

**MORPHOLOGICAL VARIATIONS OF THE CORONOID PROCESS OF ADULT
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ABSTRACT

Mandible is most durable and the strongest bone of skull, having various morphological features which can be useful in identification of race, sex and age of the skeleton. Coronoid process can be an excellent graft for maxillofacial reconstructive surgeries. Primary aim of the present study is to assess the shape and size of the coronoid process of macerated dry adult human mandibles. A total number of 50 mandibles with 100 corresponding right and left sides obtained from the museum of anatomy Departments, University of Port-Harcourt Nigeria were used in this study. Data obtained were analyzed and compared using t-test, and the findings are follows; Triangular shaped coronoid process was found to be most predominant type (45%) followed by rounded (33%) and hook (22%) types. The mean and standard deviation of the length, width and index of the right and left sides of the Triangular shaped coronoid process was found to be 14.41 ± 2.43 mm and 14.34 ± 3.16 mm, 14.30 ± 2.08 mm and 14.53 ± 2.54 mm and 102.32 ± 23.97 mm and 105.92 ± 30.75 mm respectively; while the mean and standard deviation of the length, width and index of the right and left sides of the Rounded shaped coronoid process was 13.94 ± 1.94 mm and 13.70 ± 1.65 mm, 14.98 ± 2.35 mm and 14.78 ± 2.10 mm and 109.33 ± 21.38 mm and 109.16 ± 20.19 mm respectively; and also the mean and standard deviation of the length, width and index of the right and left sides of the Hook shaped coronoid process was 13.99 ± 1.36 mm and 14.09 ± 1.57 mm, 13.58 ± 1.43 mm and 14.04 ± 1.83 mm and 97.35 ± 13.71 mm and 100.51 ± 14.89 mm respectively. With regards to asymmetry, the right and left coronoid process showed no statistically significant difference at ($p < 0.05$), though there were higher mean values on the right sides for length and coronoid index while the left showed a higher value for the width of the coronoid process. The coronoid process of a mandible has proven to be a very useful anatomical land mark in medicolegal practices, therefore extensive knowledge of the variations should be known by clinicians in every population for proper medical intervention.

INTRODUCTION

Morphological variations in anatomical structures is a natural phenomenon which takes origin from genetic, development and environmental changes that occur during the formative stages of life. The mandibular bone possesses unique variabilities which are of medico-legal relevant and one of them is the coronoid process of the mandible. According Shakya et al., 2013, muscle and bone may dynamically affect the function of each other and lead to the changes in the morphology of the bone involved. The word coronoid process is derived from Greek word "korone" means "like a crown". In humans, there is another "coronoid fossa" in humerus and a "coronoid process" present in ulna. Studies have shown the variations in the shapes of coronoid process is classified into three types as hooked, triangular and rounded. These different shapes of the coronoid process act as an evolutionary marker and is very useful in the anthropological & the forensic studies (Saurjya et al., 2020).

The Coronoid process makes an excellent donor graft site for reconstruction of orbital floor deformities, (Mintz et al., 1998). A Coronoid process graft can be used for alveolar defects repair, orbital floor repair, maxillary augmentation, repair of non-union fracture of mandible (Mintz et al., 1998). These grafts can be widely used in the reconstruction of osseous defects in oral and maxillofacial region. The Coronoid process makes a perfect donor graft site for reconstruction of orbital floor deformities Clauser et al., 1995, Mintz et al., 1998). The difference in the shape of coronoid process had been associated to various factors like attachment and action of temporalis action, unilateral chewing habit and hormonal factors.

Gouthaman et al., (2017) studied the coronoid process and stated that the coronoid process is useful for the maxillofacial surgeon and for determining the buccal vestibule during denture fabrication and helps us to understand the angle and extent opening of the mouth.

Fracture of mandible is common, but fracture of the coronoid is very uncommon (2%) and requires no treatment unless impingement is present on the zygomatic arch (Shakya *et al.*, 2013). There is paucity of data on the morphology of the coronoid process of the mandible in Nigerian population, therefore this study seeks to evaluate the morphology of coronoid process of the mandible and compare our findings with other populations.

MATERIALS AND METHODS

Study Design

A total number of 50 dry adult human mandibles, obtained from the Department of Anatomy University of Port-Harcourt, were carefully selected and used for this study.

Inclusion Criteria for Bone Selection

- Macerated dry adult mandibular bones
- Bones with normal physical appearance
- Bones without any pathological damage

Exclusion Criteria for Bone Selection

- Pathological damaged dry adult mandibular bones
- Bones without normal physical appearance
- Under aged dry macerated bone

Procedure for Shape determination and measurement

➤ Osteometric Observation of the Shapes

The different shapes of the coronoid process of the mandible were examined by physical observation by a single examiner to avoid or control interexaminer and intra examiner reliability of the different coronoid shapes. The three different shapes of coronoid process were reported based Isaac B & Holla S J classification:

1. **Triangular:** The tip of coronoid process is straight upward.
2. **Hook:** Shaped in which the tip of coronoid process is pointing backward.
3. **Rounded:** Tip is rounded

➤ Measurement of the linear anthropometric parameters for the Size

Direct anthropometric measurements will be carried out by placing the mandible in an anatomical position. The mandibles are to be placed upright with the dentine and ramus superiorly. Measurements were performed according to classical methods of physical anthropology using standard instruments. The osteometric dimensions off the bones will be measured with respect to the given landmarks.

Intercoronal Distance: is measured from the top notch of the left side to the right side of the coronoid process of the mandible.

Length of The Coronoid Process: is measured from the tip to the base of the notch of the mandible.

Width of The Coronoid Process: is measured from the lateral border of the coronoid process to the base of the notch of the mandible.

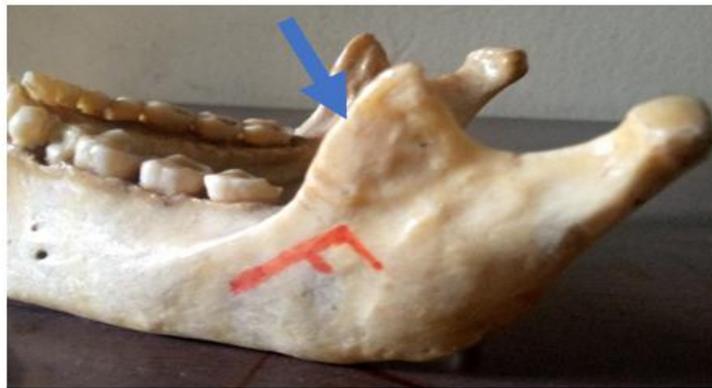


Figure 1: Triangular.



Figure 2: Rounded.



Figure 3: Hook.

Method of Data Analysis

The data collected is analyzed using SPSS version 23 to check for the mean and standard deviation, and using descriptive approach which involves the use of, simple frequency tables, chart, mean and percentages.

Result and Data Analysis

A total of 50 mandibles with 100 corresponding sides (right and left) collected from University of Port-Harcourt Nigeria, were analyzed for shape and position of lingula of the mandible.

The values for the measured parameter were expressed in percentages and mean \pm SD in descriptive statistics.

Independent sample t-test was used to determine side differences in measured parameters and Confidence interval was set at 95%, for $p < 0.05$ to be considered significant.

Table 1: Morphological analysis of various shapes of coronoid process.

Shapes	Percentage	Bilaterally	Unilateral	
			right	left
Triangular (n=45)	45%	38	4	3
Rounded (n=33)	33%	30	2	1
Hook (n=22)	22%	18	1	3

Right and Left Side Average Size of the Coronoid Process

Coronoid length: Average length of the right and left of coronoid process of the mandible in the study population was 14.17 ± 2.07 mm and 14.08 ± 2.40 mm respectively. Average length of coronoid process was slightly greater on right side by 0.09mm when compared with the left side. There was no significant difference statistically at (p -value 0.05). No significant variation in length of the coronoid process was noted between right and left sides of the mandibles.

Coronoid width: Average width of the right and left of coronoid process of the mandible in the study population was 14.39 ± 2.09 mm and 14.49 ± 2.22 mm respectively. Average width of coronoid process was slightly greater

Shape of the Coronoid Process

Triangular: the triangular shape has (45 sides) which was distributed as 38 (84.4%) bilaterally, 4(8.9%) on the right side and 3(6.7%) on the left side (table 4.1).

Rounded: The round shape was the next commonly dominated shape that has (33 sides), of which 30 (90.9%) were bilateral, 2 (6.1%) were on the right side and 1 (3%) on the left side.

Hook: The hook was the least type of shape that was observed which has (22 sides), of which 18 (81.8%) were bilateral, 1(4.5%) were on the right side and 3 (13.7%) on the left side. The distribution of the shapes of the coronoid process among the right and left sides had shown statistical significance ($P < 0.05$).

on left side by 0.10mm when compared with the right side. There was no significant difference statistically at (p -value 0.05). No significant variation in width of the coronoid process was noted between right and left sides of the mandibles.

Coronoid index: the average Coronoid index was calculated. The mean and standard deviation value of the Coronoid index was found to be 103.71 ± 21.49 mm in the right and 105.66 ± 24.30 mm in the left. Average coronoid index of coronoid process was slightly greater on left side by 1.95mm when compared with the right side. There was no significant difference statistically at (p -value 0.05). No significant variation in coronoid index was noted between right and left sides of the mandibles.

Table 2: Descriptive characteristic of the left and right coronoid process and test of mean differences.

Parameters	Descriptive Characteristics		Test of mean difference			
	Right (n=50) Mean±S.D	Left (n=50) Mean±S.D	df	t-value	P-value	Inference
Length	14.17±2.07	14.08±2.40	98	0.203	0.840	Not Significant
Width	14.39±2.09	14.49±2.22	98	-0.232	0.817	Not Significant
Index	103.71±21.49	105.66±24.30	98	-0.424	0.672	Not Significant

Shape and Size Distribution of the Coronoid Process

Triangular: The result for the measured parameters of the triangular shape of the coronoid process shows the mean and standard deviation values for the right and left **Maximum length** is 14.41±2.43mm and 14.34±3.16mm respectively, while the **width** for the right and left was 14.30±2.08mm and 14.53±2.54mm respectively, and the

Intercoronoid index for the right and left also have a mean and standard deviation value as 102.32±23.97mm and 105.92±30.75mm respectively (Table 3). However there was no significant difference of the right and left triangular shape measured linear parameters at ($p < 0.05$) to indicate asymmetry between the right and left.

Table 3: Descriptive characteristic of the left and right triangular type of the coronoid process and test of mean differences.

Parameters	Descriptive Characteristics		Test of mean difference			
	Right mean±S.D	Left mean±S.D	df	t-value	P-value	Inference
	Triangular (n=23) 46.0	Triangular (n=22) 45.0				
Length	14.41±2.43	14.34±3.16	43	0.081	0.936	Not Significant
Width	14.30±2.08	14.53±2.54	43	-0.321	0.750	Not Significant
Index	102.32±23.97	105.92±30.75	43	-0.439	0.663	Not Significant

Round: The result for the measured parameters of the triangular shape of the coronoid process shows the mean and standard deviation values for the right and left **Maximum length** is 13.94±1.94mm and 13.70±1.65mm respectively, while the **width** for the right and left was 14.98±2.35mm and 14.78±2.10mm respectively, and the

Intercoronoid Index for the right and left also have a mean and standard deviation value as 109.33±21.38mm and 109.16±20.19mm respectively (Table 4). However there was no significant difference of the right and left round shape measured linear parameters at ($p < 0.05$) to indicate asymmetry between the right and left.

Table 4: Descriptive characteristic of the left and right rounded type of the coronoid process and test of mean differences.

Parameters	Descriptive Characteristics		Test of mean difference			
	Right mean±S.D	Left mean±S.D	df	t-value	P-value	Inference
	Rounded (n=17) 34.0	Rounded (n=16) 32.0				
Length	13.94±1.94	13.70±1.65	30.7	0.381	0.706	Not Significant
Width	14.98±2.35	14.78±2.10	30.9	0.258	0.798	Not Significant
Index	109.33±21.38	109.16±20.19	31.0	0.024	0.981	Not Significant

Hook: The result for the measured parameters of the triangular shape of the coronoid process shows the mean and standard deviation values for the right and left **Maximum length** is 13.99±1.36mm and 14.09±1.57mm respectively, while the **width** for the right and left was 13.58±1.43mm and 14.04±1.83mm respectively, and the **Intercoronoid Index** for the right and left also have a mean and standard deviation value as 97.35±13.71mm and 100.51±14.89mm respectively (Table 5). However there was no significant difference of the right and left hook shape measured linear parameters at ($p < 0.05$) to indicate asymmetry between the right and left.

Table 5: Descriptive characteristic of the left and right hook type of the coronoid process and test of mean differences.

Parameters	Descriptive Characteristics		Test of mean difference			
	Right mean±S.D	Left mean±S.D	df	t-value	P-value	Inference
	Hook (n=17) 20.0	Hook (n=15) 24.0				
Length	13.99±1.36	14.09±1.57	19.9	-0.151	0.882	Not Significant
Width	13.58±1.43	14.04±1.83	20	-0.643	0.528	Not Significant
Index	97.35±13.71	100.51±14.89	19.8	-0.518	0.610	Not Significant

Table 6: Correlation between variables for the left and right side of the coronoid process.

Pearson Correlation		Side = Right		Side = Left	
		Width	ICD	Width	ICD
Shape = Hook					
Length	r	0.153	-0.176	0.204	-0.017
	P-value (Inf)	0.673 (NS)	0.626 (NS)	0.525 (NS)	0.959 (NS)
Width	r		0.266		0.479
	P-value (Inf)		0.458 (NS)		0.115 (NS)
Shape = Rounded					
Length	r	-0.052	-0.046	0.202	-0.222
	P-value (Inf)	0.842 (NS)	0.861 (NS)	0.452 (NS)	0.408 (NS)
Width	r		-0.009		0.112
	P-value (Inf)		0.972 (NS)		0.680 (NS)
Shape = Triangular					
Length	r	-0.198	-0.317	0.043	0.063
	P-value (Inf)	0.366 (NS)	0.141 (NS)	0.850 (NS)	0.781 (NS)
Width	r		-0.298		-0.022
	P-value (Inf)		0.167 (NS)		0.923 (NS)

ICD=intercoronoid distance

Table 7: Comparison of numerous studies of coronoid process of mandible.

S/N	Author (year of study)	Different Shapes of Coronoid Process		
		Triangular (%)	Rounded (%)	Hook (%)
1	Issac B (2001)	49	23.6	27.4
2	Vipul et al (2011)	54.17	21.25	24.58
3	Nirmale et al (2012)	65	7	28
4	Smita Tapas (2014)	60	22	18
5	Vikas Desai (2014)	68	8	24
6	Sheela et al., (2015)	64.97	14.01	21.02
7	Priyank Bhabhor (2015)	29.65	45	25.35
8	Abdulhaseeb (2016)	67	30	3
9	Gouthaman et al., 2017	38	26	36
10	Sufia et al (2018)	66.10	11.93	21.97
11	Khan TA et al (2011)	67	3	30
12	Prajapati VP et al (2011)	54.17	24.58	21.25
13	Hossain SMA (2011)	29.65	25.35	45
14	Mouna S et al (2015)	14	12.5	61.5
15	Sanmugam K. (2015)	49	24	17
16	Pradhan et al., 2014	46.73	35.3	17.93
17	Dhanaji S(2017)	60.76	15.38.	23.84
17	Present Study	45	33	22

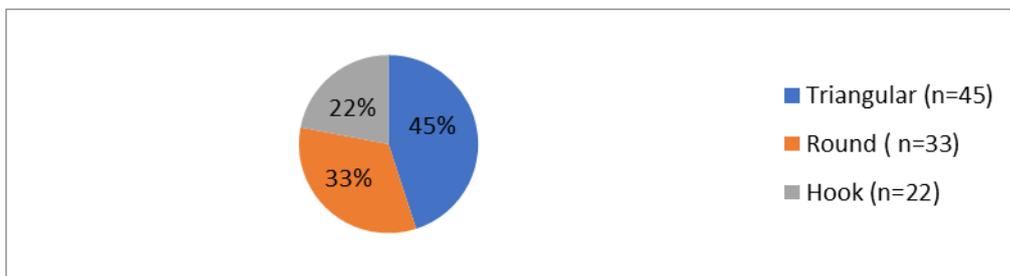


Figure 2: Pie chart showing the percentage difference of the coronoid Shapes.

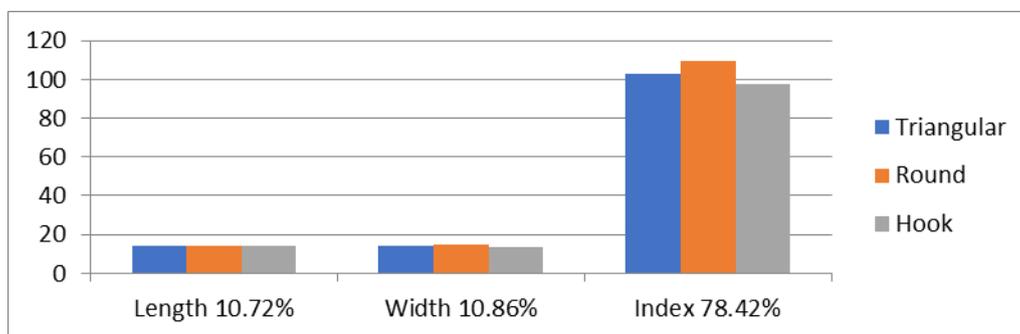


Figure 3: Bar chart showing percentage distribution of the size with the various Shapes on the right side of the coronoid process.

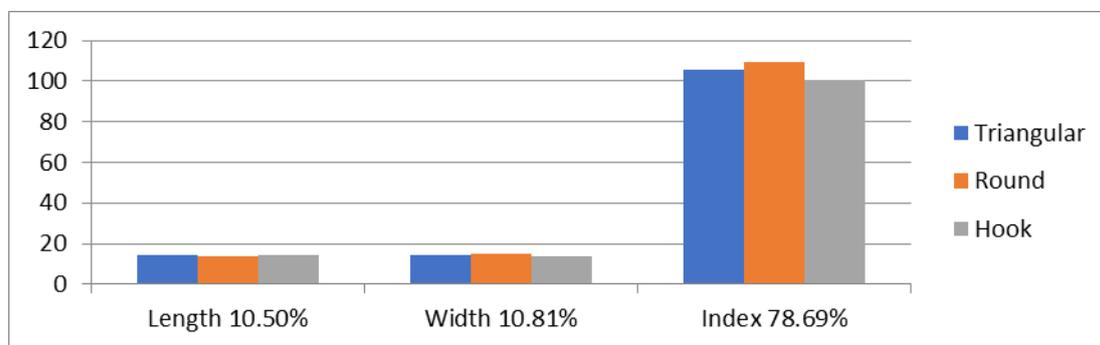


Figure 3: Bar chart showing percentage distribution of the size with the various Shapes on the left side of the coronoid process.

DISCUSSION

The unique characteristics of the mandibular landmarks in medicolegal practices and forensic identification can never be overemphasized. Several studies have evaluated the morphometry of the coronoid process of dry adult mandible to observe the differences in the morphology of the coronoid process in the population of study.

The different anatomical variations in the shape of coronoid process may results in the narrowing of the vestibular space because of the proximity of the medial aspect of the coronoid process to the distal molar teeth. This may cause impingement, which may result in the restriction of the mouth opening as well as mandibular hypomobility (Sanmugam). In reconstruction of orbital floor deformities, the coronoid process makes an excellent donor graft site. Mintz *et al.*, 1998. Clauser *et al.*, 1995, described the use of a temporalis myofascial flap both as a single and as composite flap with the cranial bone.

In this present study, the triangular shape (45%) type was the most prevalent followed by rounded shape (33%), while the hook shape was the least prevalence with 22% in the southern part Nigerian population. This finding is in accordance with the studies reported by Isaac *et al.* (2001) in Bengal Population, Tanveer *et al.* (2011) in Indian population, Nirmale *et al.* (2012) in Indian population, Smita Tapas (2014), Vikas Desai (2014), Sheela Kadam (2015), Pradhan *et al.*, 2014 and Abdulhaseeb (2016) who observed triangular shape as the most prevalent followed by round and the least prevalence was hook shape in their various studies; however this study differs with that of Vipul *et al.* (2011) in Indian population which observed the triangular shaped coronoid process to be more predominant followed by hook and rounded shaped was the least. Gouthaman *et al.*, 2017 reported three shapes of coronoid process in this order, the triangular coronoid was most common (38%), followed by hook and rounded (26%). The findings of Priyank *et al.*, (2015) was much

different, according to him hook shaped pattern of coronoid process is more common than triangular type.

In our study, bilateralism in the triangular shape was (84.4%), round shape was (90.9%), while hook was (81.8%) respectively.

The findings from this study was compared with the previous studies and it became very much clear that nearly all populations show same pattern of diversity i.e. triangular shaped is most common followed by round shaped then by hook shaped.

The variation of the shape of the coronoid process in the different population of study can be attributed to their type of diet, environmental and genetic factors.

There was variation in length of the coronoid process between right and left sides of the mandibles. The length of the right was slightly higher than the left of coronoid process of the mandible in the study population with no significant difference statistically at (p-value 0.05). However, our finding is in contradictory with, Nayak *et al.*, 2015, who reported longer coronoid process on the left side than the right side, which they further explained may be due to genetic factors, functional factors, and hormonal impact on muscle growth, bone remodeling and probably lead to enhanced functional stress on mandible due to mastication. In our study, triangular shape has the highest length, followed by the hooked and then the rounded shape, while Gouthaman et al. 2017, reported rounded has the highest length followed by triangular and the hooked in their study.

The width of the coronoid process was slightly higher on left side by 0.10mm when compared with the right side in the study population.

The Coronoid index was calculated was slightly greater on left side by 1.95mm when compared with the right side. There was no significant difference statistically at (p-value 0.05). Triangular coronoid process was found to be the longest followed by rounded and then hook shape.

The findings of the present study are consistent with most other previous studies done, on the size of the right coronoid process being greater than the left. However, the actual height, width of the coronoid process and size of ramus at coronoid showed variation which could be due to any of the above factors or due to sample variation.

Detailed review of the different populations revealed striking variations in the overall morphology of the coronoid process of the mandible which implies that the coronoid process will be a very useful tool in forensic identification of population and in medical practices. These variations could be attributed to the nature of our diet, genetic, social and cultural background of a population.

CONCLUSION

The coronoid process of a mandible has proven to be a very useful anatomical land mark in medicolegal practices, therefore extensive knowledge of the variations should be known by clinicians in every population for proper medical intervention. Also, as a useful forensic tool, there is a need to document the data for every population.

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