal-side, articular-side, and intratendinous tears.[14,21,25] These tear patterns tend to be the end result of several pathophysiologic mechanisms that can be categorized as either intrinsic or extrinsic factors. Recent studies suggest that both intrinsic and extrinsic factors may be involved in the process of partial cuff tears.[5,15,18]

Armstrong[1] first described impingement as compression of the bursa and rotator cuff tendons under the acromion and used the term *supraspinatus syndrome*. Neer[17] reported that the anterior third of the acromion and the coracoacromial ligament (CAL) were responsible for mechanical impingement on the tendinous portion of the rotator cuff and recommended removal of the anterior edge and undersurface of the anterior part of the acromion with the attached CAL to relieve symptoms. Although 19 shoulders were reported to have partial tears of the supraspinatus among the 50 shoulders that had been subjected to acromioplasty, tear pattern remains unclear.

The CAL is a thick band of fibrous tissue extending from the coracoid process along the surface of the capsule to the tuberosities between the supraspinatus and subscapularis tendons. Besides this ligament complex, acromion morphology and version of the glenoid and humeral head are also described to play an important role in mechanical impingement and related rotator cuff disease.[10]

Data on the etiology of partial-thickness rotator cuff tears are relatively lacking in the literature compared with those available on full-thickness tears. Although CAL degeneration has been proposed as a well-known indicator for subacromial impingement, the relationship between the grade of CAL degeneration and type of partial rotator cuff tear has not been investigated to date. We believe that compared with anatomic parameters, the grade of CAL degeneration may be a more predictive factor to determine impingement syndrome and type of cuff tear.

Our goal was to elucidate the role of CAL degeneration and radiologic subacromial distance and angle measurements as predictive factors in the etiology of bursal-side and articular-side rotator cuff tears.

Materials and methods

After exclusion of patients with extrinsic causes related to partial rotator cuff tears (such as shoulder instability, internal impingement, and trauma) and intrinsic causes (mainly age-related vascular and metabolic changes and shear stress that lead to degenerative tearing or intratendinous lesions), 96 patients (34 men, 62 women) with high-quality magnetic resonance images and arthroscopic video records were enrolled in the study among the 150 patients diagnosed with partial rotator cuff tears between 2008 and 2015. All patients had a history of failed conservative treatment with persistent shoulder pain and disability and underwent arthroscopic surgery. Video records consisting of the described surgery were used to evaluate the type of partial-thickness cuff tear, degree of CAL degeneration, and associated pathologic change for each patient.

Surgical technique

All patients were operated on by the same surgeon under interscalene block or hypotensive general anesthesia in the lateral decubitus position. Standard glenohumeral arthroscopy was performed to assess intra-articular rotator cuff disease, including partial rotator cuff tear and associated injuries. In patients diagnosed with articular-side partial-thickness tears, a tagging suture was placed at the tear site to evaluate the continuity of this tear from the bursal side. After glenohumeral arthroscopy, subacromial arthroscopy was performed to examine the bursal-side rotator cuff disease, CAL, acromion, and bursa.

Radiologic evaluation

Magnetic resonance images were used to measure subacromial angle and distances. Oblique coronal sections were used to calculate acromioglenoid angle (AGA), supraspinatus glenoid angle (SGA), and subacromial distance (SAD). AGA was measured as described by Banas et al.[2] This is the angle between the inferior outline of the acromion and the superior and inferior margins of the glenoid labrum. The measurement is performed on an oblique coronal image just posterior to the acromioclavicular joint. A decreased AGA has been considered an extrinsic factor causing impingement because it narrows the outlet of the supraspinatus tendon. The SGA was measured as described by Tétreault et al,[22] on an oblique coronal image just posterior to the acromioclavicular joint. This is the angle formed by the supraspinatus fossa and the labral outline of the glenoid on the oblique coronal image. An increased SGA has been thought to cause upward gliding of the humeral head through the action of supraspinatus muscle, which may increase contact pressures on the rotator cuff under the coracoacromial arch. The SAD values were evaluated in oblique coronal sections as the shortest distance between the inferior aspect of the acromion at the point directly above the head of the humerus and the center of the subchondral cortex directly under the acromion. The distance was measured electronically with a PACS workstation (RadiAnt DICOM Viewer) (Fig. 1).

Evaluation of CAL degeneration

CAL degeneration was classified according to the Royal Berkshire Hospital Classification as described by Levy et al.[12] This classification system categorizes the pathologic process into four different

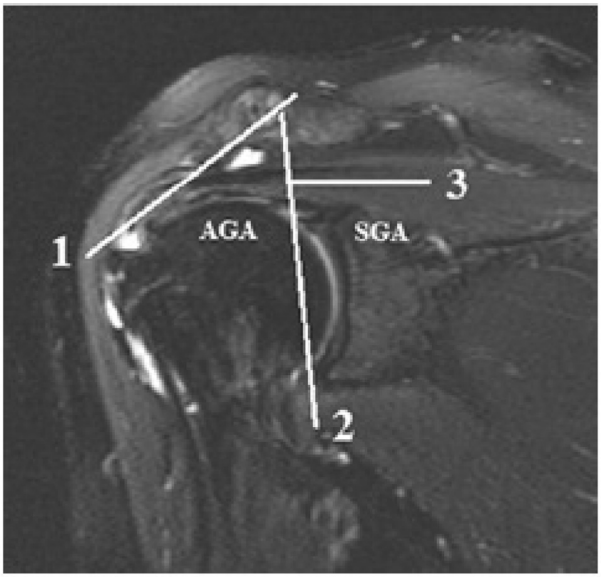

Figure 1 Acromioglenoid angle (*AGA*) and supraspinatus glenoid angle (*SGA*) in oblique coronal sections.

grades. Normal appearance of the CAL is accounted as grade 0, minor fraying as grade 1, major fraying as grade 2, and visualization of the bare bone under the CAL as grade 3 (Fig. 2). Except for the chief surgeon, all videos were evaluated independently and blindly by two more surgeons knowledgeable in shoulder surgery for at least 5 years. Cases with 100% interobserver consensus on the degree of CAL degeneration were included in the study.

Statistical analysis of demographic data, anatomic angle and distance measurements, degree of CAL degeneration, and type of partial tear was made using SPSS/PC (version 18.0 for Windows; SPSS Inc, Chicago, IL, USA). All anatomic measurements were performed by two different radiologists. The *t*-test and Pearson correlation test were used to analyze the relationship between the grade of CAL degeneration, angle and distance values, and type of partial cuff tear.

Results

The mean age of the patients at the time of surgery was 50.1 years (17-76). The average age of the patients was 51.6 ± 12.1 years with bursal-side tears and 48.9 ± 12.4 years with articular side tears. There was no significant difference between bursal-side and articular-side tears in terms of age and gender.

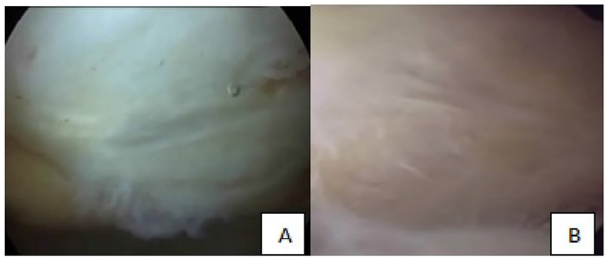

Figure 2 Arthroscopic images of grade 1 (**A**) and grade 3 (**B**) coracoacromial ligament degeneration.

Table II Number of patients and grade of coracoacromial ligament degeneration in both articular-side and bursal-side tears

RBHC	Group		Total	
	Bursal-side tears	Articular-side tears		
	No.	No.	No.	%
Grade 0	2	19	21	21.8
Grade 1	10	29	40	41.6
Grade 2	25	6	31	32.2
Grade 3	3	1	4	4.1

RBHC, Royal Berkshire Hospital Classification.

AGA average was 85° in articular-side ruptures and 84° in bursal-side ruptures. SGA average was 85° in articular side ruptures and 84° in bursal-side ruptures. SAD average was 6.7 mm in articular-side ruptures and 6.4 mm in bursal-side ruptures. There was no significant difference between bursal-side and articular-side partial cuff tear in terms of AGA, SGA, and SAD (Table I).

There were 21 patients with grade 0 (21.8%) , 40 patients grade with 1 (41.6%), 31 patients with grade 2 (32.2%), and 4 patients with grade 3 (4.1%) CAL degeneration. The average grade of degeneration was 1.72 in bursal-side tears and 0.85 in articular-side tears. Most patients with articular-side tears demonstrated grade 0 and grade 1 CAL degeneration (n = 48), whereas patients with bursal-side tears had grade 1 and grade 2 (n = 35). Compared with articular-side tears, there was also a significant positive correlation between the grade of CAL degeneration and bursal-side partial tears ($P = .001$; $r = 0.506$) (Table II).

Discussion

Since Armstrong and Neer first suggested that rotator cuff tears were caused by mechanical impingement and Bigliani reported a relationship between the shape of the acromion and the presence of rotator cuff disease, the procedure of reshaping the acromion with a partial acromioplasty to relieve mechanical pressure on the rotator cuff has been widely used in either open or arthroscopic rotator cuff repair.[3]

Table I The relationship between radiographic parameters and type of partial-thickness rotator cuff tear

	Group		*P*
	Bursal-side tears	Articular-side tears	
AGA	87°	85°	.080
SGA	84°	85°	.122
SAD-COR	0.64 cm	0.67 cm	.152
SAD-SAG	0.64 cm	0.67 cm	.113

AGA, acromioglenoid angle; *SGA,* supraspinatus glenoid angle; *SAD,* subacromial distance; *COR,* coronal sections; *SAG,* sagittal sections.

In a cadaver study, without subgrouping partial tears, Ozaki et al concluded that morphology of the acromion and subacromial lesions led to subacromial impingement–related partial cuff ruptures.[18] Panni et al, in a study of 12 cadavers with partial cuff tear (4 bursal side, 4 articular side, 4 intratendinous), showed that rotator cuff tears that involve the bursal side are often associated with changes in the CAL and the undersurface of the acromion.[19] Fukuda evaluated 249 cadaveric shoulders and found partial-thickness supraspinatus tears in 13%, with bursal-side tears in 18%, intratendinous tears in 55%, and articular-side tears in 27%.[6] In 96 shoulders, Sher et al reported a 20% prevalence of partial-thickness tears after magnetic resonance imaging, and Milgrom et al reported similar results using ultrasound.[16,20] Unfortunately, there are mostly cadaver and radiologic studies in the literature regarding the incidence and etiology of partial cuff tears. To the best of our knowledge, this study is the largest clinical trial to investigate the relationship between CAL degeneration as a component of subacromial impingement and the type of partial-thickness rotator cuff tear.

Recent studies have led to a reassessment of partial acromioplasty and CAL release in the surgical treatment of rotator cuff disease. A long-term clinical and ultrasound evaluation after arthroscopic acromioplasty in patients with partial cuff tears revealed that compared with articular-side tears, bursal-side tears had nonsignificant higher functional scores but did not protect the cuff from undergoing further degeneration. It has been shown that unnecessary acromioplasty with CAL release may lead to increases in anterosuperior and superior glenohumeral instability.[11,23] There is still no strong evidence to determine a "gold standard" treatment modality in these patients because dominant etiologic causes of partial cuff tears have not been elucidated.

In this study, the positive correlation between the grade of CAL degeneration and the presence of bursal-side tears suggests subacromial impingement to be an important etiologic factor that contributes to bursal-side tears. Although CAL degeneration alone is accepted to be a major component of subacromial impingement, the progress of CAL degeneration is driven by its increased contact with the humeral head. This mechanism may lead to a vicious circle because the existing CAL degeneration will advance as the tendon weakens more over time and reveals increased contact with CAL as a consequence of ongoing impingement. This mechanism has an important role in the correlation we have found between bursal-side tears and grade of CAL degeneration. Only 4.1% of all partial tears had grade 3 CAL degeneration, which leads to a high probability that patients with bare bone under the CAL (grade 3 CAL degeneration) experience mostly full-thickness tears.[9]

Although the factors that are purely related to articular-side partial tears are poorly understood, its inconsistency with CAL degeneration in the current study suggests that contrary to bursal-side tears, subacromial impingement is not an etiologic cause of articular-side tears.

In two different studies, Kanatli et al and Tokgoz et al showed that version of the humeral head and glenoid and SAD measurements do not have enough clinical significance as predictive markers of subacromial impingement syndrome and supraspinatus tendon tears.[8,24] Our study revealed no significant correlation regarding the described radiologic measurements and the type of partial rotator cuff tear. Compared with CAL degeneration, these parameters have no significant role in the etiology of partial cuff tears as estimated.

Conclusion

Although, to date, there is no consensus on a single algorithmic treatment approach and no high-level evidence to support a specific treatment algorithm for a patient with symptomatic partial-thickness rotator cuff tear, we recommend that shoulder surgeons consider CAL release, débridement of the degenerative ligament tissue, or acromioplasty in patients with bursal-side partial-thickness rotator cuff tear because the significant correlation between bursal-side rupture and late-stage coracoacromial degeneration indicates that impingement syndrome is a prominent cause of bursal-side partial cuff tears.

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