RESEARCH ARTICLE

Age Determination Using Epiphyseal Union of the Medial Clavicle a Radiological Study at the Delta State University Teaching Hospital Oghara Nigeria

Ukah Emmanuel[1], Wilson Josiah Iju[1], Ikubor Joyce Ekeme[2], Enaohwo Mamerhi Taniyohwo[1], Okoro Ogheneyebrorue Godswill[3]*

Ogheneyebrorue GO. Age Determination Using Epiphyseal Union of the Medial Clavicle a Radiological Study at the Delta State University Teaching Hospital Oghara Nigeria. Int J Anat Var. 2023;16(12): 447-451.

ABSTRACT

Introduction: An important bone in the human body called the clavicle exhibits sexual dimorphism and considerable morphometric changes that are influenced by things like occupation and ethnicity. The goal of the study was to develop and test a formula for predicting sex in Delta State, Nigeria using the epiphyseal union of medial clavicle.

Materials and Methods: Two hundred (200) postero-anterior chest radiographs from a Nigerian population was analyzed. Clavicle length measurements were taken using digital calipers. Statistical analyses, including t-tests, correlations, and discriminant function analysis, were conducted to evaluate sexual dimorphism and develop sex estimation formulas.

Results: The left clavicle was longer than the right in both genders, and males had longer clavicles than females. Sex prediction accuracy was 77% for the left, 75% for the right, and 80% for combined clavicles.

Conclusion: Clavicle length is a useful tool in sex estimation within the studied Nigerian population. Understanding sexual dimorphism and population-specific variations is crucial for accurate forensic identification and orthopedic interventions involving the clavicle.

Keywords: Sexual dimorphism; Clavicle length; Forensic; Accuracy

INTRODUCTION

The clavicle is a paired, S-shaped or curved, horizontally lying long bone located above the first rib. It articulates laterally to the acromion process of the scapula and medially to the manubrium of the sternum [1,2]. Its double curvature separates it into two parts; a medial two-thirds and a lateral one-thirds. The medial portion is convex anteriorly and appears rounded while the lateral one-third is convex posteriorly and seems flattened [3,4]. This geometry reflects its biomechanical function and effect of the various cervical and thoracic muscles and ligaments that attach onto it. It acts as a horizontal strut that transmits the loads from the upper limb to the axial skeleton. It also protects neurovascular structures traversing the chest to the upper extremity and neck [2,3].

The clavicle is the first bone that starts its ossification process early in the intrauterine life, precisely at the 5th to 6th week [5]. However, it is the last bone to complete its ossification process at 25-29 years of life [2,6-8]. Evident sex differences in the clavicles are visible after puberty [9]. Since it completes its development at an older age, the clavicle displays greater asymmetry and more sexual dimorphism than bones which mature earlier. Bones that mature later are highly influenced by an individual's physical activity, work and lateralized behaviors [3]. For instance, manual workers have thicker and more curved clavicles with more prominent ridges for muscular attachments [1,10].

Human identification is based on unique physical and biological parameters of an individual [11]. The evaluation of human remains involves the determination of sex, age, race and stature to aid in positive victim identification especially following mass disasters such as plane crashes and explosions as well as in medicolegal practice involving both civil and criminal cases [3,10,12]. The identification of remains in advanced post-mortem decomposition stages and following burns is more challenging due to the absence of soft tissues. 6 Therefore, the use of widely known methods of identification such as fingerprints are not feasible in such cases. Furthermore, in cases where no family positively identifies or claims the deceased or cases of financial barriers, deoxyribonucleic acid (DNA) analysis may not be affordable [9,13]. Due to its resistance to putrefaction and destruction, bone serves as an alternative means of identification through the easy and affordable methods of assessing the bone morphology and osteometric parameters [1,11,12].

Sex determination is a crucial aspect of forensic investigations, particularly in the context of fragmented remains. 3 It reduces the number of possible matches by half and is an essential initial stage in anthropologic research [5,7,9,10,13]. Morphological evaluation of bones can aid in sex determination, but it is subjective and has lower accuracy compared to metric assessment [10]. The clavicle, which is known for its durability and ability to withstand taphonomic degradation after death, is suitable for human identification [7,14,16]. Gender differences are observed in the clavicle, with females having shorter, less curved, thinner, and smoother surfaces, while males are heavier and have more prominent muscular markings [5,7]. The utilization of osteological and radiological evaluation of upper extremity bones in sex determination has been widely accepted [3,13].

The morphology and morphometry of the clavicle is also important to orthopedic surgeons in the management of clavicular fractures [4]. The clavicle is a commonly fractured bone around the shoulder region accounting for 44% of shoulder girdle injuries. Additionally, 75% of clavicular fractures occur at the mid-shaft region with the most common fracture site being the junction between the lateral one-third and the medial two-thirds [9,10,17]. Clavicular fractures can be treated conservatively, although, in cases of displaced fractures, non-union is common. Hence, operative fixation is preferred over conservative management to avoid limb shortening and subsequent functional deficits [4]. The knowledge of the clavicular morphometry is important in the designing of fixation devices and also proper anatomical restoration after reduction of the fracture [4,18,19]. For effective surgical management of clavicular fractures, the population specific baseline data on the pre-fracture clavicular length is important to inform on the choice of devices and prosthesis thus minimizing the complications and failure rates [6,7,9,18]

Several studies have been documented where the length of the clavicle was measured directly on bone [2,3,4,9,11,14,16,18,20]. Other studies measured the clavicular length on radiographs [7]. From these literature sources, the length of the clavicle varies according to gender, side, geographical location, occupation and ethnic or racial groups [9,14,20]. Clavicular parameters such

[1]*Department of Human Anatomy and Cell Biology, Faculty of Basic Medical Sciences, Delta State University, Abraka, Nigeria*
[2]*Department of Radiology, Delta State University Teaching Hospital Oghara, Nigeria*
[3]*Department of Human Anatomy, Achievers University, Owo, Ondo State, Nigeria*

Correspondence: Godswill Okoro Ogheneyebrorue, 3Department of Human Anatomy, Achievers University, Owo, Ondo State, Nigeria; E-mail: thomasgodswill23@gmail.com

Received: 01-Dec-2023, Manuscript No: ijav-23-6871; Editor assigned: 04-Dec-2023, PreQC No. ijav-23-6871 (PQ); Reviewed: 21-Dec-2023, Qc No: ijav-23-6871; Revised: 25-Dec-2023 (R), Manuscript No. ijav-23-6871; Published: 30-Dec-2023, DOI:10.37532/1308-4038.16(12).333

as its length, weight and mid-clavicular circumference have been shown to be reliable sex indicators in different population groups [3,10]. Moreover, the accuracy of predicting sex using the clavicle varies in different populations depending on the degree of sexual dimorphism [7,14]. This study therefore aimed at deriving a formula for determining sex using the length of the clavicle and further establishes the accuracy of predicting sex using the clavicular length measured on chest radiographs stored in the Radiological Unit of a Teaching Hospital in Delta State, Nigeria.

MATERIALS AND METHODS

This descriptive cross-sectional study retrospectively evaluated the postero-anterior (PA) chest radiographs of patients who visited the Radiological unit of a Teaching Hospital in Nigeria between January 2017 and December 2021. Before the commencement of data collection, we obtained ethical approval from the Research and Ethics Committee of the Hospital (Ref. No. CHW/ECC VOL 1/266).

The study sample was purposively selected and comprised radiographs of 200 patients (89 males and 111 females) aged 25 years and above. The lower limit of 25 years was chosen since the clavicles have completed their ossification by this age [20]. We included only the postero-anterior chest radiographic views which were technically adequate and with mature clavicles as evidenced by the completion of the medial clavicular epiphyseal ossification. The clavicles with visible congenital anomalies or pathological lesions such as fractures and tumors were excluded from this study. Poor quality radiographs such as those with over-penetration and patient rotation were excluded.

Using a digital caliper, the length of the clavicle was measured as the maximum distance between the midpoint of the acromial end and the midpoint of the sternal end of the clavicle.4 A single researcher measured the clavicular length to eliminate inter-examiner variations. Additionally, the length was measured in triplicate and the mean recorded to minimize intra-observer errors.

We analyzed the raw data with the aid of Statistical Package for Social Sciences Version 23.0; SPSS, Inc., Chicago, IL). We computed descriptive statistics (means and standard deviations) putting the side of the clavicle, sex and age into consideration. The paired t-test and independent t-test were used to evaluate the lateral differences and sexual dimorphism in the mean clavicular length respectively. The level of relationship between the right and left clavicular lengths was ascertained using the Pearson's correlation test.

To provide algorithms that will be useful for sex determination, discriminant function analysis was carried out using the length of the clavicle. This analysis is useful in forensic setting where the case studied is from the same reference population or biological origin studied. Eigen values, Wilk's lambda, canonical correlations and unstandardized coefficients were calculated. The unstandardized coefficients were used to compute the discriminant scores.3 Gender was the independent variable while the clavicular length was the predictor variable. Therefore, the discriminant formula derived was M=p+C1Y1 where M is the discriminant score, p is the Y-intercept, while C and Y represent the discriminant coefficient and the predictor (clavicle length) respectively. The accuracy for using the clavicular length for sex determination was determined. The level of statistical significance in this study was set at a p-value of less than 0.05.

RESULTS

The clavicular length was assessed on 200 radiographs of 111 females (55.5%) and 89 males (44.5%). The mean age of the population was 51.45±1.23 years while the age range was 25-97 years. The distribution of the study population based on age is shown on Table 1. The mean length of the left clavicle was 147.69±11.54 mm while that of the right clavicle was 145.93±11.92 mm. The minimum and maximum lengths as well as the means in each gender group are shown on Tables 1 and 2.

The left clavicle was significantly longer than the right clavicle in both males and females ($p<0.05$) (Table 3). Males had significantly longer clavicles compared to females and this was observed bilaterally ($p<0.05$). The descriptive statistics based on gender are shown on Table 4. The length of the clavicle in the males and females of different population groups is summarized in Table 3-5.

In both males and females, the length of the clavicle showed a weak positive correlation with age ($0<r<0.5$). However, this association was not statistically significant ($p>0.05$). The percentage accuracies of sex prediction using the length of each clavicle or bilateral clavicles are shown on Table 6. The probability for correct sex determination was higher using the left (154, 77.0%) than the right (150, 75.0%) clavicular length. Moreover, combining the lengths of the right and left clavicles improved the accuracy of sex prediction (160, 80.0%) [Table 6].

Table 1) *Distribution of the study population based on Age.*

Age (Years)	Female		Male		Total	
	N	%	N	%	N	%
25-30	12	10.8	15	16.9	27	13.5
31-40	19	17.1	8	9	27	13.5
41-50	30	27	15	16.9	45	22.5
51-60	16	14.4	20	22.5	36	18
61-70	19	17.1	14	15.7	33	16.5
71-80	8	7.2	7	7.9	15	7.5
81-90	3	2.7	7	7.9	10	5
>90	4	3.6	3	3.4	7	3.5
Total	111	100	89	100	200	100

Table 2) *Descriptive statistics on the length of clavicle in the studied population.*

	Clavicle	Minimum length (mm)	Maximum length (mm)	Mean ± SD (mm)
Total population	Left	112.62	170.65	147.69 ± 11.54
	Right	105.9	168.61	145.93 ± 11.92
Females	Left	112.62	164.02	141.89 ± 10.28
	Right	105.9	162.9	140.08 ± 10.99
Males	Left	127.3	170.65	154.92 ± 8.58
	Right	117.9	168.61	153.23 ± 8.55

DISCUSSION

The mean length of the right (145.93±11.92 mm) and left (147.69±11.54 mm) clavicle was larger than the length measured directly on bones from different Nigerian population groups. [15,20] and studies from other countries [Table 5] [5,9,11,14,16,18]. Notably, our findings were higher than radiographic measurements by Eboh and Ishicheli 7 who measured the clavicular length of patients in the Igbo ethnic group in Nigeria and Rajitha et al [21] who measured this parameter on radiographs of cadavers in India. On the contrary, Alcina et al [3]. In Spain reported longer clavicles in the males and shorter clavicles in females compared to the males and females herein [Table 5].

Inter-population variations in the length of the clavicle are due to several factors such as differences in race, genetics, geographical and environmental factors such as nutrition and mechanical factors [4,7,10,12,13,19]. The physical activity and occupation of the population influences the morphology of the clavicle. 1 According to Panuganti et al. [9] manual workers have heavier, and more curved clavicles which have more obvious ridges for muscular attachment. Racial variations in stature also explain the variations in the clavicular length. According to Moorkhan and Madathil [11]. Whites, American Negroes and North Indians have longer clavicles since they are more well-built and taller compared to South Indians.

Furthermore, discrepancies in the clavicular length from various studies could be due to the differences in the sample used; either cadaveric, direct bone measurements or radiological measurements. Measurements taken on radiographs may be larger from those taken on computed tomography due to inherent magnification of structures on radiographs. Measurements on postero-anterior radiographic views also vary from anteroposterior view measurements due to the variations in the distance between the study subject and the X-ray source that influence the magnification of the image. Patient positioning is therefore a factor to consider when comparing data from different populations [17]. The samples used also vary in the size, gender and age composition and these have an impact on the results obtained [22]. The varying methods of measurement could also contribute to the different findings. For instance, the variation in the landmarks used to define the clavicular length and manual measurement with a Vernier caliper verses the use of digital calipers on digital radiographs.

Our findings varied from another study carried out in Delta State Nigeria

Table 3) *Side differences in the length of the clavicle in males and females.*

Gender		Clavicle	N	Mean (mm)	Std. Deviation	t	df	P-value
Female	Pair 1	Left side	111	141.89	10.28	6.641	110	0.001*
		Right side	111	140.08	10.99			
Male	Pair	Left side	89	154.92	8.58	5.914	88	0.001*
		Right side	89	153.23	8.55			

*significant side differences

Table 4) *Gender differences in the length of the right and the left clavicles.*

Clavicle	Gender	N	Mean (mm)	Std. Deviation	F	T	df	P-value
Left side	Female	111	141.89	10.28				
	Male	89	154.92	8.58	5.248	-9.765	197.656	0.001*
Right side	Female	111	140.08	10.99				
	Male	89	153.23	8.55	7.164	-9.523	197.827	0.001*

*significant gender differences

Table 5) *Comparison of clavicular length in different studies.*

Author	Country	Sample	Sample size	SI unit	Males	Females
Alcina et al.,[3]	Spain	Dry bone	77	mm	R-155.12	R-138.38
					L-157.02	L-134.81
Rajitha et al., [21]	India	Radiograph	108	mm	R-137.99	R-127.6
					L-142.21	L-129.19
Ishwarkumar et al., [5]	South Africa	Dry bones	100	mm	R-153.52	R-138.02
					L151.82	L-141.04
					AV-152.49	AV-139.36
Benwoke et al., [15]	Nigeria	Dry bones	45	mm	R-146.96	R-136.13
					L-149.08	L-137.60
Ihunwo, [20]	Nigeria	Dry bones	40	mm	R-146.96	R-136.13
					L149.08	L-137.60
Elzawahary and El-Hamid, [14]	Egypt	Dry bones	105	mm	R-143.9	R-126.5
					L-144.5	L-128.1
Eboh and Isicheli, [7]	Nigeria	Radiographs	140	mm	R-152.01	R-132.65
					L-148.73	L-134.54
Moorkhan and Madathil, [11]	India	Dry bone	100	mm	147.97	127.4
Anand and Datta, [4]	Malaysia	Dry bone	54	cm	R-13.88	R-11.9
					L-14.04	L-12.02
Sangeeta et al., [2]	India	Dry bones	150	mm	R-149	R-139
					L-149	L-139
Panuganti et al., [9]	India	Dry bone	1128	mm	R-141.7	R-128.9
					L-143.2	L-128.0
					AV-142.5	AV-128.5
Perei, [16]	India	Dry bone	106	mm	R-142.8	R-127.4
					L-145.1	L-129.2
Current Study	Nigeria	Radiograph	200	mm	R-153.23	R-140.08
					L-154.92	L-141.89

Table 6) *Accuracies for correct sex determination using the length of the clavicle.*

	Corrected prediction rates			Correct prediction after cross validation		
Clavicle length	**Female** (%)	**Male** (%)	**Mean** (%)	**Female** (%)	**Male** (%)	**Mean** (%)
Univariate Analysis						
Left	80(72.1)	74(83.1)	154(77.0)	80(72.1)	74(83.1)	154(77.0)
Right	78(70.3)	72(80.9)	150(75.0)	78(70.3)	72(80.9)	150(75.0)
Multivariate Analysis						
Overall	84(75.7)	76(85.4)	160(80.0)	84(75.7)	76(85.4)	160(80.0)

by Eboh and Isicheli 7 probably due to the differences in methodology. We used digital radiographs and measured the clavicular length on the computer using a digital caliper provided by PACS while they measured the length of the clavicle on X-ray viewing box using a sliding Vernier caliper. Additionally, the determination of the length varied whereby, we measured the maximum distance between the midpoints of the acromial and sternal ends while Eboh and Isicheli 7 measured the horizontal line between parallel lines drawn at the sternal and acromial end of the clavicle. Our population was not specific in terms of the ethnic group while their study primarily focused on radiographs of patients from the Igbo ethnic group.

In both females and males, the left clavicle was significantly longer than the right and this was consistent with Benwoke et al [15]. And Ihunwo [20]. Among the Igbos of Nigeria, the right clavicle was significantly longer than the left in males while in females, the side difference was not statistically significant. Other studies also reported a longer left than right clavicle; however, the difference was not significant [3,4,18]. Among the Indians studied by Panuganti et al.,[9] the males had significantly longer left clavicle while females had significantly longer right clavicles. On the contrary, the Indian bones studied by Sangeeta et al [2] reported equal clavicular lengths bilaterally.

It has been previously reported that the right clavicle is significantly shorter than the left because it is more curved and more robust due to the higher mechanical loads experienced on the dominant than the non-dominant hand [3,10,16]. The use of the right hand increases its curvatures compared to the left clavicle hence making the right one shorter [23]. Therefore, handedness and preference of limb use influence the morphology of the clavicle with the clavicle of dominant hand being shorter. 9, 12, 22, 24 Hence, the assumption of symmetry of clavicular length is unreliable in some populations [24]. Bilateral differences in the length of the clavicle vary in different populations and this has been ascribed to differences in hormones, genetics, body size, diet, geographical location and activity levels as evident by the muscular attachments. Population specific asymmetry should be considered in the design of clavicular surgical appliances [2,18].

Consistent with several previous reports, the bilateral clavicles in males were significantly longer than those of females [3,4,7,9,14,16,20]. Males have longer and more robust skeleton than females with a varying magnitude in different populations due to different genetic and environmental factors such as more physical lifestyle activity, occupational stresses and higher nutritional demands in males compared to females which affect growth [7,14,16,20]. Growth and sex hormones also influence the robusticity of bones [22,25]. Female clavicles are shorter, thinner, less robust and less curved than those of males due to the influence of estrogen [1,3,23]. The clavicle in males is longer and this is evident after puberty when males have wider shoulder than hips compared to the wider hips than shoulders in females. The clavicle contributes greatly to the shoulder width [2,26]. The clavicular growth period in males is also longer than in females [2]. Additionally, males attain most of their clavicular length later (at 12 years) than in females (at 9 years) [7].

The accuracy of correct sex prediction was higher when the left clavicle length (77.0%) was used compared to that of the right (75.0%). Using DFA, Sangeeta et al [2] and Eboh and Isichelli 7 found out that the right clavicle length provided a higher accuracy of sex discrimination compared to the left (80.7%,74.3% and 82.1%, 76%). This suggests that the identification of the population of origin of the clavicle is important to estimate its accuracy in determining sex. A left clavicle from our studied population will definitely provide a high probability of correct sex allocation. The use of both right and left clavicle in the multivariate analysis yielded a higher accuracy of sex discrimination (80.0%). This suggests that, the availability of a dismembered body with both clavicles intact may yield a higher accuracy of determining sex compared to the presence of only one clavicle. Chaudhary et al [13]. In Pradesh, India used demarking point and found out that 83.5% and 54.9% of clavicles were correctly classified as males and females respectively. The overall accuracy of sex determination was 76.9%. On the contrary, among the Gujarati population in India, Chavda et al [23] used the demarking point found that sex determination of the majority of the clavicles (94.79% right and 96.58% left) was impossible.

Variations in the accuracy of using clavicular length for sex determination are dependent on the degree of inherent sexual dimorphism in a given studied population and also the condition of the specimen used [13]. Sex overlapping of clavicular variables have also been ascribed to nutritional, hormonal, genetic and socioeconomic variations which may cause hypo masculinity in male bones and hyper masculinity in females due to their influence on growth. [26-32]. This overlapping negatively affects the probability of correct sex prediction [15].

CONCLUSION

There is sexual dimorphism in the radiographic length of the clavicles studied. Moreover, this parameter showed an acceptable accuracy (77% on the left and 75% on the right) in estimating sex. Therefore, it can be used together with other sexually dimorphic methods to determine the sex of unknown remains within the studied population.

REFERENCES

1. Repalle S, Ambareesha K. Sexual dimorphism by anthropometric dimensions in adult human clavicles. Appl Physiol Anat Digest, 2018; 3(1):50-55.
2. Sangeeta K, Modi V, Mahato PK. Gender identification in a cross-sectional study using the linear horizontal length and mid-length diameter of clavicle in Indian population. Int J Acad Med Pharm, 2022; 4(4):596-599.
3. Alcina M, Rissech C, Clavero A, Turbón D. Sexual dimorphism of the clavicle in a modern Spanish sample. Eur J Anat, 2015; 19(1):73-83.
4. Anand C, Datta D. Study of morphometry of clavicle - length and angles. Int Arch BioMed Clin Res, 2021;.7(2): HA1-HA3.
5. Ishwarkumar S, Pillay P, Haffajee MR, Rennie C. Sex determination using morphometric and morphological dimensions of the clavicle within the KwaZulu-Natal population. Int J Morphol, 2016; 34(1):244-251.
6. Ramamurthi KS. Sexual dimorphism of adult human clavicles in Tamilnadu population. Sch J App Med Sci, 2016; 4(10C):3711-3713.
7. Eboh DEO, Ishicheli GK. Sex determination using radiographic anthropometric dimensions of the clavicle in an Igbo population of Nigeria. Int J Forensic Med Invest, 2019; 5(1):52-60.
8. Hughes JL, Newton PO, Bastrom T, Fabricant PD, Pennock AT. The clavicle continues to grow during adolescence and early adulthood. HSSJ, 2020; 16(2): S372-S377.
9. Panuganti PK, Reddy MV, Poojari MS, Shrish P, Kumar JA. Morphometry and sexual dimorphism of the human clavicle in South Indian population. Int J Anat Res, 2022; 10(1):8283-8290.
10. Bagal G, Takale S. Sex determination from the clavicle. J Med Sci Clin Res, 2016; 4(6):1162-1165.
11. Moorkhan LV, Madathil PT. Determination of sex from adult clavicle An autopsy-based regional study. Indian J Forensic Med Toxicol, 2020; 14(3):800-804.
12. Yegbeburu OS, Ominde BS, Igbigbi PS. A Retrospective Radiological Study on the Morphometry of Hand Digits and Phalanges: Role in Sex Determination. J Krishna Inst Med Sci, 2022; 11(2):46-61.
13. Chaudhary RS, Sandhu SS, Singh P. Sex determination using measurements of upper limb in cadavers at a tertiary care teaching center. Int J Med Res Prof, 2017; 3(2):353-356.
14. Elzawahary ZAI, El-Hamid RA. Sex assessment using clavicle measurements in Egyptian population. Ann Int Med Den Res, 2019; 5(1):FM04-FM07.
15. Benwoke WI, Aigbogun EO Jr, Bienonwu E, Johnbull TO. The clavicle as a forensic tool: sex-discriminatory characteristics in cadaveric samples of Nigeria origin. Int J Anat Res, 2019; 7(2.1):6336-42b.
16. Perei S. Evaluation of sex assessment using clavicle measurements in Indian population. J Cardiovasc Dis Res, 2023; 14(2):707-712.
17. Lima GV, La Banca V, Murachovsky J, Nascimento LGP, Almeida LHO, Ikemoto RY. Assessment of the measurement methods in midshaft clavicle fracture. BMC Musculoskelet. Disord, 2022; 23:992.
18. Ominde BS, Awori KO, Olabu BO, Ogeng'o JA. Anatomical measurements of the distal clavicle in a Kenyan population. Anat J Afr, 2015; 4(1):450-456.
19. Samala N, Bethi M. Sex determination using anthropometric dimensions of clavicle An observational study. Int J Anat Radiol Surg, 2019; 8(1):AO24-AO26.
20. Ihunwo BI. Gender determination using robustness index of the clavicle

in South-South and South East adult Nigerians. Eur J Pharm Med Res, 2019; 6(1):133-138.

21. Rajitha V, Anitha MR, Rekha G, Senthil Nathan S. Determination of sex and age from human clavicles and its radiographic images. Indian J Anat, 2016; 5(1):93-98.
22. Ominde BS, Enakpoya PO, Ejuone O, Igbigbi PS. Retrospective study on the radiographic wrist indices in a Nigerian population. Online J Health Allied Sci, 2022; 21(2):12.
23. Chavda HS, Khatri CR, Varlekar PD, Saiyad SS. Morphometric analysis and sex determination from clavicles in Gujarati population. NJIRM, 2013; 4(6):18-22.
24. Singh A, Huq SS, Dayal S, Shah PD, Murphy DP, Daruwalla ZJ. Clavicle length and hand dominance Does asymmetry exist and what are the clinical implications of this. Ortho Rheum Open Access J, 2023; 21(4):556066.
25. Ominde BS, Igbigbi PS. Morphometry of the occipital condyles in Adult Nigerians. Online J Health Allied Sci, 2021; 20(4):10.
26. Suryawanshi AK, Puranic MG, Mudiraj NR. Morphometric analysis and sex determination of adult human clavicles in Maharashtra region. Int J Recent Trends Sci Technol, 2015; 15(2):333-338.
27. Enaohwo, TM, Igbigbi PS. Cephalix index in Ovu community of Delta state. Abstract of Anat Soc Nigeria, 2006;3(26): 26.
28. Oladunni AE, Ogheneyebrorue GO, Joyce EI. Radiological assessment of age from epiphyseal fusion at the wrist and ankle in Southern Nigeria. Forensic Science International Reports, 2021; 3:100164.
29. Enaohwo TM, Okoro OG. Morphometric study of hypoglossal canal of occipital bone in dry skulls of two states in southern nigeria. Bangladesh Journal of Medical Science, 2020; 19(4): 670-672.
30. Okoro OG, Isioma CN, Owhefere GO, Akindugbagbe TF, Oladunni AE. Stages of Epiphyseal Fusion at the Distal End of Radius and Ulna in Nigeria; A Radiological study. International Research in Medical and Health Sciences, 2023; 5(5): 1-6.
31. Enaohwo T M, Okoro OG. Anthropometric study of the frontal sinus on plain radiographs in Delta State University Teaching Hospital. Journal of Experimental and Clinical Anatomy, 2018; 17(2): 49-49.
32. Nwaokoro IC, Enemodia OE, Ehebha SE and Okoro OG. Anthropometric study of the canthal parameters among the Hausa and Yoruba Ethnic groups in Nigeria. International Journal of Medical Research and Health Sciences, 2023; 12(5):48-51.