# Relation between Narrowed Coracohumeral Distance and Subscapularis Tears

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## ABSTRACT

**Purpose:** The Purpose of this study is to detect differences between the values of dynamic coracohumeral distance (CHD) measured using ultrasonography (USG) in different shoulder rotations and to investigate its correlation with subscapularis tear.

**Methods:**We prospectively enrolled consecutive patients (n = 84) who were scheduled to have arthroscopic rotator cuff repair. Patients with a history of previous shoulder surgery or shoulder fracture and patients with external rotation less than 30 were excluded from the study. Dynamic coracohumeral distance was measured utilizing ultrasonography in 3 different shoulder positions: external rotation, neutral and internal rotation. We assessed the intrarater reliability with 3 times repetition of measurement. Patients were divided into one of 3 groups according to arthroscopic findings: intact subscapularis, partial-thickness tear, and full-thickness tear of the subscapularis. The control group (n = 12) included patients without rotator cuff tears from the outpatient clinic. Subgroup analysis according to the presence of dynamic subcoracoid stenosis, defined as a coracohumeral distance less than 6 mm measured in internal rotation was performed to find the clinical effect of dynamic subcoracoid stenosis.

**Results:**A partial-thickness tear of the subscapularis tendon was present in 30 patients (35.7%) and a full-thickness tear in 13 patients (15.5%) among 84 patients. The CHD was maximum in external rotation and the narrowest in internal rotation. There were no statistical differences in the CHDs between groups with different subscapularis tear status. According to the presence of dynamic subcoracoid stenosis, patients with dynamic subcoracoid stenosis had a significantly higher incidence of partial-thickness subscapularis tear than those without stenosis (P = 0.018).

**Conclusions:** The coracohumeral distance values were narrowest in shoulder internal rotation, which is thought to be the pathogenic position. We could not confirm the correlation between coracohumeral distance and subscapularis tear. However, patients who have dynamic subcoracoid stenosis had significantly higher incidence of subscapularis tear than others without dynamic stenosis.

**Keywords:** Coracohumeral Distance, Subcoracoid Stenosis, Subscapularis Tears.

## INTRODUCTION

Numerous authors have described the frequency of the subscapularis tears to be higher than previously thought [(1-3)], so subscapularis tears have lately become a focus of clinical practice and research. In an effort to explain the etiology of subscapularis tears, studies have examined if subcoracoid stenosis, an interval of less than 6 mm between the coracoids and humeral head [(4, 5)], is related to partial- or full-thickness tears of the subscapularis tendon [(5, 6)]. Several authors have used computed tomography or magnetic resonance imaging (MRI) to evaluate the coracohumeral distance (CHD) [(6, 7)]. Nonetheless, impingement is a dynamic procedure, and symptoms of subcoracoid impingement comprise pain in the anterior shoulder, particularly in forward flexion and internal rotation [(1)]. Consequently, measuring CHD utilizing static imaging modalities, for instance computed tomography or MRI, could be limited when bearing in mind the pathogenic nature of subscapularis tear [(8)]; though, measuring dynamic CHD using ultrasonography (USG) may reflect the actual subcoracoid stenosis procedure.

The present study designed to:

- detect differences between the values of dynamic CHD measured using USG in different shoulder rotations investigate its correlation with subscapularis tears. The hypothesis was that the dynamic CHD measured using USG varies along with the shoulder rotation and would be inversely proportional to the likelihood of subscapularis tears.

## METHODS

From April 2016 to February 2017, we prospectively enrolled 84 consecutive patients who met the following inclusion criteria without randomization: (1) had rotator cuff tear verified through preoperative MRI and (2) were scheduled to undergo arthroscopic rotator cuff repair. Exclusion criteria from the study were a history of rotator cuff surgery; a passive external rotation less than 30 with the arm at the patient’s side, as this was the only significant limiting factor for the



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adequate positioning of dynamic CHD measurement; current anterior shoulder instability or a history of surgery for anterior shoulder instability; a history of shoulder fracture; and systemic inflammatory disease, such as rheumatoid arthritis. For the prospective study design, we enrolled patients consecutively from the first patient until we got at least 10 patients in a group with full-thickness subscapularis tears, to have a total of 84 patients with rotator cuff tears. For the control group, we enrolled 12 patients having shoulder pain from the outpatient clinic who did not have rotator cuff tear based on the same exclusion criteria during the same period. We obtained the institutional review board approval for the study protocol, and all patients gave informed consent. The prospectively collected data, including medical records and imaging data, were analyzed. The shortest distance between the tip of the coracoid process and the humeral head was measured at the time of the patient examination using electronic cursors. The measurement was repeated 3 times on different images with repositioning of arm to neutral position during an interval of 5 to 10 seconds in each position by the same radiologist, and the mean value of the 3 measurements was used for the calculation of CHD in each position. The CHD on the MRI axial image was also measured using the technique described by **Tan *et al.*** [9] and the distance was measured with the narrowest subcoracoid distance from the cortical margin of the coracoid process to that of the humeral head. The CHD on the MRI axial image was compared with the values of ultrasonographic measurements in each position. To show the differences of subscapularis status in a setting of dynamic situation, we defined the dynamic subcoracoid stenosis as the CHD measured with the shoulder in internal rotation (CHD-IR) less than 6 mm according to the suggested coracoplasty indication of Lo and Burkhart[4].

All statistical analyses were performed with SPSS 12.0 (SPSS, Chicago, IL), and a P value of less than 0.05 was taken as the level of statistical significance. Intraclass correlation coefficients (ICCs) were used to determine the intrarater reliability of the measures and compare the measured values of the 2 different imaging modalities (USG vs MRI) and the 95% confidence intervals (CIs) for these values were also calculated [10-12]. Student t test was used to compare CHDs between men and women and Kruskal-Wallis test was used for comparison of CHDs between different age groups. Repeated measure analysis of variance was used to compare the mean values of CHDs measured 3 times each in 3 different shoulder positions. Analysis of variance and Kruskal-Wallis test were used to compare the CHDs between the groups with and without subscapularis tears. Mann Whitney U test was used for age- and gender-matched comparison between patients with atraumatic rotator cuff tears involving full-thickness tear of subscapularis and patients having atraumatic rotator cuff tears with intact subscapularis. Fisher exact test was used to compare the incidence of subscapularis tears between groups with and without dynamic subcoracoid stenosis.

**The study was done according to the ethical board of King Abdulaziz university.**

## RESULTS

Table 1 shows patients' demographic data and operative findings. The mean value of range of motion in external rotation was 68.4 degree with a SD of 18.2 degree, and the mean value in internal rotation was 8.7±3.7 (the level of the spinous process of the vertebrae; smaller outcome means greater range of motion: 1 to 12, thoracic vertebrae; 13 to 17, lumbar vertebrae; 18, sacrum). A partial-thickness tear of the subscapularis tendon was present in 30 patients (35.7%) and a full-thickness tear in 13 patients (15.5%) among 84 patients who had rotator cuff repair surgery. The mean ages of patients in groups B (partial-thickness subscapularis tear) and C (full-thickness subscapularis tear) were statistically higher than patients in group A with intact subscapularis, but there was no significant difference in the gender ratio between 3 groups. There were significantly more patients with previous trauma history in group C than in other groups.

**Table 1.** Demographic Data and Operative Findings of Patients

| Characteristic | Group A | Group B | Group C | Control | P Value |
|---|---|---|---|---|---|
| Number of patients | 41 | 30 | 13 | 12 | - |
| Mean age | 56.5 | 62.5 | 63.4 | 51.5 | < .001 |
| Gender | | | | | |
| Male | 19 | 10 | 6 | 7 | 0.78 |
| Female | 22 | 20 | 7 | 5 | |
| Trauma history | | | | | |
| Yes | 36 | 28 | 6 | | < .001 |
| No | 5 | 2 | 7 | | |

All calculated ICCs for repeat CHD measurements of the study groups in each shoulder position were higher than 0.90, indicating excellent intrarater reliability of the USG measurements. Consistent with repeat measurements, there were significant differences in CHDs measured in different shoulder positions (P < .0001).

The CHD in external rotation was the widest, followed by CHD in neutral rotation; the CHD in internal rotation was the narrowest. We similarly found good correlation between the CHDs measured using MRI and those measured using USG in the neutral rotation (ICC = 0.779, 95% CI = 0.699 to 0.829), however we found only moderate correlation between CHD measured on MRI and those measured with USG in internal rotation (ICC = 0.595, 95% CI = 0.498 to 0.701).

Even though there was a significant decrease in CHD in female patients than in male patients in all positions (P < .0001 for external rotation, P < .0001 for neutral rotation, and P = .003 for internal rotation; Table 2), there was no significant difference in the CHD between different age groups (P = .199 for external rotation, P = .089 for neutral rotation, and P = .191 for internal rotation).

**Table 2.** The Dynamic CHDs of the Male and Female Patients According to Different Shoulder Rotations in Patients With Rotator Cuff Tears

| Dynamic CHD | Male | Female | P Value |
|---|---|---|---|
| CHD in ER (mm) | 12.3± 2.4 | 11.3 ±2.1 | < .0001 |
| CHD in NR (mm) | 11.1± 2.1 | 9.7± 1.9 | < .0001 |
| CHD in IR (mm) | 9.5 ±2.67 | 8.5 ±2.4 | .003 |

Table 3 shows the CHD of control and each subgroup, and there was no significant difference in the CHD among groups A, B, and C (P = 0.309 for external rotation, P = 0.277 for neutral rotation, and P = 0.291 for internal rotation). The CHDs of the control group in external rotation and neutral rotation were significantly larger than those of the study groups (P = 0.001 and 0.003, respectively); nevertheless, there was no significant difference in the CHD-IR between the study and control groups (P = 0.387).

As shown in Table 1, there was a significant difference in age between the study groups and a control group and there was no significant difference in gender ratio between groups. For subgroup analysis to exclude the effect of trauma, there was no significant difference in the CHD in all shoulder positions between patients with atraumatic fullthickness tear of subscapularis and patients without subscapularis tear.

**Table 3.** The Dynamic CHDs According to Different Shoulder Rotations Measured by Ultrasonography and the CHD Measured on MRI

| Dynamic CHD | Control | Group A | Group B | Group C | P Value |
|---|---|---|---|---|---|
| CHD in ER (mm) | 3.8 ±2.0 (13.7) | 2.1± 2.3 (11.7) | 1.5± 2.2 (11.4) | 1.5 ±2.5 (10.9) | .001 |
| CHD in NR (mm) | 12.0 ±2.3 | 10.2 ±2.08 | 10.0± 1.92 | 10.0± 2.6 | .003 |
| CHD in IR (mm) | 8.7± 2.3 9 | 9.2 ±2.2 8 | 8.6 ±2.72 | 8.5±2.3 | .387 |
| CHD on MRI (mm) | - | 10.1 ±2.45 | 9.9± 2.05 | 9.1 ±2.8 | .292 |

Under the definition of dynamic subcoracoid stenosis (less than 6 mm of CHD-IR), we divided patients into 2 groups and analyzed the data. There was a significant difference in the incidence of subscapularis tear including partial- and full-thickness tears according to the presence of dynamic subcoracoid stenosis (P = .018): patients with dynamic subcoracoid stenosis had a higher incidence of partial-thickness tear of subscapularis (62.5%) than those without subcoracoid stenosis (32.9%).

Of the 84 patients without dynamic subcoracoid stenosis, 40 (52.7%) had an intact subscapularis, whereas only 2 with dynamic subcoracoid stenosis had an intact subscapularis.

## DISCUSSION

No significant correlation between subcoracoid stenosis and subscapularis tears was found. The CHD varies significantly according to the shoulder rotation; it was widest in external rotation and narrowest in flexion/adduction/internal rotation. Although we could not show any correlation between the subcoracoid stenosis and subscapularis tear, there was a significant increase in the frequency of subscapularis tears in patients with dynamic subcoracoid stenosis defined as a CHD-IR less than 6 mm measured by USG.

The CHD changes according to shoulder rotations confirm the results of previous studies that showed that the CHD significantly decreased with increasing internal rotation [1, 13]. The CHD measured using USG in neutral rotation had good correlation with CHD on MRI, and this reflects the validity of ultrasonographic evaluation. Nevertheless, the CHD measured in shoulder internal rotation only moderately correlated with the CHD on MRI, and so the dynamic measurement of CHD using USG could represent an assured pathology that cannot be confirmed with static imaging modalities. There were no significant differences in the CHD regarding the tear status of subscapularis tendon amid groups with rotator cuff tears. Consequently, we could not display any correlation between the subcoracoid stenosis and subscapularis tear. Even though the CHDs of the control group in external rotation and neutral rotation were significantly larger than those of the study groups, there was no significant difference in the CHD-IR amid the study groups and the control group (P = 0.387). As there was no significant difference in the CHD measured in pathogenetic position within the study groups and control group, this outcome likewise supports our data that there might be no significant correlation between the subcoracoid stenosis and subscapularis tear. Subgroup analysis to exclude the effect of traumatic causes correspondingly echoes these outcomes. Though, there was a significant increase in the incidence of subscapularis tears in patients with dynamic subcoracoid stenosis defined as a CHD-IR less than 6 mm measured by USG. This recommends that coracoplasty might be confined to patients of subscapularis tear with dynamic subcoracoid stenosis.

Numerous authors have examined the correlation between subcoracoid stenosis and subscapularis tear using static imaging modalities, for instance MRI and computed tomography, and this correlation remains inconclusive. Some researchers [(8)] recommend that future studies utilizing dynamic imaging modality are required to assess this correlation more precisely. Therefore, we intended the current study to measure the dynamic CHD reflecting an actual situation utilizing USG. Based on our data, the dynamic CHD measurement using USG in each shoulder position had excellent intrarater reliability when applied to the detection of dynamic subcoracoid stenosis. Through the correlation analysis with CHD measured by axial image of MRI and by USG in neutral rotation, we recognized the diagnostic validity of ultrasonographic measurement for this purpose. Nonetheless, the degree of this correlation with MRI was reduced in the internal rotation position where most subcoracoid stenosis might happen [(1, 14)]. Since the fact that the CHD varied along with the shoulder rotation and the CHD in internal rotation with flexion and adduction was the narrowest in the present study, ultrasonographic assessment of dynamic CHD measurement is more consistent and reasonable than static assessment of CHD using MRI.

The progression of subacromial impingement from bursitis through to tendinopathy or tendon tear is a well-described cause of supraspinatus tendinopathy [(15)]. Though, the etiology of subscapularis tendinopathy or a tear is relatively unclear. A variation of mechanisms are involved: intrinsic tendon degeneration, trauma, and the extension of a supraspinatus tear through the rotator interval. Additionally, it can be postulated that subscapularis tears can happen secondary to attained subcoracoid impingement since subacromial impingement causing rotator cuff tears, while this is still controversial. **Lo and Burkhart [(6)]** recommended the correlation between narrowed coracohumeral space and partial- to full-thickness tears of the subscapularis tendon by a mechanism called the Roller-Wringer effect by which the coracoid procedure indents the superficial surface of the upper subscapularis tendon while stretching (tensile loading) the deep surface of the tendon during internal rotation of the shoulder. In their study, the mean CHD in patients with subscapularis tears was 5.0± 1.7 mm compared to 10.0± 1.3 mm in the control group. They stated subcoracoid stenosis as a coracohumeral interval of less than 6 mm. **Friedman et al.[(16)]** likewise defined a significant decrease in the normal space among the humeral head and the coracoid process in symptomatic patients relative to a healthy population with kinematic MRI and shoulders positioned in maximal internal rotation. They stated that the average CHD in symptomatic patients was 5.5 mm, although the average CHD in asymptomatic patients was 11 mm. Lately, **Tracy *et al.* [(17)]** utilized USG in the dynamic measurement of CHD in patients with and without subcoracoid impingement. Nonetheless, they utilized only USG in the assessment of subscapularis tendon, and so it is not likely to determine a correlation between CHD and subscapularis tears as there were no subscapularis tears detected. Consequently, the dynamic measurement modality was assumed in the current study to reproduce and simulate the pathogenicity, and patients were subdivided according to the arthroscopic results of the subscapularis tendon.

In the current study, we failed to confirm any correlation between subcoracoid stenosis and partial or full thickness subscapularis tendon tears. The lack of correlation between subcoracoid narrowing and subscapularis tear questions whether there is a need for routine coracoplasty in all patients with subscapularis tear, particularly in patients without subcoracoid stenosis. Though, the frequency of partial-thickness subscapularis tear increases in patients with dynamic subcoracoid stenosis (CHD-IR<6 mm) notwithstanding small numbers of subscapularis tear patients in the current study. Additionally, the thickness of normal subscapularis tendon was reported to be 5.4 to 8.0 mm [18, 19], and this should also be taken into consideration. Consequently, subcoracoid stenosis might not be the only cause for subscapularis tears, but only a portion of them. Therefore, our data might support the view that coracoplasty ought to be considered in patients with subscapularis tear as a result of dynamic subcoracoid stenosis, which was defined as CHD-IR less than 6 mm, for the purpose of decompression only.

## CONCLUSIONS

The measured values of CHD were significantly different in terms of shoulder rotation, and were narrowest in the position of shoulder internal rotation deemed to be the pathogenic position. We could not confirm the correlation between CHD and subscapularis tear. Conversely, patients who have dynamic subcoracoid stenosis (CHD-IR less than 6 mm) had significantly higher incidence of subscapularis tear than others without dynamic stenosis.

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