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MORPHOMETRIC STUDY OF NORMAL HUMAN AURICLE

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ABSTRACT

Background: Morphometric analysis provides objective measurements important for identifying normal and abnormal anatomical structures. The auricle is integral to facial harmony, surgical planning and forensic identification. Despite its importance there is limited normative data on auricular dimensions across age and gender in the Indian population. This study aimed to establish morphometric baselines for the human auricle and investigate differences by sex, side, and age.

Materials and Methods: A cross-sectional study was conducted on 170 individuals comprising 100 young adults (50 males and 50 females, aged 18–25) and 70 individuals distributed across seven age groups. Measurements were taken bilaterally using a digital caliper in the Frankfurt horizontal plane. Parameters measured included total ear height, ear width, conchal height and width, lobular height and width and ear projection. Data was analyzed using SPSS v23.0., Independent t-tests and one-way ANOVA were used to assess sex and age-related differences, with p<0.05 considered significant.

Results: Among young adults mean total ear height was 59.33±3.30 mm. Males exhibited significantly larger dimensions than females for ear height, width, conchal height and ear projection. Notable right-left asymmetry was observed in both sexes particulalry in ear width and ear projection. A progressive increase in all parameters was observed with age, most markedly in lobular height and total ear height. Ear projection remained relatively stable. These trends highlight the auricle's age-dependent morphological evolution and sexual dimorphism in size.

Conclusion: This study establishes normative auricular dimensions for an Indian population, revealing significant variations by age, sex, and side. The findings have practical implications in aesthetic and reconstructive surgery and forensic identification. Standardized morphometric assessment is essential for clinical accuracy and anthropological relevance.

Keywords: Auricle, Morphometry, Anthropometry, Ear dimensions, Age-related changes.

INTRODUCTION

Morphometry is defined as the measurement of shape. It provides quantitative values for qualitative description and plays an important role in dysmorphology. Metric analysis requires the choice of an appropriate standard because populations are metrically distinct.[1] Many studies have defined human body parts and their proportions morphometrically. These studies enable accurate definitions for morphometric properties of various body parts in different populations. They help to define population standards and congenital malformations.[2]

The external ear consists of the auricle or pinna and the external acoustic meatus. The auricle is the part of the external ear projected from the side of the head and seen as a crumpled structure. It serves to collect the vibrations of the air by which sound is heard. The auricle or pinna is a defining facial feature important for a harmonious, aesthetically pleasing face. It is often unnoticeable when its size, shape, position, and location are normal. However, alterations cause significant aesthetic disturbances, leading to dissatisfaction and potential psychological effects.[3]

To plastic surgeons, the auricle offers cues about age, but current literature lacks definitive parameters to define the normal youthful ear. Though the anatomy of the external ear has been described, there is minimal data to guide surgical rejuvenation of the ear.[4] This study intends to describe the aesthetic proportion of the human auricle based on normative cross-sectional data.[5] It will show morphometric differences between men and women, between right and left auricles, and age-related morphological changes. The ear conveys as much information on age and gender as other facial features. With appropriate normative data, the approach to ear rejuvenation can be better defined.[6]

Changes in facial morphology from infancy onward cause difficulty in identification. In infancy, significant changes occur due to rapid growth during the first year. The ear lobule is the last part of the auricle to develop. The lobule is absent or rudimentary in anthropoids and best developed in civilized races.[7] Ear lobule morphometry provides information on age and sex and has value in forensic investigations. It is used in otomorphology for identification through photographs or earprints. It holds significance in forensic medicine and criminology.[8]

Abnormalities of the external ear occur in various conditions and genetic syndromes. The incidence of auricular malformations at birth is notable. These malformations may include absent ear, malformed or abnormally folded pinna, prominent ears or low-set and abnormally rotated ears. Certain studies report that ear abnormalities are among the most common minor anomalies associated with neurodevelopmental conditions like autism. Hence, descriptions of abnormal facial and neck features are important in genetic diagnosis.[9]

The auricle is ovoid, with its larger end directed upward. Its lateral surface is irregularly concave, directed slightly forward, and presents several named eminences and depressions. The prominent rim is the helix; where the helix turns downward behind, a small tubercle—the auricular tubercle of Darwin—is often seen. Another curved prominence, in front of and parallel to the helix, is the antihelix, which divides into two crura enclosing the fossa triangularis. The scapha is the depression between the helix and antihelix. The antihelix curves around the concha, which is partially divided into cymba conchae (upper) and cavum conchae (lower). The tragus is a small pointed eminence in front of the concha. Opposite the tragus is the antitragus, separated by the intertragic notch. Below this is the lobule, composed of tough areolar and adipose tissue, making it soft unlike the firm and elastic remainder of the auricle. The comparison of physical characteristics in populations can be studied using anthropometry, a system of techniques to quantify external dimensions of the human body.[10]

We this background we undertook this study to explore morphometric differences in male and female auricles, between right and left auricles, and age-related changes in auricle morphology, comparing findings with existing literature.

MATERIALS AND METHODS

The study was conducted in a medical college and a primary school in Mumbai. Study group consist of students of medical College, indoor patients of ENT department and students of the primary school, Mumbai. Written consent was taken from each subject and wherever necessary from the guardians of subjects. The clinical examination was done and a detailed history was taken to exclude trauma, congenital anomalies, surgeries or any other diseases of external ear.

For comparison between males and females, 100 medical students (50 males and 50 females) of age group 18-25 years (Group-I) were selected and morphometric study of the auricle was conducted on both the sides.

For age changes in morphometry of auricle 70 subjects from the following seven age groups were analysed. (Table 1)

Table 1: Age groups of studied cases for analysis of morphometry of auricle

Serial no.	Group	Age (yrs)	No. of subjects
1	A	1-5 yrs	10
2	B	6-10 yrs	10
3	C	11-15 yrs	10
4	D	16-20 yrs	10
5	E	21-40 yrs	10
6	F	41-60 yrs	10
7	G	>60 yrs	10

The head of subject was positioned in the Frankfurt horizontal plane and the measurements were taken directly from right and left auricle of each subject. The measurements were taken with an electronic digital calliper. The Frankfurt plane (also called auriculoorbital plane) used here was established at the world congress on Anthropology in Frankfurt, Germany in 1884 and declared as anatomical position of skull. It was decided that a plane passing through the inferior margin of orbit (the point called orbitale) and upper margin of each external auditory meatus (a point called the Porion) was most nearly parallel to the surface of earth and also close to the position of head normally carried in the living subject. The measurements were taken by single observer throughout the study. Each measurement was measured twice for minimising the errors. Following parameters were measured. (Table 2)

Table 2: List of parameters studied for morphometric analysis of auricle

Total Ear height:	The distance between the highest point of auricle and lowest point of ear lobe.
Ear width:	The distance between the most anterior and posterior point of the auricle.
Conchal height:	The distance from intertragic incisure to the lower crux of helix.
Conchal width:	The distance from the base of tragus to the antihelix.
Lobular height:	The distance from intertragic incisure to caudal part of the lobule.
Lobular width:	The horizontal width of the lobule at the midpoint of lobular height.
Ear projection:	The distance from the helix to the mastoid process at the tragal level.

Statistical analysis for this study was done using SPSS version 23.0. Continuous variables such as total ear height, ear width, conchal height and width, lobular height and width, and ear projection were expressed either as mean ± standard deviation (SD). Categorical variables like age group and sex were presented as frequencies and percentages. For comparative analysis between male and female subjects independent t-test was used. To evaluate age-related changes in auricular dimensions across the seven defined age groups one-way ANOVA was employed. All measurements were taken twice by a single observer to minimize inter-observer variability and a p-value of <0.05 was considered statistically significant.

RESULTS

The analysis of the auricular dimensions in young adults (aged 18–25 years, Group I) showed that the average total ear height was 59.33 mm (±3.30), establishing it as the largest measured parameter. This was followed by ear projection at 21.08 mm (±2.60) and conchal width at 22.08 mm (±1.66). The ear width measured 30.56 mm (±2.58), while conchal height averaged 19.89 mm (±1.55). Among the lobular dimensions, lobular width was greater at 20.73 mm (±2.03) compared to lobular height, which measured 17.25 mm (±2.30) (Table 3).

Table 3: Summary of Mean Auricular Dimensions (18–25 yrs, Group I)

Parameter	Mean ± SD (mm)
Total ear height	59.33 ± 3.30
Ear width	30.56 ± 2.58
Conchal height	19.89 ± 1.55
Conchal width	22.08 ± 1.66
Lobular height	17.25 ± 2.30
Lobular width	20.73 ± 2.03
Ear projection	21.08 ± 2.60

The analysis of side-to-side differences in male subjects revealed that the right ear had a greater ear width (31.79 ± 2.45 mm) compared to the left (30.66 ± 2.35 mm), and this difference was statistically significant (p<0.02). Additionally, the left ear showed a higher projection (22.52 ± 2.97 mm) than the right (21.48 ± 2.59 mm), with this difference also reaching statistical significance (p=0.001). Thus, only ear width and ear projection demonstrated significant lateral asymmetry in males (Table 4).

Table 4: Analysis of various parameters in right and left ear in males

Parameter	Right Mean ± SD	Left Mean ± SD	P-value
Total ear height	60.79 ± 4.04	60.59 ± 4.24	0.81
Ear width	31.79 ± 2.45	30.66 ± 2.35	<0.02
Conchal height	20.27 ± 1.61	19.98 ± 1.54	0.074
Conchal width	22.37 ± 1.56	22.53 ± 1.73	0.47
Lobular height	17.54 ± 2.27	17.35 ± 2.11	0.328
Lobular width	20.90 ± 2.05	20.98 ± 1.65	0.738
Ear projection	21.48 ± 2.59	22.52 ± 2.97	0.001

The analysis of side-to-side differences in female subjects showed that ear width was significantly greater on the right side (30.38 ± 2.53 mm) compared to the left (29.40 ± 2.46 mm). Additionally, lobular height also exhibited a significant side-to-side difference, being slightly higher on the right (17.20 ± 2.32 mm) than the left (16.90 ± 2.42 mm), with a p-value of 0.037. All other parameters including total ear height, conchal height and width, lobular width, and ear projection showed no significant differences between the right and left sides (p>0.05). (Table 5).

Table 5: Analysis of various parameters in right and left ear in Females

Parameter	Right Mean ± SD	Left Mean ± SD	P-value
Total ear height	57.98 ± 3.53	57.97 ± 3.13	0.94

Ear width	30.38 ± 2.53	29.40 ± 2.46	0.0002
Conchal height	19.65 ± 1.50	19.64 ± 1.45	0.93
Conchal width	21.78 ± 1.97	21.65 ± 1.95	0.51
Lobular height	17.20 ± 2.32	16.90 ± 2.42	0.037
Lobular width	20.45 ± 2.02	20.57 ± 2.35	0.561
Ear projection	19.98 ± 2.59	20.34 ± 2.66	0.206

The analysis of auricular measurements on the right side between male and female subjects showed that males had significantly greater total ear height (60.79 ± 4.04 mm) compared to females (57.98 ± 3.53 mm). Ear width was also higher in males (31.79 ± 2.45 mm) than in females (30.38 ± 2.53 mm), and this difference was statistically significant (p=0.0055). Males further exhibited significantly larger conchal height (20.27 ± 1.61 mm vs. 19.65 ± 1.50 mm; p=0.048) and ear projection (21.48 ± 2.59 mm vs. 19.98 ± 2.59 mm; p=0.046). (Table 6).

Table 6: Comparison of various parameters of right ear in males and females

Parameter	Male Right ± SD	Female Right ± SD	P-value
Total ear height	60.79 ± 4.04	57.98 ± 3.53	0.0004
Ear width	31.79 ± 2.45	30.38 ± 2.53	0.0055
Conchal height	20.27 ± 1.61	19.65 ± 1.50	0.048
Conchal width	22.37 ± 1.56	21.78 ± 1.97	0.10
Lobular height	17.54 ± 2.27	17.20 ± 2.32	0.472
Lobular width	20.90 ± 2.05	20.45 ± 2.02	0.269
Ear projection	21.48 ± 2.59	19.98 ± 2.59	0.046

The analysis of auricular measurements on the left side between male and female subjects showed that males had significantly greater total ear height (60.59 ± 4.24 mm) compared to females (57.97 ± 3.13 mm), with a p-value of 0.0006. Ear width was also notably higher in males (30.66 ± 2.35 mm) than in females (29.40 ± 2.46 mm), and this difference was statistically significant (p=0.010). Conchal width was greater in males (22.53 ± 1.73 mm) than in females (21.65 ± 1.95 mm), with a significant p-value of 0.019. Additionally, ear projection was markedly higher in males (22.52 ± 2.97 mm) compared to females (20.34 ± 2.66 mm), and this difference was highly significant (p=0.0002). (Table 7).

Table 7: Comparison of various parameters of left ear in males and females

Parameter	Male Left ± SD	Female Left ± SD	P-value
Total ear height	60.59 ± 4.24	57.97 ± 3.13	0.0006
Ear width	30.66 ± 2.35	29.40 ± 2.46	0.010
Conchal height	19.98 ± 1.54	19.64 ± 1.45	0.240
Conchal width	22.53 ± 1.73	21.65 ± 1.95	0.019
Lobular height	17.35 ± 2.11	16.90 ± 2.42	0.324
Lobular width	20.98 ± 1.65	20.57 ± 2.35	0.311
Ear projection	22.52 ± 2.97	20.34 ± 2.66	0.0002

The analysis of age-related trends in total ear height and ear width demonstrated a clear pattern of progressive increase across all age groups. Total ear height on both sides showed a steady rise from early childhood to older adulthood, increasing from 50.04 ± 3.70 mm (right) and 50.01 ± 3.98 mm (left) in the 1–5 years group to 68.91 ± 6.20 mm (right) and 68.66 ± 4.99 mm (left) in individuals over 60 years, indicating an approximate growth of 19 mm. Similarly, ear width also increased with age, starting at 28.90 ± 1.22 mm (right) and 27.00 ± 1.78 mm (left) in the youngest age group and reaching 34.57 ± 3.25 mm (right) and 32.93 ± 2.63 mm (left) in the oldest group. (Table 8).

Table 8: Age-related trends in total ear height and ear width

Age Group (yrs)	Total Ear Height Right ± SD	Ear Width Right ± SD	Total Ear Height Left ± SD	Ear Width Left ± SD
1–5	50.04 ± 3.70	28.90 ± 1.22	50.01 ± 3.98	27.00 ± 1.78
6–10	53.54 ± 3.62	27.81 ± 2.77	53.22 ± 3.72	26.90 ± 2.02
11–15	56.20 ± 1.97	31.07 ± 1.48	56.37 ± 2.11	30.48 ± 1.90
16–20	58.39 ± 3.01	30.73 ± 1.32	58.66 ± 2.88	29.50 ± 1.20
21–40	60.88 ± 3.79	31.25 ± 2.78	60.04 ± 3.28	30.64 ± 2.96
41–60	63.55 ± 2.34	32.28 ± 2.22	63.44 ± 3.25	31.34 ± 1.99
>60	68.91 ± 6.20	34.57 ± 3.25	68.66 ± 4.99	32.93 ± 2.63

The analysis of age-related changes in conchal height and conchal width revealed a general trend of gradual increase with advancing age. Conchal height on the right side rose from 16.61 ± 1.21 mm in the 1–5 year age group to a peak of 20.66 ± 1.55 mm in the 41–60 year group, with a slight decrease to 20.34 ± 0.92 mm in individuals over 60. A similar pattern was observed on the left, starting at 17.11 ± 0.96 mm and increasing to 20.84 ± 1.65 mm in the oldest group. Conchal width also demonstrated an overall increase, starting from 20.40 ± 1.36 mm (right) and 20.22 ± 1.23 mm (left) in the youngest group, reaching up to 22.80 ± 2.39 mm (right) and 23.71 ± 1.65 mm (left) in individuals above 60 years. (Table 9).

Table 9: Age-related changes in conchal height and conchal width

Age Group	Conchal Height Right ± SD	Conchal Width Right ± SD	Conchal Height Left ± SD	Conchal Width Left ± SD
1–5	16.61 ± 1.21	20.40 ± 1.36	17.11 ± 0.96	20.22 ± 1.23
6–10	17.30 ± 0.96	21.38 ± 2.12	17.95 ± 1.17	20.04 ± 1.40
11–15	18.87 ± 1.09	21.95 ± 1.44	19.04 ± 0.63	21.47 ± 1.72
16–20	19.53 ± 0.99	21.67 ± 1.67	19.93 ± 1.47	21.19 ± 1.98
21–40	19.43 ± 1.23	21.61 ± 1.28	19.49 ± 1.09	21.66 ± 1.27
41–60	20.66 ± 1.55	23.26 ± 1.38	20.79 ± 1.69	21.68 ± 1.38
>60	20.34 ± 0.92	22.80 ± 2.39	20.84 ± 1.65	23.71 ± 1.65

The analysis of age-related trends in lobular height and lobular width revealed a clear and progressive increase with advancing age, particularly in lobular height. On the right side, lobular height rose from 14.11 ± 2.15 mm in the 1–5 year age group to 23.21 ± 3.93 mm in individuals over 60 years, while on the left side it increased from 13.43 ± 2.00 mm to 23.89 ± 3.32 mm across the same age span. Lobular width showed a less pronounced but steady rise, increasing from 17.43 ± 2.22 mm (right) and 18.11 ± 1.73 mm (left) in early childhood to 22.69 ± 2.29 mm (right) and 22.91 ± 2.59 mm (left) in the oldest age group. (Table 10)

Table 10: Age-related trends in lobular height and lobular width

Age Group	Lobular Height Right ± SD	Lobular Width Right ± SD	Lobular Height Left ± SD	Lobular Width Left ± SD
1–5	14.11 ± 2.15	17.43 ± 2.22	13.43 ± 2.00	18.11 ± 1.73
6–10	14.21 ± 1.80	18.28 ± 2.23	13.56 ± 1.70	18.21 ± 2.44
11–15	16.26 ± 1.69	21.88 ± 1.56	16.13 ± 2.01	21.00 ± 2.54
16–20	16.78 ± 2.45	19.38 ± 2.18	16.08 ± 2.27	19.69 ± 2.09
21–40	17.05 ± 2.54	20.55 ± 1.79	16.97 ± 2.65	20.61 ± 2.34
41–60	20.27 ± 3.14	22.65 ± 2.39	19.86 ± 2.59	21.28 ± 1.55
>60	23.21 ± 3.93	22.69 ± 2.29	23.89 ± 3.32	22.91 ± 2.59

The analysis of age-related variations in ear projection demonstrated relatively stable values across all age groups, with only minor fluctuations observed. On the right side, ear projection ranged from 20.22 ± 2.49 mm in the 16–20 year group to a peak of 22.16 ± 2.68 mm in the 41–60 year group. Similarly, on the left side, the lowest value was noted in the 21–40 year group (19.89 ± 2.66 mm), while the highest was seen in the 41–60 year group (23.29 ± 3.12 mm). (Table 11)

Table 11: Age-related variations in ear projection

Age Group	Ear Projection Right ± SD	Ear Projection Left ± SD
1–5	21.04 ± 3.00	22.17 ± 3.40
6–10	20.91 ± 2.79	23.27 ± 2.83
11–15	20.59 ± 1.92	20.89 ± 2.09
16–20	20.22 ± 2.49	22.26 ± 3.99
21–40	20.36 ± 3.47	19.89 ± 2.66
41–60	22.16 ± 2.68	23.29 ± 3.12
>60	21.47 ± 3.50	22.42 ± 2.49

DISCUSSION

This study presents a comprehensive analysis of auricular morphometry among young adults aged 18–25 years. In this study parameters evaluated were total ear height, ear width, conchal dimensions, lobular size and ear projection. Total ear height has long been recognized as a significant anthropometric marker in clinical assessment of congenital anomalies, such as Down syndrome, and also in traditional prognostic beliefs. In many cultures longer ears were considered a symbol of longevity and wisdom. Modern research by Bozkir and Karakas reported that total ear height reaches adult dimensions by 13 years in boys and 12 years in girls.[11] In our cohort, the mean total ear height was 59.33 mm. Males had higher values, averaging 60.79 mm on the right and 60.59 mm on the left, compared to 57.98 mm and 57.97 mm in females. Side-to-side differences were not statistically significant; however, inter-sex comparisons revealed significantly greater dimensions in males. These results are closely aligned with North American data where average ear height in men was reported to be significantly more as compared to women.[12] Interestingly, populations such as the Japanese exhibit higher auricular height with average values reportedly exceeding 70 mm. These differences suggest ethnic variability in auricular dimensions.[13] Ear width develops earlier than ear height with maturity reached by the age of 7 in males and 6 in females. This dimension holds diagnostic relevance in craniofacial anomalies including Apert and Crouzon syndromes where ear width serves as an important phenotypic indicator. In our study population the mean ear width was 30.56 mm with males again showing higher values than females. Notably, the right ear was significantly wider than the left in both sexes, a pattern also observed in previous studies. The male ear width averaged 31.79 mm on the right and 30.66 mm on the left, while females measured 30.38 mm and 29.40 mm respectively. These findings mirror those of a Turkish population-based study where male and female ear widths were 33.3 mm and 31.3 mm, respectively. Similar observations were reported in earlier Indian datasets lending further support to regional consistency.[14]

Conchal dimensions, which are crucial for the ergonomic design of hearing aids and auricular prostheses were also evaluated in this study. The mean conchal height in our study was 19.89 mm. Among males the conchal height was marginally higher than females, and only the right-sided male-female comparison reached statistical significance. Conchal width averaged 22.08 mm across the cohort with minor variations between sides and sexes that were mostly non-significant, except for the female left side. These values are higher than those recorded by Bozkir and Karakas in Turkish subjects, where bilateral conchal height was approximately 17.2 mm, indicating probable ethnic influences.[11] Other Indian studies such as those by Natekar and Desouza have shown variable results, which may be attributed to methodological differences and sample heterogeneity.[15]

Lobular dimensions undergo notable changes with age and have significant implications in aesthetic and reconstructive surgery. The current study found the average lobular height to be 17.25 mm, and lobular width to be 20.73 mm. While no statistically significant sex differences were observed, a significant right-left disparity was found in females. McKinney and colleagues16 previously highlighted age-related lobular elongation a finding echoed by Azaria et al in their study that emphasized the cosmetic importance of stable lobular width in surgical planning.[17] Our results fall within the ranges reported in Turkish populations, where lobular heights range from 17.5 mm to 18.4 mm.

Ear projection, another critical parameter in surgical correction of auricular deformities such as microtia or prominent ears demonstrated a mean value of 21.08 mm. Male participants showed significantly higher projection than females on both sides, with a statistically significant side difference also present in males. These results are consistent with findings from Sforza C 18 and Wang B 19, who underscored the role of ear projection in determining optimal placement for hearing aids and cosmetic outcomes. In contrast, lower projection values, typically around 17.0–17.6 mm, have been reported in Turkish populations, reinforcing the concept of population-specific variation.[11]

An age-stratified analysis of auricular dimensions from early childhood to late adulthood revealed a progressive increase in all morphometric parameters, with the most pronounced growth observed after the age of 3 years. This finding supports the longitudinal data published by researchers such as Heathcote JA et al who have previously reported similar trends in ear size enlargement with age. Although the magnitude of gender and side differences was generally modest, statistically significant male predominance and right-side dominance were evident in multiple measurements.

Variations in methodology, sample size, and ethnic composition likely account for discrepancies observed between our findings and those of previous Indian studies. Nevertheless, the normative data generated from this study offer a reliable and regionally relevant reference point for clinical evaluation, prosthetic design, and anthropological research in South Asian populations.

CONCLUSION

Morphometric analysis yields objective, quantifiable data critical for establishing age, sex, and population-specific anatomical norms, detecting congenital or disease-related morphological deviations, and monitoring growth or treatment outcomes. It informs the customization of reconstructive and aesthetic surgical procedures, implants and prostheses, and the ergonomic design of wearable devices, while also underpinning forensic and anthropological profiling. To ensure its clinical and research value, rigorous standardization of landmark definitions, measurement techniques, and analytical workflows is essential for accuracy, reproducibility, and interstudy comparability.

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