



## Do coracohumeral interval and glenoid version play a role in subscapularis tears?

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**Purpose:** To study the effect of the coracohumeral interval and orientation of the glenoid for causation of subscapularis tears and literature review for the need of coracoplasty.

**Methods:** This is a retrospective cohort study of patients who underwent arthroscopic shoulder surgery from January 2013 to December 2017. The coracohumeral interval and orientation of the glenoid in patients with arthroscopically diagnosed subscapularis tears (group A, n = 40) were compared with 2 control groups (group B, n = 38 [intact subscapularis with supraspinatus and infraspinatus cuff tears] and group C, n = 39 [intact rotator cuff]). Group A1 (n = 23) consisted of the isolated subscapularis and combined subscapularis + supraspinatus tears, and group A2 (n = 17) all the 3 rotator cuff tears. The measurements were made on preoperative axial magnetic resonance imaging. Statistical analysis was performed to compare the groups.

**Results:** The mean coracohumeral interval was  $8.81 \pm 2.69$  mm in group A and  $10.62 \pm 2.21$  and  $10.39 \pm 2.59$  mm in control groups B and C, respectively; this difference was statistically significant ( $P = .002$  and  $.01$ , respectively). The mean glenoid version in patients with subscapularis tears was  $-3.7^\circ$ , whereas the mean version in patients with intact cuff was  $-3.4^\circ$ , and this difference was not statistically significant ( $P = .74$ ). The mean glenoid version was  $-4.69^\circ \pm 4.22^\circ$  in group A1 and  $-3.28^\circ \pm 4.04^\circ$  in group B, with no statistically significant difference ( $P = .07$ ).

**Conclusion:** The coracohumeral interval was significantly decreased in patients with subscapularis tears. The glenoid was retroverted in the subscapularis group but was not statistically significant.

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Rotator cuff tears are one of the most common pathologies affecting the shoulder joint occurring in approximately 20% of the general population.<sup>17,24</sup> Subscapularis injuries are comparatively rarer with cadaveric studies showing an incidence between 3% and 13%.<sup>18</sup> Arthroscopic examination of clinically symptomatic patients with rotator cuff tears identified subscapularis tendon pathology in 6.5%–28% of the cases.<sup>20,21</sup> When open rotator cuff repair was more prevalent, subscapularis tears, especially articular surface tears, were either missed, neglected, or treated conservatively, leading to compromised results. With the advancement of arthroscopic

techniques and a better understanding of arthroscopic and native subscapularis anatomy and its biomechanics, there is an increased interest in appropriate management of subscapularis tears.<sup>7,26</sup> The etiology of these tears has been considered to be multifactorial, which includes intrinsic, extrinsic, and traumatic causes.<sup>2</sup>

Among the extrinsic factors, scapular morphology has been considered to play a role in rotator cuff tears.<sup>22</sup> A reduced subcoracoid space (leading to stenosis and impingement) and the orientation of glenoid have been attributed with subscapularis tears.<sup>13,14</sup> However, the role of both these parameters in subscapularis tears has not been conclusively proven with studies for and against the same. The normal coracohumeral interval (CHI) was measured to be 8.7–11 mm.<sup>9,10</sup> Richards et al<sup>25</sup> demonstrated a significant relationship between a narrow CHI and subscapularis tears, whereas Balke et al<sup>2</sup> and Tollemar et al<sup>32</sup> did not find any significant association between traumatic subscapularis tears and

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the CHI. Concerning glenoid version (GV), Tétreault et al.<sup>30</sup> demonstrated a significant relationship between anterior rotator cuff tears (subscapularis with or without supraspinatus tears) and a retroverted glenoid and vice versa for the posterior rotator cuff tears. However, subsequent imaging and cadaveric comparative studies did not reveal any significant relationship between the GV and rotator cuff pathology.<sup>8,15</sup> To our knowledge, the role of both parameters has not been simultaneously studied in comparison with different types of rotator cuff tears. Our study aimed to compare the effect of both CHI and GV on subscapularis tears in 3 different groups of patients and discuss the review of literature for coracoplasty in patients with subcoracoid stenosis. We hypothesized that the CHI would be reduced and the glenoid would be more retroverted in subscapularis tears as compared with those with an intact subscapularis.

## Materials and methods

This is a retrospective cohort study where patients who underwent arthroscopic shoulder surgery from January 2013 to December 2017 were considered. Patients with subscapularis rotator cuff tears were considered as the subjects, and patients with rotator cuff tears without subscapularis tears and normal rotator cuffs were considered as controls and are included for this study. Our exclusion criteria were patients without a standardized magnetic resonance imaging (MRI), MRIs that were not available in our institutional PACS system (Picture Archiving and Communication System), or whose MRI was of poor quality and unreadable. The patients were divided into 3 groups. Group A consisted of patients with subscapularis tears. For assessing GV and its association with anterosuperior and posterior rotator cuff tears, group A was in turn subdivided into group A1, which includes patients with both isolated subscapularis tear and combined subscapularis and supraspinatus tears (constituting the anterosuperior rotator cuff tear group), and group A2, with supraspinatus, infraspinatus, and subscapularis tears. We had 2 control groups: group B consisting of patients with combined supraspinatus and infraspinatus tears (with an intact subscapularis, constituting the posterior rotator cuff tear group) and group C consisting of patients who underwent shoulder arthroscopy but did not have a rotator cuff and subcoracoid pathology (labral tears and adhesive capsulitis). Age, sex, side, and mode of injury of all the patients were documented.

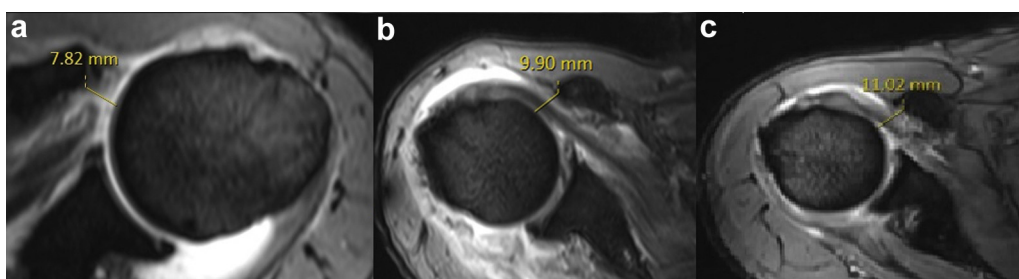
All radiological measurements were made using the PACS system and were performed independently by a fellowship trainee in sports medicine and a radiologist trained in musculoskeletal radiology. On the preoperative axial MRI, we used the method previously described by Tan et al.<sup>29</sup> to measure the CHI. On the axial image with the greatest amount of subcoracoid narrowing, the distance between the posterior aspect of the coracoid process and the anterior humeral head was measured and documented (Fig. 1).

The GV angle was also measured on the axial images using the method described by Tétreault et al.<sup>30</sup> The first axial cut in which the posterior border of the glenoid neck was visible was chosen and a line was drawn along the axis of the glenoid. The second line was drawn by joining 2 points, one on the posterior glenoid neck and the other at the junction where the scapular spine meets the scapular body medially. The angle ( $\alpha$ ) formed by these 2 lines in the posteromedial quadrant was measured (Fig. 2). The version angle was calculated by subtracting  $90^\circ$  from the  $\alpha$  angle ( $\alpha - 90^\circ$ ). The glenoid was considered anteverted if the angle was positive and negative if the angle was retroverted. Statistical analysis was performed using the Student *t*-test. Intraclass correlation coefficients (ICCs) between the 2 independent observers and intraobserver reliability were analyzed using the Pearson correlation coefficient analysis. Binomial regression analysis was used to ascertain the effects of both parameters.

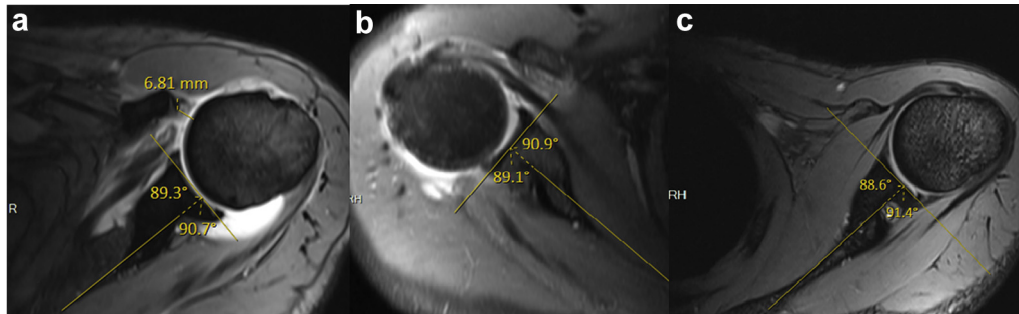
## Results

The patients' characteristics are summarized in Table I. Group A (study group with subscapularis tears) comprised 40 patients with the mechanism of injury being traumatic in 36 cases and degenerative in 4 cases. Group B (supraspinatus + infraspinatus tears - posterior rotator cuff tears) comprised 39 patients with a mean age of 58.5 years, and group C (intact rotator cuff) consisted of 39 patients in which 19 patients had labral pathology and 20 patients had adhesive capsulitis. The mean age of patients with subscapularis tears did not show any significant difference when compared with group B ( $P = .208$ ). However, they were significantly older when compared with the patients in group C ( $P < .001$ ). Almost half of the patients in the intact cuff group had labral pathology and they belonged to the younger age group. In all 3 groups, patients were predominantly males with the right side being more affected than the left. The patients in group A1 were younger than those in group A2, and the difference was statistically significant ( $P = .03$ ). The intraclass coefficient between the 2 observers was 0.91 for CHI and 0.77 for GV. The intraobserver reliability for both observers was also good. The ICC for observer 1 was 0.88 for CHI and 0.94 for GV. The ICC for observer 2 was 0.93 for CHI and 0.82 for GV. The mean CHI in the subscapularis tear group (group A) was significantly smaller than that in patients with combined supraspinatus + infraspinatus tears (group B,  $P = .002$ ) and in patients with an intact rotator cuff (group C,  $P = .01$ ) (Table I).

The mean GV was assessed in all 3 groups of patients and is summarized in Table I. For assessing the effect of GV on anterosuperior and posterior rotator cuff tears, the mean version of A1 was separately analyzed. Even though the anterosuperior rotator cuff tear group was more retroverted than the posterior rotator cuff tear group, this difference was not statistically significant ( $P = .08$ ). There was also no statistically significant difference in the version



**Figure 1** Measurement of coracohumeral interval (CHI) in all the 3 groups. (a) CHI of group A1: 7.82 mm, where the arrow is showing a torn subscapularis tendon with subcoracoid stenosis; (b) CHI of group B: 9.90 mm, showing an intact subscapularis tendon without subcoracoid stenosis; (c) CHI of group C (intact cuff): 11.02 mm.



**Figure 2** Measurement of the glenoid version (GV) angle in all the 3 groups. (a) Group A patient with the GV of 0.7° anteversion with subcoracoid stenosis (CHI: 6.81 mm) and subscapular tear; (b) group B patient with the GV of 0.9° retroversion; (c) group C (intact cuff) with the GV of 1.4° anteversion.

in the subscapularis tear group in comparison with the intact rotator cuff group ( $P = .74$ ) (Table 1).

Binomial logistic regression was performed to ascertain the effects of CHI and GV on the likelihood that participants sustain subscapularis tears. The logistic regression model was statistically significant ( $P < .0005$ ). The model explained 12% of the variance in subscapularis tears and correctly classified 68.8% of cases. Of the 2 predictor variables, only 1 was statistically significant: the CHI. Increasing CHI decreased the likelihood of subscapularis tears. Power analysis for CHI between groups A and B at the 95% confidence interval showed post hoc power of 90.2%, thus making it adequately powered.

## Discussion

The most significant findings of the present study were that the patients with a shorter CHI had increased susceptibility to subscapularis tears in different subsets of rotator cuff tears and the orientation of the glenoid did not play a significant role in the causation of subscapularis tears.

The subscapularis muscle is responsible for internal rotation and plays a very important role in the anterior stabilization of the shoulder, thus maintaining normal shoulder biomechanics.<sup>5,33</sup> Studies have reported that a large number of rotator cuff tears involve the subscapularis muscle, with Bennet et al reporting approximately 34% involvement in their series.<sup>4,27</sup> Undertreatment of these tears can lead to inferior outcomes of associated rotator cuff repairs.<sup>25</sup> Prompt diagnosis and treatment of subscapularis tears are thus extremely important in providing good functional outcomes after rotator cuff repair. Among the numerous causative factors, scapular morphology in the form of subcoracoid stenosis and glenoid retroversion has been implicated in various studies.<sup>13,14</sup>

On comparing the CHI, it was noted that the CHI in patients with subscapularis tears was significantly lower than that in patients with an intact subscapularis. However, our mean value of 8.81 mm was higher than the mean of 5 mm in patients with subscapularis tears, as observed by Richards et al.<sup>25</sup> Nair et al<sup>19</sup> also observed a mean of 5.33 mm in their study. However, there was no mention

regarding the position of the arm by Richards et al, whereas Nair et al obtained all MRIs with the humerus in maximal internal rotation. For ease of diagnosis, all our patients underwent imaging with the shoulder externally rotated and the palm facing upward, and this could have contributed to the difference in measurements from the present study. This was further elucidated by Brunkhorst et al,<sup>6</sup> who observed that the coracohumeral distance decreased by 16.4% at a mean glenohumeral internal rotation angle of 36.6° in healthy male participants using an in vivo 3-dimensional biplane fluoroscopy system. They observed a mean of 12.7 mm in neutral rotation as compared with 10.6 mm in internal rotation. In this study, it was noted that patients with an intact rotator cuff had a mean of 10.39 mm and this was within the reported normal range.<sup>9,11</sup> The narrow CHI in the above-mentioned studies could also be explained by the bigger tears in their patients. The mean CHI of this study was similar to that of Balke et al,<sup>2</sup> reporting a mean of 8.6 mm in degenerative subscapularis tears. However, contrary to our findings, they did not note any significant difference between traumatic tears and controls. Most of our patients had traumatic tears but with a significantly decreased CHI when compared with controls. The predictive value of CHI in diagnosing subcoracoid impingement has also been questioned. Giaroli et al<sup>12</sup> reported false-positive subcoracoid impingement in MRIs of patients without any surgical evidence of subcoracoid impingement concluding that the CHI is poorly predictive of subcoracoid impingement using routinely performed MRI. There was no mention regarding the involvement of subscapularis in their study. Tollemar et al<sup>32</sup> also did not find any correlation between the coracohumeral distance and subscapularis tears in their MRI-based study. They also studied 2 new parameters including the lateral extent and caudal extent of the coracoid and concluded that routine coracoplasty may not be necessary for subscapularis repairs. Some authors state that the subcoracoid impingement might be the sequelae to massive rotator cuff tears after anterior translation of the humeral head and that the reduced CHI may not be the cause but the consequence of subscapularis tears.<sup>3,28</sup>

Preoperative CHI measurement and diagnosis of subcoracoid stenosis/impingement and subscapularis tears have their

**Table 1** Patients characteristics and mean values of MRI parameters: coracohumeral interval (CHI) and glenoid version (GV) angle of each group where the retroversion angle is in the negative range and the anteversion angle is in the positive range

	Number of patients	Age (yr)	Male/female	Right/left	CHI (mean $\pm$ SD) (mm)	Glenoid version (mean $\pm$ SD) (°)	Retroversion, n (range) (°)	Anteversion, n (range) (°)
Group A (group A1+A2)	40	55.6 $\pm$ 8.9	31/9	24/16	8.81 $\pm$ 2.69	-3.7 $\pm$ 4.2	33 (-0.3 to -13.6)	7 (0.7 to 1.6)
Group A1 (subscapularis with supraspinatus tears)	23	53.0 $\pm$ 8.1	18/5	14/9	9.15 $\pm$ 2.55	-4.7 $\pm$ 4.2	20 (-0.7 to -12.6)	3 (0.8 to 1.6)
Group A2 (all the 3 cuff tears)	17	58.9 $\pm$ 9.1	13/4	10/7	8.35 $\pm$ 2.34	-2.3 $\pm$ 3.8	13 (-0.3 to -13.6)	4 (0.7 to 2.4)
Group B (supraspinatus tears + infraspinatus)	39	58.5 $\pm$ 11.1	32/6	23/15	10.62 $\pm$ 2.21	-3.3 $\pm$ 4.0	33 (-0.3 to -10.6)	6 (0.1 to 7.7)
Group C (intact rotator cuff)	39	41.33 $\pm$ 14.9	23/16	24/15	10.39 $\pm$ 2.59	-3.4 $\pm$ 3.7	33 (-0.3 to -11.5)	6 (0.8 to 3.4)

implications to determine the need for coracoplasty as an additional procedure during arthroscopic rotator cuff repairs. The indications for coracoplasty have also been reported in the literature. However, routine need for it remains controversial. Park et al<sup>23</sup> noticed improved outcomes after coracoplasty in patients with subcoracoid impingement (CHI < 6 mm). They also reported improvement in the internal rotation after coracoplasty. However, Ayanoglu et al<sup>1</sup> did not notice any difference in functional outcomes after coracoplasty where they included all patients with a CHI of less than 7 mm and divided them into 2 groups; one group underwent coracoplasty and the other did not. They concluded that routine coracoplasty may not be necessary for the treatment of isolated subscapularis tears. Similar findings were also noticed by Kim et al,<sup>16</sup> after dividing patients with isolated subscapularis tears into 2 groups depending on whether coracoplasty was performed or not. Both their groups also had a mean CHI of less than 7 mm, and there was no significant difference between the groups. In the present study, our mean CHI was 8.81 and none of our patients underwent coracoplasty. The decision was made after an intraoperative assessment of subcoracoid space and impingement where the arthroscope in the anterolateral viewing portal and shoulder is taken through a various range of movements after subscapularis repair. The improved centering of the humeral head in the axial plane after subscapularis repair leading to an adequate CHI could also explain why coracoplasty was not required in the present study.

On the assessment of version, we did not find any significant difference on comparing patients with subscapularis tears (including other cuff tears as well) and patients with intact rotator cuff, with an increased retroversion of only 0.3° in the subscapularis tear group. Tétreault et al<sup>30</sup> observed that anterosuperior rotator cuff tears were retroverted (−5°) compared with posterior rotator cuff tears, which were anteverted (3°). Our patients were also grouped accordingly. It was observed that the glenoid was retroverted in the anterosuperior rotator cuff tear group, the posterior rotator cuff tear group (difference of 1.4° with the anterosuperior rotator cuff group), and the intact rotator cuff group (difference of 1.3°) with no significant difference. Studies have compared version in patients with rotator cuff tears and controls with varying results. Whereas Tokgoz et al<sup>31</sup> noted a significantly increased retroversion (of 2.3°) in patients with supraspinatus tears compared with controls, Dogan et al<sup>8</sup> did not observe any significant difference between rotator cuff tears and controls. Our study did not demonstrate any such difference with all groups having a predominantly retroverted glenoid including patients with an intact rotator cuff. Kandemir et al<sup>15</sup> in their cadaveric study also did not find any significant difference in GV between shoulders with a full-thickness tear and those with an intact rotator cuff.

It is evident from our study that a reduced CHI with increased retroversion even though not statistically significant could play a contributory role in the causation of subscapularis tears and the need for coracoplasty can be assessed from the intraoperative assessment of subcoracoid space during rotator cuff repair.

Our study had a few limitations. As there were very few shoulders with isolated subscapularis tears, we had to include both subscapularis and supraspinatus tears while assessing version. A larger sample size with isolated subscapularis tears could have established a statistical significance between retroversion and the former. The functional outcomes of patients were not assessed, and a comparison of the same could have added more value to the study. Our control group consisting of intact rotator cuff had shoulders with adhesive capsulitis and labral pathology. A control group with normal shoulders would have been ideal.

## Conclusion

There was a significant relationship between subscapularis tears and a reduced CHI. Glenoid version, even though more retroverted in the subscapularis tear group, was not statistically significant.

## Disclaimer

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