<u>original research</u>

The Relationship Between Shoulder Impingement Syndrome and Coracoacromial Ligament Degeneration a Predictive Factor for Shoulder Acromioplasty

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ABSTRACT

Objective • The coracoacromial ligament (CAL) connects the acromion and coracoid process of the scapula. This study aimed to explore the correlation between CAL degeneration and shoulder pathology, specifically focusing on the efficacy of acromioplasty in treating shoulder impingement in patients with varying degrees of CAL degeneration.

Methods • 49 patients diagnosed with bursal-side partial rotator cuff tear were assessed for CAL degeneration and categorized into three grades. They were then randomized into acromioplasty and non-acromioplasty groups to compare the outcomes. Acromiohumeral distance (AHD) and fatty infiltration was evaluated on imaging examinations. American Shoulder and Elbow Score (ASES) and Visual

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INTRODUCTION

Shoulder pain, representing 16% of musculoskeletal complaints, not only leads to work absenteeism but also significantly impairs quality of life due to limitations in range of motion and persistent nocturnal discomfort¹⁻⁴ SAIS is primarily characterized by the mechanical compression of structures such as the supraspinatus tendon within the subacromial space, a condition that can progress from bursitis to a complete rotator cuff tear.^{2,3}

The initial treatment of subacromial impingement syndrome is conservative such as steroid injections and physiotherapy methods, which is effective for some patients of early stage.⁵ But for cases not responding to conservative Analogue Scale (VAS) was recorded to evaluate the shoulder function before and two years after surgery.

Results • Grade III CAL patients demonstrated significantly reduced AHD and increased VAS scores compared to Grades I and II. Post-acromioplasty, Grade III patients showed a statistically significant improvement in ASES scores compared to the non-acromioplasty group. **Conclusion** • The study indicates that CAL degeneration is a significant indicator of shoulder impingement. Notably, acromioplasty significantly improves shoulder function in patients with severe CAL degeneration, suggesting its potential as a targeted treatment in managing shoulder impingement. (*Altern Ther Health Med.* [E-pub ahead of print.])

treatment, arthroscopic acromioplasty is widely used in treatment of subacromial impingement. Acromioplasty is known as an arthroscopic surgical procedure of acromion, in which the synovium and hyperostosis under subacromial space is debrided and decompressed, thereby the impingement of repaired structures is prevented.⁶ However, controversy still exists since there are studies reporting no benefit of this procedure.⁷

The coracoacromial ligament (CAL) connects the acromion and coracoid process of scapula. As part of the coracoacromial arch, the CAL has been suggested to contribute to the restraint of anterosuperior humeral head displacement, also having a potential role in shoulder biomechanics, stability, and proprioception.8 It has long been implicated as a pain generator in impingement syndrome, first described by Dr Charles Neer in the early 1970s.⁹ Controversy still remains on when to do the acromioplasty and what to do with CAL during acromioplasty due to the increased risk of anterior and superior glenohumeral translation after release.^{10,11} As we know, there is little related research concerning the detailed relationship between CAL and acromioplasty. In this research, we aimed to find out the relationship between impingement and CAL rupture and whether CAL degeneration can act as an indicator guiding acromioplasty.

METHODS

Patients and Information

From December 2018 to June 2020, patients diagnosed with unilateral bursal-side partial tear of the rotator cuff in Peking University People's Hospital were included in this research. Exclusion criteria also included patients with a history of trauma, surgery to the shoulder, or a diagnosis of calcifying tendinitis within the last 6 months. After that, 49 patients met the criteria. All the data were extracted from the electronic database of Peking University People's Hospital. Written consent was informed and obtained from the participants. This study was performed according to the Declaration of Helsinki. Approval was granted by the Ethics Committee of Peking University People's Hospital (2021PHB233).

Shoulder function

We used the American Shoulder and Elbow Score (ASES) and Visual Analogue Scale (VAS), both validated and reliable tools, to evaluate the shoulder function and pain intensity respectively. ASES is to evaluate the shoulder function before surgery and two years after surgery. This system was developed by the American Association of Shoulder and Elbow Surgeons to measure shoulder pain, function, or disability. The pain and function subscales each account for 50 points, with a total score range of 0-100 points. The higher the score was, the better the shoulder joint functioned. Visual Analog Scale (VAS) to evaluate the pain of the shoulder, varying from 1 (no pain/functional impairment) to 10 (maximum pain/functional impairment). All the ASES and VAS scores were recorded. Patients were followed up for two years. The ASES was recorded at the final follow-up at 2 years, and the increased ASES value was calculated.

Radiologic evaluation

The Anterioposterior (AP) and outlet view (Y view) were applied to measure the subacromial distances. The acromiohumeral distance (AHD) values were evaluated on AP view as the shortest distance between the inferior aspect of acromion at the point directly above the head of humerus and the center of subchondral cortex directly under the acromion (Figure 1). Magnetic resonance images (MRI) were used to measure the fatty infiltration of the rotator cuff. For the fatty infiltration of supraspinatus, the Goutallier grade was observed on oblique sagittal position. The extent of muscle degeneration was defined and described by Goutallier et al. Grade 0 indicated normal muscle, grade 1 was some fatty streaks, grade 2 was defined as <50% fatty muscle atrophy, grade 3 was 50% fatty muscle atrophy, and grade 4 indicated >50% fatty muscle atrophy.¹² The Goutallier classification was originally intended to describe the performance of computed tomography (CT) and expanded later by Fuchs et al. to describe MRI results.13 The AHD values and Goutallier grades were assessed by two experienced orthopedic surgeons with established inter-observer and intra-observer reliability.

Figure 1. Measuring acromiohumeral distance (AHD) on AP view



Figure 2 Different appearance and grade of CAL. (a) normal appearance of the CAL (grade I) (b) light fraying of ligament (grade II) (c) heavy fraying of ligament or visualization of bare bone (grade III).



Arthroscopy surgery and evaluation

All patients agreed to join the RCT (Randomized Controlled Trial) and signed the informed consent. Patients were randomized into two groups using a computergenerated random number table, ensuring an equal chance of assignment to either group. The odd numbers represented patients who were going to receive acromioplasty (Group A), the even numbers represented the debridement-only (no acromioplasty) patients (Group B).

All procedures were performed under general anesthesia. The patients were positioned in beach-chair position, and normal arthroscopic portals were established. The glenohumeral joint cavity was examined first by a conventional posterior approach. After checking the structures and ensuring there was no glenohumeral joint tear, we moved on to the subacromial space to work on. After debridement, CAL was observed and the degeneration was categorized into three different grades according to the pathologic process: Normal appearance of the CAL is accounted as grade I, light ligament fraying as grade II, and heavy ligament fraying or visualization of the bare bone under the CAL as grade III (Figure 2). For acromioplasty, the coracoacromial ligament was cut off and removed; smooth the anterolateral part of the acromion with a motorized burr. After that, all the tears were repaired by one experienced shoulder surgeon using doublerow repair with suture anchors under the arthroscope. Then, the patients were protected with a sling and underwent routine rehabilitation process after surgery.

Statistical analysis

Data results were expressed as mean \pm SD. Analyses were performed using GraphPad Prism version 7.0 software (GraphPad Software, San Diego, CA, USA). Student's *t* test was used to make two group comparisons. Differences were regarded as statistically significant at *P* < .05. Comparisons of three or more groups were made using one-way analysis of variance (ANOVA) for single-factor variables followed by Turkey post-hoc tests or two-way ANOVA for two-factor variables.The significance level was set at 5% for these analyses.

RESULTS

The study cohort comprised 49 patients, including 24 males and 25 females, with a mean age of 59.7 years (range: 36-84 years) (Table 1). The average pre-operative Visual Analogue Scale (VAS) score was 5.63 ± 2.1 , indicating a moderate level of pain. The American Shoulder and Elbow Score (ASES) improved significantly from an average pre-operative score of 39.78 ± 16.49 to a post-operative score of 93.56 ± 7.93 . After measuring on the bony structures on X-ray (AP View), the average preoperative AHD was 8.03 ± 2.05 mm.

During arthroscopic examination, CAL degeneration was categorized as follows: grade I (n=18), grade II (n=16), and grade III (n=15). Patients with grade III CAL degeneration had a significantly smaller preoperative acromiohumeral distance (AHD) compared to grades I and II (8.03 ± 2.05 mm; *P* = .0003). Furthermore, the preoperative VAS score was notably higher in grade III patients compared to grades I and II (*P* = .0019), indicating more severe shoulder pain in this group. Spearman analysis revealed no correlation between the degree of CAL degeneration and Goutallier classification for fatty infiltration of the rotator cuff on MRI (*P* > .05). This finding suggests that CAL degeneration is not directly associated with the degree of fatty infiltration in the rotator cuff.

In order to find out if acromioplasty could make any difference in different situation of CAL, patients of different CAL degenerated grades were further randomized into two groups (Group A and Group B), as shown in the table below (Table 2). For the 15 patients of CAL grade III, the increased ASES between the two years of Group A was significantly higher than Group B (P = .032, P < .05), meaning a better shoulder function improvement after receiving acromioplasty. But for patients of grade II and grade I (lighter degeneration groups), there was no significant difference between acromioplasty and non-acromioplasty groups (P > .05).

DISCUSSION

Shoulder pain is a common issue, with an estimated prevalence ranging from 4% to 26%¹⁴ The most common cause

Table 1. Basic information of patients

Criteria	Total	
Number of patients	49	
Age	59.7±10.22	
Gender (n)		
Female	25	
Male	24	
Side (n)		
Right	27	
Left	22	

 Table 2. Number of patients randomized into different groups

Group \ CAL	I (n=18)	II (n=16)	III (n=15) ^a
A (acromioplasty)	8	7	7
B (no acromioplasty)	10	9	8

 $^{a}P < .05$

Figure 3. (a) The preoperative AHD was the lowest in group III, compared with other groups. (b) VAS score was significantly higher than the other 2 groups preoperatively.



is shoulder impingement syndrome, reflecting a problem with the rotator cuff or subacromial bursa.¹⁵ The pathological mechanism is a structural narrowing in the subacromial space.¹⁶ Patients with shoulder impingement syndrome suffer from painful entrapment of soft tissue whenever they elevate the arm. Until now, many methods are used to classify acromial morphology,¹⁷⁻¹⁹ such as Bigliani classification, the modified Epstein classification and the acromial angle classification. In 1986 Bigliani et al described a classification method that qualitatively distinguishes the acromial morphology. The Bigliani classification is the most commonly used, but it has been reported with varying interobserver reliability with kappa (κ) between 0.25 and 0.52.²⁰⁻²² Subsequent attempts to find a reliable classification method of the acromial morphology have been made by Toivonen et al, who introduced the acromial angle classification in 1995 as a quantitative method of studying the acromial morphology.²³ The acromial angle classification divides the morphology of the acromion into 3 categories and has shown moderate to good reliability. Epstein introduced another classification method in 1993, which was later modified by Stehle et al into the 'modified Epstein classification.¹⁷

The incidence of partial-thickness rotator cuff tears (PT-RCTs) is higher than that of full-thickness rotator cuff tears (FT-RCTs) and may be the cause of unexplained shoulder pain.²⁴ PT-RCTs, which are classified arthroscopically according to localization and the depth of the tear, can be on the articular surface, on the bursal face, or intratendinous. Bursal-sided tears are thought to be caused by subacromial impingement and are more painful than articular-sided

tears.²⁵ Bursal- or articular-sided tears with a depth <3 mm are classified as grade 1, tears with a depth of 3 to 6 mm as grade 2, and tears with a depth >6 mm (>50% of tendon thickness) as grade 3.²⁶ Sometimes acromioplasty or arthroscopic debridement treatments fail in high-grade tears, repair methods such as trans tendon repair, tear completion and repair, and transosseous repair give better results.²⁷ There is a lack of consensus about whether arthroscopic debridement or repair is the best treatment option for Ellman grade 2 tears. Since the mechanism of bursal-sided tears is thought to be due to subacromial impingement, acromioplasty is generally performed for the treatment.

Implications of CAL Degeneration

The coracoacromial ligament extends inferomedially from the inferior anterolateral surface of acromion to the lateral border of coracoid process.8 It has been described in terms of its location at the glenohumeral joint and its role in shoulder pathology.^{28,29} Together with the acromion's inferior aspect and the scapula's coracoid process, the CAL forms the coracoacromial arch that limits superior displacement of the humeral head from the glenoid. Preliminary biomechanical data have shown the CAL to be a dynamic transmitting brace between the coracoid process and acromion rather than a static restraint to superior humeral migration, which plays an important role in shoulder biomechanics. However, little is known concerning about the detailed relationship between CAL degeneration and shoulder impairment. Some researchers reported that CAL degeneration was more severe in anterosuperior-type massive rotator cuff tears. The severity of CAL degeneration did not affect the retear rate of the supraspinatus tendon.³⁰ Some clinical studies also suggest that sacrificing CAL could lead to shoulder instability, calling into question the benefits of acromioplasty.^{31,32} Unlike previous studies that focused on maintaining shoulder stability, our research uniquely demonstrates the role of CAL in shoulder pain and impingement. In this study, we aimed to find out the relationship between CAL and subacromial impingement. Current data in this study showed that the subacromial space was closely related with CAL degeneration. The more severe CAL degenerated, the smaller AHD was on X-ray. This further proved that CAL rupture was a sign of shoulder impingement. Also our results indicated that the VAS was higher in severe CAL leision group (group III, heavy CAL fraying or visualization of the bare bone), compared with the grade I and grade II groups, meaning that CAL act as a pain generator of shoulder and dealing with CAL during surgery might improve the shoulder function, which is meaningful for future diagnosis and treatment.

Role of Acromioplasty in Shoulder Impingement

Acromioplasty is a surgical procedure in which the subacromial space is decompressed, and the mechanical pressure on the rotator cuff was relieved at the same time.^{33,34} Ellman first described an arthroscopic acromioplasty, which is commonly performed during rotator cuff repair to reduce

external impingement, but its effectiveness is controversial.35-37 Several randomized studies have demonstrated negligible benefits with acromioplasty performed alongside rotator cuff repair, with no significant differences in either patientreported outcome scores or retear rates.³⁹ Some researchers have reported that the presence of type 2 or 3 acromion in preoperative planning in >80% of the patients and symptoms related to impingement or subacromial bursitis in physical examination indicate acromioplasty.³⁸ Our findings regarding the relationship between CAL degeneration and shoulder impingement align with this study but provide new insights into a more appropriate indicator. In this study, we aimed to explore the results and prove that the acromioplasty could make a difference for patients with highly degenerated CAL (grade III), since the III° degeneration indicated severe impingement according to the results in the former part which may guide the future diagnosis and treatment of shoulder impingement. But for slightly degenerated CAL such as grade I and grade II, little difference was seen between Group A and Group B, but we can still perform acromioplasty in avoid of development. However, some researchers have reported that acromioplasty with coracoacromial (CA) ligament release may increase the instability in superior glenohumeral ligaments, which calls for further biomechanical and clinical study in the future.¹⁰

Study Limitations and Future Directions

This study has some limitations. First, we only included patients of bursal-side tears but didn't study the pattern of CAL in full-thickness or articular-side tears, which may cause some bias and need further study. What's more, the sample size of this study was limited. Future studies should investigate the pattern of CAL in full-thickness or articularside tears with larger sample size, to provide a more comprehensive understanding of shoulder dysfunction and improve the generalizability of our findings.

CONCLUSIONS

This study demonstrates that the degree of CAL degeneration is a significant indicator of shoulder impingement severity. We found that acromioplasty significantly improves outcomes in patients with advanced CAL degeneration, underscoring its critical role in treating shoulder impingement. The degree of CAL rupture, as evidenced by our study, should be considered a key factor in deciding whether to perform acromioplasty. Further studies are needed to validate the use of CAL degeneration degree as a decision-making tool for acromioplasty and to understand its long-term impacts on shoulder function.". In conclusion, our findings suggest that the assessment of CAL degeneration can significantly guide the surgical management of shoulder impingement, particularly in determining the need for acromioplasty.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Written consent was informed and obtained from the participants. This study was performed according to the Declaration of Helsinki. Approval was granted by the Ethics Committee of Peking University People's Hospital (2021PHB233).

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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AUTHORS' CONTRIBUTIONS

Yichong Zhang and Yan Zhang contributed equally to this work. Yichong Zhang and Jianhai Chen designed the conception and study. Acquisition and analysis of data was performed by Mingtai Ma. Yichong Zhang and Yan Zhang drafted and revised the article critically for important intellectual content. Jianhai Chen and Yan Zhang approved the final version to be submitted. All authors have approved the final article.

CONFLICTS OF INTEREST

The authors declare no potential financial or non-financial conflicts of interest.

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