

# A Study of Auricle Morphology for Identification in Indians.

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## ABSTRACT

**Background:** External ear is a significant feature for human face identification. Its size, shape and spatial location on human face are vital from aesthetic point of view. The knowledge of morphometry of normal human auricle and its symmetry is also required for the surgical resection. Aim: The aim of the current study was to estimate the morphometry of external ear and its anatomical landmarks with respect of identification. **Methods:** In the current, morphometric, cross sectional study was done on 400 Indian students (males = 200 and females = 200) of Teerthanker Mahaveer Medical College and Research Centre. The parameters was analysed by using camera and adobe Photoshop software (version 7.0). The data was statistically analyzed by using student's t test.  $p < 0.05$  was considered statistically significant. **Results:** In our cohort, all parameters were higher in males except left lobular width, which was higher in females. The mean observation of the right and left ear length of males were  $4.61 \pm 0.41$  cm,  $4.54 \pm 0.44$  cm respectively, while in females were  $3.68 \pm 0.42$  cm,  $3.67 \pm 0.54$  cm respectively. The mean value of the right and left ear width of males were  $3.17 \pm 0.37$  cm,  $3.03 \pm 0.47$  cm respectively, and while in females  $2.57 \pm 0.32$  cm,  $2.55 \pm 0.41$  cm respectively. The mean value of the left right and left lobular length of males were  $1.56 \pm 0.12$  cm,  $1.50 \pm 0.19$  cm and in females were  $1.09 \pm 0.13$  cm,  $1.08 \pm 0.13$  cm respectively. The mean values of the right and left lobular width of males were  $1.58 \pm 0.26$  cm,  $1.51 \pm 0.37$  cm and in females were  $1.53 \pm 0.35$  cm,  $1.53 \pm 0.35$  cm respectively. Free lobule = 88.5% and the attach lobule = 11.5% respectively. **Conclusion:** This study makes possible the identification of an individual such as race, sex and age whose identity is unknown. Medico legally it is considerable parameter for forensic investigation to optimize the crime.

**Keywords:** External Ear, Identification, Morphometry.

## INTRODUCTION

"Earology" was first described by Johann Casper Lavater and it was used by the various individuals such as Haken Jorgensen, who established a system of recording which is the morphology of the ear using ear dimensions and ear moulds from criminals in Denmark at the turn of the last century.<sup>[1]</sup>

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Study of the ear is known as Earology it is also known as Otomorphology, is the study of physiognomy of the external ear like as finger prints which are different from person to person. The human external ear or pinna is the most distinctive feature of the face. The structure of ear

is a sign to determine the age and sex. Most of the authors believe that even after completion of development of external ear, it increases in their size.<sup>[2-4]</sup> The lobe of the ear is deliberately an imperative feature of beauty in several other societies.<sup>[5]</sup>

"Identification" is a psychological procedure by which an individual integrate an aspect, emotions, or quality of the other and is transformed partially or completely and it is done by means of a sequence of identifications that the personality is indicated and constituted.<sup>[6]</sup>

### Pinna or Auricle

Auricle looks like a trumpet which is attached to the side of the skull and is directed downward forward and laterally as if one is trying to catch sound from the ground directly.

It is made up of a single sheet of yellow elastic fibro-cartilage bearing numerous undulations. Outermost rim of the auricle is known as Helix and ends in a crus with a concavity. Sometime it bears a

tubercle known as *DARWIN'S TUBERCLE*. Initially it was called as *AURICULAR TUBERCLE*. Just in front and parallel to it lies Anti helix, which bifurcates like 'Y' shape with a concavity known as Fossa Triangularis. In between helix and anti helix lies Scaphoid fossa. Crus leads into a big depression known as concha (Well of the ear). In the floor of the well lies the opening of External Acoustic Meatus, which is guarded anteriorly by conical projection known as Tragus. Tragus is separated from another bulge known as Antitragus, which lies in a notch/incisura. However lower part of pinna is devoid of cartilage and is made up of a fibro fatty tissue known as Lobule. Cartilage is firmly fused to the overlying skin.

**Embryological Facts**

Developmentally the external ear is developed with the appearance of six tissue elevations, the auricular hillocks, which is formed around the margins of the posterior part of the first branchial cleft. Out of the six, three are on the caudal edge of

the first arch and three on the cranial edge of the second arch. The most ventral hillock on the first pharyngeal arch, which subsequently forms the tragus, can be identified. The lobule is the last part to develop. The contribution of the first pharyngeal arch which is made for the auricle is greatest at the end of second month of pregnancy, after that the contribution becomes relatively reduced as growth continues, until eventually the area of skin supplied by the mandibular nerve extends little above the tragus.<sup>[7]</sup>

**Types of Ear**

- **Round**
- **Square**
- **Diamond**
- **Crescent**
- **Rectangular**
- **Reverse triangular**
- **Triangular**[Figure:-1]

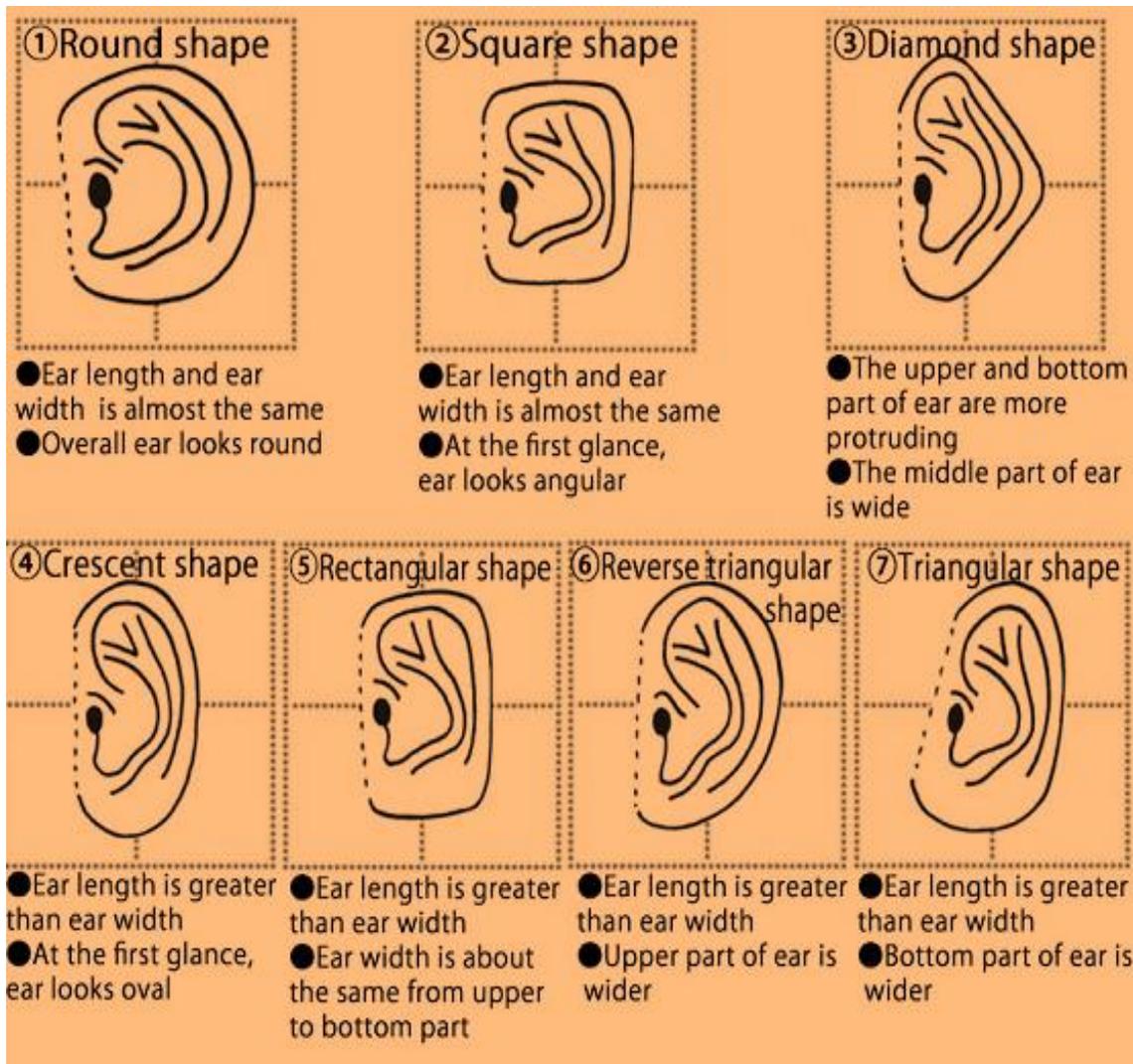


Figure 1: Photograph Showing the Different Types of the Ear.

### Ear Lobule

The human earlobe is composed of adipose connective tissues and tough areolar tissues deficient the elasticity and the firmness of the rest of the auricle.

There are two types of ear lobes:-**a)** Free type ear lobe, **b)** Attach ear lobe.<sup>[8]</sup>

*Altmann* proposed that the pattern of free lobule is dominant while the attached lobule signifies the recessive trait.<sup>[9-10]</sup> Some other authors also say that normal population have free earlobes.<sup>[11]</sup>

Auricle can be used efficaciously for the identification of disaster victims.<sup>[12]</sup> In India, *Veerappan* was identified by the use of morphology of ear to confirm their identity. *Veerappan* was the sandal wood smuggler who was killed by Special Task Force in 2004. He was identified by numerous morphological landscapes of his external ear, with a flat tragus being attached with the curved portion of the helix and squarish lobule which was enlarge.<sup>[13]</sup>

The dimensions of the external ear are capable for different purposes like:-

**Medico-legal importance:-** Ear parameters like lobule that is influenced by the age dependent changes on individual Identification through ear prints or through photographs is of significance in forensic medicine and criminology.

**Prosthesis:-** Because of the congenital malformation of the auricle is very common like microtia so the ear transplantation is done by plastic surgeon. Knowledge of the ear morphology provides guidelines to rectify the ear deformity.

**Beautification:-** Human auricle is also imperative ornamental tool for the different societies, tribes, races etc. mostly females decorated their ear with different types of auricular ornaments.

**Recognition:-** Measurements are required to compare the pinna or auricle from different racial background, growth assessment and development of an individual.

**Hearing aids:-** Protrusion of an ear is helpful for designing of hearing aids instruments like ear microphone.

## MATERIALS AND METHODS

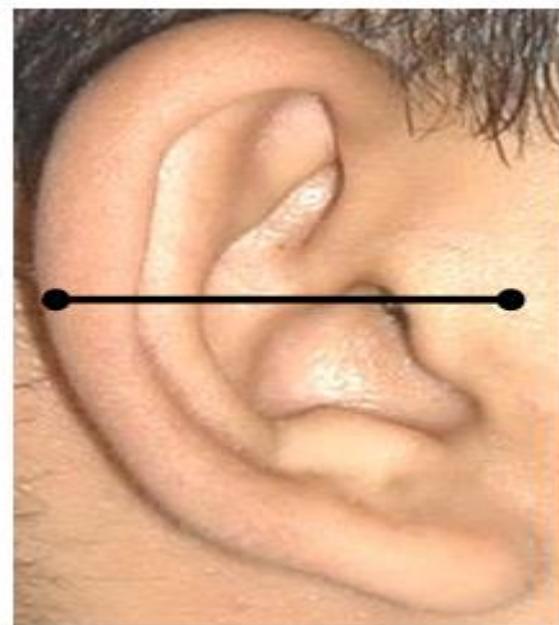
This is the cross-sectional study composed of external ear with their advantages like personal identification. The subjects included in this study were the students of age 18-25 years from Teerthanker Mahaveer Medical College and Research Centre. Among Indian population about

400 healthy subjects with normal ear were selected in this study.

The present study included the following parameters for the measurements of the external ear:



**Figure 2: Total length of ear:** Measurement of the distance between the most superior point of the ear or pinna and the most inferior point of the earlobe.



**Figure 3: Total width of ear:** Measurement of the distance between the most anterior point and the most posterior point of the pinna.

### Material Required In the Study:-

**Camera:-** Unique digital signal processing skill, the Mega Pixel Engine facilitates great resolution system.

**Adobe Photoshop software (version 7.0):-** The Adobe Photoshop is software which is used to

enhance the contrast, brightness, size and produce a clear image for the measurements



**Figure 4: Total lobular length:** Measurement of the distance between the intertragic notch and the most inferior point of the ear lobule.



**Figure 5: Total lobular width:** Measurement of the distance between the most anterior point and the most posterior point of the ear lobule.

**Inclusion Criteria:-**

- a) Healthy individuals within the age group of 18-25 years.
- b) North Indian subjects were included.
- c) Interested individuals were only included in this study.

**Exclusion Criteria:-**Individuals whose normal ear morphology was altered by trauma, accidents or surgery or since birth were excluded from this study.

**Protocol of the Procedure:-**

Lateral surface of Auricle was photographed using the following protocols:-

- The subjects were asked to sit comfortably on a chair and aligned the camera lens and photographer.
- To pass a mid-vertical grid line which is aligned by camera, the mid sagittal plane of face was used, while the Frankfurt horizontal plane was used to pass mid horizontal grid line aligned by the camera.
- After fulfilling all the criteria, ear features were then apprehended by means of digital camera and maintained the distance approximately 90cm between the lens and the subject.
- Digital images were taken and transferred to a computer and the images were analyzed with Adobe Photoshop software (version 7.0).
- First off all the various soft tissue landmarks were tagged on the subject's ear photo and then all above mentioned parameters were measured.

**Statistical Analysis:-**

For the purpose of analysis of the study, the data obtained was subjected to statistical analysis by using t- test (independent sample t-test) for the comparison of measurements taken from right and left ears between both sexes. Mean and standard deviation was calculated for all the parameters.  $p < 0.05$  was considered statistically significant.

**Mean:-** Sum of all the observed value/number of observation.

$$X = \Sigma X / N$$

**Standard Deviation:-**Standard deviation of a randomly selected variable, data set, statistical population or probability distribution is the square root of its variable.

$$S = \sqrt{\frac{\Sigma (X - \bar{X})^2}{N}}$$

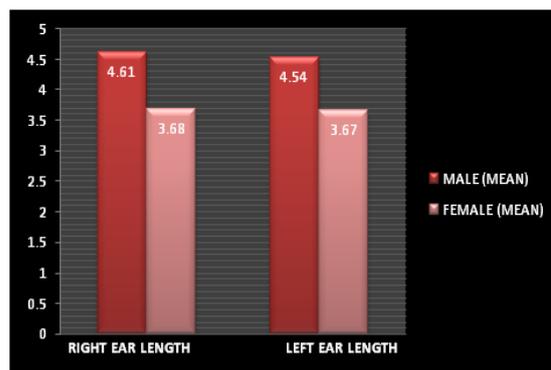
**RESULTS**

The present study provides valuable data pertaining to the ear morphology and their different parameters in North Indian Population. There are 400 subjects (males and females) in our cohort for present study.

**Table 1:** Comparison of Left-Right Ear Length in Both Genders

Measurements	Male Mean±SD	Female Mean±SD	t-value	p-value
Right	4.61±0.41	3.68±0.42	15.91	<0.05*
Left	4.54±0.44	3.67±0.54	12.55	<0.05*

In the [Table 1] first quadrant shows that the mean and standard deviation of the right and left ear length of males are 4.61±0.41 cm, 4.54±0.44 cm respectively. Second quadrant shows that the mean and standard deviation of the right and left ear length of females are 3.68±0.42 cm, 3.67±0.54 cm respectively. Third quadrant shows that the t-value of right and left ear length in both the sexes are 15.91 cm, 12.55 cm and the fourth quadrant revealed that the p-value in both the sexes (p-value for right ear length = <0.05 which is statistically significant and p-value for left ear length = <0.05 which is also statistically significant).

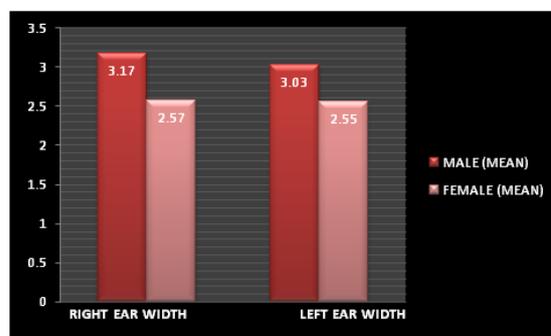


**Figure 6:** Bar Diagram Showing Comparison of Left-Right Ear Length in Both Gender.

**Table 2:** Comparison of Left-Right Ear Width In Both Gender

Measurements	Male Mean±SD	Female Mean±SD	t-value	p-value
Right	3.17±0.37	2.57±0.32	12.17	<0.05*
Left	3.03±0.47	2.55±0.41	7.59	<0.05*

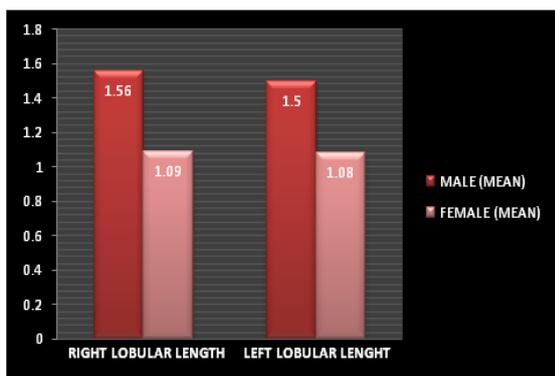
In the [Table 2] First quadrant showing that the mean and standard deviation of the right and left ear width of males are 3.17±0.37 cm, 3.03± 0.47 cm respectively. Second quadrant revealed that the mean and standard deviation of the right and left ear width of females are 2.57 ± 0.32 cm, 2.55± 0.41 cm respectively. Third quadrant showing that the t-value of right and left ear width in both genders are 12.17 cm, 7.59 cm respectively. Fourth quadrant showing the p- value of the left and right ear width in both the genders (p-value of right ear = <0.05 which is statistically significant and p-value of left ear = <0.05 which is statistically significant).



**Figure 7:** Bar Diagram Showing Comparison of Left-Right Ear Width in Both Gender.

**Table 3:** Comparison of Left-Right Lobular Length in Both Gender

Measurements	Male Mean±SD	Female Mean±SD	t-value	p-value
Right	1.56±0.12	1.09±0.13	26.94	<0.05*
Left	1.50±0.19	1.08±0.13	18.33	<0.05*



**Figure 8:** Bar Diagram Showing Comparison of Left-Right Lobular Length In Both Gender.

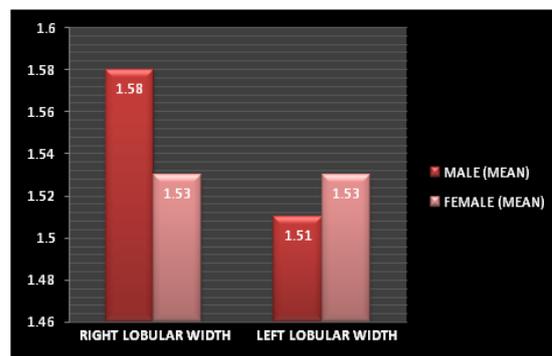
In the [Table 3] First quadrant showing that the mean and standard deviation of the right and left lobular length of males are 1.56± 0.12 cm, 1.50± 0.19 cm respectively. Second quadrant revealed that the mean and standard deviation of the right and left lobular length of females are 1.09± 0.13 cm, 1.08± 0.13 cm respectively. Third quadrant showing that the t-value of right and left lobular length in both genders are 26.94 cm, 18.33 cm. Fourth quadrant showing the p- value of the left and right lobular length in both the genders (p-value of right ear lobular length = <0.05 which is statistically significant and p-value of left ear

lobular length = <0.05 which is also statistically significant).

**Table 4:** Comparison of Left-Right Lobular Width in Both Gender

Measurements	Male Mean±SD	Female Mean±SD	t-value	p-value
Right	1.58±0.26	1.53±0.35	1.24	0.22
Left	1.51±0.37	1.53±0.35	0.97	0.74

In the [Table 4] First quadrant showing that the mean and standard deviation of the right and left lobular width of males are 1.58± 0.26 cm, 1.51± 0.37 cm respectively. Second quadrant revealed that the mean and standard deviation of the right and left lobular width of females are 1.53± 0.35 cm, 1.53± 0.35 cm. Third quadrant showing that the t-value of right and left lobular width in both genders 1.24 cm, 0.97 cm. Fourth quadrant showing the p- value of the left and right lobular width in both the genders (p-value of right ear lobular width = 0.22 which is >0.05 and it is statistically insignificant and p-value of left ear lobular width = 0.74 which is >0.05 which is statistically insignificant).

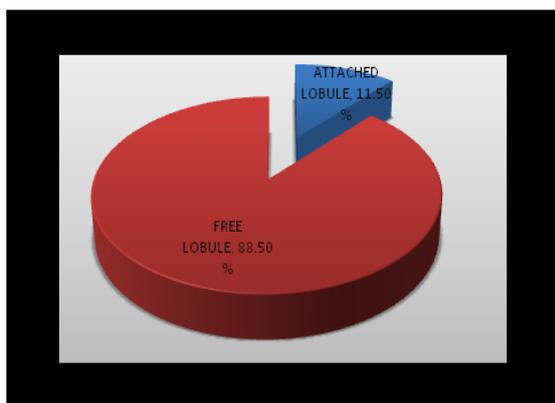


**Figure 9:** Bar Diagram Showing Comparison of Left-Right Lobular Width in Both Gender.

**Table 5:** Percentage Showing the Attached and Free Lobule in the Total Subject

Measurements	Year	Region	Total NO.	Percentage
Attached Lobule	2016	North Indian Population	46	11.5%
Free lobule			354	88.5%

In the [Table 5] There are 400 students [attached lobule = 46 (11.5%) and free lobule = 354 (88.5%)] and the pie diagram showing the percentage of free ear lobule is more than that of the percentage of attached ear lobule among Indian population.



**Figure 10:** Pie Diagram Showing the Percentage of Both Types.

## DISCUSSION

The human external ear or pinna is the most distinctive feature of the face. The structure of ear is a sign to determine the age and sex. Most of the authors believe that even after completion of development of external ear, it increases in their size.<sup>[2-4]</sup> The lobe of the ear is deliberately an imperative feature of beauty in several other

societies.<sup>[5]</sup> Previous observations have depicted that human auricle sizes appear not to be associated to the capacity or accuracy of hearing. On the other hand, the ear is documented as an ornamental organ and it is related to the physiognomy and aesthetics of the human face.<sup>[14]</sup>

Several studies have shown that the mean length of the male external ear is higher than that of the mean length of the female ear in different age groups and population.<sup>[15-19]</sup> In our study the mean difference of the ear length of the both sides was significantly greater in males than that of the females.

*Kalcioglu et al.* revealed their result that there was statistically insignificant difference in the mean of ear width between females and males.<sup>[18]</sup> *Farkas et al.* have stated that male ears are more wider than the females but are not significantly different.<sup>[15]</sup> *Ferrario et al.* worked out in Italy subjects in between adolescence to mid adulthood and found that males had wider ear than that of the females and also found that male mean length of ear is significantly higher than the females.<sup>[16]</sup> *Healthcote JA et al.* presented their research that men had larger ear in all the parameters than the women, and also mentioned that ears increases in length as well as in width with increment of age. He concluded that inclusive size of the external ear varies according to the ethnic groups.<sup>[2]</sup>

All above mentioned study and researches had a close match with our findings which clearly

signifies that male ears increase in all the parameters in comparison to that of females.

Azaria R et al included a total of 547 subjects with healthy ear morphology. After examination he found due to effect of ethnic origin and their colour combination, Sephardic and Ashkenazi Jews had long left ear lobule in comparison with Asian, Ethiopian, and American Jews and Arabs. They also revealed that black people have shorter ear lobule as compared to fair and dark skinned subjects. His finding showed that the sex and age were the factors that signified the affects to ear lobe.<sup>[20]</sup>

Lai and Walash et al. found that the attached ear lobule occupies 67.1% among Japanese individuals and 64.1% in Chinese subjects, which is quite higher as compared to 35.1% in Indians.<sup>[21]</sup>

Chattopadhyay et al. worked out and revealed their result that among the Jats of Delhi the frequency of attached ear lobe is 18.70%.<sup>[22]</sup> Frequency of free ear lobules and attached lobules observed by Pal in tribes of the Andaman islands is 24.44% and 48.89% respectively.<sup>[23]</sup> By Dutta & Ganguly, free lobules in Brahmins is 63.92% and attached ear lobes in Muslims of Central India is 25.49%.<sup>[24]</sup> In a study by Bhasin, it was observed that 43.2% of the persons who were Nepali male subjects had attached ear lobes.<sup>[25]</sup>

In the present study 400 subjects were selected, out of which 354 i.e. 88.5% had free and 46 i.e. 11.5% had attached ear lobule. The free lobule was found to be most common type of ear lobule in Indian population.

In a study by Sidra Shireen et al, the mean observations of right ear length, lobular length and width was found to be  $6.42 \pm 0.61$  cm,  $2.01 \pm 0.30$  cm and  $1.96 \pm 0.25$  cm respectively in the male population and these observations showed an insignificant difference in female right ear length with a mean value of  $6.34 \pm 0.39$  cm, while mean value of female right ear lobular length and width were significantly different than male observations having the value of  $1.85 \pm 0.21$  cm and  $1.77 \pm 0.16$  cm respectively. Meanwhile the average values of left ear length, lobular length and width was measured to be  $6.19 \pm 0.44$  cm,  $1.91 \pm 0.31$  cm and  $1.85 \pm 0.18$  cm respectively in the male population. The values were statistically similar to that of right ear observations. Left ear length in female was insignificantly different with a mean value of  $6.14 \pm 0.45$  cm whereas left ear lobular length and width in females were significantly different having mean values  $1.77 \pm 0.24$  cm and  $1.57 \pm 0.18$  cm respectively.<sup>[26]</sup>

The results obtained in our study had a difference than the above mentioned observations. According to the measurements, the mean values of right ear length, lobular length and width in male population was found to be  $4.61 \pm 0.41$  cm,  $1.56 \pm 0.12$  cm and  $1.58 \pm 0.26$  cm respectively. Among these

parameters, mean ear length and lobular length in females were significantly lower having the values  $3.68 \pm 0.42$  cm and  $1.09 \pm 0.13$  cm while the lobular width was insignificantly lower in females having mean value of  $1.53 \pm 0.35$  cm. On the other hand, on measuring the left ear parameters in males, the values of ear length, lobular length and width were found to be  $4.54 \pm 0.44$  cm,  $1.50 \pm 0.19$  cm and  $1.51 \pm 0.37$  cm respectively. In the females, left ear length and lobular length as similar to right ear's observation were significantly lower having values  $3.67 \pm 0.54$  cm and  $1.05 \pm 0.13$  cm. The left ear lobular width was insignificantly different in females ( $1.53 \pm 0.35$  cm).

## CONCLUSION

The external ear paradigm is gaining increasing momentum. Ear or the auricle is also an organ of cosmetic purpose because all the females wear ear rings for beautification. Racial differences by the measurement of auricle were documented in the present study. We concluded that variation in the ear between and within the Indian Population have been recognised to be a complex interaction between environmental and genetical point of view. We also noticed that ear is an organ which continuously increases during the period of life.

The result of present study shows that majority of males have higher mean value of ear parameters than the females except the lobular width of left ear which was more in females than in males (F= 1.53 cm, M= 1.51 cm). Apart of this, we found that free lobule is dominant in most of the subjects (88.5%) and the attach lobule is a recessive trait (11.5%).

- Ear parameters are essential parameters for deciding the race, sex and age of an individual whose identity is unknown.
- Measurements are required to compare the pinna or auricle from different racial background, growth assessment and development of an individual.
- Morphometric database of auricle is a potential suggestion for the diagnosis of any type of congenital malformation, acquired deformities and syndromes.
- Because we are using photographic method so it is easier how to measure the parameters and make a useful phenomenon for purpose of forensic investigation to optimize the crime.

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