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Analysis of morphometric and somatoscopic traits of auricle of ear in India: Relation with diversified ethnicities

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Abstract:

BACKGROUND: India is a country with large population and a mixture of ethnicities with Indo-Aryan, Dravidian, and Mongoloid ethnicities largely located in the six zones of the country, predominantly in North, South, and Northeast zones, respectively. There is a possibility of differences in auricular features among them and such data may be useful in different fields. Hence, the morphometry and somatoscopy of auricles were studied in the Indian population from the six zones of India.

MATERIALS AND METHODS: Measurements of auricles of the ear of 350 individuals from six zones of India were taken and somatoscopic variations were also recorded.

RESULTS: Morphometric parameters showed no zone-wise difference except prominence of the ear, which was different in the West and Central zones. All morphometric parameters showed sexual dimorphism. There was positive correlation between "auricle length (AL) to auricle attachment/root (AR)" as well as "AL to face length (FL)". Somatoscopic parameters showed no statistically significant zone-wise difference. Rolled helix, free ear lobes, and the presence of Darwin tubercle showed predominance in the population.

CONCLUSION: Although the North, Northeast, and South zones of India are supposed to have predominance of particular ethnicities, the present study derived that these ethnicities do not reflect in zone-wise differences in most of the parameters. Strong positive correlation of AL to auricle root as well as to FL has practicability in various fields, especially in reconstructive surgeries or in forensic identification. Although West and Central zones showed the difference in auricle prominence, there is still a need for appropriate definition of a "prominent ear".

Keywords:

Auricle, ear, ethnicity, forensic, reconstruction

Introduction

Auricle of the external ear is attached to the side of the face and has very distinct features due to the typical patterns formed by the curves of helix and antihelix, and also by the different ways of attachment of ear lobes to the cheek. They give the characteristic appearance to the face, and they may correspond to the ethnicity of an individual. It is reported that historians and archeologists tried to explore the ethnicity of the residents of Easter Island with the help of shape and length of auricles of the ear of the 1000 giant statues on the island (Pratt, 2009).

Studies have been conducted on different facial features to see if they correspond with the ethnicity of an individual as the people of the same ethnicity may have a similar genetic constitution (Klimentidis and Shriver, 2009). India is a large country consisting of 29 states which are broadly formed on the basis of a

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language the people speak, and hence, the nearby states have different languages but with many similarities. It is a multiethnic country, the diversity of which comes from a very long-term process of migration and intermarriage. The Dravidian-speaking Indus civilization thrived around 2500-1700 BC. It is supposed that the Aryans dominated by people with linguistic affinities to people in Iran and Europe migrated to occupy northwestern and then North-Central India around the period of 2000-1500 BC and subsequently spread southward and eastward. The Northwestern and North-Central India have ethnic affinities with European and Indo-European people from southern Europe, the Caucasus region, and southwest and central Asia. In Northeast states of India as well as somewhat in West Bengal, and Ladakh, much of the population closely resembles Tibetans and Buramans (Encyclopedia Britanica).

Usually, India is divided into six different political zones, which are actually based on language and ethnicity of the regions. Hence, in the present study, we considered the country divided into six different zones (Maps of India). The study participants had their ancestral origin from these zones of India. Morphometric and somatoscopic variations of auricles of these individuals were recorded, and an effort was made to search differences among individuals based on the zones of India from which they came.

Morphological as well as somatoscopic variations in a population are used in various ways in different fields of life. The knowledge of anatomical variations of auricle is useful to understand the developmental aspects, genetic significance, and surgical significance, for example, for the physicians, dysmorphologists, surgeons, cosmetologists, dentists, and forensic experts. In addition, it is used in wide variety of fields, for example, in industrial designing for the manufacturing of different devices, ornaments, clothing design, ergonomics as well as biometrics and many more (Burge and Burger, 1999; Sharma *et al*., 2007; Mahmut *et al*., 2009; Singh and Purkait, 2009). It has been known for years that low-set ears or malformed ears can give us a clue about genetic/developmental abnormalities. Earprints had been used as proofs in medicolegal cases (Mahmut *et al*., 2009). The study of variations in normal dimensions of the auricle is useful to plastic surgeons and cosmetologist for otoplasty or making artificial ears, to sculptors, to manufactures of mannequins, hearing aids or hearing devices, and in the emerging field of ear biometrics. Comparison of ear based on morphological examination can be used as corroborative evidence (Chattopadhyay and Bhatia, 2009).

Materials and Methods

The present work was carried out in 350 (215 males and 135 females) volunteers in the age group of 17–25 years. The participants were from 6 different zones of India (Maps of India): North (110), Northeast (11), East (30), South (16), West (126), and Central (57) zones. The study was conducted during the period of 2010–2013. The Institutional Ethical Committee approval was obtained. Informed consent was obtained from the participants prior to the commencement of the study. Individuals with altered external ear morphology either by trauma, accidents or surgery, were excluded from the study. Equipments used were digital caliper, spreading caliper, and a measuring tape. The measurements for all these parameters were taken in centimeters.

Morphometric parameters were auricle length (AL) (highest length measured from the superior to the inferior aspect of auricle), auricle width (distance from the attachment of tragus through the external auditory canal to the margin of the helical rim at the widest point), attachment/root of auricle (AR) (distance between otobasion superior-Obs and otobasion inferior-Obi), auricle projection (maximum distance of the outer edge of the helix of the auricle to mastoid at tragal level), face length (FL) (distance between nasion-n and gnathion-gn), face width (distance between the right and left zygoma-zy, i.e., bizygomatic distance), position of auricle of ear from anterior midline – PEA (distance between subnasal-Sn and tragion– t), position of auricle of ear from posterior midline- PEP (distance between midpoint of posterior attachment of auricle-r and external occipital protuberance– o).

Auricle attachment/root (AR) to AL and AL to FL indices were calculated

1. Auricle root length to AL index = (Auricle root length × 100)/AL
2. Auricle-Face index = (AL × 100)/FL.

Somatoscopic parameters were-ear lobe whether attached or free, form of helix whether flat or rolled, presence or absence of Darwin tubercle, level of the superior margin of the helix to decide normal or low-set ear (Magri *et al*., 1983), and preauricular area for the presence or absence of tags, pits, or sinuses.

The data were tabulated. ANOVA test was used to compare the significance of the difference between their means.

Results

The data were collected independently from participants belonging to six different zones of India. ANOVA test was used to compare the significance of the difference between their means. For AL, width and attachment; and FL, face width, PEA, and PEP, there was no statistically significant difference found among the various zone-wise groups [Table 1].

Since the *P* value for "auricle projection" was 0.018, i.e., < 0.05, it implied that the difference in the auricle projection was zone-wise significant. Thus, a *post hoc* test (Sidak test) was carried out to see which of these zones are showing a significant difference. From multiple comparison table, it was understood that the significant difference in ANOVA was because of the significant difference in West and Central zones ($P = 0.007 < 0.05$). All other zones ($P > 0.05$) independently did not show significant difference [Table 2].

There was positive correlation between "AL to AR" as well as "AL to FL." The correlation coefficient for "AL to AR" (0.559)was greater than that for "AL to FL" (0.425) [Table 3]. AR to AL and AL to FL indices were calculated and zone-wise comparison was made which showed no significant difference among the various zones [Table 4].

Somatoscopic parameters included the presence or absence of Darwin tubercle, flat/rolled helix, and ear lobe attachment to cheek. In the study population, the attached ear lobe was found to be present in 34.6% of individuals , whereas it was free in 65.4% of individuals. Rolled helix was present in 99.1% and was absent in 0.9%. Darwin tubercle was found in 82.9% individuals and was absent in 17.1%. Zone-wise comparison of these parameters was done, which did not show statistically significant difference. There was only one individual with low-set ears out of 350 individuals, while preauricular tag was also found to be present only in 1 subject.

Discussion

In the present study, age group ranged between 17 and 25 years. The individuals were from different zones of India (North, Northeast, East, West, South, and Central). India is a large country with 29 different states. The northern, southern, western, central, eastern, and north-eastern states have their own individuality. Ethnic groups in India are 72% Indo-Aryans, 25% Dravidians, and 3% Mongoloids (The world factbook). Indo-Aryans are mostly located in Northern states, Dravidians in Southern states, and Mongoloids in North-eastern states; however, in general, there is a mixture of these in all the zones of the country (Mujumder, 2001). We tried to see if there are differences in the morphological and somatoscopic characteristics of the auricle of the ear in the people of different zones. The typical appearance of the auricle of the ear is due to the arrangement of the curves of helix and antihelix; different ways of attachment of lobes and the presence or absence of Darwin tubercle which gives uniqueness to the ear. If there is diversity in the measurements and somatoscopic traits of auricle due to differences in ethnicity, the data may not only be useful for forensic identification but also for all the above-mentioned fields. In the present study, the statistical tests showed no significant difference in the morphometric and somatoscopic characteristics of auricles of different zones. This can be corroborated by a study of the ethnicity of the Indian population by using genomic data where it showed there is mixture of ethnicities in the Indian population (Mujumder, 2001). However, the difference in the "projection" was statistically significant between the West and Central zones. ($P = 0.007$, which is <0.05). The mean value for West zone was 2.1613, while that for the Central zone was 1.835. The trait may be used as supportive evidence with the other methods of identification.

It has been seen that AL and width are the most commonly measured parameters in the morphometric studies of the external ears. In the present study, mean AL was 5.74 cm (standard deviation [SD] 0.4) and mean auricle width was 3.07 cm (SD 0.32), both of which were comparable to the values of these parameters recorded in studies in a similar population. (Sharma *et al*., 2007; Singh and Purkait, 2009). However, in a study comparing auricles among different ethnicities, the people from the Indian subcontinent showed larger auricles of the ear (mean length of 6.8 cm and mean breadth of 3.6 cm) (Alexander *et al*., 2011).

Many researchers have mentioned that the AL and auricle width values are greater in males than in females in almost all age groups (Brucker *et al*., 2003; Ferrario *et al*., 1999; Shah *et al*., 1991; Preedy, 2012) In the present study also, there was a statistically significant sex

Table 1: Morphometric data: Zone-wise comparison

Parameters (cm)	Mean (SD)					
	North	North East	East	South	West	Central
AL	5.76 (0.46)	5.69 (0.40)	5.73 (0.39)	5.81 (0.33)	5.68 (0.45)	5.81 (0.37)
Auricle width	3.05 (0.32)	2.86 (0.36)	3.02 (0.35)	3.15 (0.42)	3.07 (0.32)	3.09 (0.39)
Auricle attachment	4.57 (0.49)	4.67 (0.37)	4.43 (0.55)	4.45 (0.51)	4.45 (0.46)	4.54 (0.51)
Auricle projection	1.99 (0.60)	1.97 (0.45)	1.97 (0.57)	2.05 (0.46)	2.16 (0.55)	1.83 (0.59)
FL	11.77 (0.71)	11.88 (0.38)	11.55 (0.76)	11.62 (0.58)	11.62 (0.76)	11.72 (0.74)
Face width	12.70 (0.67)	13.20 (0.74)	12.67 (0.65)	12.60 (0.69)	12.70 (0.75)	12.76 (0.65)
PEA	10.51 (0.75)	10.79 (0.79)	10.63 (0.67)	10.36 (0.78)	10.32 (0.72)	10.58 (0.72)
PEP	10.98 (0.70)	11.20 (0.66)	11.10 (0.49)	10.88 (0.67)	11.02 (0.74)	11.06 (0.77)

AL - Auricle length, FL - Face length, SD - Standard deviation, PEA - Position of auricle of ear from anterior midline, PEP - Position of auricle of ear from posterior midline

difference in AL as well as auricle width ($P = 0.000$, which is <0.025). There was sex-wise statistically significant difference in remaining morphometric parameters also.

The correlation of "AL to auricle attachment" and that of "AL to face FL" were strong positive [Table 2], knowledge of which again might be very helpful for identification and other purposes, especially to forensic experts in mass disasters or to plastic surgeons or to the artists for the knowledge and use of proportionate ear to face dimensions.

The "prominent" ears have been defined by many researchers as those having the projection distance of more than 2 cm (Hunter *et al*., 2009). As per this criterion, the prevalence of prominent ears in the present study was 49.14%. The prominent ears were found more in males (60%) than in females (42.33%). However, there are no definitive criteria to decide the definition of the prominence of the ear. The definition of the prominent ear is different by different research workers, for example, one study proposes the criterion for the prominent ear as the one having projection distance of >2.5 cm (Alexander *et al*., 2011). Many times, it is a perception of an individual and it may be different according to the volunteer and the researcher (Alexander *et al*., 2011), which suggests the need for an appropriate definition of "prominent ear." There was no mention of correlation of ethnicity with the prominence of auricle in the literature.

There was no zone-wise statistically significant difference in any somatoscopic parameters.

The presence of Darwin's tubercle shows variable percentages in populations of India. A study mentions a frequency of 40% in the central region of India (Singh and Purkait, 2009). The present study found 82.9% frequency of presence of Darwin's tubercle. Rolled helix was found to have much common occurrence as compared to the flat helix as the values obtained in the present study were 0.9% and 99.1%, respectively – similar as mentioned in the literature (Bartel-Friedrich and Wulke, 2007). An Indian study found a very high value of 98.75% of attached and just 1.25% of free ear lobe; however, the numbers of ears studied were 80 in this study (Sharma *et al*., 2007), whereas another report from the study of the Indian population has mentioned that free lobes were more common in females than in males (Singh and Purkait, 2009). In the present study, free ear lobes were more than attached, and there was no sex difference in the attachment of ear lobe. A study suggested the relation of earlobe-shape to race (Overfield and Call, 1983), but there was no mention of the relation of the type of earlobe-attachment to race or ethnicity. Although genetically, free ear lobes show dominant trait while attached ear lobes show recessive trait (Hotta, 2011), it was not seen in a particular zone in the present study-again indicating mixture of ethnicities in the Indian population. From the previous studies, it was seen that the presence of low-set ears and preauricular pits or tags are an uncommon finding (Farkas, 1978; Singh and Purkait, 2009; Preedy, 2012; Turchi and Tunkel, 2006) which was the same in the present study.

Table 2: Multiple comparisons (Sidak test) for projection of auricle

Zone (I)	Zone (J)	Mean difference (I-J)	SE	*P*
North	East	0.0167	0.1187	1.000
	South	−0.0604	0.1542	1.000
	West	−0.1698	0.0752	0.311
	Central	0.1563	0.0940	0.785
	North-East	0.0132	0.1822	1.000
East	South	−0.0772	0.1784	1.000
	West	−0.1866	0.1170	0.831
	Central	0.1395	0.1299	0.993
	North-East	−0.0035	0.2031	1.000
South	West	−0.1093	0.1529	1.000
	Central	0.2167	0.1630	0.953
	North-East	0.0736	0.2257	1.000
West	Central	0.3261*	0.0919	0.007***
	North-East	0.1830	0.1811	0.996
Central	North-East	−0.1430	0.1897	1.000

SE - Standard error, *indicates significant difference in west and central regions, ***P value is <0.05, which is not seen for any other regions

Table 3: Correlation of auricle length with auricle attachment and face length

AL	AR	FL
Pearson correlation	0.559	0.425
P	<0.05	<0.05
n	350	350

AL - Auricle length, FL - Face length, AR - Auricle root attachment

Conclusion

India is a country with a large population and has 72% Indo-Aryans, 25% Dravidians, and 3% Mongoloids. Over many centuries there has been a mixture of all ethnicities. Auricular projection showed a significant difference in the individuals between the West and Central zones ($P = 0.007$ <0.05). Rest of the parameters did not show significant differences in individuals from different

Table 4: Auricle attachment to auricle length index and auricle length to face length index - zone-wise comparison

Index	North	East	South	West	Central	North-East
AR to AL index	79.404	77.327	76.8406	78.6088	78.2044	82.3884
AL to FL index	49.2537	49.7484	50.0618	48.9831	49.6962	47.9544

AL - Auricle length, FL - Face length, AR - Auricle root attachment

zones ($P > 0.05$). Thus although the north, northeast, and south zones are supposed to have the predominance of particular ethnicities, the present study derived that these ethnicities do not reflect in zone-wise differences in most of the parameters except the auricular projection Second, the present study found sexual dimorphism in all morphometric parameters. Third, the present study found predominance of free ear lobes (65.4%), rolled helices (99.1%), and the presence of Darwin tubercle (82.9%). Finally, a positive correlation was found between auricle attachment and AL (correlation value 0559); so also between auricle attachment and FL (correlation value 0.425). Based on these findings, the present study may prove supportive as one step ahead in identification practicability, when other facial features shall also be used for this purpose in future.

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Conflicts of interest
There are no conflicts of interest.

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