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ORIGINAL ARTICLE

Assessment of age changes and gender differences based on anthropometric measurements of ear: A cross-sectional study

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Abstract

Aim: To assess the age changes and gender differences based on anthropometric measurements of the ear and to create a database for the reported population.

Materials and Methods: This study was conducted among 200 individuals who reported to private dental teaching hospital as outpatient. The study population was explained about the procedure, and informed consent was obtained. The size of the auricle was measured bilaterally. The study population was subdivided into three subgroups. Group I included individuals between 20 and 39 years, Group II between 40 and 59 years, and Group III above 60 years.

Results: The total ear index among women with mean and standard deviation was 4.97 ± 0.6 cm, and men were 5.02 ± 0.4 cm. The lobe index among men with mean and standard deviation was 1.153 ± 0.0163 cm, and women were 1.243 ± 0.0147 cm with a significant $P < 0.0001$.

Conclusion: The anthropometric measurements of ear index were higher in men than women, with no age changes after 20 years of age for both men and women. Hence, this data are considered reliable and can be used for various purpose including forensics, identification, plastic surgeries, and research.

Introduction

The legal and fundamental aspects in forensics identification of human remains are distinguishing features from one person to another.[1] For any attribute to be used for identification purpose its necessary to possess few fascinating properties. One such property is uniqueness of the attribute altogether.[2] Forensic anthropology is one of the subdisciplines in forensic biology which usually applied in identification of human remains or body measurement for use in anthropological classification and comparison which also known as anthropometric study. In identifying a person, their individuality must be established, by determinative set of qualities that distinguishes them from all others.[3]

Alphonse Bertillon was the first scientist to discover that ear can be used as a means of identification because of its uniqueness. Many studies included anthropometric measurements of human ear to determine age, sex, individual identification, etc.[4]

Human ear is classified as external ear, middle ear, and internal parts. External ear comprises pinna and external acoustic meatus. The anatomy of human ear consist of different parts such as helix which forms the outer rim, antihelix is a structure that runs parallel to helix, intertragic notch forms a hairpin bend, and concha is present on the center area.[5]

As the fingerprint pattern, the human external ear characteristics are unique to an individual.[6] There are several advantages of using the ear as an information source for human identification. The ear features a rich structure of characteristic ear parts. The location of those characteristic parts with respect to their size, direction, angles, and relation inside the ear are distinctive to humans, and thus, is used as a modality for human identification.[7] To date, an indisputable fact among forensic scientists, anatomists, and anthropologists are that the unique structure of an ear permits identification.[8]

Morphological features of humans are used as biometric traits for identifying individuals. It is accepted and known fact that external ear is a potential candidature even among monozygotic twins.[9] The statistical data on anthropometric measurements of body dimensions are beneficial in forensics, apparel sizing, prosthesis, and in optimizing products.[10]

Abeysekera and Shahnavaz mentioned that a piece of equipment designed might fit 90% of united state male population and Germans, 80% of French population, 65% of Italy population, 45% of Japan population, 20% of thais, and 10% of Vietnam population.[11] In addition to ear, morphological characters such as skin color, stature, and hair color have been incorporated in recent times in identification system to enhance its function.[12]

It is believed that form of the ear does not change until death once after it attains the mature form. There are many techniques introduced for human individualization and identification extending from Bertillon system to fingerprint and DNA analysis. Uniqueness of the ear interested us to create a database based on anthropometric measurements of ear among 200 individuals who reported as outpatient to our hospital. The study attempts to assess the age changes and gender differences based on anthropometric measurements of ear and to create a database for the reported population.

Materials and Methods

Individuals

This study was conducted among 200 individuals who reported to private dental teaching hospital as outpatient. The study was done after obtaining clearance from the Institutional Review Board and Ethical Clearance in accordance Helsinki's declaration. The study population was explained about the procedure and informed consent was obtained. The size of the auricle was measured bilaterally as described by De Carlo *et al.* and methodology was adopted from Brucker *et al.*[4,13]

The individuals reporting to the department of oral medicine and radiology, above 20 years of age without any ear abnormality or pathology were included in the study. The study population was subdivided into three subgroups. Group I included individuals between 20 and 39 years, Group II between 40 and 59 years, and Group III above 60 years of age and patients with anomalies, syndromes, previous surgeries of the ear, and heavy earring wearers were excluded in the study.

Anthropometric measurements

The head position was positioned parallel to Frankfort's horizontal plane. The parameters total ear height (TEH), ear width (EW), lobular height (LH), and lobular width (LW) on both the sides were measured by digital vernier caliper.

Parameters measured

THE = Distance from ear lobule (L) to projection of helix (H).
EW = Distance from anterior (A) and posterior (P) points of ear.
LH = Distance from the lobule (L) to the base of tragal notch (T).
LW = Distance measured as the transverse/horizontal width of the lobule (C-D).
Ear index = Ear width/Ear height × 100
Lobule index = Lobule width/Lobule height × 100

All the parameters were measured by a single investigator to minimize the bias. Arithmetic mean was calculated for the right and left side ear measurements for accuracy. The data were subjected to statistical analysis. Unpaired *t*-test to find difference between gender and ANOVA to find difference between age groups using SPSS (version 19) was performed.

Results

The total ear index among women with mean and standard deviation was 4.97 ± 0.6 cm, and men were 5.02 ± 0.4 cm. The lobe index among men with mean and standard deviation was 1.153 ± 0.0163 cm and women were 1.243 ± 0.0147 cm. The comparison of measurements of total ear index between the groups among woman is given in Table 1 and among men it is given in Table 2. Ear index and lobe index showed higher values in men when compared to female individuals shown in Graph 1. This coincided with lobe index too, where $P < 0.0001$ which shows statistical significance.

Discussion

Ear plays a pivotal role in many fields. Anthropometric measurements of year play a significant role because of its uniqueness. Ear reaches its maximum growth at the age of 13 years in males and 12 years in females and does not get affected as age advances.

Purkait (2007) in their research on application of external ear in personal identification, reported a classification system using soft biometric traits based on ear features and proposed that this can be used as a tool in forensic research.[14]

Tharwaat *et al.* proposed fast and accurate ear recognition system based on principal component analysis and concluded

Table 1: Comparison of total ear index between the groups among female subjects

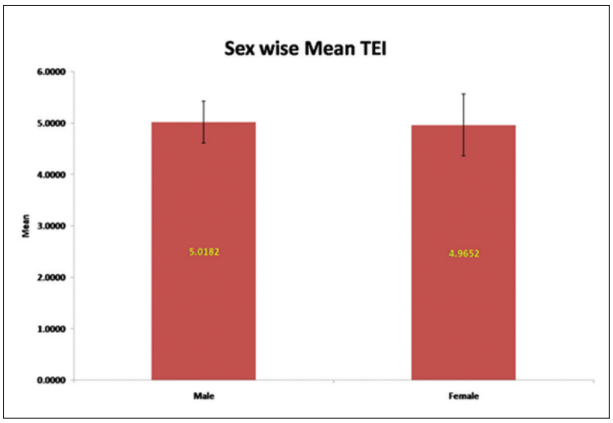
Age group	*N*	Mean	SEM	SD	95% CI	
					Lower limit	Upper limit
1	74	17.4982	0.32968	2.83599	16.852027	18.144373
2	38	18.1709	0.4643	2.86214	17.260872	19.080928
3	5	20.6144	1.48677	3.32452	17.700331	23.528469

SD: Standard deviation, SEM: Standard error mean, CI: Confidence interval

Table 2: Comparison of total ear index between the groups among male individuals

Age group	*N*	Mean	SEM	SD	95% CI	
					Lower limit	Upper limit
1	48	19.833	0.38395	2.66006	19.080458	20.585542
2	31	20.7912	0.43431	2.41816	19.939952	21.642448
3	4	21.2897	2.66577	5.33153	16.064791	26.514609

SD: Standard deviation, SEM: Standard error mean, CI: Confidence interval



Graph 1: Comparison of lobe index between male and female

that the proposed algorithm is more superior than using whole ear images.[15]

Zulkifli *et al.* in his research on an anthropometric comparison of the cross-sectional external ear between Monozygotic Twin to explore the potential of anthropometric data from the external ear in individualization of monozygotic twin among 95 pairs of identical twins aged between 7 and 31 years old throughout Malaysia. He concluded that 4 pairs showed significant differences of ear pattern between their twin pairs.[9]

Deopa *et al.* conducted study on age and sex-related dimensions with anthropometric measurements of the ear in 177 medical students and compared right and left ear index. In the results, left ear indices are higher than right in female population, and no significant difference was seen in male population when compared to female population. They mentioned that anthropometric measurement of the ear in males were 6.03 cm and females it was 5.77 cm.[10]

Ekanem *et al.* in their work mentioned that the size of ear lobe did not show difference between male and female.[16] Barut and Aktunc added that the mean height of ears when compared with left and right side the measurements was higher in males than in females.[17] Bozkir *et al.* reported that the height of left ear was 63.1 and 59.7 mm in men and women, respectively.[18]

Brucker *et al.* in their research on age and sex-related differences of morphometric analysis of external ear reported that the mean TEH was 6.30 cm, for men the ear measurement is 6.3 and 5.6 cm in females.[4]

Asai *et al.* in their study found a total height of left ear lobe was 62.4 and 58.5 mm in males and females, respectively, in North Americans and also found a measurement of 70.1 mm in the Japanese population. This study suggests that there is variation in TEH based on geographic areas.[19]

Mckinney *et al.* in his study found a mean ear height of 6.50 cm and mean LH of 1.80 cm with no significant correlation between the height of earlobe and aging. He also added that for male the maturity of ear reaches at 13 years of age and for females at 12 years of age were ear attains the maximum height.[20]

The anthropometric measurements in our study reveal that the measurement of ear in males is comparatively higher than female individuals which are consistent with all above studies. The total ear index in male was 5.02 cm, and female was 4.97 cm. When the measurements compared between the group there were no significant changes seen; this proves that ear morphology does not get altered once it attains maturity irrespective of gender.

In addition, in our study, we have intented to maintain these anthropometric measurements as a database in our oral medicine and radiology department along with the demographic data. This database might help forensic odontologist to assess the age and gender and the measurements would help in identifying individual from one another.

Conclusion

Our study aimed at assessing the age changes and gender differences based on anthropometric measurements of the ear and to create a database for the reported population. Our results showed the anthropometric measurement of ear index for male was higher than female and as age progress, there were no significant changes seen. We also developed a database of the reported population which can be used in future for varied application. The limitation of this study measured the ear index manually which may cause bias in the results. With recent advancements in computer technology measurements can be done to improve the accuracy. Furthermore, this study was done in a smaller population where the results cannot be extrapolated for a larger population.

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