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Study on Morphometry, Types and Angulations of Coracoid Process

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ABSTRACT
Coracoid process is a birds beak like projection which arises superolaterally from the upper border of head. The morphometry of coracoid process according to its types helps in reconstruction of a bony tunnel between coracoid process and clavicle. Its morphology is very important in coracoid impingement resulting in aggravated shoulder pain. 204 scapulaes for the present study were procured by the dissected cadavers of Anatomy Department of HIMS, Hassan and also collected from the 1st year medical students. Two methods are utilized for taking linear measurements, angulations and categorizing into different types one is by goniometer and the other is by digital image analysis software imagemeter. The horizontal process length in the present study is 35.54±4.129 (GM), 35.37±4.42 (IM), ×10.17±2.158 (GM), 10.16±2.158 (GM), 5.22±1.413 (GM), 5.20±1.429 by ±4.129±4.423±2.158, Vertical process length, thickness and breadth 8.82±2.241 (GM), 8.82±2.249 (IM)/ 20.75±3.042 (GM), 20.80±3.005 (IM), ×7.12±1.974 (GM), 7.12±1.974 (IM). Vertical process angulation in sagittal plane by both methods is 125.7±7.640. Coronal plane vertical process angulation is 142.02±7.524 by both the methods. Axial plane vertical process angle is 64.74±11.579 and axial plane horizontal process angle is 128.67±7.8. Interprocess angulation is about 71.19±8.726 (GM) and 0.866±-1.703 (IM). The measurements of linear and angular parameters by goniometer and Imagemeter are similar. So imagemeter estimation of the angles and morphological parameters can be applied as it is easier, less time consuming and is reliable as the data coincided with the goniometer analysis. GM-goniometer, IM-imagemeter.

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Key Words
Coracoid process, glenoid cavity, coracoid impingement, coracoid fractures

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INTRODUCTION

The coracoid process is a birds beak like projection which arises superolaterally from the upper border of head and is bent sharply so as to project forwards and slightly laterally[1]. A positive and significant relationship between the coracoid process width and glenoid width was found in Chinese population in relation to Indian population which would be useful to compensate for glenoid bone loss[2]. The morphological classification and the measurements of coracoid process adding to its types helps in reconstruction of a bony tunnel in between coracoid process and clavicle[3]. The malposition of the tunnel may lead to the cause of Iatrogenic fractures[4]. The coracoid process morphology has been implicated in coracoid impingement syndrome mainly resulting in anterior shoulder pain aggravated by forward flexion and internal rotation[5]. The angle of the horizontal process is decreased in the axial plane presumed by taking CT in the rotator cuff tear injuries[6]. In the modified technique yanbin *et al*.[7] introduced it describes a base plate three column glenoid construct fixation technique used in simple and complex type of CP fractures with cannulated screws. So the thickness, width of superior and Inferior coracoids pillars become important[7]. Many literatures have defined the morphological variations of Coracoid Process in the Chinese, Asian, Malaysian populations based on ethnicity, age and gender.

There are few literatures which have measured the angles of the coracoid process according to the plane of CT scan. So this study has been undertaken to study the types, morphology and angles of the coracoid process in relation to glenoid process according to the standard planes of CT scan. The knowledge of the above parameters becomes important as[1] it may suggest a guideline for development of radiographical views in visualizing coracoid process and its parts[2] and this study may help the surgeons to correct the surgical alignment of coracoid process during coracoid process repair.

MATERIALS AND METHODS

This is a cross sectional study 204 scapulae are studied which are collected from the Anatomy department and also collected from the students of 1st year M.B.B.S. Linear and angular readings were collected by Goniometer and by image analysis software data Imagemeter as per the CT scan planes. Photos about 540×1200 megapixel is taken for uploading to Imagemeter app. (Image Meter by Dirk Farin is an android based application used to measure both linear and angular parameters in an image.)

Inclusion criteria: Scapulae with intact coracoid process.

Exclusion criteria: Damaged scapulas with degenerated osteophytes.

Methodology: Various shapes of tip of coracoid process is noted and divided into different groups. Accordingly measurements of vertical and horizontal process was taken by means by digital vernier callipers corrected to 0.1 mm^{-1}. Angular orientation of coracoid process in standard planes will be measured through digital images viewed by digital image analysis software imagemeter and also recorded manually by goniometer.

Procedure for taking linear measurements in both Goniometer and Imagemeter:

- Length of Horizontal part-distance from the tip to the end of Horizontal part
- Width of Horizontal part-Anterior Posterior distance 1 cm posterior to the tip
- Thickness of the Horizontal process-superoinferior distance 1 cm posterior to the tip
- Vertical process height-distance from the angle to the base (Inferior pillar) of coracoid process.
- Breadth of vertical process-distance from medial to lateral part of the base or inferior pillar
- Thickness of vertical process-Anterior posterior distance of the base or Inferior pillar

Angulation of the coracoid process by goniometer:

- Vertical process angle in coronal plane-one arm of the goniometer placed along the axis of glenoid connecting superior and Inferior pillars of glenoid cavity and another arm passes along the amid line axis of vertical process
- Vertical process angle in sagittal plane-one arm is placed along the lateral border of the scapula passing along the glenoid surface. One arm is placed along the vertical process and the angle is noted by means of protractor
- Vertical process angle in axial plane-for standardization in the axial plane the articular surface of the glenoid was placed on horizontal surface parallel to the floor. One arm is placed perpendicular to the surface and another arm placed is along the vertical process and the angle is noted by means of protractor
- Horizontal process glenoid in axial plane one arm placed perpendicular to the surface and another arm placed along the Horizontal process angle
- Interpillar angle Inter process: Angle Each arm placed along the mid axis of vertical and horizontal pillars and the angle is noed by protractor in between

Angulation of the coracoid process by imagemeter: Scapula is photographed by digital camera and the image is uploaded to the digital software called Imagemeter:

- **Vertical process angle in coronal plane:** One axis is drawn along the glenoid cavity connection the superior and Inferior pillars and the another axis is drawn along a midline axis of vertical process
- **Vertical process angle in sagittal plane:** One axis is drawn along the lateral border of scapula passing through glenoid cavity. Another axis is drawn along the axis of vertical process and the angle is measured
- **Vertical process angle in axial plane:** For standardization the articular surface of glenoid cavity is placed on a horizontal surface parallel to the floor. One axis is drawn perpendicular to the surface and another axis drawn along the axis of vertical process and angle is measured
- **Horizontal process angle in axial plane :** One axis is drawn perpendicular to the articular surface of glenoid cavity. Another axis is drawn along the axis of Horizontal process
- **Interpillar/inter coracoid angle:** Each axis is drawn passing through the mid axis of vertical and horizontal process and the angle is measured

RESULTS

The statistical analysis was carried by using software statistical package for the social service (SPSS) version 22. Comparison between the different analytical methods is done by applying Independent "T" Test. Mean and SD values of each parameter is noted. p-value <0.05 is considered significant (Table 1).

Horizontal process: Length of HP by GM is 35.54±4129 and by Imagemeter is 35.37±4.423. Mean difference (GM) is 0.172 (95% CI is -0.662) and Mean difference (IM) is 0.172 95% CI (1.007) is not statistically significant. (p = 0.685) Breadth of HP (GM) is 10.17±2.158. Mean difference is 0.010 (95% CI is -0.411) Breadth of HP (IM) is 10.16±2.151. Mean difference is 0.010 (95% CI is -0.411) is not statically significant (p = 0.963) for both the methods. Thickness of the horizontal process is 5.22±1.413 (GM)/ 5.20±1.429 (IM) mm^{-1} is not statistically significant (p = 0.889). The length of Vertical Process by GM is 8.82±2.249. I ts mean difference is 0.000. (95% CI is -0.439). The above values are statistically not significant as p-value is 1.000. The length by IM is 20.75±3.042. Its mean difference is 0.049 (95% CI is -0.639). The above values are not statistically significant (p-value is 1.000) Table 2 Fig. 1.

VP breadth by GM is 20.75±3.042 is -0.639 and by IM is 20.80±3.005 (MD is -0.049 and 95% CI is 0.870)

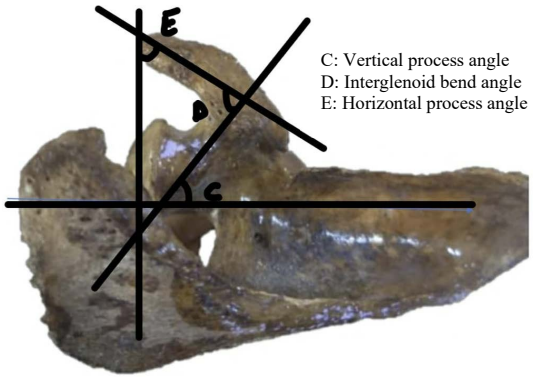

Fig. 1: Axial plane showing

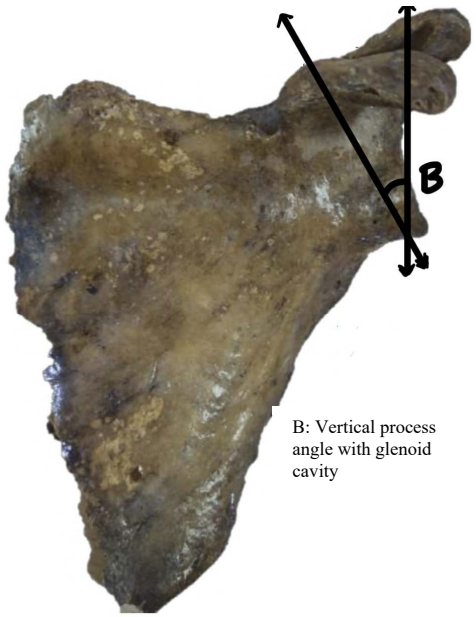

Fig. 2: Coronal plane showing

Table 1: CI-Confidential interval MD (mean difference)

	Mean	SD	MD	CI 95%	p-value
Length of HP					
GM	35.54	4.129	0.172	-0.662	0.685
IM	35.37	4.423	0.172	1.007	0.685
Breadth HP					
GM	10.17	2.158	0.010	-0.411	0.963
IM	10.16	2.151	0.010	-0.411	0.963
Thickness HP					
GM	5.22	1.413	0.020	-0.258	0.889
IM	5.20	1.429	0.020	-0.258	0.889

GM: Goniometer, *IM: Imagemeter, *HP: Horizontal process

the above mentioned values are not statistically significant (p-value is 0.870 for both)

The values of VP thickness by GM and IM are 7.12±1.974 mm^{-1} and 7.12±1.974 mm^{-1}. Mean difference is 0.000 (95% CI is -0.315). Hence the values are not statistically significant (p-value is 1.000) Fig. 2-3.

Angulation of the coracoid process is measured as this gives an idea of alignment of radiographic plane to the plane of coracoid process. It is perpendicular to each other.

The vertical process angle in sagittal plane by GM is 125.71±7.640° and by IM is 125.61±7.706°. Mean difference is 0.099 and 95% CI is 0.762 to±1.399. The above values are not statistically significant as p-value is 0.897. The values of VP angle in coronal plane and VP and HP angle in axial plane are not statistically significant as the p-value of all of these is 1.000 (Fig. 4).

The p-value for the classification of coracoid process by above methods is 0.000 which is highly significant. The p value of the side of the scapula is 0.000 which is also highly significant (Table 3).

DISCUSSION

In the present study, type II coracoid processes are more prevalent 85% (maximum) and type III are about 18% (least). In chinese population the prevalence of type I (30%) is more and type III (least) about 29% as done by the studies of Leizhang *et al.*[3]. The above suggest that any more prevalence of the type depends on the regional, race variations.

Coracoid process morphometry and angulations have got wider implications and form a basis of understanding conservative or surgical treatment of shoulder joint impingement Verma *et al.*[8] and Rajan *et al.*[9] have done studies on the different measurements of acromion, coracoid and glenoid processes and showed relevance to the various

Table 2: Physical parameters

Parameters	Mean	Sd	Md	95% CI	p-value
VP length					
GM	8.82	2.249	0.000	-0.439	1.000
IM	8.82	2.249	0.000	-0.439	1.000
VP breadth					
GM	20.75	3.042	-0.040	-0.639	0.870
IM	20.80	3.005	-0.049	-0.639	-0.870
VP thickness					
GM	7.12	1.974	0.000	-0.385	1.000
IM	7.12	1.974	0.000	-0.385	1.000

VP: Vertical process, IM: Imagemeter, GM: Goniometer

Table 3: Planes

Parameters	Mean	Sd	Md	95% CI	p-value
Sagittal plane VP angle					
GM	125.71°	7.6°	0.099°	0.762-1.399	0.897
IM	125.61°	7.706°	0.099°	0.762-1.399	0.897
Coronal plane VP angle					
GM	142.02°	7.524°	0.099°	0.747-1.468	1.000
IM	142.02°	7.524°	0.099°	0.747-1.468	1.000
Axial plane VP angle					
GM	64.78°	11.579°	0.000°	1.149-2.259	1.000
IM	64.78°	11.579°	0.000°	1.149-2.259	1.000
Axial plane HP angle					
GM	128.67°	7.888°	0.000°	0.783 -1.539	1.000
IM	128.67°	7.888°	0.000°	0.783-1.539	1.000
Inter process/interpillar angle					
GM	71.19°	8.726°	0.000°	0.866-1.703	1.000
IM	71.19°	8.726°	0.000°	0.866-1.703	1.000

VP: Vertical process, GM: Goniometer, IM: Imagemeter

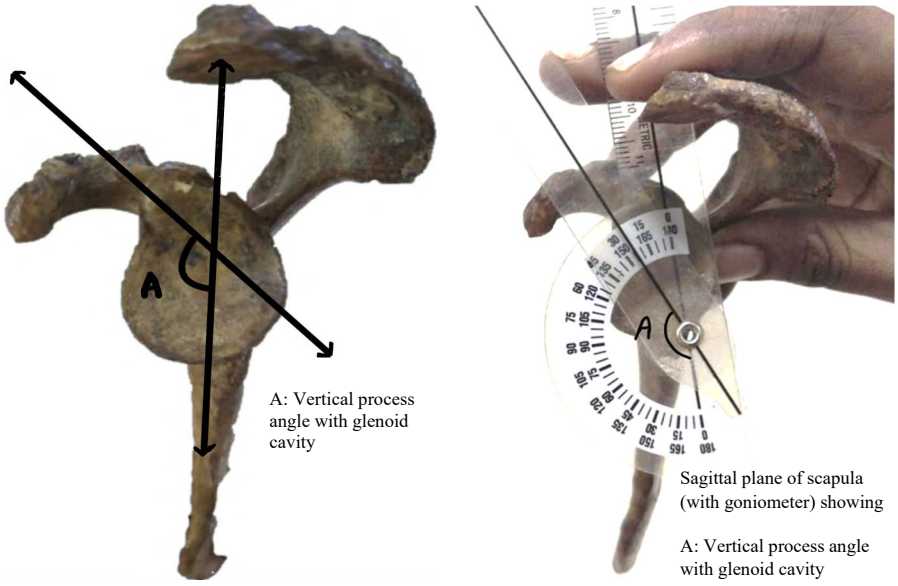

Fig. 3: Sagittal panel showing

Table 4: Decrease in the horizontal process angle in axial plane as compared

Parameters		Sagittal plane (pooled)	Bhatia *et al* (pooled)
VP angle	GM	125.71±7.640º	849±7.3
VP angle	IM	125.61±7.705	126.1±7.3
Coronal plane			
VP angle	GM	142.02±7.524	134.6±5.5
VP angle	IM	142.02±7.524	
Axial plane			
VP angle	GM	64.78±11.579	51.2±8.3
VP angle	IM	64.78±11.579	
Inter process/Inter pillag angle	GM	71.19±8.726	84.9±7.3
Inter process/Inter pillar angle	IM	71.19±8.726	

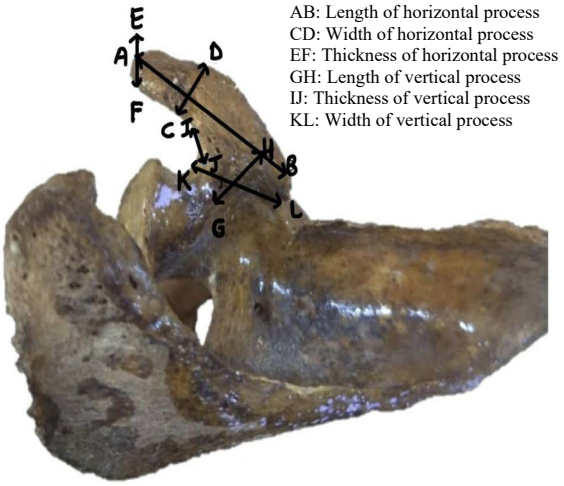

Fig. 4: Axial plane showing

pathologies of coracoid process. In the above studies horizontal part and base is taken into consideration as superior and inferior pillar.

The horizontal process length in the present study is ±4.129+4.423 mm/±2.158 / ±1.413/5.20±1.429 mm by GM and IM methods by Verma *et al.*[8] have reported mean length of coracoid as 35.54×14.5×7.95 mm. The findings of our study in relation to the length of coracoid process are similar to study done by Verma *et al*[8].

In Rios *et al*. [10] the vertical process length is 11.9±1.8 mm and the width is about 24.9±2.4 mm. In Coale *et al*.[11] studies the width is about 27.9±2.5 mm.

In the present study, the vertical process length, thickness and breadth are 8.82±2.241 (GM)/ 8.82±2.249 (IM)×20.76±3.042/20.80±3.005/ ×7.12±1.974/7.12±1.974 and the width of the vertical process is nearer to Rios *et al.*[10] and Coale *et al.*[11] studies. Bhatia *et al.*[12] in their study have got vertical process measurement as 31.1×16.6×9.9 mm. The thickness is more than the present study. The thickness is important for the measurement of diameter of the screw used to fix the coracoid process.

In our present study the length of vertical process is less than the other studies. The lesser the length of the vertical pillar or horizontal pillar predisposes to the coracoid impingement.

In the present study angles have been studied in ıe sagittal plane, coronal plane and vertical plane as escribed by Bhatia *et al*. 2007[12]. There is no other erature to compare it with the present study. All the ngle parameters have been compared to the study one by Bhatia *et al.*[12]. Table 4 shows that there is decrease in the horizontal process angle in axial plane as compared to Bhatia *et al.*[12] and increase in the vertical plane angulation in the axial plane. Interpillar angle is also found to be decreased. An increase in axial angulation by either pillars, decrease in interpillar angulation and decrease in length of either pillar will predispose to coracoid impingement. Sagittal plane vertical process angulation is similar to that of Bhatia *et al*.

Existing studies till now describe two pillar frame work formed by the lateral scapular border and scapular spine[13]. The present study measurement of angular orientation of the inferior coracoid pillar with reference to glenoid would be relevant to surgeons to utilize coracoid process for fixation of scapular glenoid fractures and implantation of glenoid components.

CONCLUSION

The length and thickness of superior and inferior pillars gives a clue for surgeons for screw fixations. Angulations help the radiologists in proper alignments of the radiographic plane to the plane of coracoid process.This study utilizes goniometer and Image meter methods to describe linear as well as angular parameters of coracoid process with reference to planes of CT scan. The measurements are similar in both the methods so it is not statistically significant ($p>0.05$). We conclude that imagemeter method can be applied to measure as it is less time consuming, easy to carry out and it is reliable as the data collected by goniometer method which is considered as gold standard method is same as imagemeter analysis.

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