Original Article

The Angular Relationships Between the Coracohumeral Ligament and Adjacent Shoulder Structures Are Variable

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Purpose: To describe the arthroscopic anatomy of the coracohumeral ligament (CHL) in relation to visible anatomic reference points to aid in the execution of a more effective arthroscopic medial-lateral rotator interval closure. **Methods:** Detailed dissection to identify the CHL was performed in 4 shoulders from 2 fresh-frozen donor cadavers with a deltopectoral approach. The angular relationship between the CHL and the superior border of the subscapularis tendon was determined via gross dissection. Arthroscopic images were used to determine the angular position of the CHL in relation to both the glenoid articular surface and the intraarticular segment of the tendon of the long head of the biceps brachii (LHB). **Results:** Analysis of 4 cadaveric shoulders via gross dissection demonstrated the CHL to subtend a mean angle of 29° (range 16° to 39°) with respect to the superior border of the subscapularis tendon. Arthroscopic analysis of 4 cadaveric shoulders demonstrated the CHL to subtend a mean angle of 59° (range 38° to 77°) with respect to the glenoid articular surface. Additionally, arthroscopic analysis of 2 cadaveric shoulders demonstrated the CHL to subtend a mean angle of 29° (range 11° to 47°) with respect to the LHB tendon. **Conclusion:** Although the position of the CHL in relation to the subscapularis tendon, glenoid articular surface, and LHB tendon demonstrates a moderate degree of anatomic variability, these structures provide valuable anatomic reference points for the identification of the course of this significant static shoulder stabilizer. **Clinical Relevance:** Comprehensive understanding of the angular relationships between the CHL and adjacent shoulder structures may assist with the execution of a more effective arthroscopic rotator interval closure.

The rotator interval (RI), the triangular region of the shoulder capsule between the supraspinatus and subscapularis tendons, is the anatomic location of the coracohumeral ligament (CHL) and superior glenohumeral ligament (SGHL). First described by DePalma[1] in 1983 as a dense fibrous structure extending from the coracoid base to the greater and lesser tuberosities near the bicipital groove, the CHL has since been studied for its role in glenohumeral joint instability. Specifically, the CHL has been described as a check-rein limiting glenohumeral excursion in extremes of forward elevation and external rotation.[2] Further, its suspensory function restrains anterior and inferior translation, providing static stability to the glenohumeral joint.[3] As a result, RI closures are often incorporated in soft tissue repairs to address shoulder instability.[4-9]

Open and arthroscopic suture techniques have been described that differ fundamentally with respect to the direction of closure and the degree to which the CHL is shortened. Several modern arthroscopic techniques for rotator interval closure are performed in the superior-inferior direction.[5-9] However, these techniques have failed to reproduce the beneficial results of open medial-lateral CHL imbrication.[10] Anatomic studies have shown that the CHL traverses the rotator interval from medial to lateral and suggest that any gainful shortening of this ligament to augment shoulder

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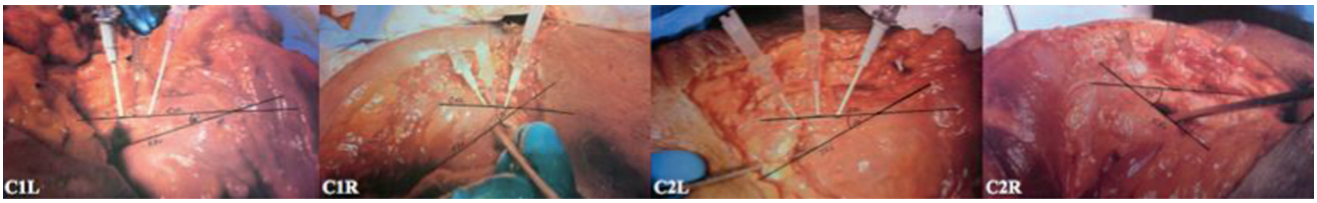


C1L = Cadaver 1 Left Shoulder; C1R = Cadaver 1 Right Shoulder; C2L = Cadaver 2 Left Shoulder; C2R = Cadaver 2 Right Shoulder

Fig 1. Angular relationship between the coracohumeral ligament (CHL) and subscapularis via gross dissection.

stability is only attained when tissues are imbricated in this direction.[11-14] Detailed knowledge of these intra-articular relationships should affect a true arthroscopic shortening of the CHL with results comparable to that of open medial-lateral CHL imbrications without the morbidity associated with open procedures. Therefore, the purpose of this morphological cadaveric study is to describe the arthroscopic anatomy of the CHL in relation to visible anatomic reference points to aid in the execution of a more effective arthroscopic medial-lateral rotator interval closure. We hypothesized a medial-lateral vector of the CHL with similar angular relationship to both the biceps and subscapularis tendons.

Methods

This morphologic analysis was exempt from institutional review board approval given the basic science cadaveric design. Four cadaveric shoulders from 2 fresh-frozen donor cadavers were analyzed. Detailed dissection to identify the CHL was performed with a deltopectoral approach, with the cadaveric shoulder in the supine position. Three 18-gauge spinal needles were placed into the glenohumeral joint through the CHL in 2-mm increments. The angular relationship between the CHL and the superior border of the subscapularis tendon was determined via gross dissection.

The shoulders were then placed in the lateral decubitus position in 45° abduction and 20° forward flexion. The intraarticular aspect of the glenohumeral joint was viewed arthroscopically with use of a routine posterior arthroscopic portal placed inferior and medial to the posterolateral edge of the acromion. The intra-articular course of the CHL, localized by spinal needles, was then clearly visualized arthroscopically. Arthroscopic images were taken to identify the intraarticular course of the CHL. The camera and light source were positioned consistent with the anatomic position of the glenohumeral joint as the patient lay in the lateral decubitus position. The arthroscopic images were then used to determine the angular position of the CHL in relation to the glenoid articular surface and the intraarticular segment of both the LHB and subscapularis tendons. All measurements were performed using a protractor on the printed images as depicted in Figs 1 and 2. All angular relationships were determined and recorded in this manner.

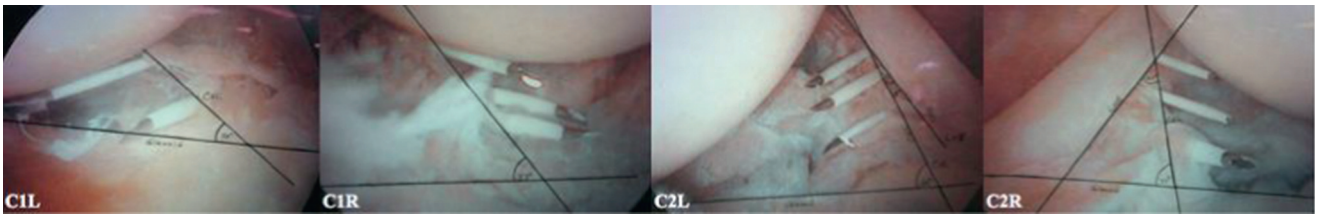
Results

Four cadaveric shoulders from 2 fresh-frozen donor cadavers were included for analysis. All angular relationships identified between the CHL and the superior border of the subscapularis tendon, the glenoid articular surface, and the LHB tendon in each of the cadaveric specimens are depicted in Table 1. Analysis of 4 cadaveric shoulders via gross dissection demonstrated the CHL to subtend a mean angle of 29° (range 16° to 39°) with respect to the superior border of the subscapularis tendon (Fig 1). Arthroscopic analysis of 4 cadaveric shoulders demonstrated the CHL to subtend a mean angle of 59° (range 38° to 77°) with respect to the glenoid articular surface (Fig 2). Additionally, arthroscopic analysis of 2 cadaveric shoulders demonstrated the CHL to subtend a mean angle of 29° (range 11° to 47°) with respect to the LHB tendon (Fig 2).

Discussion

In this quantitative morphologic analysis of 4 cadaveric shoulders, we demonstrated the CHL to subtend a mean angle of 29° with respect to the superior border of the subscapularis tendon. Additional arthroscopic analysis demonstrated the CHL to subtend a mean angle of 59° with respect to the glenoid articular surface and a mean angle of 29° with respect to the LHB tendon. Comprehensive understanding of the angular relationships between the CHL and adjacent shoulder structures may assist with the execution of a more effective arthroscopic rotator interval closure. Rather than merely narrowing the rotator interval space with a superior-inferior arthroscopic closure, which does little to affect the length of the CHL, a direct medial-lateral CHL imbrication should confer the mechanical benefits previously reported with open medial-lateral CHL shortening procedures.[4,15]

The role of the rotator interval in shoulder stability has long been a topic of clinical study. In their biomechanical model of 8 fresh-frozen cadaveric shoulders, Harryman et al.[4] reported that open sectioning of the capsular interval increased humeral external rotation,



C1L = Cadaver 1 Left Shoulder; C1R = Cadaver 1 Right Shoulder; C2L = Cadaver 2 Left Shoulder; C2R = Cadaver 2 Right Shoulder

Fig 2. Angular relationship between the coracohumeral ligament (CHL), glenoid surface, and long head of the biceps via arthroscopic imaging.

adduction, flexion, extension, and obligate anterior translation during flexion. In addition, medial-lateral imbrication of the RI capsule improved posterior and inferior instability. In another cadaveric model, Itoi et al.[15] evaluated axial humeral translation following a fixed superior-inferior translational force with the joint capsule under various conditions: intact, vented, CHL sectioned, and RI capsule incised. With the arm in internal and neutral rotations, capsular venting affected superior-inferior translation; however, CHL sectioning and RI capsular incision did not. Further, whereas CHL sectioning affected both inferior and superior stability with the arm in external rotation, RI capsular incision influenced only superior stability. Kuhn et al.[16] demonstrated a similar contribution of the CHL to glenohumeral stability with the arm in abduction and external rotation in their biomechanical evaluation of 20 cadaveric shoulders. The authors demonstrated that isolated sectioning of the CHL resulted in the greatest degree of external rotation instability compared with the isolated sectioning of the superior, middle, and anterior band of the inferior glenohumeral ligaments. Additionally, Wolf et al.[17] reported that RI closure appeared to decrease glenohumeral laxity in all tested directions, inferior in particular, at a greater degree than thermal capsulorrhaphy.

Several studies have investigated the utility of arthroscopic RI closure in the setting of shoulder instability to supplement select stabilization procedures.[5,6,8,9] Van der Reis and Wolf[18] described arthroscopic closure of the deep capsular layer within the rotator cuff interval from the SGHL to the middle glenohumeral ligament (MGHL) to supplement arthroscopic capsulolabral reconstruction. This technique caused visible MGHL and inferior glenohumeral ligament (IGHL) superior shifting and anterosuperior capsular imbrication, resulting in a statistically significant decrease in humeral elevation, extension, and external rotation. Although previous techniques required RI closure viewing from the subacromial space, Gartsman et al.[19] reported on interval closure under direct intraarticular visualization with subsequent extra-articular knot tying. Subsequently, Taverna et al.[20] advocated for a 3-step all-inside technique to permit direct intraarticular visualization for RI capsular tightening and knot tying.

Regardless of the technique used, these arthroscopic RI closure techniques share an inherent limitation in that each was performed in the superior-inferior direction, in contrast to the open medial-lateral rotator interval closure initially described by Harryman et al.[4] Further, arthroscopic closure involves a shift of the MGHL, which may not affect CHL tension.

Despite the variety of surgical techniques described in the literature, arthroscopic RI closures have failed to reproduce the results realized via open CHL imbrication.[10] As a result, concerns have been raised regarding the application of arthroscopic RI closure. In particular, superior-inferior imbrication is felt to produce different stabilizing effects compared with an open medial-lateral rotator interval imbrication. Provencher et al.[7] explored these differences in 14 fresh-frozen cadaveric shoulders. Both the open and arthroscopic techniques resulted in a significant loss of external rotation;

Table 1. Angular relationship between the CHL, subscapularis tendon, glenoid articular surface, and LHB tendon

Specimen	Image	Angle	Result	Image	Angle	Result	Image	Angle	Result
C1L	Gross	CHL-SSc	16°	Arthroscopic	CHL-GAS	38°	Arthroscopic	CHL-LHB	NR
C1R	Gross	CHL-SSc	39°	Arthroscopic	CHL-GAS	53°	Arthroscopic	CHL-LHB	NR
C2L	Gross	CHL-SSc	26°	Arthroscopic	CHL-GAS	68°	Arthroscopic	CHL-LHB	11°
C2R	Gross	CHL-SSc	35°	Arthroscopic	CHL-GAS	77°	Arthroscopic	CHL-LHB	47°
Mean angle			29°			59°			29°

C1L, cadaver 1 left shoulder; C1R, cadaver 1 right shoulder; C2L, cadaver 2 left shoulder; C2R, cadaver 2 right shoulder; CHL, coracohumeral ligament; GAS, glenoid articular surface; LHB, long head of the biceps; NR, not recorded; SSc, subscapularis tendon.

however, posterior instability persisted in both scenarios. Anterior stability was improved with the arm in neutral position with the open technique, whereas the arthroscopic technique resulted in improved anterior stability with the arm in abduction. However, sulcus stability appeared to improve only via the open technique. In a cadaveric multidirectional instability model of 8 match-paired specimens, Farber et al.[10] found that medial-lateral RI closure restored range of motion to the intact state better than superior-inferior closure. Additionally, compared with superior-inferior closure, medial-lateral closure significantly decreased posterior translation with the arm positioned in abduction and external rotation.

The above findings reinforce the concern that many open and arthroscopic closures are fundamentally different from one another. The CHL has been shown to cross the RI from medial to lateral in multiple anatomic studies, suggesting that shortening this ligament to augment shoulder stability is attained only when the RI is imbricated in this direction.[11-14] Because superior-inferior closure techniques do not effectively shorten the course of the CHL, it is unlikely that any variation of this technique will reproduce the positive results of open medial-lateral RI imbrication.

This study aims to provide orthopaedic surgeons with a reliable method to arthroscopically identify the course of the CHL. Our results indicate that a surgeon can approximate the course of the CHL arthroscopically using the angular relationships between the CHL and subscapularis tendon (29°), glenoid articular surface (59°), and LHB tendon (29°). With accurate arthroscopic localization of the CHL, surgeons may reliably proceed with arthroscopic medial-lateral RI closures as an alternative to the more commonly performed superior-inferior RI closures. This change in technique should affect a true shortening of the CHL, thus reproducing the favorable results reported with open medial-lateral CHL imbrications without the associated morbidity of an open procedure. However, future clinical studies are warranted to confirm the clinical efficacy of performing arthroscopic medial-lateral RI closures as a component of the surgical management of recurrent shoulder instability.

Limitations

In consideration of the accurate interpretation of study results, limitations of this study warrant attention. First, the sample size is small, so the measured relationships between the CHL and subscapularis tendon, glenoid articular surface, and LHB tendon may be subject to type II error. In addition, the use of fresh frozen cadaveric specimens may result in some degree of inaccuracy owing to the difference in appearance of soft tissues of cadaveric shoulders compared with the shoulders of living patients.

Conclusion

Although the position of the CHL in relation to the subscapularis tendon, glenoid articular surface and LHB tendon demonstrates a moderate degree of anatomic variability, these structures provide valuable anatomic reference points for the identification of the course of this significant static shoulder stabilizer.

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