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Morphometrical variation in the structure of the external ear: A comparative study in males and females of North India

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Abstract

Introduction: The morphometric knowledge of human ear is important for anthropologists, forensic experts, plastic surgeons, physicians and prosthetic manufacturers. Therefore the aim this study was to evaluate the normal morphometry of external ear in male and female students in North India and compare that with the previous studies.

Materials and Methods: The study comprised 100 students (56 males and 44 females) aged 16-26 years. The study was conducted in the Department of Anatomy, Heritage Institute of Medical Sciences, Varanasi, UP, India. The various features of ear evaluated were shape, type of ear lobe, presence of Darwin's tubercle, length and breadth of ear, concha and ear lobule, ear length above and below tragus, ear index and lobule index. The data was recorded and compared with student's t-test in SPSS 20.

Results: Pinna was symmetrical in 94.44% of males and 95.65% of females. About 38.8% of male and 36.9% of females had attached ear lobes. The most common shape of external ear observed was oval in both male and females for right and left ears. In case of males measurement of the right ear parameters were high except for length of ear above tragus. In case of females measurement of left ear parameters were high except for length of tragus, width of concha, length of lobule, ear index and lobule index. Ear index was high in male ears while lobule index was high in female ears.

Conclusion: The differences observed in ear morphometry implies the possibilities of interindividual or population based variability in external ear features. These measurements hence may be helpful in the field of forensic science as biometric identifier, cosmetic surgery to treat any structural defaults in ear and prosthetic manufacturing companies to prepare artificial auricles.

Key words: Anthropometry, Pinna, Forensic, Biometry

Introduction

Measurement of dimensions of human body inorder to understand the physical variation is commonly known as anthropometry. It plays crucial role in personal identification, plastic surgery and prosthetics [1]. Forensic anthropologists have to frequently deal with the challenging task of indentifying the individuals from the deceased remains. However, expertise in this field can only be obtained via rigorous studies on living individuals [2]. Previous studies have shown that appropriate measurement of human body parts can aid in correct identification of an individual. Among such parts, anthropometry of ear is worth to study.

Human ear is broadly segregated to external ear, middle ear and internal ear. Pinna, a cartilaginous projection of external ear, consists of various parts such as helix, antihelix, scapha, tragus, antitragus, triangular fossa, concha and ear lobe. A helical fold can be observed very often at the junction of descending and superior parts of helix and is termed as Darwin tubercle [3]. Development of ear in fetus starts within a short period of time after conception. By 38th day of gestation few features become recognizable. By 56th day ear occupies its definite position and its shape become recognizable on 70th day [4].]. The shape of the ear remains fixed since birth and is not subjected to changes in absence of any physical trauma or any congenital abnormalities [5]. As ear morphology tends to be hereditary, ear characteristics may be used for assessment of familial relationships [6]. As per Altmann, presence of free lobule in ear signifies a dominant trait, while presence of attached lobule implies a recessive trait [7].

In humans, one of most defining facial feature is ear as it shows structural variation with respect to age and gender [8]. Some of the features of external ear are very distinctive and peculiar that they resemble the fingerprint of an individual [9]. Since orientation, shape and size of human external ear is very specific [10], it has been recognised as one of the important anthropological variable to study racial variation and some genetic anomalies at an early age [11].

Ear though is useful, is an underutilized human organ despite of its potential to be used as biometric identifier [12]. It was first used as a tool for identification of criminals by Bertillon [8]. External ear has several features that make it a suitable biometric identifier. To name some include:

- Universal occurrence
- No alteration in shape and size for longer period of time
- Presents the properties of measurability, acceptability, accuracy and circumvention [3].

In the cases where valid fingerprints are lacking ear biometry can be used for identification of individual. By comparative analysis of human ear morphometry, it can serve as a valid tool in identification process. Ear prints are frequently observed on the surfaces of doors and windows at the crime scenes where the person has tried to listen and determine whether the premises is occupied or free before committing the crime especially burglary [13]. Due to technical advances and development of various sensors, use of ear as biometric tool is pacing up. In 2004, a sandalwood smuggler from Indian subcontinent was identified by evaluating the ear morphometry [14] such as large and square shaped lobule and flat tragus that was contiguous with curved part of helix.

Besides in forensic medicine, knowledge of ear morphology is also important for plastic surgeon. Making self look good via cosmetic surgery or face renovation is a popular trend in western countries. This trend is also increasing in eastern countries like India. Also for rectification of congenital deformities, a plastic surgeon needs to have a sound knowledge about the normal shape and size of ear [14]. Additionally, morphological parameters such as ear length, ear width, ear lobular length, ear lobular width etc can aid in stature estimation and evaluation of sexual dimorphism [15].

Though many texts have described anatomy of human ear there is still presence of lacunae with respect to morphometric variations among different groups of people. This gap has to be filled as it is essential for the purpose of personal identification, medico legal cases, cosmetic surgical procedures to rectify defects and in manufacturing prosthesis. The scientific basis of variation in features of human ear can be strengthened only with sound knowledge on selection and use of morphological features of ear and the factors that maintain individual variations.

Therefore we aimed to undertake this study to evaluate the external ear morphology and morphometry among the students and compare our results with that of available literatures.

Materials and methods

This study was carried out in the department of anatomy, Heritage institute of medical sciences, Varanasi, UP. We took 100 individuals of age group ranging between 16-26 years and the morphometric and somatoscopic data related to external ear were collected. All the participants were briefed about the study and the informed consent from participants and ethical clearance from the institute were obtained prior to study.

Inclusion criteria*:* Individuals of age group 16-26 years

Exclusion criteria: Individuals with craniofacial trauma, ear disorders or congenital abnormality and ear surgery were excluded.

The anatomical properties of ear used for study were as follows:

1. Morphometric parameters

a. Total ear length or pinna length: Distance between superior end of pinna and inferior aspect of pinna lobule.

b. Ear breadth: Distance between root of ear to helix where concavity is maximum.

c. Length of ear above tragus: Length from superior part of ear to tragion.

d. Length of ear below tragus: Length from intertragic notch to inferior part of lobule.

e. Length of tragus: Length between intertragic notch to tragion.

f. Length of concha: Distance from intertragic notch to the posterior aspect of tragus.

g. Breadth of concha: Distance from point where helix concavity is maximum to the posterior aspect of tragus.

h. Length of ear lobe: Distance from intertragic notch to inferiormost aspect of ear.

i. Width of ear lobe: Maximal distance across the lobe taken transversely.

j. Ear index: (Ear width/Ear length) X 100

k: Lobule index: (Lobule width/Lobule length) X 100

2. Somatoscopic parameters

a. Shape of ear (Round, Oval, Triangular, Rectangular)
b. Attachment of lobule (free or attached)
c. Darwin tubercle (present or absent)

Measurements were taken using vernier calliper. The data obtained were recorded and analysed statistically using SPSS 20.

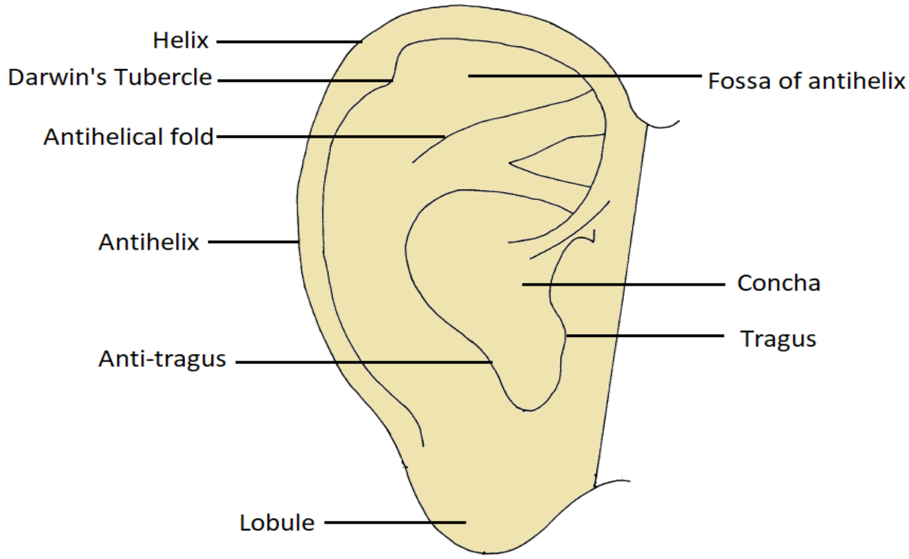

Figure 1: Parts of ear

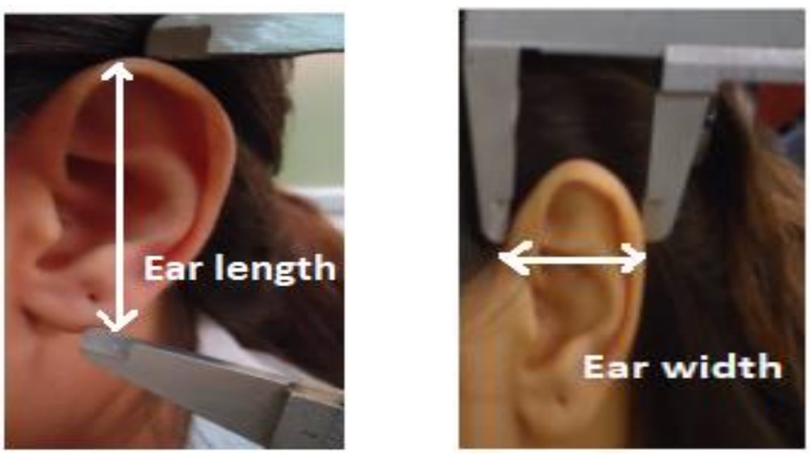

Figure 2: Measurement of ear length and ear breadth

Figure 3: Measurement of lobule length and lobule breadth

Result

Table 1: Distribution of patient

Gender	N(%)
Male	54 (54%)
Female	46 (46%)
Total	100 (100%)

Table 2: Shapes of ear

Gender	Shape (N/%)						
	Symmetrical	**Asymmetrical**	**Side**	**Round**	**Oval**	**Triangular**	**Rectangular**
Male (54)	51 (94.44%)	3 (5.56%)	Right	15(27.78%)	17(31.48%)	10(18.52%)	12(22.22%)
			Left	14(25.92%)	19(35.18%)	8(14.81%)	13 (24.07%)
Female (46)	44 (95.65%)	2 (4.35%)	Right	11 (23.91%)	21 (45.65%)	7 (15.21%)	7 (15.21%)
			Left	11 (23.91%)	19 (41.3%)	8 (17.39%)	8 (17.39%)

Table 3: Ear lobe types

Ear lobe	Male (n/%)	Female (n/%)
Attached	21 (38.8%)	17 (36.9%)
Free	33 (61.1%)	29(63.04%)

Table 4: Occurrence of Darwin's tubercle

Ear lobe	Male (n/%)	Female (n/%)
Present	47 (87.03%)	39 (84.78%)
Absent	7 (12.96%)	7 15.2%)

Table 5: Morphometric parameters of ear

Parameters	Side	Male	Female	p
Total ear length (mm)	Right	64.22±4.05	56.36±2.29	<0.01**
	Left	62.38±3.66	58.2±2.37	<0.01**
	p	<0.01**	<0.01**	
Ear breadth (mm)	Right	32.39±2.41	28.11±2.91	<0.01**
	Left	31.18±2.46	29.13±1.88	<0.05*
	p	<0.05*	>0.05	
Length of ear above tragus (mm)	Right	27.35±3.71	27.09±1.92	>0.05
	Left	29.42±6.92	28.77±2.06	>0.05
	p	<0.01**	<0.05*	
Length of ear below tragus (mm)	Right	21.44±3.16	20.46±3.68	>0.05
	Left	21.36±4.58	20.71±4.21	>0.05
	p	>0.05	>0.05	
Length of tragus (mm)	Right	13.85±3.07	13.68±3.44	>0.05
	Left	13.21±3.59	13.62±3.19	>0.05
	p	>0.05	>0.05	
Length of concha (mm)	Right	25.68±2.83	24.31±1.29	>0.05
	Left	25.09±2.59	24.86±1.47	>0.05
	p	>0.05	>0.05	
Width of concha (mm)	Right	20.39±5.85	18.32±1.09	<0.05*
	Left	19.26±4.12	18.04±1.28	<0.05*
	p	<0.05*	>0.05	
Length of ear lobule (mm)	Right	3.49±6.11	2.81±2.65	<0.05*
	Left	2.41±7.06	2.19±1.79	>0.05
	p	>0.05	>0.05	
Width of ear lobule (mm)	Right	17.36±2.19	16.22±2.77	>0.05
	Left	17.07±3.29	16.89±3.74	>0.05
	p	>0.05	>0.05	
Ear index	Right	50.79±5.38	49.75±4.21	>0.05
	Left	50.28±5.81	49.02±4.91	>0.05
	p	>0.05	>0.05	
Lobule index	Right	225.46±79.05	268.74±106.19	<0.01**
	Left	217.02±91.68	246.40±101.31	<0.01**
	p	>0.05	<0.05*	

In our study 54% were males and 46% were females. Pinna was symmetrical in 94.44% of males and 95.65% of females while asymmetrical in 5.65% and 4.35% of females respectively. About 38.8% of male and 36.9% of females had attached ear lobes and 61.1% and 63.04% respectively had free ear lobes. The most common shape of external ear observed was oval (Males: 31.48% right, 35.18% left; females: 45.65% right, 41.3% left), followed by rectangular shape (Males: 22.22% right, 24.07% left; females: 15.21% right, 17.39% left) in both genders. Darwin's tubercle was present in 87.03% of males and 84.78% of females (table 4).

The morphometric measurements ear are shown in table no.5 We measured total ear length, ear breadth, length of ear above and below tragus, tragus length, length and width of concha, length and width of ear lobe, ear index and lobule index of both right and left ear in both genders. It was observed that total ear length, total ear breadth and width of concha were significantly high in males for both right and left ears compared to females. However the ear index obtained was significantly high in female participants. In case of length of concha, significant difference was observed for right ear only. When compared between right and left ear of the same gender, it was found that the length of right ear was significantly high in case of males while in females the length of left ear was significantly high. With respect to ear breadth, significant difference was observed between right and left ear in case of males only. The length of ear above tragus was significantly high for left ear in both males and females. Likewise the width of concha was more for left ear compared to right ear in case of males and lobule index was more for left ear compared to right ear in case of females.

Discussion

The concept of earology was first developed by Johann Casper Lavater. Later on the system of recording data of ear morphology from ear moulds and ear measurements from Danish criminals was established by experts like Haken Jorgensen. Further, it was also reported previously that disaster victims can be successfully identified using features of pinna [16]. The variations in ear features may be attributed to difference in patterns of auricular growth and genetic factors.

The shape of ear may be round, oval, rectangular and triangular. In this study the most common shape of external ear observed was oval followed by rectangular shape in both genders. Our results were supported by that of Bozkir MG *et al* and Kumar P *et al* [5, 17].

In this study both male and female showed higher occurrence of free ear lobe (61.1% and 63.04%) and our findings were in accordance with that of Verma K *et al* [18] and Maitreyee M *et al* [3] while contradicted with that of Verma P *et al* [19] and Sharma A *et al* [6] who showed higher frequency of free ear lobes. We also compared shape of ear on both sides and observed that most of the subjects in both genders have symmetrical ear lobes.

In our study total ear length was 64.22±4.05, 62.38±3.66 in males and 56.36±2.29, 58.20±2.37 in females in right and left sides respectively. The ear develops to its complete size by 13 years of age in males and 12 years in females. The length of ear in males was more than that of females and it may be due to more release of growth hormones during growth period or due to changes in elastic fibres which occurs faster in males [20]. Our results were comparative with that of Imhofer R *et al* [21] and Asai Y *et al* [22].

Other morphometric parameters studied (such as ear breadth, length of ear above and below tragus, length and width of concha, length, width of lobule and ear index) were higher in males while lobule index was higher in females. These findings were supported by that of Ekanem AU *et al* [12] and Deopa D *et al* [23]. Wang B *et al* also showed similar results (i.e. higher ear length, lobule and auricular sizes in males compared to females) [24].

In this study the measurement of right ear for all parameters was high except for length of ear above tragus in case of males while incase of females measurements of length of tragus, width of concha, length of ear lobule, ear index and lobule index were high for right ear. In contrast to our results, the study of Faakuu E *et al* showed that, the measurement of left ear were generally high compared to right ear except for ear height [25]. Similar findings were also documented by other studies like that of Ahmed AA *et al* [26]. Further, Acar M *et al* [27] documented greater right ear width than left in Turkish females which was not in line with our study. The results of present study is partly supported by an Indian study of Murgod V *et al* who showed statistically significant differences in length and breadth and statistically insignificant difference in lobule length between right and left ears in males and females [28]. Ahmed AA *et al* reported significant gender based variation in lobule width but not in lobule length [25]. Kalra D *et al* [29] in contrast to the present study reported insignificant differences in ear index in males and females for both right and left ears. However, good symmetry of ear measurements between right and left and ear have been reported by several authors [30, 31]

Once the ear develops to its mature size, further increase in size may be due to secondary elongation caused by gravitational forces. According to Ferrario VF *et al* [32], ear indices were significantly higher for both sides in males compared to a female which was against our results. However our results were not statistically significant.

Conclusion

We studied the morphometric variation of human ear and compared them with the available literatures. Our results may be useful in the field of forensic medicine for identification of individual or in cosmetic surgery for the rectification of ear related abnormalities or facial rejuvenation. The limitation of this study is the use of small sample size and we did not consider the age related morphological variation of ear. Therefore larger studies with more sample size must be conducted which can further provide supportive evidences for the use of ear as biometric identifier as well as for successful cosmetic surgery.

References

1. Singhal J, Sharma N, Jain SK, Budhiraja V, Rastogi R, Garg R et al. A study of auricle morphology for identification in Indians. Annals of International Medical and Dental Research, 2016; 2(4):217.
2. Abbas A, Rutty GN. Ear piercing affects ear prints: The role of ear piercing in human identification. J Forensic Sci, 2005; 50(2):386-92.
3. Maitreyee M. Pinna of ear: a potential biometric identifier. International Journal of Research in Medical Sciences, 2017; 5(9):3843-46.
4. Standring S, Barley NR, Collins P. External ear. Gray's Anatomy. 40[2]th edition. London: Churchill Livingstone, 2008:618.
5. Bozkir MG, Karakas P, Yavuz M, Dere F. Morphology of the external ear in our adult population. Aesthetic Plast Surg, 2006; 30:255-59.
6. Sharma A, Sidhu NK, Sharma MK, Kapoor K, Singh B. Morphometric study of ear lobule in northwest Indian male subjects. Anat Sci Int, 2007; 82: 98-104.
7. Altmann F. Malformations of the auricle and the external auditory meatus: A critical review. AMA Archives of Otolaryngology, 1951; 54(2):115-39.

8. Jaberi KR, Kavakebian F, Mojaverrostami S, Najibi A, Safari M, Hassanzadeh G *et al.* Nasofacial anthropometric study among students of Shiraz University of Medical Sciences, Iran: A population based study. Indian Journal of Otolaryngology and Head & Neck Surgery, 2019; 71(2):206-11.
9. Dhanda V, Badhan JS, Garg RK. Studies on the development of latent ear prints and their significance in personal identification. Problems of Forensic Sciences, 2011; 88:285-95.
10. Akpa A, Ibiam A, Ugwu C. Anthropometric study of the pinna among south East Nigerians. J of Expt Res, 2013; 1:47-50.
11. Hunter AG, Yotsuyanagi T. The external ear: More attention to detail may aid syndrome diagnosis and contribute answers to embryological questions. American Journal of Medical Genetics Part A, 2005; 135(3):237-50.
12. Ekanem AU, Garba SH, Musa TS, Dare ND. Anthropometric study of the Pinna (Auricle) among adult Nigerians resident in Maiduguri Metropolis. Journal of Medical Sciences, 2010; 10:176-80.
13. Chattopadhyay PK, Bhatia S. Morphological examination of ear: A study of an Indian population. Legal Medicine, 2009; 11:S190-3.
14. Sangeetha S, Anisha B. Anthropometric measurements of human ear lobule in adult student population. Int J Anat Res, 2017; 5(2.2):3784-87.
15. Laxman K. A study of determination of stature in hyderabad population from external ear morphometry. Medico Legal Update, 2019; 19(1):164-68.
16. Saul FP, Saul JM. Planes, trains and fireworks, In Hard evidence: Case Studies in Forensic Anthropology (Ed. Steadman, D. W.). Englewood Cliffs, NJ: Prentice Hall,2003; 266-77.
17. Kumar P, Singla A. Ear biometric: sex, bilateral and ethnic differences among brahmin and yadav communities of Bundelkhand region using PCA technique. Int J Scientific & Eng Res, 2013; 4:799-805.
18. Verma K, Bhawana J, Kumar V. Morphological variations of ear for individual identification in forensic cases: a study of an Indian population. Res J Forensic Sci, 2014; 2(1):1-8.
19. Verma P, Sandhu HK, Verma KG, Goyal S, Sudan M, Ladgotra A. Morphological variations and biometrics of Ear: An aid to personal identification. Journal of Clinical and Diagnostic Research, 2016; 10(5): ZC138-42.
20. Azaria R, Adler N, Silfen R, Regev D, Hauden DJ. Morphometry of the adult human ear lobe: a study of 547 subjects and clinical application. Plastic Reconstr Surg, 2003; 3:2398-402
21. Imhofer R. Die Bedeutung der Ohrmuschel Fiir Feststellung der Identitat. Archivfiir die Kriminologie, 1906; 26:150-63
22. Asai Y, Yoshimura M, Nago N, T Yamada. Why do old men have big ears? Correlation of ear length with age in Japan. BMJ, 1996; 312:582.

23. Deopa D, Thakkar HK, Prakash C, Niranjan R, Barura MP. Anthropometric measurements of external ear of medical students in Uttarakhand. J Ana Soci India, 2013; 62:79-83.
24. Wang B, Dong Y, Zhao Y, Shizhu Bai S, Wu G. Computed tomography measurement of the auricle in Han population of North China. J Plast Reconstr Aesthetic Surgery, 2011; 64(1):34-40.
25. Faakuu E, Abaidoo CS, Appiah AK, Tetteh J. Morphological study of the external ear among the dagaabas in the upper west region of Ghana. Scientific African, 2020; e00408.
26. Ahmed AA, Omer N. Estimation of sex from the anthropometric ear measurements of a Sudanese population. Leg Med (Tokyo), 2015; 17:313-9.
27. Acar M, Ulusoy M, Alkan SB. Comparison of some morphometric parameters of the ear on Turkish and African Students. Asian Journal of Biomedical and Pharmaceutical Sciences, 2017; 7: 1-8 .
28. Murgod V, Angadi P, Hallikerimath S, Kale A. Anthropometric study of the external ear and its applicability in sex identification: assessed in an Indian sample. Australian Journal of Forensic Sciences, 2013; 45:431-44.
29. Karla D, Karla A, Shirish G. Anthrometric measurements of external ear: an in vivo study. International Journal of Enhanced Research in Medicines & Dental Care, 2015; 2:10-16 .
30. Sharma N. Anthropometric measurement and cross-sectional surveying of ear pinna characteristics in Northern India. Journal of Experimental and Clinical Anatomy, 2016; 15:102-6.
31. Alexander KS, Stott DJ, Sivakumar B, Kang N. A morphometric study of the human ear. J Plast Reconstr Aesthet Surg, 2011; 64:41-7.
32. Ferrario VF, Sforza C, Ciusa V, Serrao G, Tartaglia GM. Morphometry of the normal human ear: a cross-sectional study from adolescence to mid-adulthood. J Craniofac Genet Dev Biol, 1999; 19:226-33.