A Community Based Morphometric Study of Auricle in Both Sexes of Healthy Adult Population of Garhwal Region of Uttarakhand

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Abstract

Background: The auricle serves key functions in hearing, appearance, and individual identification, with its dimensions varying across populations. Auricular measurements have important applications in clinical, anthropological and forensic science. A literature search reveals no studies on auricular parameters in the Garhwal region of Uttarakhand. This study was undertaken to establish normal auricular dimensions in the adult population of this area and to explore ethnic and gender-based variations. **Material and Methods:** A cross-sectional study was conducted in the Garhwal region of Uttarakhand, involving 208 healthy volunteers (119 males and 89 females) in the community setting. Standard instruments were employed to measure various auricular parameters. **Results:** The Present study revealed the length of auricle, concha and lobule to be 62.1±3.8mm, 27.5±1.8mm and 17.7±2.4mm in males and 58.0±3.7mm, 25.2±2.3mm and 17.7±2.4mm in females respectively. Auricle, conchal and lobular width were found to be 33.1±2.8mm, 19.3±2.0mm and 19.5±2.4mm in males and 30.1±2.2mm, 17.9±1.9mm and 18.5±2.0mm in females respectively. **Conclusion:** Normal dimensions of the auricle in adults of the Garhwal region of Uttarakhand were determined. Significant gender variations in all parameters except lobular length and bilateral asymmetry in lobular width were found. This study will provide valuable inputs for forensic, ergonomic and clinical fields, especially in this geographical area.

Keywords: Auricle; Anthropometry; Sexual Dimorphism; Prosthesis; Ergonomics.

INTRODUCTION

The auricle is important for the collection of sound waves for hearing,[1] facial aesthetics,[2] and personal identification.[3,4] Its unique anthropometry, including auricular, conchal and lobular dimensions, has a significant role in medical, ergonomic, forensic and anthropological fields.[3] Morphometry of the auricle is important in surgery for reconstruction, biomechanics for designing prostheses, ergonomics for manufacturing ear accessories, including earphones and ornaments,[5,6] and forensic science for biometric identification.[3] This study has provided normal-region and gender-specific anthropometric data,[4] which will also help clinicians rule out congenital anomalies.[2]

A search across the available literature shows gender- and ethnicity-specific ear dimensions in varied populations around the world, yet the Garhwal region of Uttarakhand has been explored very little in terms of auricular morphology and morphometry. This geographic area is prone to various types of natural and artificial disasters, including earthquakes, landslides, and mining-related accidents. This leads to a large number of facial feature reconstructions by plastic surgeons, underscoring the importance of maintaining normal auricular dimensions specific to this region for both males and females.

In view of the above, this study was conducted in the Garhwal region of Uttarakhand to explore and determine the normal morphometry of the ear specific to the inhabitants of this area.[7,8]

MATERIALS AND METHODS

A cross-sectional observational study,[5] was conducted in the Garhwal region of Uttarakhand. A total of 208 healthy adults, both sexes aged 18 to 40 years, were included in the study.

Sample size was calculated using the formula: $z^2 \times p(1-p)/e^2$. Where z is the z-score (1.96 for a 95% confidence interval), p is the standard deviation of 0.84 (taken from a previous similar study),[9] and e is the margin of error (taken as 0.05). So, the sample size was calculated to be 206. Multi-stage sampling,[10] was used. The Garhwal region administratively includes 15

blocks, and, based on the sample size (206), 14 subjects were selected from each block. These subjects (14 from each block) were further grouped into six age groups (each comprising an interval of 4 years), yielding two individuals per age group (1-2 male and 1-2 female). A computer-generated random-number table was used to select participants.

The subjects did not include those with congenital anomalies, auricular deformities, head and neck trauma, surgery in the head and neck region, deformed lobules or more than one piercing. Ethnicity was determined on the basis that two ancestral generations were residing in the specified area of Garhwal, Uttarakhand.

The Institutional Ethics Committee granted permission for this study vide their letter no: MC/IEC/2024/38 dated 01Jul24. Informed, written and witnessed consent in the vernacular of the individual was taken.

Length and width of the auricle, concha and lobule were measured using Vernier callipers as depicted in [Photograph 1].[11] The participants were made to sit in an upright, relaxed position, with their heads in Frankfurt's horizontal plane.[12, 13]

Auricle length [[Figure 1]: distance between superaurale and subaurale.[14]

Auricle width [Figure 1]: distance between preaurale to postaurale.[14]

Conchal length [Figure 2]: distance between concha superior and incisura intertragica inferior.[14]

Conchal width [Figure 2]: distance between incisura anterior auris posterior to the strongest anti-helical curvature.[14]

Lobular length [Figure 3]: distance between subaurale and incisura intertragica inferior.[3]

Lobular width [Figure 3]: distance between the lobule anterior and the lobule posterior.[3]

The data were then analysed statistically using SPSS-19. Mean and Standard deviation were calculated. An independent-samples t-test,[15] was used to determine whether any significant difference exists between the ears and between males and females. p-value<0.05 was considered significant and <0.01 highly significant.

RESULTS

A total of 208 individuals, both sexes, were measured. Means of ear dimensions are illustrated in Tables 1and 2 and plotted on Charts 1A, 1B, 2 and 3.

Fig 1:Auricle length: A1(Superaurale)-A2(Subaurale)
Fig 1:Auricle width: B1(Preaurale)-B2(Postaurale)
Fig 2:Conchal length:C1(Concha superior)-C2(Incisura inter-tragica inferior)
Fig 2:Conchal width:D1(Incisura anterior auris posterior)-D2(Anti-helical curvature)
Fig 3:Lobular length: E1(Incisura inter-tragica inferior)-E2(Subaurale)
Fig 3:Lobular width:F1(Lobule anterior)-F2(Lobule posterior)

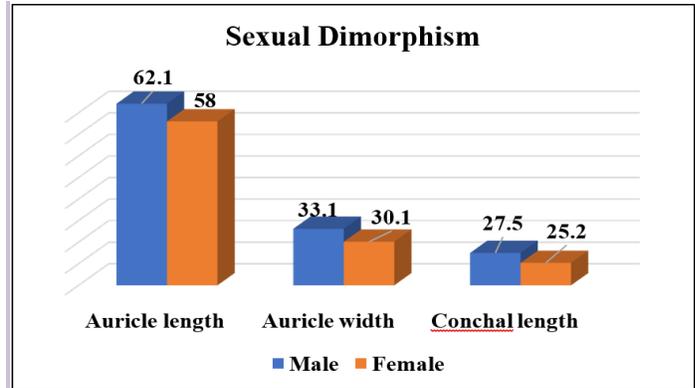**Photograph 1**

Chart 1A: Ear dimensions of male and female.
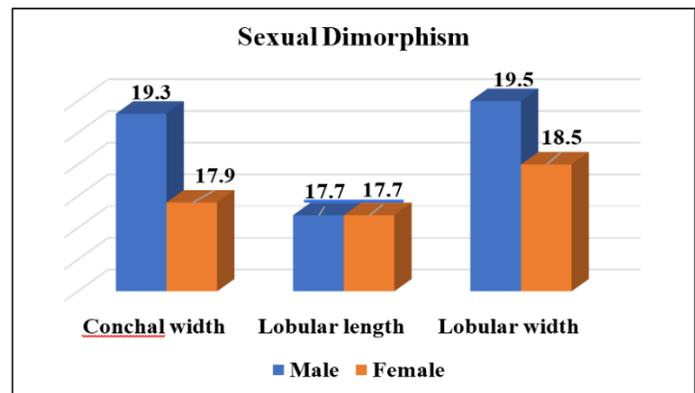
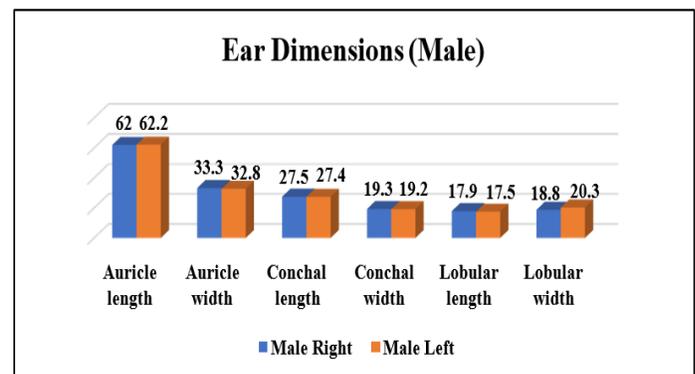

Chart 1B: Ear dimensions of male and female.
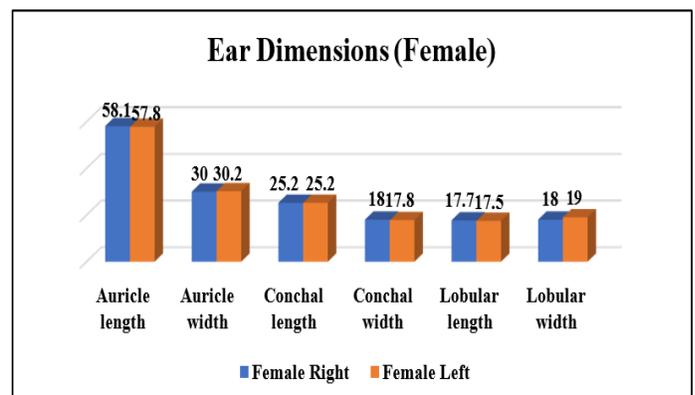

Chart 2: Ear dimensions of both sides for male.

Chart 3: Ear dimensions of both sides for female.

Table 1: Ear dimensions of male and female.

Parameters	Male		Female		p-value
	N	Mean±SD(mm)	N	Mean±SD(mm)	
Auricle length	119	62.1±3.8	89	58.0±3.7	0.000
Auricle width	119	33.1±2.8	89	30.1±2.2	0.000
Conchal length	119	27.5±1.8	89	25.2±2.3	0.000
Conchal width	119	19.3±2.0	89	17.9±1.9	0.000
Lobular length	119	17.7±2.4	89	17.7±2.4	0.876
Lobular width	119	19.5±2.4	89	18.5±2.0	0.001

Table 2: Ear dimensions of both sides for male and female.

Parameters	Male				Female			
	N	Mean±SD(mm)		p-value	N	Mean±SD (mm)		p-value
		Right	Left			Right	Left	
Auricle length	119	62.0±4.0	62.2±3.9	0.662	89	58.1±3.8	57.8±3.7	0.560
Auricle width	119	33.3±2.9	32.8±3.0	0.247	89	30.0±2.3	30.2±2.4	0.538
Conchal length	119	27.5±2.0	27.4±1.9	0.800	89	25.2±2.4	25.2±2.3	0.934
Conchal width	119	19.3±2.4	19.2±2.1	0.671	89	18.0±2.3	17.8±1.9	0.661
Lobular length	119	17.9±2.6	17.5±2.4	0.210	89	17.7±2.4	17.5±2.5	0.534
Lobular width	119	18.8±2.6	20.3±2.7	0.000	89	18.0±2.1	19.0±2.3	0.002

Table 3: Comparison of ear dimensions of various authors.

S No.	Author	Place of study	Male			Female		
			n	Mean±SD (mm)	p-value	n	Mean±SD (mm)	p-value
1.	AgarwalS & MalasiA,[8](2025)	Dehradun	120	60.6±4.8	0.008	120	56.0±5.9	0.005
2.	Hiware SD et al,[3] (2024)	Saudi Arabia	98	60.5±5.4	0.011	102	54.9±4.5	0.000
3.	Kumari A et al,[16] (2022)	North India	100	60.8±3.7	0.011	100	56.6±3.0	0.005
4.	Singh AB et al,[2] (2022)	North India	78	62.9±4.8	0.195	52	59.9±4.0	0.005
5.	Boesoirie SF et al,[5] (2022)	Sudan	47	62.9±4.7	0.256	53	60.9±4.2	0.000
6.	Prasad RJ et al,[17] (2022)	Nepal	110	66.7±4.9	0.000	110	59.5±3.8	0.006
7.	Rani D et al,[12] (2021)	Himachal Pradesh	71	61.2±3.6	0.109	69	57.9±2.8	0.852
8.	Nigam R et al,[9] (2019)	North India	62	62.4±8.4	0.741	58	59.3±5.2	0.079
9.	Japatti SR et al,[18] (2018)	Maharashtra	49	60.7±4.7	0.045	107	58.7±3.9	0.202
10.	Deopa D et al,[7] (2013)	Uttarakhand	93	60.4±3.6	0.001	84	57.4±3.8	0.294
11.	Present study (2025)	Garhwal,Uttarakhand	119	62.1±3.8	-	89	58.0±3.7	-

DISCUSSION

The present study has established normal morphometric data for the auricle in healthy adult males and females from the Garhwal region of Uttarakhand. The results of the present study were compared with those reported by other authors in different population groups and are illustrated in [Table 3].

Significant differences in ear dimensions were found between the present study and those reported by other authors in their studies done in different population groups. These regional and racial variations might be due to the influence of environmental and genetic factors during an individual's growth and development. These results will contribute to the growing body of evidence that auricular morphology exhibits sexual dimorphism and regional variation, signifying the need for population-specific data for clinical, forensic and ergonomic applications. Purkait R and Singh P,[14] in 2007 in their study in Central India found similar ethnic variations in auricular dimensions. The findings also revealed statistically significant differences in ear dimensions between the sexes except for lobular length, which may be due to differences in the constitutional makeup of the two genders. It is consistent with previous studies conducted in other regions of India and globally. Kumari A et al.[16] in 2022 measured the auricular dimensions of the North Indian population and found similar results. These findings also align with those observed by Agarwal S and Malasi A,[8] in their study in Dehradun in 2025.

Across all measured parameters, length of auricle, concha and width of auricle, concha and lobule, males consistently exhibited larger dimensions than females. This observation aligns with the findings of Deopa D et al.[7] in their 2013 study of medical students in Uttarakhand, they also reported significantly greater auricular measurements in males. Similarly, Padmawar GB et al.[19] in 2025 documented sex-based differences in auricular dimensions in a study conducted in Mumbai, noting that males had larger values than females. These differences might be attributed to hormonal influences on craniofacial growth and the general trend of larger body proportions in males.

This study did not find a statistically significant difference in lobular length between the sexes, consistent with findings by Kumari A et al.[16] in their 2022 study on the North Indian population. The bilateral symmetry of auricular dimensions was also examined. All parameters showed no statistically significant bilateral variation, except lobular width. It showed bilateral asymmetry in both genders and was statistically significant. It could also have genetic and developmental basis. This finding is consistent with the study of Agarwal S and Malasi A,[8] on medical students in Dehradun in 2025. However, the results obtained by Singhal J et al,[20] stand in contrast to the current findings, which found lobular width to be more on the right side in males and no difference in lobular width in females. Such asymmetry, though not clinically significant in most cases, may have implications in reconstructive surgeries and prosthetic

design, where precision is of paramount importance.

The clinical relevance of ear morphometry is multifaceted. In plastic and reconstructive surgery, accurate measurements are essential for procedures such as otoplasty, auricular reconstruction following trauma or congenital anomalies and prosthetic fitting. Knowledge of normal data will aid surgeons in achieving facial symmetry and aesthetic harmony. From an anthropological perspective, auricular morphology reflects genetic, environmental and cultural influences. The Garhwal region, with its unique Himalayan geography and relatively homogenous population, offers a distinct anthropometric profile. Padmawar GB et al,[19] emphasised the need for regional studies to capture ethnic diversity in cranio-facial features. The current study also contributes to this endeavour by providing baseline data for this region. In biomedical engineering, auricular measurements modulate the design of hearing aids, earphones and auricular prosthetics. Boesoirie SF et al.[5] In their 2022 study on the Sundanese ethnic group, using the Photogrammetric method, they highlighted the importance of conchal and lobular dimensions in optimising device fit and comfort. The data from this study can guide engineers in tailoring products for the Garhwali demographic, enhancing user experience and device efficacy.

One of the strengths of this study lies in its community-based approach, which ensures representation from a broader cross-section of the population. This enhances the generalizability of the findings and provides a more accurate reflection of the auricular morphology of this region. However, certain limitations must be acknowledged: the study design precludes analysis of age-related changes, and it was focused on a single ethnic group.

CONCLUSION

This community-based study provides normative data on ear dimensions for both sexes in the adult population of the Garhwal region. The results showed statistically significant differences in various parameters of both sexes, except lobular length. No significant difference was found between the ear parameters of both sides, except for lobular width. This might be due to region- and gender-specific genetic makeup. These findings have practical utility in reconstructive surgeries and are of great importance for this hilly terrain, which frequently encounters disasters resulting in mass casualties. It will also help in the field of ergonomics, forensic, anthropology and cosmetic surgery. By establishing a region-specific database, this study will contribute significantly to the anatomical database and demonstrate the importance of community-based, region-specific anthropometric researches.

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Conflicts of interest

There are no conflicts of interest.

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