

Anthropometric Assessment of the Normal Adult Human Ear

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Abstract

Purpose: Knowledge of anthropometric measurements of the external ear is important as variations exist based on gender, age and ethnicity. This study has derived anthropometric data pertaining to the external ear in the Maharashtrian population. **Materials and Methods:** Nine variables of the external ear were measured in 505 Maharashtrian adults (aged 18–64 years) using photoanthropometric methods. **Results:** Descriptive data and the left-right symmetry for the study population were obtained. **Conclusion:** These data have applications in screening for or monitoring diseases, otoplastic surgery, forensics, industrial design, apparel design and ergonomics.

Keywords: Auricle, ear reconstruction, external ear, otoplasty, photoanthropometry

INTRODUCTION

An important organ contributing to the esthetics of the human face is the ear. The size, shape, position and projection of the ear all influence the appearance of the individual. The external ear consists of the external auditory meatus and the auricle or pinna. The latter is most commonly associated with congenital abnormalities such as microtia, macrotia, malposed ear, accessory auricle, lop ear and protruding ear; which may be associated with Down's syndrome, Potter's syndrome and Turner syndrome.^[1] Acquired defects result from traumatic injuries and pathologic conditions, especially cancer. Five to eight percent of all skin cancers are located on the auricle^[2] as its projection and exposure make it more prone to actinic damage. Rectifying these abnormalities requires information about normal auricular dimensions, the auricle's bilateral position on the face and general conformation. Some studies of the ear involving syndromes and anomalies have been published, but few studies have investigated the ear in the normal population.

Recent anthropometric studies of the external ear from different parts of the world prove that much variability exists depending on the age, sex and ethnic group, and even in the same person between the right and left ears.^[3] In spite of this, the available literature suggests that males have larger ears than females, the length and width of the ear keep on increasing with age,

and the general size of the ear varies in populations of different ethnicities.^[4] Very few studies on anthropometric data of the normal human ear in the Indian population are available and anthropometric measurements given in the Western literature are less likely to be of use in the Indian population.^[3,5,6]

The purpose of this study is to gather photoanthropometric data about the ear (auricle) in the Maharashtrian population using photogrammetry which is less invasive to a patient, is less time-consuming, and provides a permanent record of data.

MATERIALS AND METHODS

This study is a cross-sectional observational study, wherein no intervention was carried out on the participants. Every fifth patient in the age of 18–64 years was selected to get 505 participants from among the patients reporting to the outpatient department of our institute in May 2015. Individuals of Maharashtrian origin willing to give informed written consent permitting the publishing of photographs of their ears taken with a customized grid were included; those with

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a history of craniofacial trauma, ear diseases, congenital or acquired anomalies and/or ear surgeries, uncooperative and mentally handicapped individuals and wrestlers, boxers or practitioners of martial arts^[7] were excluded.

Similar to the technique of Liu,^[8] a 1 mm × 1 mm grid was printed on a clear A4-sized sticker sheet and pasted over an 8 cm × 8 cm × 3 mm clear glass piece and the excess sheet was trimmed off. A customized acrylic platform was fabricated with provision for mounting the camera and housing the glass and grid so that the photographs taken were uniform for all individuals. The mounting for holding the glass was fixed with an LED light strip that was connected to a 9 V battery to provide good illumination [Figures 1 and 2]. Informed written consent for permission to photograph the external ear and use the photographs for anthropometric study was taken from all the participants.

All participants were asked to remove their ear accessories. They were then seated upright in a chair such that their Frankfurt horizontal plane was parallel to the floor. A plain white sheet of paper having a cut out at the center for the ear was placed to demarcate the ear margins from the hair and rest of the face. The custom-made platform was placed such that the plane of the mounted grid was parallel to and just touching the plane of the auricle. Then, photographs of the left and right auricles of each individual were taken in the same fashion by a principal investigator [Figures 3-6]. The images and data were transferred to a computer and resized proportionately such that 1 mm of the grid in the image was equal to 1 mm of the standard measuring scale, when the image was printed on A4-sized paper. On the printed images, various landmarks of the auricle were identified. A straight line was drawn marking the attachment of the auricle to the skin of the face. A perpendicular was drawn to this first line such that it was tangential to the highest point on the helix. Another perpendicular was drawn to the first line such that it was tangential to the lowest point on the lobule. Another line is drawn parallel to the first line and tangential to the outermost point on the helix of the auricle. A rectangle was thus drawn tangential to the four borders of the auricle. This rectangle defined the boundaries of the auricle [Figure 7]. The following measurements were made.

- Ear length – Perpendicular distance between the tangents to the highest point on the helix and the lowest point on the lobule
- Ear breadth – Perpendicular distance between the straight line marking the attachment of the auricle to the skin of the face and the tangents to the outermost point on the helix
- Ear length above tragus – Perpendicular distance between the tangent to the highest point on the helix and the superior-most point of the tragus
- Ear length below tragus – Perpendicular distance between the tangent to the lowest point on the lobule and the inferior-most point of the tragus
- Tragus length – Perpendicular distance between the superior-most and inferior-most points on the tragus

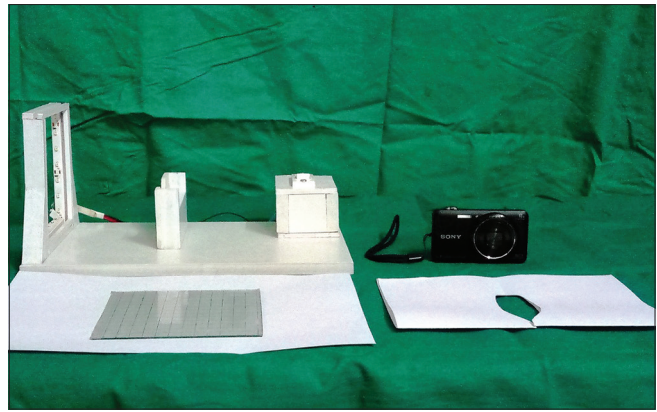


Figure 1: Armamentarium used for the study

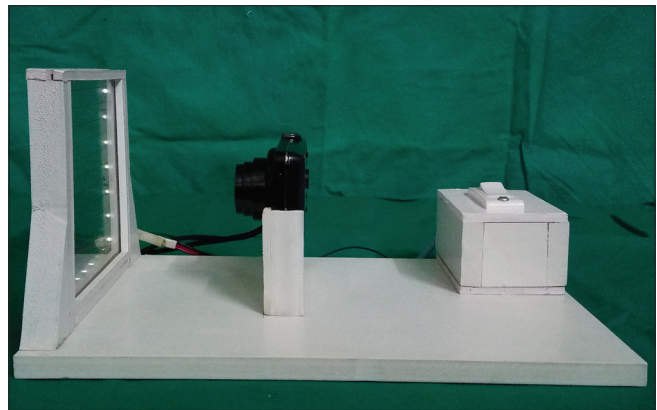


Figure 2: Arrangement of armamentarium for the study



Figure 3: Method of recording the photographs

- Concha length – Perpendicular distance between the superior-most and inferior-most points on the concha, in a plane parallel to the straight line marking the attachment of the auricle to the skin of the face
- Concha breadth – Perpendicular distance between the anterior-most and posterior-most points on the concha, in a plane perpendicular to the straight line marking the attachment of the auricle to the skin of the face
- Lobule height – Perpendicular distance between the point of attachment of the lobule to the skin of the face, to the



Figure 4: Method of recording the photographs

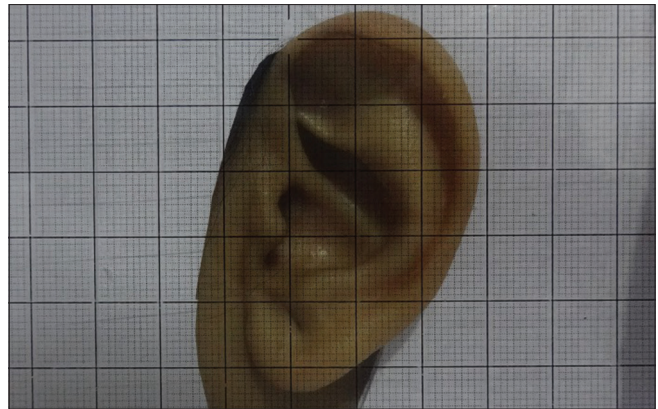


Figure 5: Photograph of left ear of participant

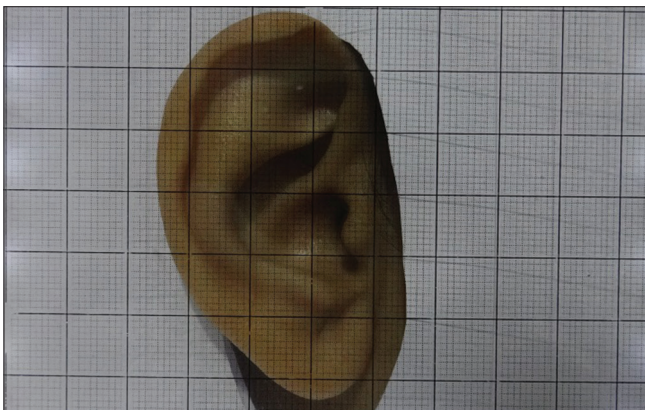


Figure 6: Photograph of right ear of participant

- tangent drawn to the lowest point on the lobule
- Lobule width – Perpendicular distance between the point of attachment of the lobule to the skin of the face, to the outermost point on the lobule in a plane perpendicular to the straight line marking the attachment of the auricle to the skin of the face.

All measurements were made with a scale to the closest millimeter by the same principal investigator and entered in a tabular format along with the age and sex of each participant. Taking guidelines from the study of Sforza *et al.*,^[9] the assimilated data were divided into four age groups: 18–30 years, 31–40 years, 41–50 years and 51–64 years, and further segregated based on gender.

Statistical analysis

The data were subjected to statistical analysis using SPSS Version 20 (IBM Corp., Armonk, NY). Shapiro–Wilk’s test was done to determine normality of the data. Data were not found to be normally distributed; thus, nonparametric tests were done. Mann–Whitney U-test was done to determine statistical significance in the values for males and females within each age group. Spearman’s correlation coefficient test was conducted to determine the symmetry between right and left sides among individual age groups and also for whole population. Correlation coefficient (*r* value) was interpreted as follows:

- <0.2 indicates slight correlation
- 0.2–0.4 indicates weak correlation

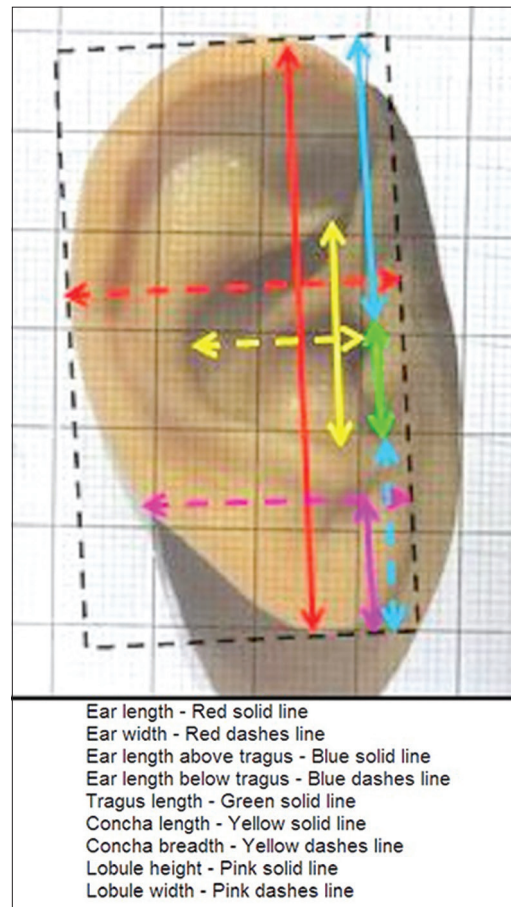


Figure 7: Guide to measurement of the various variables of the ear

- 0.4–0.7 indicates moderate correlation
- 0.7–0.9 indicates high correlation
- >0.9 indicates almost perfect correlation.

RESULTS

Age and sex distribution of study population

This study included 505 participants within the age range of 18–64 years (mean age = 38.33 ± 11.994 years). 225 were males (mean age = 40.96 ± 12.017 years) and

Table 1: Age and sex distribution of study population

Age group (years)	Sex	n	Mean age ± SD
18-30	Male	49	24.02±4.166
	Female	107	25.04±4.086
	Total	156	24.72±4.125
31-40	Male	65	36.35±2.875
	Female	85	35.69±2.866
	Total	150	35.98±2.879
41-50	Male	56	45.98±2.838
	Female	55	45.6±2.948
	Total	111	45.79±2.886
51-64	Male	55	56.36±3.439
	Female	33	58.15±3.104
	Total	88	57.03±3.412
Total	Male	225	40.96±12.017
	Female	280	36.21±11.571
	Total	505	38.33±11.994

n=Sample size, SD=Standard deviation

Table 2: Descriptive data of study population and comparison of mean left ear measurements among males and females aged 18-30 years

Variable	Sex	n	Mean ± SD	SE	P
Left ear length	Male	49	60.53±4.574	0.653	0.002*
	Female	107	58.38±3.594	0.347	
Left ear breadth	Male	49	31.61±2.636	0.377	0.001*
	Female	107	30.16±2.741	0.265	
Left ear length above tragus	Male	49	28.39±2.907	0.415	0.027*
	Female	107	27.24±3.129	0.302	
Left ear length below tragus	Male	49	19.22±3.287	0.47	NS
	Female	107	18.56±3.291	0.318	
Left ear tragus length	Male	49	12.88±2.377	0.34	NS
	Female	107	13.06±2.464	0.238	
Left ear concha length	Male	49	22.06±3.654	0.522	NS
	Female	107	21.22±3.16	0.306	
Left ear concha breadth	Male	49	16.14±3.014	0.431	NS
	Female	107	15.62±2.452	0.237	
Left ear lobule height	Male	49	11.57±2.693	0.385	NS
	Female	107	11.27±2.583	0.25	
Left ear lobule width	Male	49	20.14±2.872	0.41	0.008*
	Female	107	18.86±3.223	0.312	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS=Not significant

280 females (mean age = 36.21 ± 11.571 years). The age groups, number of male and female participants in each group and their mean ages have been enlisted in Table 1.

Descriptive data of the study population

The mean values, standard deviation, and standard error for each variable of each ear in the study population are enlisted in Tables 2-9.

18-30 years age group

Evaluation of 156 participants, 49 males and 107 females (mean age = 24.72 years), was done. It was observed that

Table 3: Descriptive data of study population and comparison of mean right ear measurements among males and females aged 18-30 years

Variable	Sex	n	Mean ± SD	SE	P
Right ear length	Male	49	60.65±4.711	0.673	0.006*
	Female	107	58.69±3.92	0.379	
Right ear breadth	Male	49	31.47±2.77	0.396	0.003*
	Female	107	30.09±2.876	0.278	
Right ear length above tragus	Male	49	28.37±2.651	0.379	0.005*
	Female	107	27.06±2.781	0.269	
Right ear length below tragus	Male	49	19.16±3.46	0.494	NS
	Female	107	18.72±3.581	0.346	
Right ear tragus length	Male	49	13.06±2.096	0.299	NS
	Female	107	13.21±2.632	0.254	
Right ear concha length	Male	49	21.71±3.26	0.466	NS
	Female	107	21.02±3.311	0.32	
Right ear concha breadth	Male	49	15.86±3.028	0.433	NS
	Female	107	15.37±2.23	0.216	
Right ear lobule height	Male	49	11.39±2.532	0.362	NS
	Female	107	11.28±2.532	0.245	
Right ear lobule width	Male	49	19.69±3.33	0.476	NS
	Female	107	18.79±3.188	0.308	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS=Not significant

Table 4: Descriptive data of study population and comparison of mean left ear measurements among males and females aged 31-40 years

Variable	Sex	n	Mean ± SD	SE	P
Left ear length	Male	65	62.62±3.74	0.464	<0.001*
	Female	85	60.18±3.267	0.354	
Left ear breadth	Male	65	32.26±2.906	0.36	0.004*
	Female	85	30.79±2.875	0.312	
Left ear length above tragus	Male	65	28.91±3.06	0.38	0.015*
	Female	85	27.58±3.375	0.366	
Left ear length below tragus	Male	65	20.34±3.089	0.383	NS
	Female	85	19.68±3.137	0.34	
Left ear tragus length	Male	65	13.35±2.407	0.299	NS
	Female	85	12.87±2.636	0.286	
Left ear concha length	Male	65	22.65±3.29	0.408	NS
	Female	85	21.92±2.791	0.303	
Left ear concha breadth	Male	65	16.11±2.873	0.356	NS
	Female	85	16.22±2.551	0.277	
Left ear lobule height	Male	65	12.06±3.22	0.399	NS
	Female	85	11.95±2.716	0.295	
Left ear lobule width	Male	65	20.62±2.805	0.348	NS
	Female	85	19.59±2.917	0.316	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS= Not significant

males had slightly larger dimensions for left ear length, right ear length, left ear breadth, right ear breadth, left ear length above tragus, right ear length above tragus, left ear length below tragus, right ear length below tragus, left ear concha length, right ear concha length, left ear concha breadth, right

Table 5: Descriptive data of study population and comparison of mean right ear measurements among males and females aged 31-40 years

Variable	Sex	n	Mean±SD	SE	P
Right ear length	Male	65	62.63±3.757	0.466	0.002*
	Female	85	60.62±3.251	0.353	
Right ear breadth	Male	65	31.92±2.757	0.342	0.044*
	Female	85	31.00±2.976	0.323	
Right ear length above tragus	Male	65	28.69±3.015	0.374	0.022*
	Female	85	27.52±3.449	0.374	
Right ear length below tragus	Male	65	20.54±3.103	0.385	NS
	Female	85	19.82±3.215	0.349	
Right ear tragus length	Male	65	13.40±2.492	0.309	NS
	Female	85	13.29±2.802	0.304	
Right ear concha length	Male	65	22.42±3.446	0.427	NS
	Female	85	21.61±3.004	0.326	
Right ear concha breadth	Male	65	15.98±2.753	0.341	NS
	Female	85	15.94±2.49	0.27	
Right ear lobule height	Male	65	11.86±3.211	0.398	NS
	Female	85	12.01±2.643	0.287	
Right ear lobule width	Male	65	20.52±2.494	0.309	NS
	Female	85	19.72±2.885	0.313	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS=Not significant

Table 6: Descriptive data of study population and comparison of mean left ear measurements among males and females aged 41-50 years

Variable	Sex	n	Mean±SD	SE	P
Left ear length	Male	56	64.38±3.769	0.504	<0.001*
	Female	55	61.04±3.771	0.508	
Left ear breadth	Male	56	33.05±3.343	0.447	0.017*
	Female	55	31.65±2.75	0.371	
Left ear length above tragus	Male	56	30.04±3.045	0.407	0.003*
	Female	55	27.98±3.654	0.493	
Left ear length below tragus	Male	56	21.16±3.622	0.484	NS
	Female	55	20.02±2.871	0.387	
Left ear tragus length	Male	56	13±3.015	0.403	NS
	Female	55	12.8±2.49	0.336	
Left ear concha length	Male	56	22.8±3.6	0.481	NS
	Female	55	21.78±2.955	0.398	
Left ear concha breadth	Male	56	16.16±2.702	0.361	NS
	Female	55	16.53±2.308	0.311	
Left ear lobule height	Male	56	11.98±2.611	0.349	NS
	Female	55	12.49±2.603	0.351	
Left ear lobule width	Male	56	20.71±3.001	0.401	NS
	Female	55	20.13±3.025	0.408	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS=Not significant

ear concha breadth, left ear lobule height, right ear lobule height, left ear lobule width and right ear lobule width as compared to females. On the other hand, females had slightly higher values for left ear tragus length and right ear tragus length as compared to the males. The P values for left ear

Table 7: Descriptive data of study population and comparison of mean right ear measurements among males and females aged 41-50 years

Variable	Sex	n	Mean±SD	SE	P
Right ear length	Male	56	64.79±3.581	0.479	<0.001*
	Female	55	60.98±4.025	0.543	
Right ear breadth	Male	56	32.93±3.241	0.433	0.004*
	Female	55	31.11±2.833	0.382	
Right ear length above tragus	Male	56	30.13±3.009	0.402	0.003*
	Female	55	28.18±3.459	0.466	
Right ear length below tragus	Male	56	21.43±3.577	0.478	0.048*
	Female	55	20.2±2.704	0.365	
Right ear tragus length	Male	56	13.02±2.583	0.345	NS
	Female	55	12.67±2.487	0.335	
Right ear concha length	Male	56	22.34±3.694	0.494	0.021*
	Female	55	21.84±3.096	0.417	
Right ear concha breadth	Male	56	15.82±2.758	0.368	NS
	Female	55	16.33±2.604	0.351	
Right ear lobule height	Male	56	11.98±2.618	0.35	NS
	Female	55	12.35±2.612	0.352	
Right ear lobule width	Male	56	20.84±3.091	0.413	NS
	Female	55	20.02±3.177	0.428	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS=Not significant

Table 8: Descriptive data of study population and comparison of mean left ear measurements among males and females aged 51-64 years

Variable	Sex	n	Mean±SD	SE	P
Left ear length	Male	55	64.96±3.727	0.502	NS
	Female	33	61.97±11.081	1.929	
Left ear breadth	Male	55	32.85±2.683	0.362	NS
	Female	33	31.94±3.84	0.668	
Left ear length above tragus	Male	55	29.27±3.472	0.468	NS
	Female	33	28.94±2.68	0.467	
Left ear length below tragus	Male	55	21.53±2.686	0.362	NS
	Female	33	21.73±4.064	0.707	
Left ear tragus length	Male	55	14.38±2.513	0.339	0.010*
	Female	33	13.21±3.855	0.671	
Left ear concha length	Male	55	23.18±3.05	0.411	NS
	Female	33	21.82±3.225	0.561	
Left ear concha breadth	Male	55	15.78±3.403	0.459	NS
	Female	33	16.09±3.225	0.561	
Left ear lobule height	Male	55	12.69±3.805	0.513	NS
	Female	33	12.7±3.057	0.532	
Left ear lobule width	Male	55	20.58±3.041	0.41	NS
	Female	33	19.76±2.75	0.479	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS=Not significant

length, right ear length, left ear breadth, right ear breadth, left ear length above tragus, right ear length above tragus and left ear lobule width were <0.05 and hence statistically significant. All other variables of the ear between males and females in this age group had a P > 0.05 and hence were not significant

Table 9: Descriptive data of study population and comparison of mean right ear measurements among males and females aged 51-64 years

Variable	Sex	n	Mean±SD	SE	P
Right ear length	Male	55	65.05±3.572	0.482	NS
	Female	33	64.15±4.487	0.781	
Right ear breadth	Male	55	33±2.931	0.395	NS
	Female	33	32.06±3.691	0.642	
Right ear length above tragus	Male	55	29.02±3.514	0.474	NS
	Female	33	28.94±2.692	0.469	
Right ear length below tragus	Male	55	21.82±2.855	0.385	NS
	Female	33	22.21±4.233	0.737	
Right ear tragus length	Male	55	14.38±2.571	0.347	0.012*
	Female	33	13.06±3.622	0.631	
Right ear concha length	Male	55	22.89±3.332	0.449	NS
	Female	33	21.73±3.233	0.563	
Right ear concha breadth	Male	55	15.62±3.2	0.431	NS
	Female	33	16±3.052	0.531	
Right ear lobule height	Male	55	12.6±3.541	0.478	NS
	Female	33	12.52±2.785	0.485	
Right ear lobule width	Male	55	20.6±3.004	0.405	NS
	Female	33	19.33±3.089	0.538	

Mann-Whitney U-test. *Statistically significant. n=Sample size; SD=Standard deviation; SE=Standard error; P=Significance; NS=Not significant

Table 10: Correlation of right and left side measurements of study population aged 18-30 years

Variables	n	r	r ²	P
Left ear length - right ear length	156	0.927	85.90%	<0.001*
Left ear breadth - right ear breadth	156	0.835	69.70%	<0.001*
Left ear length above tragus - right ear length above tragus	156	0.863	74.40%	<0.001*
Left ear length below tragus - right ear length below tragus	156	0.871	75.60%	<0.001*
Left ear tragus length - right ear tragus length	156	0.875	76.50%	<0.001*
Left ear concha length - right ear concha length	156	0.86	73.90%	<0.001*
Left ear concha breadth - right ear concha breadth	156	0.838	70.20%	<0.001*
Left ear lobule height - right ear lobule height	156	0.907	82.20%	<0.001*
Left ear lobule width - right ear lobule width	156	0.887	78.60%	<0.001*

*Statistically Significant. n=Sample size; r=Coefficient of correlation; r²=Strength of correlation; P=Significance; NS=Not significant

[Tables 2 and 3]. The Spearman’s correlation coefficient (r) was calculated and the highest strength of correlation was seen for left ear length–right ear length (r² = 85.9%), while the least was observed for left ear breadth–right ear breadth (r² = 69.7%). The P value for all the correlations

was found to be <0.05, and hence, the correlations were statistically significant [Table 10].

31–40 years age group

Evaluation of 150 participants, 65 males and 85 females (mean age = 35.98 years), was done. It was observed that males had slightly larger dimensions for left ear length, right ear length, left ear breadth, right ear breadth, left ear length above tragus, right ear length above tragus, left ear length below tragus, right ear length below tragus, left ear tragus length, right ear tragus length, left ear concha length, right ear concha length, right ear concha breadth, left ear lobule height, left ear lobule width and right ear lobule width as compared to females. On the other hand, females had slightly higher values for left ear concha breadth and right ear lobule height as compared to the males. The P values for left ear length, right ear length, left ear breadth, right ear breadth, left ear length above tragus, and right ear length above tragus width were <0.05 and hence statistically significant. All other variables of the ear between males and females in this age group had a P > 0.05 and hence were not significant [Tables 4 and 5]. The highest strength of correlation was seen for left ear length–right ear length (r² = 85.0%), while the least was observed for left ear concha breadth–right concha ear breadth (r² = 68.8%). The P value for all the correlations was found to be <0.05, and hence, the correlations were statistically significant [Table 11].

41–50 years age group

Evaluation of 111 participants, 56 males and 55 females (mean age = 45.79 years), was done. It was observed that males had slightly larger dimensions for left ear length, right ear length, left ear breadth, right ear breadth, left ear length above tragus, right ear length above tragus, left ear length below tragus, right ear length below tragus, left ear tragus length, right ear tragus length, left ear concha length, right ear concha length, left ear lobule width and right ear lobule width as compared to females. On the other hand, females had slightly higher values for left ear concha breadth, right ear concha breadth, left ear lobule height and right ear lobule height as compared to the males. The P values for left ear length, right ear length, left ear breadth, right ear breadth, left ear length above tragus, right ear length above tragus width and right ear concha length were <0.05 and hence statistically significant. All other variables of the ear between males and females in this age group had a P > 0.05 and hence were not significant [Tables 6 and 7]. The highest strength of correlation was seen for left ear lobule width–right ear lobule width (r² = 85.7%), while the least was observed for left ear length above tragus–right concha ear length above tragus (r² = 74.1%). The P value for all the correlations was found to be <0.05, and hence, the correlations were statistically significant [Table 12].

51–64 years age group

Evaluation of 88 participants, 55 males and 33 females (mean age = 57.03 years), was done. It was observed that males had slightly larger dimensions for left ear length, right ear length, left ear breadth, right ear breadth, left ear length above

Table 11: Correlation of right and left side measurements of study population aged 31-40 years

Variables	n	r	r ²	P
Left ear length - right ear length	150	0.922	85%	<0.001*
Left ear breadth - right ear breadth	150	0.851	72.40%	<0.001*
Left ear length above tragus - right ear length above tragus	150	0.914	83.50%	<0.001*
Left ear length below tragus - right ear length below tragus	150	0.864	74.60%	<0.001*
Left ear tragus length - right ear tragus length	150	0.848	71.90%	<0.001*
Left ear concha length - right ear concha length	150	0.878	77%	<0.001*
Left ear concha breadth - right ear concha breadth	150	0.83	68.80%	<0.001*
Left ear lobule height - right ear lobule height	150	0.913	83.30%	<0.001*
Left ear lobule width - right ear lobule width	150	0.898	80.60%	<0.001*

*Statistically Significant. n=Sample size; r=Coefficient of correlation; r²=Strength of correlation; P=Significance; NS=Not significant

Table 12: Correlation of right and left side measurements of study population aged 41-50 years

Variables	n	r	r ²	P
Left ear length - right ear length	111	0.925	85.50%	<0.001*
Left ear breadth - right ear breadth	111	0.885	78.30%	<0.001*
Left ear length above tragus - right ear length above tragus	111	0.861	74.10%	<0.001*
Left ear length below tragus - right ear length below tragus	111	0.921	84.80%	<0.001*
Left ear tragus length - right ear tragus length	111	0.88	77.44%	<0.001*
Left ear concha length - right ear concha length	111	0.899	80.80%	<0.001*
Left ear concha breadth - right ear concha breadth	111	0.877	76.90%	<0.001*
Left ear lobule height - right ear lobule height	111	0.907	82.20%	<0.001*
Left ear lobule width - right ear lobule width	111	0.926	85.70%	<0.001*

*Statistically Significant. n=Sample size; r=Coefficient of correlation; r²=Strength of correlation; P=Significance; NS=Not significant

tragus, right ear length above tragus, left ear tragus length, right ear tragus length, left ear concha length, right ear concha length, right ear lobule height, left ear lobule width and right ear lobule width as compared to females. On the other hand, females had slightly higher values for left ear length below tragus, right ear length below tragus, left ear concha breadth, right ear concha breadth and left ear lobule height as compared to the males. The P values for left ear tragus length and right ear tragus length were <0.05 and hence statistically significant. All other variables of the ear between males and females in this age group had a P > 0.05 and hence were not significant [Tables 8 and 9]. The highest strength of correlation was seen for left ear lobule height–right ear lobule height (r² = 88.1%), while the least was observed for left ear length below tragus–right concha

ear length below tragus (r² = 67.7%). The P value for all the correlations was found to be <0.05, and hence, the correlations were statistically significant [Table 13].

DISCUSSION

The ear is an extremely important constituent of the human face, functionally as well as esthetically. Every individual wants to have normal-appearing esthetically pleasing ears, and the demand for the same is highest in individuals with congenital or acquired deformities of the ear. Achievement of good functional and esthetic rehabilitation not only boosts one’s self confidence but also translates into better social acceptance. The dimensions of the external ear and its various parts vary in different ethnic groups, and this requires that surgeons base their reconstructions on data specifically gathered from each of the ethnic groups. Thus, the current study attempted to furnish data regarding the external ear for normal individuals of Maharashtra.

During this study, it was observed that the shape, curves and lines of the ears of each person are entirely unique. Various shapes of the ear were observed in our study population, i.e., oval, round, triangular or rectangular and variations of those shapes. The position and size of the intertragal notch also varied from person to person. Another important observation in our study was that lobules may be attached or free. Lobules can also be narrow, wide, pointed, squared, flat, creased, etc.

In the last few years, ear dimensions have been investigated in various ethnic groups, using direct as well as indirect anthropometry and photography.^[3,5,10-16] In spite of the ethnical variations in the actual ear dimensions and position,^[3,5,11,15] all these studies found that the human external ear continues to grow even after skeletal maturity is reached. With increasing age, gradual changes in the microscopic structure of ear cartilage have also been reported, with decrease in the elastic fibers and in the density of cartilage cells.^[10] Purkait and Singh^[3] in their study even mentioned about the age-related decrease in skin elasticity and resilience. These microscopic changes may explain the macroscopic increments in ear dimensions with increasing age.

Irrespective of the ethnicity of the study population, the findings of Purkait and Singh,^[3] Sharma *et al.*,^[5] Ito *et al.*,^[10] Azaria *et al.*,^[11] Brucker *et al.*,^[12] Meijerman *et al.*,^[15] and Bozkir *et al.*^[16] suggest that males have longer and wider ears as compared to females. In our study, males were found to have slightly longer and wider ears as compared to females in all age groups. Thus, gender dimorphism was demonstrated in our study, but the dimensional difference was not statistically significant.

In the present study, we observed that age-related dimensional changes were not identical for all variables: ear length increased faster and for a longer duration as compared to the ear width. This was in agreement with the findings of Purkait and Singh,^[3] Meijerman *et al.*,^[15] Niemitz *et al.*,^[17] and

Table 13: Correlation of right and left side measurements of study population aged 51-64 years

Variables	n	r	r ²	P
Left ear length - right ear length	88	0.914	83.50%	<0.001*
Left ear breadth - right ear breadth	88	0.882	77.70%	<0.001*
Left ear length above tragus - right ear length above tragus	88	0.884	78.10%	<0.001*
Left ear length below tragus - right ear length below tragus	88	0.823	67.70%	<0.001*
Left ear tragus length - right ear tragus length	88	0.909	82.60%	<0.001*
Left ear concha length - right ear concha length	88	0.908	82.40%	<0.001*
Left ear concha breadth - right ear concha breadth	88	0.898	80.60%	<0.001*
Left ear lobule height - right ear lobule height	88	0.939	88.10%	<0.001*
Left ear lobule width - right ear lobule width	88	0.902	81.30%	<0.001*

*Statistically Significant. n=Sample size; r=Coefficient of correlation; r²=Strength of correlation; P=Significance; NS=Not significant

Gualdi-Russo.^[18] Various studies, such as those by Sharma *et al.*,^[5] Ito *et al.*,^[10] Kalcioğlu *et al.*,^[13] and Niemitz *et al.*,^[17] reported that childhood and adolescent growth patterns were faster than those reported after adulthood.

The study conducted by Sforza *et al.*^[9] compiled the sex- and age-related linear and angular dimensions of healthy Italian Caucasians ears. Their results showed progressive increase of ear dimensions with age; ear length increased more than ear width. There was no difference in the angles, ratios, and symmetry indices. As compared to the results obtained in their study, it was seen that for the similar age group, Italian Caucasian men had ear lengths comparable to Indian men, whereas ear length for females and ear breadth for both males and females were on the higher side in the Italian Caucasians.

Ekanem *et al.*^[19] carried out direct measurement of the ear length, lobule length, and lobule width by calipers in a group of 217 adult Nigerians (aged 18–65 years) and the results indicate that the mean total ear height and mean lobular height were higher in the males than in the females while the females had a higher mean lobular width than that in males. The results of our study as compared to that of Ekanem *et al.*^[19] establish that for the similar age, Maharashtrians have higher total ear length, comparable lobule length, and higher lobule width as compared to the Nigerians.

In the study conducted by Shireen and Karadkhelkar,^[20] the mean values of ear length, ear breadth, lobule height and lobule width of right and left ears in the students (18–25 years) of Bidar, Karnataka, were compiled. Their study has established the existence of sexual dimorphism in external ear dimensions and also the differences between the auricular indices of both sides. Their results suggest a correlation between the ear variables. Our study establishes an insignificant gender dimorphism and a significant correlation between the different variables of the right and left side ears. The results obtained in

our study suggest that people in the age group of 18–30 years and of Maharashtrian ethnicity, both men and women, have slightly smaller dimensions for ear length and lobule length but slightly higher values for ear width and lobule width as compared to their counterparts from Karnataka. This implies that within India also, people of different ethnicity have different dimensions of the various ear variables and hence the shape of the ear also varies.

Anthropometric study of the normal human auricle conducted on adult men in Central India by Purkait and Singh^[3] concluded that in comparison with other ethnic groups, Indian males seem to have the smallest auricular and lobular lengths, although their respective widths are comparable with those of others. However, we observed that auricles of Nigerians were smaller in dimension than those of Maharashtrians. Analysis of our data shows that compared to Central Indians, people of Maharashtra had greater ear length but had lesser dimensions for ear breadth, lobule length, lobule width, concha length and concha width. Thus, even within the Indian subcontinent, widespread variations in the dimensions of the auricle exist.

CONCLUSION

Knowledge of the normal auricular dimensions is a prerequisite to be able to diagnose congenital malformations, syndromes, and acquired deformities of the ear. The dimensions of the ear are affected by age and sex. The external ear is not bilaterally symmetrical, but the asymmetry is not statistically significant. The contralateral normal ear serves as reference for otoplastic surgeries. Males have slightly larger external ears as compared to females. The human ear continues to grow even after the attainment of adulthood. The photogrammetric method adopted in the study for measurement of linear ear dimensions has potential in ear morphometry.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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