

## Gender Determination Using Volume of the Clavicle in Nigerian Population

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**Abstract:** The clavicle is known to be a useful bone in metric determination of gender in forensic anatomy and anthropology. Gender determination is primary criteria of identification. The clavicle is the only long bone that lies horizontally and usually resists environmental degradation. Apart from the pelvis, skull, calcaneus, radius and ulna, the clavicle appears to be a very reliable and useful bone for gender determination. The aim of this study was to scientifically use volume of the clavicle to determine gender in human skeletons in adult Nigerians. Direct measurements of volume of the clavicle was conducted on 40 clavicles (25 males and 15 females), extracted from adult human bodies, which were well macerated and dried. These clavicles were sourced from the Anatomy Department of various Universities in South-south and South-eastern region of Nigeria. Degraded, deformed and fractured clavicles with associated tumors were excluded. The volume of the bone was measured in milliliters (ml) by water displacement techniques using thread, measuring cylinder, pipette, and beaker. Data were analyzed using statistical package for social science (IBM version 23) and p-values  $\leq 0.05$  was considered significant. From the result, mean volume of right male clavicle was  $26.85 \pm 5.19$ ml and left was  $27.78 \pm 5.05$ ml. The mean volume of right female clavicle was  $21.85 \pm 1.96$ ml and left was  $22.53 \pm 1.81$ ml. The volume of the clavicle was found to be statistically significant in gender determination. This data has provided morphometric database of the clavicle in Nigerian population which could be of assistance to forensic scientists in gender determination and a useful guide to orthopedic implant manufacturers and orthopedic surgeons in determining the correct size and shape of plates and intramedullary nails in clavicular anomaly.

**Keyword:** Clavicle, gender, volume, statistical, orthopedic.

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### I. Introduction

The clavicle is a long bone that lies in the front of the chest wall. It forms the anterior portion of the shoulder girdle, and curves somehow like the italic letter 'f'. [1] It is a small bone but is able to bear significant force by the action of the muscles and ligaments that attaches to it. [2] It has a shaft and two ends which are sternal and acromial ends. [3] Most times, especially in forensic studies, one is confronted with the identification of sex of the individual from skeletal remains. The clavicle appears to be a reliable bone apart from pelvis, skull, calcaneus, radius and ulna useful in sex prediction, and also exhibit sexual dimorphism. [4] The male bones are more massive and heavier than female bones, structures like crest, ridges, tuberosities and lines of muscle attachment and ligaments are more strongly marked in males; this is a general rule that governs the size of joints and articular surface of the bones. [5] The clavicle shows much restraint to environmental factors and by findings has been proven reliable in gender determination. [6] The use of the clavicle for sex determination is still found to be inadequately represented in the forensics. In forensic studies, it has been stated that when 100% accuracy is required there should be no overlapping of the values for both sexes, the male bones overlap from hypo masculine to hyper masculine whereas, the female bone tends to have a range of hypo-femininity; thus, the overlapping causes difficulty in sex determination. [7][8] [9] In Nigeria the dearth of scholarly work on clavicular morphometry created the need for this study in order to provide data for clavicular parameters and reference values for the Nigerian population. This data will be utilized in the diagnosis and treatment of diseases related to the clavicles. Data provided will also help the orthopedic-implant manufacturer in determining correct size and shape of plates and intramedullary nail in the treatment of clavicular fracture in the Nigerian population. The study will further enhance the prediction of gender in cases of commingled bodies, plane crashes and missing remains.

### II. Materials And Methods

A total of 40 clavicles extracted from adult human bodies of known sex (25 males and 15 females) of right and left clavicles were sourced from Anatomy Departments of the following Universities: University of Port Harcourt Rivers State, Igbinedion University, Okada, Ambros Ali University Ekpoma Edo State and

Nnamdi Azikiwe University, Akwa, Anambra State. Selections were specifically bodies ascertained to be adult with age ranging from 25-70 years; clavicles with complete ossification, normal morphology were included in the present study. Bone showing deformity, degradation and fracture were excluded.

### **Volume of clavicle**

The volume of the bone was measured in milliliters (ml) by water displacement techniques. A glass cylinder of 500mls capacity having side nozzle at the top, sufficient to accommodate a clavicle was used. The cylinder was filled with water to the brim; it was ensured water doesn't spill through the nozzle. The clavicle was suspended into the cylinder, with a thread at one end of the clavicle. The lowering was done slowly; the amount of water displaced by the bone was accessed using a measuring cylinder and pipette. Average of three measurements was taken for each clavicle; the average value obtained was considered the volume of the clavicle (Yadav and Agarwal, 1983; Shobha, 2010; Jatti *et al.*, 2012).



**Figure 1:** Determination of clavicular volume using water displacement technique

### **Data Analysis**

The statistical analysis was performed using SPSS (IBM)® Version 23.0; SPSS, Inc., Chicago, IL) and XLSTAT (Version 2015) Statistical packages. Continuous Variables were presented in mean (S.D). Paired sample t-test was used for side comparison while student t-test was used to determine sex-differences. Confidence interval was set at 95% with significance of the difference accepted at  $P \leq 0.05$ .

### **III. Results**

The results presented were measurement of the volume of the clavicle, tables were used to represent and compare mean values for the males and the females clavicles. The descriptive characteristics comparison of gender, side differences in the mean values were represented in Tables 1-3. Table 4 shows comparison of mean value in the present study with other studies.

The mean  $\pm$  (S.D) values obtained for right left clavicle were  $26.85 \pm 5.19$ ml and  $27.78 \pm 5.05$ ml for males (M) and  $21.85 \pm 1.96$ ml and  $22.53 \pm 1.81$ ml for females (F) respectively.

The result in Table 1 was based on 40 cadaveric measurement of the clavicle comprising of 25 males and 15 females. The evaluation of the interpredictability of both sides of the clavicle was presented in Table 1 with categorization into total as well as sex specific relationships. The volume of the right and left clavicle were significant with positive correlation for the male and females. For the male clavicle, the volume was significant with correlating value (R vs L volume;  $r=0.791$ ,  $P < 0.001$ ), while the female value was (R vs L volume;  $r=0.972$ ,  $P < 0.001$ ). The side-specific sex differences illustrated in Table 2 showed significant morphometric asymmetry in clavicular volume. The mean difference Volume of males and females were M (M.D=0.94ml [L>R],  $P=0.169$ ), F (M.D). . However, for the right clavicular volume, t-test showed that values were significantly higher in males than females ( $P < 0.001$ ), Volume (M.D $\pm$ S.E.D= $4.99 \pm 1.15$ ml,  $t=4.324$ ,  $P < 0.001$ ), The left clavicle showed significantly greater values in males when likened to females; Volume (M.D $\pm$ S.E.D= $5.25 \pm 1.11$ ml,  $t=4.718$ ,  $P < 0.001$ ), (Table 3a and b).

**Table 1:** Descriptive characteristics and inter-predictability of the clavicle (side)

Parameters	Total (N=40)			Male (N=25)			Female (N=15)		
	Mean±S.D	r	P-value (Inf.)	Mean±S.D	R	P-value (Inf.)	Mean±S.D	R	P-value (Inf.)
R. Volume (ml)	23.71±5.56	0.669	<0.001 (S)	26.85±5.19	0.791	<0.001 (S)	21.85±1.96	0.972	<0.001 (S)
L. Volume (mm <sup>3</sup> )	25.68±5.31			27.78±5.05			22.53±1.81		

Note: R = Right, L = Left, N = Distribution, S.D = Standard deviation, r = Pearson’s correlation, P-value = Probability value, Inf = Inference (S = Significant, NS = Not Significant)

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**Table 2:** Side difference evaluation using paired sample t-test (cadaveric measurement)

Parameters	Total (N=40)				Male (N=25)				Female (N=15)			
	Mean	S.D	t-value	P-value	Mean	S.D	t-value	P-value	Mean	S.D	t-value	P-value
R. Vs L Volume (ml)	-1.97	4.43	-3.154	0.003 (S)	-0.94	3.31	-1.419	0.169 (NS)	-0.68	0.47	-5.608	<0.001 (S)

Note: F-value = Fisher’s calculated value, EVA = Equal variance assumed, Inf. = Inference, EVNA = Equal variance not assumed, df = degree of freedom, t-value = t-test calculated value, P-value = Probability value, M.D = Mean difference, S.E.D = Standard error of the difference, C.I = Confidence interval, S = Significant, NS = Not Significant.

**Table 3:** Evaluation of the sex difference in right and left clavicular parameters using student t-test (cadaveric measurement)

Parameter	Levene's Test for Equality of Variances			t-test for Equality of Means					
	F-value	P-value	Inf	df	M.D	S.E.D	t-value	P-value	Inf.
R. Volume (ml)	7.514	0.009	EVNA	33.531	4.99	1.15	4.324	<0.001	S
L. Volume (ml)	11.655	0.002	EVNA	32.778	5.25	1.11	4.718	<0.001	S

Note: F-value = Fisher’s calculated value, EVA = Equal variance assumed, Inf. = Inference, EVNA = Equal variance not assumed, df = degree of freedom, t-value = t-test calculated value, P-value = Probability value, M.D = Mean difference, S.E.D = Standard error of the difference, Inf = Inference (S = Significant, NS = Not Significant).

**Table 4:** Comparison of mean volume of male and female clavicle in the present study with other studies:(ml)

Authors	Population	Male		Female	
		Right	Left	Right	Left
Yadav and Agarwal (1983)	North India	22.55	23.12	11.45	11.24
Shobha (2010)	India-North Karanataka	17.52	17.86	12.57	11.30
Jatti <i>et al.</i> (2012)	Karanataka zone	17.52	17.86	12.57	11.30
Present Study	Nigeria	26.86	27.78	21.85	22.53

**Note:** F-value = Fisher’s calculated value, EVA = Equal variance assumed, Inf. = Inference, EVNA = Equal variance not assumed, df = degree of freedom, t-value = t-test calculated value, P-value = Probability value, M.D = Mean difference, S.E.D = Standard error of the difference, Inf = Inference (S = Significant, NS = Not Significant).

#### IV. Discussion

In most forensic anthropometric measurement s, males most times have greater bone dimensions than the females [9]. This is also the similar for the clavicle as evident in the present and previous studies. Studies established that the clavicular volume is larger in males than in females. A comparison on the findings in this study with that of other populations, confirms the existence of racial and gender differences between various groups studied.[10], [11], [12].

From the present study it can be seen that the mean volume obtained for male clavicles were generally higher than that of female clavicles. This is in line with the findings of *Jatti et al.*, Shobha and Yadav and Agarwal.[ 10, 11,12]. The study also showed that sexual dimorphism of the clavicle by volume is statistically significant (P <0.001). In the present study the mean volume of the male right clavicle was found to be 26.85ml, which was higher than the values obtained by Yadav and Agarwal (22.55ml) [12], *Jatti et al.*(17.52ml) [10] and Shobha(17.52ml) [11]. For the female, the mean value for volume in the present study was 21.85ml, which was higher than *Jatti et al.*(12.57ml) [10] Shobha(12.57ml) [11], Yadav and Agarwal(11.45ml) [12].The mean volume of the male left clavicle in the present study was 27.78ml, this was higher than the values obtained by Yadav and Agarwal(23.12ml) [12], *Jatti et al.* (17.8ml) [10] and Shobha (17.86ml) [11]. The mean volume of the female clavicle in the present study is 23.53ml, was higher than *Jatti et al.* (11.30ml) [11], Shobha (11.30ml) [10] and Yadav and Agarwal (11.24ml). [12] The mean volume of male and female clavicles in the present study (Nigeria) was significantly higher than that of Yardav and Agarwal (North India), Shobha (India North Karanataka) and *Jatti et al* (India North Karanataka). The observed difference between the volume of the clavicle in the present study (Nigeria) and that of other studies (India) can be attributed to nutritional, climatic, genetic make-up and inheritance which exert a substantial influence on the individual differences in body configuration [13]. It could also be attributed to the use of freshly processed samples in the present study instead of the very dried bones used in the other studies.

#### V. Conclusion

The study has been able to generate baseline values of clavicular mean volume for adult Nigerians using clavicle extracted from cadavers. The mean clavicular volume showed high statistical significant difference between males and females in the Nigerian population. The data generated from this study will provide a useful guide to orthopedic surgeons in the treatment of clavicular fractures and orthopedic implant manufacturers in the construction of correct shape and size of plates and intramedullary nails.

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#### CONFLICT OF INTEREST

There is no conflict of interest.

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