ORIGINAL ARTICLE

Auricular Anthropometry in South Western Nigeria Populace: Age and Sex Disparity, a Tool for Identification and Auricular Reconstruction among Nigerian Blacks

Shuaib Kayode AREMU

ENT Department, Federal Teaching Hospital Ido-Ekiti/Afe Babalola University, Ado- Ekiti, Nigeria

ABSTRACT

INTRODUCTION: There are population variations among people from different regions around the world in terms of auricle dimensions. This means it is not suitable to use foreign standards of auricle dimensions as a guideline for Nigerians undergoing plastic pinna reconstruction.

Knowledge about the normal human ear dimensions and morphological features of various populations can be helpful from the anthropological and forensic point of view to provide data procedures for the inclusion and exclusion of persons for identification on the basis of ear variations collected from criminals.

METHODOLOGY: This was a cross-sectional study conducted among the populace of South-West, Nigeria between. Two hundred subjects (100 males and 100 females) between 10 and 50 years of age were selected for the study. They are divided into four age range groups in years. Group A (10-20), B (21-30), C (31-40) and D (41-50). The anthropometric parameters of the external ear were measured by the indirect method and variation according to age and sex were studied. These are the Total length of the ear (TLE), the Total width of the ear (TWE), Total lobular length (TLL) and Total lobular width (TLW).

RESULTS: Our study showed the distribution of age and sex into four groups(A-B) with most of the males falling in B (N=32) while the females in group A (N=36). The age range for the subjects enrolled in the study was between 10 to 50 years. Group B has the highest number of subjects (N=64), while Group D had the least number of subjects (N=32) as well as the least number of male subjects (N=12).

CONCLUSION: This study has shown a significant difference between auricular anthropometry in relation to age and sex of the subjects studied with men having relatively higher mean values than women. (*Int J Biomed Sci* 2019; 15 (3): 91-97)

Keywords: Anthropometry; auricle; age; sex

INTRODUCTION

The human auricle is composed of the helixantihelical complex, the conchal complex and the lobule, which is the most distinctive feature of the human face and is particularly influential in determining its appearance (1, 2). The external ear consists of auricle or pinna and external acoustic meatus. The auricle is made up of elastic cartilage lined by the skin on both sides. The lower part of the auricle is made up of connective tissue covered by

Corresponding author: Dr. Shuaib Kayode Aremu, ENT Department, Federal Teaching Hospital Ido-Ekiti/Afe Babalola University, Ado-Ekiti, Nigeria. Phone: +2348033583842; E-mail: shuaib.aremu@gmail.com.
Received August 20, 2019**; Accepted** September 13, 2019

skin which is known as lobule. The ear pinna is formed between fourth to sixth weeks of gestation when the neural crest cells of the first and second pharyngeal arches interact with the underlying surface ectoderm of these arches. At this time six auricular hillocks appear, which are derived from the first and second pharyngeal arches (3). These hillocks develop into the folds of the pinna and gradually get shifted to their final position on the head. The cartilaginous framework and connective tissues of the pinna are derived from the neural crest cells and the muscles of the pinna are derived from the head mesoderm (3). Anthropometry refers to the study of dimensions of different parts of the human body which shows variation according to age, sex, and race. Thus, the study of these physical variations plays an important role in establishing the identity of an individual as well as being of importance in plastic surgeries and prosthesis development (4).

It is well-established fact that a detailed knowledge of the morphologic dimensions, location, and asymmetry of the normal auricle is essential for the diagnosis of congenital abnormalities and syndromes, forensic investigations and for the ergonomic design of hearing aids (5-7). Therefore, a large number of anthropometric studies of normal auricle have been assessed in various populations, for instance, Koreans, (8), Sudanese Arabs,[2] Chinese (9), Indians (10), Italians (11-14), Britons (1), Americans (15), Germans (16), and Japanese (17). The shape, dimension, and orientation of each auricle are as individualized as a fingerprint (18). Some of the above studies showed findings such as 1) The mean dimensions of the auricle are larger in males than in females regardless of ethnicity; 2) The dimensions of auricle increase with increasing age; 3) Significant differences in ear dimensions exist among various ethnicities (e.g., Europeans have larger ear dimensions than Asians.

According to some studies, the irregularities on the surface of pinna can be considered for the identification of the individual. Abeysekera and Shahnavaz reported in their study that

the earpiece designed for males of the United States fitted only in 95% Germans, 75% Frenchmen, 60% Italians, 45% Japanese, and 10% Thais (19) That the size and shape of pinna differ in people of different nations have also been reported (4, 13, 19). Besides this, some studies reported that not only the ethnic group but also age and sex are the determinants of ear anthropometry (20, 21). The medial surface shows irregularities which correspond to its lateral surface and thus also shows ethnic age, and sex variations (21).

The identification of an individual by age and sex possesses difficulty in revealing its identity. Various parameters have been used to establish the identification of individuals.

Anthropometry of external features of the pinna is one of them (13). Different studies proved that variations in ear proportions during growth, aging, and according to sex were reported. These differences were noticed in diverse ethnic groups such as Italian, European, Caucasian, Turkish, Dutch-German, North American, and other countries (12-14). Several different methods are used for the anthropometric measurement of the auricle. In general, these can be divided into contactable (Vernier calipers and ruler, etc.) and non-contactable methods (3D scanner, computed tomography, magnetic resonance imaging, and photography).

Vast knowledge of normal ear dimensions will be of much use for the plastic surgeons in reconstruction pinna defects. The forensic specialist needs the ear pinna dimensions for identifying a person, whereas the manufacturer needs the knowledge for making ear prosthesis.

The dimensions vary in different ethnic groups, which necessitate them to base their observations on the data specific to the ethnic group (22). The morphometric standards vary in various ethnic groups. North Western Indian population was found to have smaller ear lobule than Japanese or Caucasians (23).

Our study also facilitates the identification of an individual by forensic experts and anthropologists. This study was conducted to identify various morphological features of the pinna among the populace of south-west, Nigeria which will be of use for plastic reconstruction and prosthesis molding and installation for Nigerian with auricular trauma or congenital malformation.

METHODOLOGY

Ethics Statement

Ethical clearance with protocol number ERC/2018/07/25/130A dated 25/7/2018 was obtained from Federal Teaching Hospital Ido-Ekiti (FETHI) research and ethics committee. The aim of the study was explained to the participants, and informed consent of each consented participant was sought and obtained. Confidentiality and anonymity were maintained.

Minimum Sample size determination

The minimum sample size was calculated using the formula for a cross-sectional study

$N=Z^2pq/d^2$ and

$N_f = n/(1+n/N)$

For a population that is less than 10,000.

Prevalence was assumed at 50% and a bound on the error of ± 5%, precision level of 0.5 and a confidence level of 95%. An upward adjustment for 10% to account for non-response and inappropriate entries, gave a sample size of 270. Only 215 subjects consented for the study within the time frame the study was conducted. However after excluding individuals with congenital or infectious ear diseases and craniofacial injuries we were left with 200 subjects.

Study area and subjects

This was a cross-sectional study conducted among the populace of South-West, Nigeria between September 2018 and December 2018.

The Two hundred subjects (100 males and 100 females) who consented were between 10 and 50 years of age (age range that greatly desires and benefits from auricular cosmesis) According to age, the subjects were divided into four Age groups in years (A–D). Group A (10-20), B (21-30), C (31-40) and D (41-50) (Table 1). Individuals with a positive history of congenital ear disease, craniofacial injury, infectious ear disease and those who have undergone surgery of the ear were excluded from the study. Informed verbal consent explaining the purpose and method of the study was obtained from the study subjects while the same was taken from the parents if the subject's age is <16 years.

For the purpose of this study a unique digital signal processing technology and a Cyber-shot HX805 Sony camera with an 18.2-megapixel camera were used to enable the high-resolution system. The subject was made to sit comfortably on a chair in such a way that the subject looked straightforward keeping the face in Frankfurt plane, i.e., the inferior borders of orbit and center of external auditory meatus lies in the same horizontal plane.

The lateral surface of the auricle was photographed (Figure 1) in such a way that mid-vertical grid line of the camera aligned to pass through the mid-sagittal plane of the face while the mid-horizontal pass through the Frankfurt horizontal plane. Posterior view of the auricle is photographed (Figure 5) by aligning the mid-vertical grid line of the camera to pass through the base of the auricle coming in contact with the mastoid prominence while the mid-horizontal passes through the tragal level. Ear features are captured using a digital camera. Digital images are transferred to a computer and the images are analyzed with Adobe Photoshop software (version 7.0, Adobe Systems, San Jose, California). First of all, various soft tissue landmarks are tagged on the subject's ear photograph and then different parameters were measured by Image J 1.48 software ImageJ (v 1.48 Java 1.6.0_20 64 bits).

The following anthropometric parameters of the external ear were measured by indirect method and variation according to age and sex were studied:

a. Total length of ear (TLE) (Figure 2)
b. Total width of ear (TWE) (Figure 2)
c. Total lobular length (TLL) (Figure 3)
d. Total lobular width (TLW) (Figure 4)

Table 1. Distribution of age and sex in the study

Genders	Distribution of age and sex				
	A (10-20)	B (21-30)	C (31-40)	D (41-50)	Total
Male	28	36	24	12	100
Female	32	28	20	20	100
Total	60	64	44	32	200

Figure 1. Showing the lateral view of the auricle with all the four parameters to be measured.

Figure 2. showing the measurement of TLE and TWE of a subject.

Figure 3. Shows TLL of a subject.

Figure 4. Shows TLW of a subject.

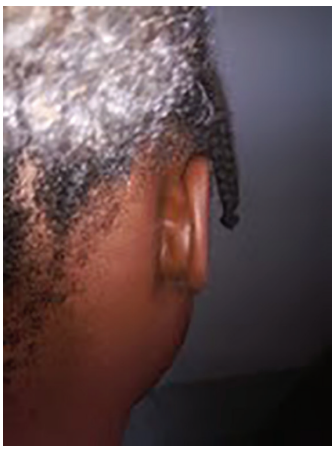

Figure 5. Posterior view of the auricle.

TLE was calculated as the measurement from the highest point of the pinna to the lowest point of the pinna. The distance between the anterior and posterior points of the external ear was considered as TWE. The TLL was considered as the measurement from the midpoint of the base of the intertragic notch to the lowest point of the lobule. LW was measured as the transverse distance of the ear lobule passing through the center of the length of the lobule.

The results were calculated as the mean ± standard deviation. Chi-square was used to institute the association between age, sex, and external ear anthropometry. The data were analyzed using BM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp., and P<0.05 was considered as the level of significance.

RESULTS

The total number of subjects enrolled in the study was 200 (Male=100, Female=100). Table 1 of our study showed the distribution of age and sex into four groups (A-B) with most of the males falling in B (N=32) while the females in group A (N=36). The age range for the subjects enrolled in the study was between 10 to 50 years. Group B has the highest number of subjects (N=64), while Group D has the least number of subjects (N=32) as well as the least number of male subjects (N=12).

In this study, we analyzed our data by means of statistical parameters (mean [standard deviation], median, and range) to get better accuracy for the pinna measurements. The standard deviation predicts the variability in the values. The combined results of both ears relating the different morphometric measurements (TLE, TWE, TLL, and TLW) to the four age groups (A-D) are shown in Table 2. It illustrates the mean and standard deviations. All parameters of the cohort for both right and left ears showed an increase in values of mean and standard deviation with increasing age. The mean ± SD of TLE for the Right ear in Group A was 49.20 ± 1.48, while that of Group D was 54.75 ± 2.42 (Table 2). The Standard deviations (SD) were insignificant in both ears for all the parameters in Group C & D except for the right TLE of Group D (54.75 ± 2.42).

Across all the cohorts, Group D had the highest average lengths of all the parameters under the study in relation to the right ear. For instance, the average measurement of TLE is 54.75 mm with a standard deviation of 2.42mm for both males and females. The corresponding left ear TLE average length is 54.63 mm with a standard deviation of 2.48 mm. Also, across all the cohorts A has the least average length of parameters.

Table 3 showed the different morphometric parameters of the pinna in relation to sex. The data were analyzed using the t-test for independent samples between genders on both sides. It was observed that males showed statistically significant higher mean values of TLE (Figure 2) than females for both right and left ear. This is evident from P=0.001 and P=0.000 respectively. Concerning TWE females have statistically significant higher mean than males for the right ear (P=0.001). However, for the left ear males have statistically significant higher mean value than females (P<0.05). In relation to TLL (Figure 3), men were observed to have significantly higher mean values compared to their counterparts. In regards to TLW, men have significantly higher mean values for the right ear. In contrast, women have statistically significant higher mean values than men (P=0.013).

Table 2. Different morphometric measurements of pinna in relation to age

Side	Parameters (mm)	Age group (years), mean ± SD			
		Group A	Group B	Group C	Group D
Right ear	TLE	49.20 ± 1.48	50.88 ± 2.13	53.73 ± 0.97	54.75 ± 2.42
	TWE	29.80 ± 1.65	30.75 ± 1.26	32.27 ± 0.45	33.12 ± 0.67
	TLL	10.00 ± 1.08	11.59 ± 1.97	11.54 ± 0.79	11.75 ± 0.67
	TLW	19.33 ± 1.08	20.88 ± 0.93	21.36 ± 0.78	22.13 ± 0.94
Left ear	TLE	49.15 ± 1.54	51.00 ± 2.25	53.45 ± 0.99	54.63 ± 2.48
	TWE	30.33 ± 2.72	31.00 ± 1.18	32.09 ± 0.52	33.12 ± 0.94
	TLL	9.93 ± 0.77	11.15 ± 0.60	11.54 ± 0.79	11.75 ± 0.67
	TLW	19.40 ± 0.15	20.81 ± 1.08	21.36 ± 0.78	22.13 ± 0.94

TLE, Total length of ear; TWE, Total width of ear; TLL, Total lobule length; TLW, Total lobule width; SD, Standard Deviation.

Table 3. Different morphometric parameters of pinna in relation to sex

Parameters (mm)	Side	Sex	Mean ± SD	P	Median	Range
TLE	Right	Male	51.72 ± 2.85	0.001	52	9-11
		Female	51.52 ± 2.71		51	10-11
TLE	Left	Male	51.64 ± 2.71	0.000	52	9-11
		Female	51.60 ± 2.65		52	10-11
TWE	Right	Male	31.12 ± 1.76	0.001	31	6-7
		Female	31.24 ± 1.71		31	6-7
TWE	Left	Male	31.12 ± 1.76	0.013	32	11-11
		Female	31.24 ± 1.71		31	6-11
TLL	Right	Male	11.36 ± 1.81	0.025	11	10-11
		Female	10.90 ± 0.96		11	5-11
TLL	Left	Male	11.04 ± 1.00	0.005	11	4-5
		Female	10.09 ± 1.00		11	5-5
TLW	Right	Male	20.60 ± 1.53	0.008	21	5-5
		Female	20.08 ± 1.19		21	5-5
TLW	Left	Male	20.56 ± 1.58	0.013	21	5-5
		Female	20.88 ± 1.18		21	5-5

TLE, Total length of ear; WE, Total width of ear; TLL, Total lobule length; TLW, Total lobule width; SD, Standard Deviation.

DISCUSSION

Knowledge about the normal human ear dimensions and morphological features of various populations can be helpful from the anthropological and forensic point of view to provide data procedures for the inclusion and exclusion of persons for identification on the basis of ear variations collected from criminals. (Hence, this study provided detailed knowledge about the morphometric measurements of the pinna amoung south-west Nigerians). Farkas *et al.* (24) reported asymmetry between left and right ears in children, but it tended to fade in adulthood. On the con-

trary, the studies by Alexander *et al*. (1) and Sforza *et al*. (14) indicated good symmetry between left and right ears. Barut& Aktunc (25) noted significantly larger left ears for all parameters in children. Knowledge about the normal human ear dimensions and morphological features of various populations can be helpful. Our study showed findings which are contrary to those of Farkas *et al*. (25) and Barut & Aktunc (25) but similar to those of Alexander *et al*. (1) and Sforza *et al*. (14) as we found out that that as age interval increases all the parameters measurement also increases. The pattern of age-related changes is different for the different parameters. The patterns are almost identical on both sides of the ear (Table 2).

The TEL is important in the evaluation of congenital anomalies (Down Syndrome), facial reconstruction and in forensic purposes. The ear reaches its mature height at 13 years in males and at 12 years in females (13). In our present study, it was observed that males showed statistically significant higher mean values of TLE than females for both right and left ear. This is evident from P=0.001 and P=0.000 respectively (Table 3). The results were comparable with the studies done by Purkait R (10), Bozkir *et al*. (26), and Asai Y *et al*. (17), where the TLE of the left ear in men was found to be higher than that of women. The release of more growth hormone in males than females during this age group supports the results.

Most of other anthropometric dimensions of the ear in Pradhumanet etal's study (27) (ear length above tragus, ear length below tragus, ear breadth, concha length, concha breadth lobule height, lobule width) were noted significantly higher in males than females in both populations. The results were similar to the findings of Ekanem *et al*. (28), Eboh DEO (29) and Deopa D *et al* (4). We also made the same observations in our present study.

Concerning TWE females have statistically significant higher mean than males for the right ear (P=0.001). However, for the left ear males have statistically significant higher mean value than females (P<0.05). In relation to TLL, men have significantly higher mean values compared to their counterparts. In regards to TLW, men have significantly higher mean values for the right ear. In contrast, women have statistically significant higher mean values than men (P=0.013).

The outputs above report that there were significant differences in pinna length across all age groups in relation to gender with all the measurement increasing with age. Similarly, this study finds that the length of the pinna was significantly larger in men than women. The data clearly shows that earlobe sizes differ significantly between women and men with men having relatively higher mean values than women. Despite the ear length being larger in men than women, their earlobe length remains nearly identical to women in my cohort. We believe that the data used in this research study has generated some very useful parameters for ear morphology. More importantly, the relation of the ear and earlobe morphology to advancing age.

The auricle reaches its mature height at 13 years in male and at 12 years in females (30).

Anthropometric studies had been carried out on the external ear of children with different conditions such as cleft lip/palate, Down's syndrome, chromosomal abnormalities like aneuploidy (31-33). The diagnostic values of abnormality of the external ear to establish the existence of an abnormality of the urinary tract, as a result of coincidence in the period of embryogenesis have been reported (33). An acquired deformity that develops with aging may include elongation or Ptosis of the earlobe (34). The ear is important and under-recognized defining the feature of the face whose shape conveys information about age and sex that is clearly difficult to characterize (35). McKinney *et al* proved that there is no significant correlation between the earlobe height and age (36). Brucker *et al* (13) on their morphometric study of the external ear, age and sex-related differences, obtained a mean total ear height of 6.30 cm and an average lobular height of 1.88 cm. He also observed that though the total ear height was larger in the men, their lobular height and width remained nearly identical to women (13).

Limitations of the study

This study is not without limitations. The logistic reasons such as funds and having consented patients resulted in the limited sample size. The study was also carried out in a tertiary hospital setting which may not show the total picture of what is obtained in the entire country. Sample is not age and gender matched.

Ethical approval was obtained from the ethical committee of our institution

CONCLUSION

This study has shown that earlobe sizes differ significantly between women and men with men having relatively higher mean values than women.

CONFLICT OF INTEREST

The authors declare that no conflicting interests exist.

REFERENCES

1. Alexander KS, Stott DJ, Sivakumar B, Kang NA. Morphometric study of the human ear. *J. Plast. Reconstr.Aesthet. Surg.* 2011; 64 (1): 41-47.
2. Ahmed AA, Omer N. Estimation of sex from the anthropometric ear measurements of a Sudanese population. *Leg. Med. (Tokyo).* 2015; 17 (5): 313-319.
3. Van De Water TR, Staecker H. Otolaryngology: Basic Science and Clinical Review. *Thieme Medical Publishers Inc: New York.* 2006; p251.
4. Deopa D, Thakkar HK, Prakash C, Niranjan R, *et al*. Anthropometric measurements of external ear of medical students in the Uttarakhand region. *J. Anat. Soc. India*. 2013; 62: 79-83.
5. Coward TJ, Scott BJ, Watson RM, Richards R. Laser scanning of the ear identifying the shape and position in subjects with normal facial symmetry. *Int. J. Oral. Maxillofac. Surg.* 2000; 29 (1): 18-23.
6. Purkait R, Singh P. Anthropometry of the normal human auricle: a study of adult Indian men. *Aesthetic Plast. Surg.* 2007; 31 (4): 372-379.
7. Tatlisumak E, Yavuz MS, Kutlu N, Asirdizer M, *et al*. Asymmetry, handedness, and auricle morphometry. *Int. J. Morphol*. 2015; 33 (4): 1542-1548.
8. Jung HS, Jung HS. Surveying the dimensions and characteristics of Korean ears for the ergonomic design of ear-related products. *Int. J. Ind. Ergon*. 2003; 31 (6): 361-373.
9. Wang B, Dong Y, Zhao Y, Bai S, *et al*. Computed tomography measurement of the auricle in the Han population of north China. *J. Plast. Reconstr.Aesthet. Surg.* 2011; 64 (1): 34-40.
10. Purkait R. Progression of growth in the external ear from birth to maturity: a 2-year follow-up study in India. *Aesthetic Plast. Surg.* 2013; 37 (3): 605-616.
11. Sharma A, Sidhu NK, Sharma MK, Kapoor K, *et al*. Morphometric study of ear lobule in northwest Indian male subjects. *Anat. Sci. Int.* 2007; 82 (2): 98-104.
12. Gualdi-Russo E. Longitudinal study of anthropometric changes with aging in an urban Italian population. *Homo*. 1998; 49 (3): 241-259.
13. Ferrario VF, Sforza C, Ciusa V, Serrao G, *et al*. Morphometry of the normal human ear: a cross-sectional study from adolescence to mid-adulthood. *J. Craniofac. Genet. Dev. Biol*. 1999; 19 (4): 226-233.
14. Sforza C, Grandi G, Binelli M, Tommasi DG, *et al*. Age- and sex-related changes in the normal human ear. *Forensic Sci. Int.* 2009; 187 (1-3): 110.e1-7.
15. Brucker MJ, Patel J, Sullivan PK. A morphometric study of the external ear: age- and sex-related differences. *Plast. Reconstr. Surg.* 2003; 112 (2): 647-652.
16. Niemitz C, Nibbrig M, Zacher V. Human ears grow throughout the entire life according to complicated and sexually dimorphic patterns-conclusions from a cross-sectional analysis. *Anthropol. Anz.* 2007; 65 (4): 391-413.
17. Asai Y, Yoshimura M, Nago N, Yamada T. Why do old men have big ears? Correlation of ear length with age in Japan. *B. M. J.* 1996; 312 (7030): 582.
18. Murgod V, Angadi P, Hallikerimath S, Kal A. Anthropometric study of the external ear and its applicability in sex identification: assessed in an Indian sample. *Aust. J. Forensic Sci.* 2013; 45 (4): 431-444.
19. Abeysekera JD, Shahnavaz H. Body size variability between people in developed and developing countries and its impact on the use of imported goods. *Int. J. Ind. Ergon.* 1989; 4: 139-149.
20. Agnihotri G, Singh D. Craniofacial anthropometry in newborns and infants. *Iran J. Pediatr.* 2007; 17 (4): 332-338.
21. Azaria R, Adler N, Silfen R, Regev D, *et al*. Morphometry of the adult human earlobe: A study of 547 subjects and clinical application. *Plast Reconstr Surg.* 2003; 111 (7): 2398-2402.
22. Ruma P, Singh P. Anthropometry of the Normal Human Auricle: A Study of Adult Indian Men. *Journal of aesth plastic Surg.* 2007; 31: 372-379.
23. Sharma A, Sidhu NK, Sharma MK, Kapoor Kanchan, *et al*. Morphometric study of ear lobule in northwest Indian male subjects. *Anatomical Science International*. 2007; 82: 98-104.
24. Farkas LG, Posnick JC, Hreczko TM. Anthropometric growth study of the ear. *Cleft Palate Craniofac. J.* 1992; 29 (4): 324-329.
25. Barut C, Aktunc, E. Anthropometric measurements of the external ear in a group of Turkish primary school students. *Aesthetic Plast. Surg.* 2006; 30 (2): 255-259.
26. Bozkir MG, Karakas P, Yavuz M, Dere F. Morphometry of the external ear in our adult population. *Aesthetic Plast. Surg.* 2006; 30 (1): 81-85.
27. Pradhuman Verma, Harpreetkaur Sandhu, Kanika Gupta Verma, Sharry Goyal, *et al*. Morphological Variations and Biometrics of Ear: An Aid to Personal Identification. *Journal of Clinical and Diagnostic Research*. 2016; 10 (5): ZC138-ZC142.
28. Ekanem AU, Garba SH, Musa TS, Dare ND. Anthropometric study of the pinna [15] (auricle) among adult Nigerians resident in Maiduguri metropolis. *J. Med. Sci*. 2010; 10 (6): 176-180.
29. Eboh D. Morphological changes of the human pinna in relation to age and gender of Urhobo people in Southern Nigeria. *J. Exp. Clin. Anat.* 2013; 12 (2): 68-74.
30. Ito I, *et al*. A morphological study of age changes in adult human auricular cartilage with special emphasis on elastic fibers. *Laryngoscope*. 2001; 111: 881-886.
31. Nathan N, Latham K, Cooper J, Perlyn C, *et al*. Anthropometry of the external ear in children with cleft lip and palate in comparison to age-matched controls. *J. Craniofac. Surg.* 2008; 19: 1391-1395.
32. Sforza C, Dellavia C, Tartaglia GM, Ferrario VF. Morphometry of the ear in Down's syndrome subjects: A three-dimensional computerized assessment. *Int. J. Oral. Maxillofac. Surg.* 2005; 34: 480-486.
33. Lettieri L, Rodis JF, Vintzileous AM, Feeney L, *et al*. Ear length in second-trimester aneuploid fetuses. *Obstetr. Gynecol*. 1993; 81: 57-60.
34. Perrin P, Barthelme H, Moyo D, Pem C, *et al*. External ear and abnormality of the urinary tract: A comparative study of 2 series (100 and I50 cases). *Rev. Laryngol. Otol. Rhinol. (Bord).* 1999; 112: 399-403.
35. Sidra S, Vrushali P. Karadkhelkar. Anthropometric Measurements of Human External Ear. *Journal of Evolution of Medical and Dental Sciences*. 2015; 4 (59): 10333-10338.
36. McKinney P, Giese S, Placik O. Management of the ear in rhytidectomy. *Plast Reconstr Surg.* 1993; 92 (5): 85866.