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Morphometric Analysis of External Ear Parameters Among Medical Students in Himachal Pradesh, India

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Abstract

Introduction: In humans, ear is the most defining feature of the face and its structures shows the signs of age and sex. The human ear is unique and auricular biometrics has been adopted as reliable aid in personal identification in forensic sciences and has important applications in clinical anatomy and reconstructive surgery. Population-specific anthropometric data are essential for establishing normative reference values and understanding regional variations in auricular morphology.

Aim: This study aimed to determining the mean values of the different morphometric measurements from the right and left ears among undergraduate medical students of Himachal Pradesh and to assess bilateral variations in auricular dimensions.

Materials and Methods: The present study was conducted among 120 undergraduate medical students of Shri Lal Bahadur Shastri Government Medical College, Mandi, Himachal Pradesh of age group 18-25 years. Morphometric measurements of both ears were obtained using a digital vernier caliper. Parameters measured included ear height, ear width, lobular height, lobular width, and tragus length. Ear Index and Lobule Index were calculated using standard anthropometric formulae.

Results: The mean left ear height, ear width, lobular height, lobular width, and tragus length were 60.63 ± 5.76 mm, 31.92 ± 4.46 mm, 22.09 ± 3.90 mm, 18.83 ± 3.42 mm, and 17.58 ± 2.17 mm, respectively. The corresponding right ear measurements were 60.75 ± 5.65 mm, 32.15 ± 4.49 mm, 22.05 ± 4.39 mm, 18.44 ± 3.69 mm, and 17.36 ± 2.48 mm. The Ear Index was 52.65 for

the left ear and 52.92 for the right ear, while the Lobule Index was 85.25 and 83.63respectively.

Conclusion: Comparison of bilateral measurements showed only minor differences between the right and left ears. The right ear demonstrated slightly greater mean ear height and ear width, whereas the left ear exhibited marginally higher lobular width and tragus length measurements.

Keywords: External ear, Auricle, Ear index, Lobule index, Sexual dimorphism, Medical students, Himachal Pradesh.

Introduction

The external ear (auricle or pinna) is an important anatomical structure that contributes to hearing, sound localization, and facial aesthetics. Its size, shape, position, and projection vary considerably among individuals and are influenced by factors such as age, sex, ethnicity, and genetic background. The external ear consists of the auricle and the external acoustic meatus, with the auricle functioning to collect and direct sound waves toward the tympanic membrane.[1]

Morphometric assessment of the external ear has important applications in clinical anatomy, anthropology, forensic science, plastic and reconstructive surgery. Auricular measurements provide valuable information for the evaluation of normal anatomical variations, congenital anomalies, traumatic deformities, and acquired defects of the external ear.[2] In addition, the unique morphology of the auricle makes it useful in personal identification and forensic investigations.[3]

Several studies have demonstrated that auricular dimensions vary according to age, sex, ethnicity, and population background. Age-related enlargement of the auricle and significant sexual dimorphism have been reported, with males generally exhibiting larger ear dimensions than females.[4]

Furthermore, anthropometric studies have highlighted the forensic significance of auricular measurements in personal identification and sex estimation. Morphometric investigations have also documented bilateral asymmetry and population-specific variations in ear dimensions, emphasizing the influence of genetic, geographic, and environmental factors on auricular morphology. These findings underscore the need for establishing regional normative data for different populations. [5]

Despite the growing body of literature on auricular anthropometry, data regarding the morphometric characteristics of the external ear among young adults from Himachal Pradesh remain limited. Therefore, the present study was undertaken to evaluate the morphometric and morphological characteristics of the external ear and to establish baseline anthropometric data for this population. Such data may be useful in clinical practice, reconstructive and aesthetic surgery, forensic identification, anthropological research, and the design of ear-related medical and ergonomic devices.

Aim: To evaluate the morphometric parameters of the external ear among medical students of Himachal Pradesh and to assess bilateral variations in auricular dimensions.

Objectives:

1. To measure ear height, ear width, lobular height, lobular width, and tragus length of both ears.
2. To calculate the Ear Index and Lobule Index.
3. To compare morphometric measurements between the right and left ears.
4. To establish baseline anthropometric data for young adults of Himachal Pradesh.

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Materials and Methods: A cross-sectional observational study was conducted among undergraduate medical students of Shri Lal Bahadur Shastri Government Medical College (SLBSGMC), Mandi at Nerchowk, Himachal Pradesh, India. The study was undertaken to evaluate the morphometric characteristics of the external ear and to establish baseline anthropometric data for the study population.

Study Population: The study included apparently healthy undergraduate medical students who voluntarily participated in the study. Both male and female students were enrolled after obtaining informed consent.

Inclusion Criteria: Undergraduate medical students of SLBS Government Medical College, Mandi and participants willing to provide informed consent.

Exclusion Criteria: History of congenital ear deformities and previous surgery involving the external ear. Trauma or burns and acquired deformities affecting the auricle.

Data Collection: Demographic details including age, sex, and state of domicile were recorded using a predesigned proforma. Morphometric measurements of both the right and left external ears were obtained with the participant in a relaxed sitting position and the head maintained in the Frankfurt horizontal plane.

Instrument Used: All measurements were recorded using a Digital Vernier Caliper. Each measurement was taken carefully using standard anthropometric landmarks to minimize observer error.

Morphometric Parameters Measured

The following parameters were recorded bilaterally:

1. Ear Height (EH): Distance between Supraurale (H) and Subaurale (L).
2. Ear Width (EW): Distance between Preaurale (A) and Postaurale (P).
3. Lobular Height (LH): Distance between Tragion (T) and Subaurale (L).
4. Lobular Width (LW): Maximum transverse width of the ear lobule.
5. Tragus Length (TL): Maximum vertical length of the tragus.

Anthropometric Landmarks

The measurements were obtained using the following standard landmarks (Figure-1)

- Preaurale (A): Most anterior point of the auricle.
- Postaurale (P): Most posterior point of the auricle.
- Supraurale (H): Most superior point of the helix.
- Subaurale (L): Most inferior point of the ear lobule.
- Tragion (T): Point located at the upper margin of the tragus at the intertragic notch.
- Anterior Lobular Point (C): Most anterior point of maximum lobular width.
- Posterior Lobular Point (D): Most posterior point of maximum lobular width.

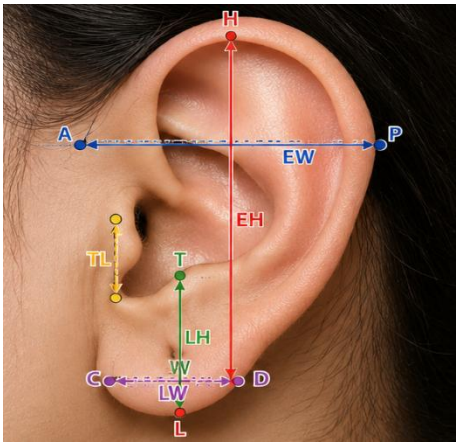


Figure 1: Anthropometric Landmarks

The following indices were calculated:

Ear Index (EI)

$$EI = \frac{\text{Ear Width}}{\text{Ear Height}} \times 100$$

Lobule Index (LI)

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$$LI = \frac{\text{Lobular Width}}{\text{Lobular Height}} \times 100$$

Both indices were calculated separately for the right and left ears.

Ethical Considerations: -The study was conducted after obtaining approval from the Institutional Ethics Committee of Shri Lal Bahadur Shastri Government Medical College, Mandi. Written informed consent was obtained from all participants prior to data collection, and confidentiality of participant information was maintained throughout the study.

Results

A total of 120 undergraduate medical students participated in the study. The mean age of the participants was 20.27 ± 1.26 years, with an age range of 18–23 years. Of the total participants, 62 were males and 58 were females (Table 1).

Table 1: Demographic Characteristics of Study Participants (N = 120)

Variable	Value
Male	62
Female	58
Total Participants	120
Age Range (Years)	18–23

The mean left ear height, ear width, lobular height, lobular width, and tragus length were 60.63 ± 5.76 mm, 31.92 ± 4.46 mm, 22.09 ± 3.90 mm, 18.83 ± 3.42 mm, and 17.58 ± 2.17 mm, respectively (Table-2).

The corresponding mean values for the right ear were 60.75 ± 5.65 mm for ear height, 32.15 ± 4.49 mm for ear width, 22.05 ± 4.39 mm for lobular height, 18.44 ± 3.69 mm for lobular width, and 17.36 ± 2.48 mm for tragus length (Table-2).

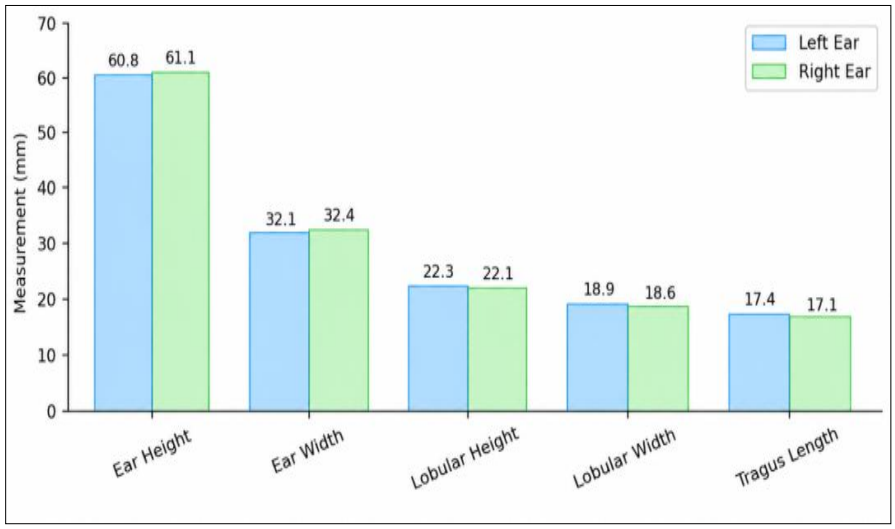
Table 2: Bilateral Comparison of External Ear Measurements

Parameter	Left Ear (Mean ± SD)	Right Ear (Mean ± SD)
Ear Height (mm)	60.63 ± 5.76	60.75 ± 5.65
Ear Width (mm)	31.92 ± 4.46	32.15 ± 4.49
Lobular Height (mm)	22.09 ± 3.90	22.05 ± 4.39
Lobular Width (mm)	18.83 ± 3.42	18.44 ± 3.69
Tragus Length (mm)	17.58 ± 2.17	17.36 ± 2.48

Comparison of bilateral measurements showed only minor differences between the right and left ears. The right ear demonstrated slightly greater mean ear height and ear width, whereas the left ear exhibited marginally higher lobular width and tragus length measurements (Figure -2).

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Figure 2: Bilateral Comparison of External Ear Measurements



Auricular Indices

The Ear Index (EI) and Lobule Index (LI) were calculated separately for both ears using standard anthropometric formulae:

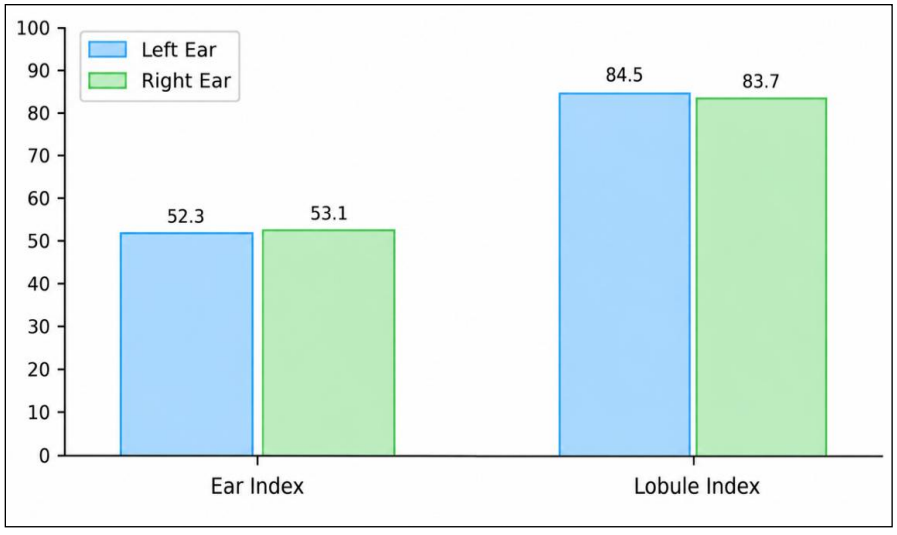
- Ear Index (EI) = Ear Width / Ear Height × 100
- Lobule Index (LI) = Lobular Width / Lobular Height × 100

The calculated Ear Index was 52.65 for the left ear and 52.92 for the right ear. Similarly, the Lobule Index was 85.25 for the left ear and 83.63 for the right ear. These findings indicate comparable auricular proportions on both sides (Table 3) (Figue-3).

Table 3: Ear and Lobule Indices

Parameter	Left Ear	Right Ear
Ear Index	52.65	52.92
Lobule Index	85.25	83.63

Figure 3: Ear Index and Lobule Index



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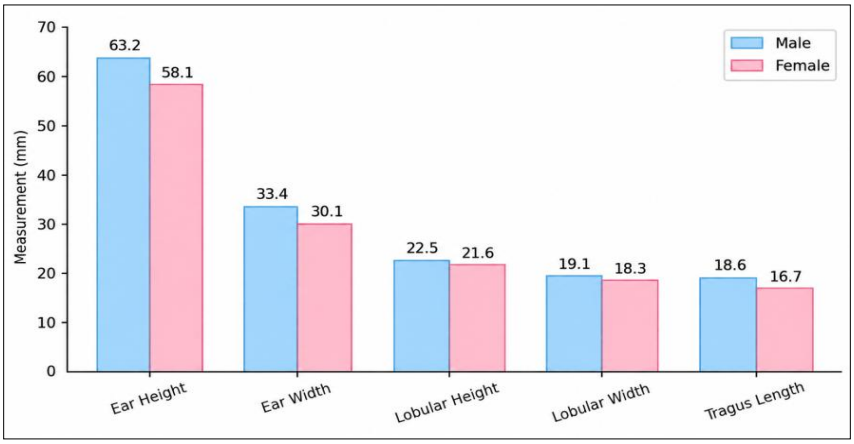
Sex-wise Comparison of Auricular Measurements

Sex-wise comparison demonstrated that males had larger auricular dimensions than females for all measured parameters. Mean ear height was 63.09 mm in males compared to 57.99 mm in females, while mean ear width measured 33.45 mm in males and 30.27 mm in females. Similarly, lobular height, lobular width, and tragus length were greater among males than females (Table 4) (Figure- 4).

Table 4: Sex-wise Comparison of Left Ear Morphometric Parameters.

Parameter	Male (n=59) Mean (mm)	Female (n=55) Mean (mm)
Ear Height	63.09	57.99
Ear Width	33.45	30.27
Lobular Height	22.50	21.64
Lobular Width	19.23	18.41
Tragus Length	18.66	16.42

Figure 4: Sex-wise Comparison of Auricular Measurements (Male vs Female)



Correlation between Ear Height and Ear Width

Scatter plot analysis demonstrated a significant positive correlation between ear height and ear width on both sides. Linear regression analysis revealed that ear width increased proportionately with increasing ear height.

For the left ear, the regression equation was:

$EW = -1.447 + 0.550 \times EH$ with a correlation coefficient of $r = 0.712$, coefficient of determination $R^2 = 0.506$, and $p < 0.001$.

For the right ear, the regression equation was:

$EW = -3.129 + 0.581 \times EH$ with a correlation coefficient of $r = 0.731$, coefficient of determination $R^2 = 0.535$, and $p < 0.001$.

Males showed higher values than females.

Table 5:

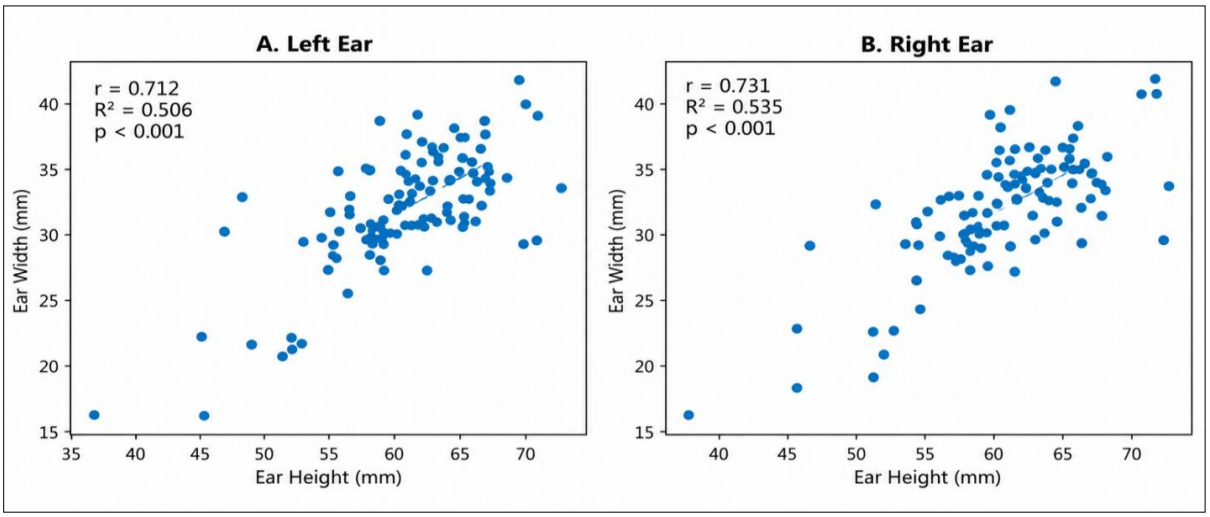
Parameter	Male	Female	p-value
Ear Height	63.09	57.99	<0.001

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Ear Width	33.45	30.27	<0.001

These findings indicate a strong positive relationship between ear height and ear width, suggesting that individuals with greater ear height tend to have proportionately wider ears (Figure- 5).

Figure 5 (A & B panels): Ear Height vs Ear Width with Regression Analysis



Scatter plots demonstrating the relationship between ear height and ear width in the study population. (A) Left ear and (B) right ear. A significant positive correlation was observed between ear height and ear width on both sides. Linear regression analysis showed that ear width increased proportionately with increasing ear height. The regression equations were EW = −1.447 + 0.550 × EH for the left ear ($r = 0.712$, $R^2 = 0.506$, $p < 0.001$) and EW = −3.129 + 0.581 × EH for the right ear ($r = 0.731$, $R^2 = 0.535$, $p < 0.001$)

Discussion

The present study evaluated the morphometric characteristics of the external ear among undergraduate medical students of Himachal Pradesh. Anthropometric assessment of the auricle is important in clinical anatomy, forensic identification, plastic and reconstructive surgery, and the design of hearing aids and auricular prostheses. Establishing population-specific normative data is therefore of considerable scientific and clinical relevance. [6]

In the present study, the mean ear height and ear width were comparable between the right and left sides, indicating a high degree of bilateral symmetry. The observed auricular dimensions fall within the range reported in previous anthropometric studies conducted in Indian and other populations. Similar observations have been reported by Deopa et al., Purkait and Singh, and Bozkir et al., who documented relatively symmetrical auricular measurements in healthy adults.

Variations in ear dimensions among different populations may be attributed to genetic, ethnic, environmental, and nutritional factors.

Lobular height and lobular width are important parameters in reconstructive and cosmetic procedures involving the ear. In the present study, the lobular measurements demonstrated only minor differences between the two sides. These findings suggest that the earlobe maintains relatively consistent proportions bilaterally in healthy young adults. Comparable observations have been reported by Alexander et al. and

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Sforza et al., who noted relatively stable lobular proportions in normal populations.[7]

The Ear Index and Lobule Index provide an assessment of the proportional relationship between auricular dimensions. The calculated indices in the present study demonstrated comparable values for the right and left ears, further supporting the presence of overall bilateral symmetry in auricular morphology. Similar use of auricular indices has been reported in anthropometric studies to facilitate comparisons between different populations and ethnic groups. [8-9] Such indices may be useful in anthropometric comparisons across populations and in planning reconstructive procedures.

The present study contributes baseline anthropometric data for young adults of Himachal Pradesh, a population for which limited auricular morphometric data are available. These measurements may serve as reference values for anatomists, forensic experts, plastic surgeons, and otorhinolaryngologists. Similar studies from Uttarakhand, North India, and other populations have emphasized the importance of regional anthropometric databases for clinical and forensic applications. [10-11]

An important finding of the present study was the significant positive correlation between ear height and ear width on both sides. Pearson's correlation analysis demonstrated a strong positive association between these parameters in the left ear ($r = 0.712$, $p < 0.001$) and right ear ($r = 0.731$, $p < 0.001$). Regression analysis further indicated that ear width increased proportionately with increasing ear height, suggesting that ear height is a useful predictor of ear width. Similar relationships between auricular dimensions have been reported in previous anthropometric studies, indicating coordinated growth patterns of the external ear. Such correlations may be valuable in reconstructive surgery, forensic facial approximation, and the design of auricular prostheses, where estimation of one parameter from another may be required. [12]

Conclusion

The present study provides baseline morphometric data on the external ear among undergraduate medical students of Himachal Pradesh. Auricular measurements demonstrated a high degree of bilateral symmetry, while males exhibited larger dimensions than females, indicating sexual dimorphism. A significant positive correlation was observed between ear height and ear width on both sides, suggesting that ear height may serve as a useful predictor of ear width in anthropometric, forensic, and reconstructive applications.

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