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Anatomy Section

# Coracoid Process of Scapula: Morphometric Analysis in South Indian Population

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## ABSTRACT

**Introduction:** Shoulder pain in subcoracoid impingement syndrome was due to intrusion of rotator cuff tendons in the coracohumeral space. One of the predisposing factors for subcoracoid impingement syndrome was limited subcoracoid space which causes impingement of lesser tubercle of humerus against the coracoid process to produce pain in the anterior region of shoulder. Coracoid process was also used as graft in Latarjet operation done to treat glenohumeral instability. So, understanding the morphometry of coracoid process is very important for orthopaedic surgeons for various surgical procedures.

**Aim:** To analyse the morphometry of coracoid process, coracoglenoid distance and shape of coracoglenoid space among South Indian population.

**Materials and Methods:** This was a cross-sectional study done between March 2018 to September 2018 on 100 dried human scapulae obtained from the bone bank of Department of Anatomy of Private Medical Colleges in South India. Maximum length, breadth, thickness, height of coracoid process, coracoglenoid distance and maximum width of glenoid cavity were measured in millimetres (mm) using digital vernier callipers with the precision of 0.01 mm.

**Results:** Total of 100 dried human scapulae (51 of right side, 49 of left side) were studied and analysed. The average length of coracoid process was 39.47±3.29 mm. The average breadth of coracoid process was 13.91±1.36 mm. The mean thickness of coracoid process was 8.24±1.003 mm. The mean coracoglenoid distance was 27.19±2.42 mm. Breadth of coracoid represents 57.92% of Glenoid width and thickness of coracoid represents 34.27% of Glenoid width. Most common variety of coracoglenoid space found in our study was round bracket shape which was in 51% of scapulae, followed by square bracket shaped in 30% and fish hooked shaped in 19% of scapulae.

**Conclusion:** Morphometry of coracoid process will be taken into account while treating patients with subcoracoid impingement syndrome. Thickness of coracoid process was always smaller than the breadth of coracoid. Hence, the breadth was taken into account when coracoid process was used as a graft to reconstruct glenoid bone loss in recurrent shoulder dislocation.


**Keywords:** Coracoglenoid space, Graft, Glenoid fossa, Latarjet operation, Subcoracoid space

## INTRODUCTION

The osseous extension over the glenoid cavity of scapula is called coracoid process. It is focused upwards and forwards to lend space for attachment of muscles and ligaments [1]. The zone in between the middle of humeral head and coracoid process of scapula in shoulder region is called sub-coracoid space which accommodate articular capsule of gleno-humeral joint, the tendon of subscapularis and subacromial bursa [2,3]. Shoulder pain in sub coracoid impingement syndrome is due to intrusion of rotator cuff tendons in the sub-coracoid space. Patients complain of pain particularly during flexion, medial rotation and adduction [4]. Misirliogle M et al., in their study done on 40 patients in the year 2012 found that 35% of patients had subcoracoid impingement along with subacromial impingement as the cause of their chronic shoulder pain [5].

One of the predisposing factors for subcoracoid impingement syndrome is limited sub-coracoid space which causes impingement of lesser tubercle of humerus against the coracoid process to produce pain in the anterior region of shoulder. Limiting skeletal structure provides shape and size of the subcoracoid space. Any disparity in the above measurements can be obvious to result in impingement [6-9]. In addition to the narrow subcoracoid space, risk factors for developing subcoracoid impingement syndrome include trauma resulting in fracture of coracoid, scapular neck and humeral head or neck [2].

Comprehension of the morphometry of coracoid process was eminent ahead of Laterjet procedure for glenohumeral instability with significant bone loss where coracoid process of scapula can be used as bone graft and transferred to glenoid defect [10]. Acceptable length and width of coracoid process was taken as a prerequisite for proper positioning of screws during surgery thereby preventing failure of operation [11].

The study was conducted to analyse the morphometry of coracoid process, coracoglenoid distance and shape of coracoglenoid space among South Indian population in order to know the role of coracoid morphometry in causing the subcoracoid impingement syndrome. There is limited data available on the morphometric analysis of coracoid process in South Indian population. The present study was conducted to compare with other studies done on various population and also to compare breadth and thickness of coracoid process with the width of glenoid fossa to throw light upon using coracoid process as a graft in Latarjet procedure in case of glenohumeral instability.

## MATERIALS AND METHODS

This was a cross-sectional type of study done between March 2018 to September 2018 conducted on 100 dried human scapulae obtained from the bone bank of Department of Anatomy of Private Medical Colleges in Karnataka and Kerala states of South India. The 50 dried human scapulae (26 right and 24 left) were obtained from Akash Medical College Bengaluru, Karnataka while remaining 50 samples (25 right and 25 left) were obtained from Sree Narayana Institute of Medical Sciences, Ernakulam, Kerala.

### Study Procedure

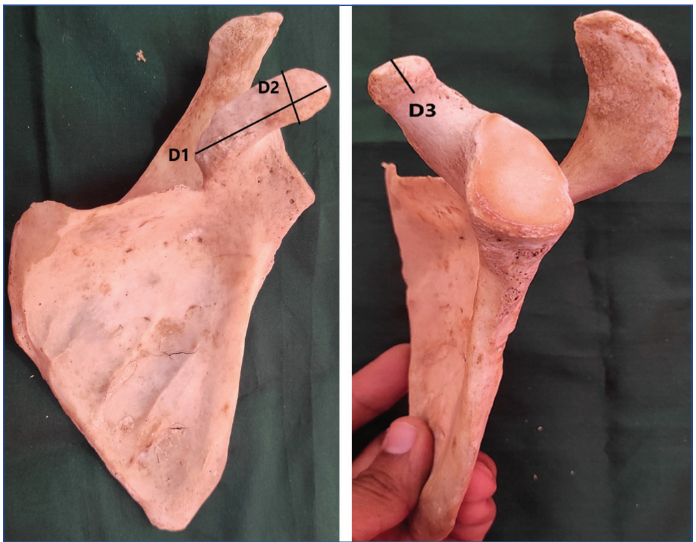
All scapulae were collected using convenient sampling method. The scapulae were collected irrespective of age and gender. Among the

100 scapulae collected, 51 were of right side and 49 of left side. The scapulae included in this study were free from damage and scapulae with broken edges and degenerative changes of coracoid process were excluded from the study. The following eight measurements were planned for the morphometric analysis of coracoid process and measured by using digital vernier callipers in millimetres with a precision of 0.01 millimetres.

**D1- Maximum length:** Tip of coracoid process to end of horizontal part of coracoid process [Table/Fig-1].

**D2- Maximum breadth:** Lateral border to the medial border of coracoid process 1 cm behind the tip of coracoid process [Table/Fig-1].

**D3- Maximum thickness:** Superior surface to inferior surface of coracoid process 1 cm behind the tip of coracoid process [Table/Fig-2].



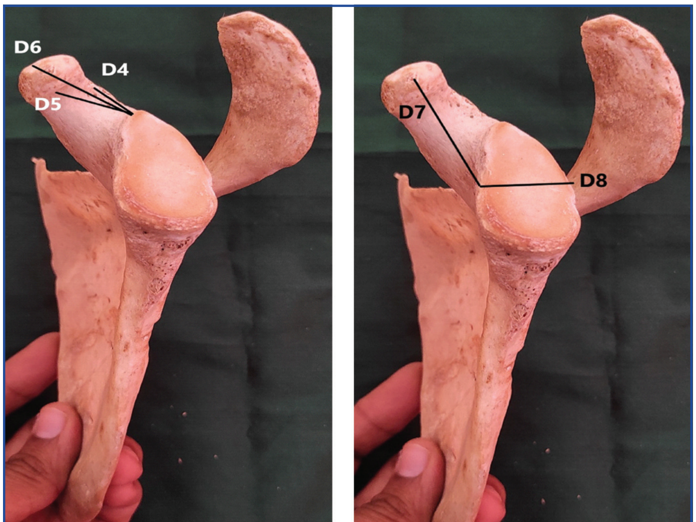

**[Table/Fig-1]:** Measurement of maximum length (D1) and Maximum breadth (D2) of Coracoid process. **[Table/Fig-2]:** Measurement of maximum thickness (D3) of Coracoid process. (Images from left to right)

**D4- Height:** Supraglenoid tubercle to the end of vertical part coracoid process [Table/Fig-3].

**D5- Height:** Supraglenoid tubercle to the undersurface of coracoid process 1 cm behind its tip [Table/Fig-3].

**D6- Height:** Supraglenoid tubercle to the superior surface of coracoid process 1 cm behind its tip [Table/Fig-3].

**D7- Coracoglenoid distance:** Tip of coracoid process to middle of anterior rim of circumference of glenoid cavity [Table/Fig-4].




**[Table/Fig-3]:** Measurement of maximum height (D4), Height from supraglenoid tubercle to undersurface (D5), Height from supraglenoid tubercle to superior surface (D6) of coracoid process. **[Table/Fig-4]:** Measurement of coracoglenoid distance (D7) and Maximum width of glenoid fossa (D8). (Images from left to right)

**D8- Maximum width of Glenoid fossa:** Midpoint of anterior rim to midpoint of posterior rim of circumference of glenoid fossa [Table/Fig-4].

Maximum width of glenoid fossa was compared with maximum breadth and maximum thickness of coracoid process, its ratio was then analysed to know how much percentage of glenoid width can be contributed by the maximum breadth and maximum thickness of coracoid process [12]. Observations were made to categorise the shape of coracoglenoid space (anterosuperior border of glenoid cavity to posterolateral border of coracoid process) into three types as represented by Gumina S et al., [3].

- Type I- Round bracket [Table/Fig-5],
- Type II– Square bracket [Table/Fig-6]
- Type III- Fish hooked [Table/Fig-7].

**[Table/Fig-5]:** Round bracket shaped Coracoglenoid space.
**[Table/Fig-6]:** Square bracket shaped Coracoglenoid space.
**[Table/Fig-7]:** Fish hooked shaped Coracoglenoid space. (Images from left to right)

Mean value of Coracoglenoid distance (D7) was calculated in scapula with three different types of Coracoglenoid space and compared on right and left side of scapula.

## STATISTICAL ANALYSIS

The data was entered into Microsoft Excel- 2010 and followed by analysis using Statistical Package for Social Sciences (SPSS) version 20.0. The mean, standard deviation and the level of significance were calculated for each parameter. Independent samples t-test was applied to each of these parameters for assessing statistical significance. The p-value <0.05 was taken as statistically significant. Spearman correlation test was used to analyse the correlation between breadth of coracoid and width of glenoid fossa. Wilcoxon signed rank test was performed to compare breadth and thickness of coracoid process and p-value <0.001 is taken as statistically significant.

## RESULTS

Hundred scapulae were used in this study to measure the 8 parameters mentioned in materials and methods 51 were of right side and 49 of left side. The average length of coracoid process was 39.47±3.29 mm. The average breadth of coracoid process was 13.91±1.36 mm. The mean thickness of coracoid process was 8.24±1.003 mm. The mean height from supraglenoid tubercle to undersurface of coracoid process was 13.55±1.53 mm. The mean height from supraglenoid tubercle to superior surface of coracoid process was 19.46±1.92 millimetres. The mean coracoglenoid distance was 27.19±2.42 millimetres. The mean width of glenoid fossa was 24.2±2.34 millimetres. The average values for the measurements obtained from the eight parameters were categorised under right and left scapulae and depicted in [Table/Fig-8]. The p-value was obtained using independent samples t-test shows that the morphometric measurement of right and left side of coracoid process of scapula was not statistically significant.

After calculating the ratio of maximum breadth of coracoid and maximum width of glenoid fossa, it was observed that breadth of coracoid represented 40.29-79.07% of Glenoid width with an average of 57.92%. Maximum thickness of coracoid represented 24.13-60.07%

| Parameters | Mean and SD* | | p-value* |
|---|---|---|---|
| | Right (mm) | Left (mm) | |
| D1: Maximum Length | 39.32±3.31 | 39.64±3.30 | 0.692 |
| D2: Maximum Breadth | 13.93±1.41 | 13.89±1.33 | 0.888 |
| D3: Maximum Thickness | 8.18±0.94 | 8.30±1.07 | 0.555 |
| D4: Maximum Height | 19.13±1.89 | 19.13±1.71 | 0.992 |
| D5: Height from supraglenoid tubercle to undersurface of coracoid process 1 cm behind its tip | 13.38±1.64 | 13.72±1.41 | 0.209 |
| D6: Height from Supraglenoid tubercle to superior surface of coracoid process 1 cm behind its tip | 19.46±2.02 | 19.46±1.81 | 0.820 |
| D7: Coracoglenoid distance | 26.99±2.52 | 27.39±2.32 | 0.390 |
| D8: Maximum Width of Glenoid fossa | 24.06 ±2.43 | 24.37±2.24 | 0.506 |

**[Table/Fig-8]:** Measurements of coracoid process of scapulae in millimetres.
*p<0.05 to be statistically significant; p-value was obtained from Independent sample t-test; *SD: Standard deviation

of Glenoid width with an average of 34.27%. Spearman correlation test showed no correlation {Correlation coefficient (r)=-0.02} between breadth of coracoid and width of glenoid fossa and it was not statistically significant (p-value=0.79). Wilcoxon signed rank test performed between breadth and thickness of coracoid showed that thickness of coracoid is smaller than the breadth of coracoid and it was statistically significant (p-value <0.001).

Most common variety of coracoglenoid space found in the present study was round bracket shape which was in 51% of scapulae. Coracoglenoid space was found to be square bracket shaped in 30% of scapulae and fish hooked shaped in 19% of scapulae [Table/Fig-9]. Mean Coracoglenoid distance among scapula with round bracket shaped coracoglenoid space was 26.77±2.57 mm, square bracket shaped coracoglenoid space was 27.8±1.94 mm and fish hooked shaped coracoglenoid space was 28.1±2.17 mm. Comparison of mean coracoglenoid distance with various shapes of coracoglenoid space in scapula of right and left side was not statistically significant [Table/Fig-10]. Least coracoglenoid distant measured was 21.7 mm which was in scapula with round bracket shaped coracoglenoid space and maximum coracoglenoid distant measured was 31.76 mm which was in scapula with fish hooked shaped coracoglenoid space.

| Coracoglenoid space | Right n (%) | Left n (%) | Total n (%) | p-value (Chi-square test) |
|---|---|---|---|---|
| Round shape | 26 (50.98%) | 25 (51.02%) | 51 (51%) | 0.984 |
| Square bracket | 15 (29.41%) | 15 (30.61%) | 30 (30%) | |
| Fish hooked | 10 (19.60%) | 9 (18.36%) | 19 (19%) | |
| Total number of scapula | 51 | 49 | 100 | |

**[Table/Fig-9]:** Percentage of occurrence of various shapes of coracoglenoid space in right and left scapula.
*p<0.05 to be statistically significant; p-value was obtained from Chi-square test

| Shape of coracoglenoid space | Round bracket (n=51) | | Square bracket (n=30) | | Fish hooked (n=19) | |
|---|---|---|---|---|---|---|
| Side of scapula | Right (n=26) | Left (n=25) | Right (n=15) | Left (n=15) | Right (n=10) | Left (n=09) |
| Coracoglenoid distance (D7) (Mean±SD*, mm) | 26.29± 2.59 | 27.26± 2.56 | 27.13± 2.06 | 27.80± 1.82 | 28.78± 2.25 | 27.22± 2.10 |
| p-value* | 0.18 | | 0.35 | | 0.14 | |

**[Table/Fig-10]:** Comparison of mean coracoglenoid distance with various shapes of coracoglenoid space in right and left side of scapula.
*p-value <0.05 to be statistically significant; p-value was obtained from Independent sample t-test; *SD: Standard deviation

## DISCUSSION

Coracoid process, glenoid fossa and humeral head are the major structures which take part in any shoulder movements. Morphometry of coracoid process is crucial to know the etiology of subcoracoid impingement syndrome. Prominent coracoid process can reduce the potential space between coracoid process and lesser tubercle of humerus which can lead to coracoid impingement syndrome causing anterior shoulder pain [4]. Cases of coracoid impingement syndrome refractory to conservative management were treated by coracoplasty which involve excision of posterolateral border of coracoid process [6].

Most common variety of coracoglenoid space found in the present study was round bracket shaped followed by square bracket and then fish hooked shape. This was in agreement with study done by Gumina S et al., [Table/Fig-11] [3,13,14]. Coracoglenoid distance was least in scapula with round bracket shaped coracoglenoid space and it was maximum in scapula with fish hooked shaped coracoglenoid space. The above finding was similar to the study done by Gumina S et al., in 204 scapulae in the year 1999, in Italy [3]. Incidence of idiopathic subcoracoid impingement syndrome would be higher among individuals with round bracket shaped coracoglenoid space [3]. Calcifying tendinitis involving the subscapularis and supraspinatus tendons resulting in increase in the volume of subcoracoid tissue which would also result in subcoracoid impingement syndrome [15]. Comparison of morphometry of coracoid process with other studies is given in [Table/Fig-12] [3,13,14,16-19]. Variations in the coracoid morphometry were seen among various ethnic groups. Fathi M et al., in their study done in 2017 in 118 specimens found that the length and thickness of coracoid process was larger in Indian and Chinese population compared to Myanmarese [18].

| Author and year of study | Sample size (n) and population | Round bracket shaped coraco-glenoid space | Square bracket shaped coraco-glenoid space | Fish hooked shaped coraco-glenoid space |
|---|---|---|---|---|
| Gumina S et al., [3] 1999 | n=204 Italy | 45% | 34% | 21% |
| Verma U et al., [13] 2017 | n=100 North India | 44% | 38% | 18% |
| Das SR et al., [14] 2020 | n=104 North India | 55.76% | 31.74% | 12.5% |
| Present study | n=100 South India | 51% | 30% | 19% |

**[Table/Fig-11]:** Comparison of percentage of occurrence of various types of coracoglenoid spaces with other studies [3,13,14].

Tendinitis of supraspinatus was common towards its insertion on the greater tuberosity as it's an avascular zone [20]. The degenerated tendon increases in size with age specially in diabetic patients [21]. Many extrinsic factors were involved as biological causative factors in causing subcoracoid impingement syndrome such as injury, heavy physical loading, vibration, smoking, infection and fluoroquinolones. Further genetic factors also play a role as studies have showed marked sympathetic innervation in the perivascular tissue of painful tendons compared to healthy tendons [22,23].

In the present study, the breadth of coracoid process represented an average of 57.92% of glenoid width and thickness of coracoid represented 34.27% of glenoid width. The breadth of coracoid process at mid-point represented 52% of glenoid width and thickness of coracoid process represented 40% of glenoid width in the study done by Jia Y et al., in 84 specimens in china in 2020 [24]. This is a significant finding which can be taken into account during Latarjet procedure which uses coracoid process as bone graft to reconstruct glenoid bone loss and restores the glenoid defect in recurrent shoulder dislocation [25,26].

Hurley ET et al., in their study conducted among 62 athletes in the year 2021 states that, recurrent shoulder instability in athletes can

| Author, year of study and sample size (n) | Population studied | Length (D1) (mm) | Breadth (D2) (mm) | Thickness (D3) (mm) | Height (D4) (mm) | Coraco-glenoid distance (D7) (mm) |
|---|---|---|---|---|---|---|
| Gumina S et al., [3] 1999 n-204 | Italian | 38.15 | -- | 7.19 | -- | 22.1 |
| Polguj M et al., [16] 2011 n-86 | Poland | 44.6 | -- | --- | --- | --- |
| Fathi M et al., [18] 2017 n-118 | Indian | 43.32 | 13.63 | 11.47 | 15.94 | -- |
| | Myanmarese | 39.19 | 13.02 | 8.58 | 14.79 | -- |
| | Chinese | 42.47 | 13.17 | 9.08 | 15.26 | -- |
| Verma U et al., [13] 2017 n-100 | North India | 35.54 | 14.5 | 7.95 | 20.10 | --- |
| Kumar V et al., [17] 2018 n- 64 | North India | 40.94 | 13.59 | 8.3 | --- | 26.23 |
| Das SR et al., [14] 2020 n- 104 | North India | 39.91 | 14 | 8.32 | 22.87 | --- |
| Khan R et al., [19] 2020 n- 164 | South Africa | 40.94 | 13.59 | 8.3 | --- | 26.23 |
| Present study n-100 | South Indian | 39.47 | 13.91 | 8.24 | 19.13 | 27.19 |

**[Table/Fig-12]:** Comparison of morphometric analysis of coracoid process with previous studies done in different population (Measurements in millimetres).

be treated by two surgical techniques such as Arthroscopic Bankart Repair and Open Latarjet procedures [26]. In Arthroscopic Bankart Repair, capsulolabral tissues were fixed to glenoid rim where as in Open Latarjet procedure, coracoid process was used as graft and fixed to glenoid to treat recurrent shoulder dislocations. They concluded in the study that recurrence rate of shoulder instability was much lower with Open Latarjet technique [26]. Apart from primary instability and recurrent instability of shoulder, patients with failed prior instability surgery also had good clinical outcome following Open Latarjet procedure [27]. Latarjet procedure to treat glenohumeral instability was done in two ways. First was the classic technique in which inferior surface of coracoid was fixed to the glenoid fossa which uses thickness of coracoid process. Second technique was the modified technique in which coracoid was rotated first to 90 degree and then its medial surface was fixed to the glenoid fossa in which width of the coracoid process was taken into account [28]. So, it is very important for the orthopaedician to have a prior knowledge about the morphometry of the coracoid process in order to avoid complications after coracoid graft transfer such as non union and fractures [29].

## Limitation(s)

The present study did not compare the data in various age groups and gender differentiation among various ethnic groups. Further research including the above deficiencies with large sample size would enlighten the upcoming orthopaedic surgeons.

# CONCLUSION(S)

The data provided by the study highlights the least coracoglenoid distance in the scapula with round bracket shaped coracoglenoid space. This interpretation concludes that individuals with round bracket shaped coracoglenoid space were more prone for sub-coracoid impingement syndrome. Comparison of morphometric measurements of right and left side of coracoid process of scapula was not statistically significant. Study showed no significant correlation between breadth of coracoid and width of glenoid fossa. However, thickness of coracoid process was smaller than the breadth and it was statistically significant. Hence, breadth of coracoid process was taken into account while using coracoid as a graft in Latarjet procedure to treat glenoid bone loss in recurrent shoulder dislocation.

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