A study of sexual dimorphism of human auricle by morphometry and topographical location

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Abstract

Aims and objectives: Features of human body parts or organs or bones have been studied to identify differences in males and females. The present study was performed to assess gender differences in morphometric parameters of auricle of ear; and to see whether there exists any sexual dimorphism in positioning of auricle. Materials and Methods: Measurements were taken on 350 young individuals within the age group of 17-25 years by digital and spreading calipers and recorded in centimeters. The morphometric parameters were auricle length, auricle width, auricle root/attachment, projection of auricle, face height, face width, position of auricle from anterior midline, and position of auricle from posterior midline. The independent t-test was used to test the significance of difference between males and females. Results: The difference in the morphometric parameters showed statistical significance. The indices i.e. 'Position of auricle from posterior midline' [PEP] to face width [FW] index was statistically significant sex-wise, which was less in males than in females; while 'Position of auricle from anterior midline' [PEA] to 'Position of auricle from posterior midline' [PEP] index was also statistically significant sex-wise, which was more in males than in females. Conclusion: There was significant difference in measurements as well as position of auricle in males and females. The two indices related to the position of auricle from the midline may be of value in forensic identification and in fields like surgery, anthropometry, art, and ergonomics. Corresponding landmarks on dry skull may be used to estimate sex in skeleton.

Key Words: dimorphism, gender, ear, topography, forensic

Introduction

Features of human body parts or organs or bones have been studied to identify differences in males and females. Such variations are useful for identification of sex during a forensic investigation as well as for applications in different fields like facial reconstructive surgery, cosmetology, human genetics, anthropological studies, ergonomics related to manufacturing of various devices according to the need of such gender based differences. Research workers have observed that there are significant differences in length and breadth as well as other features of the auricle of ear between males and females. As the auricle forms an important landmark on face, its position is also equally important. Low set ears are considered as indicators for genetic abnormalities. Few research studies have also shown that position of ear in relation to facial midline also is variable and can be a significant finding. In the present study, we have recorded morphometric data of auricles of 350 young individuals from six different regions of India – North, South, East, West, Central, and Northeast. Not only did the observations of the present study reiterate the findings of the previous research workers regarding the sexual dimorphism, but it also gave a positive indication with regards to position of auricle, which showed statistically significant difference in males and females. Such findings may help or support the other methods of gender identification and will also be useful in other fields as mentioned above.

Material and Methods

The study was carried out after the approval by Institutional Ethical Committee. Morphometry of auricle was carried out on 350 young individuals [215 females and 135 males] belonging to the age group of 17-25 years after obtaining an informed consent. The
subjects for the study were chosen from six different regions of India – North [Punjab, Haryana, Himachal Pradesh, Uttar Pradesh, and Uttarakhand], South [Karnataka, Tamil Nadu, Andhra Pradesh and Kerala], East [West Bengal, Bihar, Orissa, and Jharkhand], West [Maharashtra, Gujarat, Goa and Rajasthan], Central [Chhattisgarh and Madhya Pradesh], and Northeast [Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura]; for taking different measurements of auricle. Measurements were taken by digital caliper and spreading caliper and recorded in centimeters. The eight morphometric parameters were auricle length, auricle width, auricle root/attachment, projection of ear, face height, face width, position of ear from anterior midline and position of ear from posterior midline. The measurements pertaining to study were recorded with the help of standard landmarks.

**Morphometric Parameters:**

1. **Auricle length** – Maximum length measured from the superior to the inferior aspect of the external ear
2. **Auricle width** – Transverse distance from the center of attachment of tragus through the external auditory canal to the margin of the helical rim at the widest point
3. **Attachment/root of auricle** – Distance between otoposion superior - Obs [most cranial attachment of auricle to head] and otoposion inferior - Obi [most caudal attachment of earlobe to face]
4. **Auricle projection** – Distance of the outer edge of the helix of the ear to mastoid
5. **Face height** – Distance between nasion - n [point at the intersection of the frontal and nasal bones] to gnathion - gn [the lowest median landmark on the lower border of the mandible]
6. **Face width** – Distance between right and left zygoma - zy i.e. bizygomatic distance [maximum distance between the most lateral points of the zygomatic arches]
7. **Position of auricle of ear from anterior midline [PEA]** – Distance between subnasal - Sn [junction between lower border of nasal septum and cutaneous portion of upper lip] and tragion – t [Fig. 1].
8. **Position of auricle of ear from posterior midline [PEP]** – Distance between midpoint of posterior attachment of auricle - r and external occipital protuberance – o [Fig. 2]

**Results**

A statistical analysis of the data collected using eight morphometric parameters was carried out to see, if there was any significant difference with respect to sex. The independent t-test was used to test the significance of difference between male and female groups. The study group consisted of 215 females and 135 males from six different regions of India. Since the p-value for all the morphometric parameters was less than that of 0.025, it implied that the difference in the morphometric parameters, like auricle width, auricle length, auricle root attachment, projection, face height, face width, PEA, and PEP was significant at 5% level. [Table 1]

With the help of the parameters measured in the present study, we calculated different ear indices as follows:

1. **Auricular index** = [Auricle width x 100]/Auricle length
2. **Auricle root length to Auricle length index** = [Auricle root length x 100]/Auricle length
3. **Auricle-Face index** = [Auricle length x 100]/Face height
4. **PEA to face width [FW] index** = [PEA x 100]/FW
5. **PEP to face width [FW] index** = [PEP x 100]/FW
6. **PEA to PEP index** = [PEA x 100]/PEP

'PEP to face width [FW] index' was statistically significant sex-wise, which was less in males than in females. 'PEA to PEP index' was also statistically significant sex-wise, which was more in males than in females. Auricular index, auricle root length to auricle length, auricle to face index, PEA to face width [FW] index were statistically insignificant. [Table 2]

**Discussion**

In most of the morphometric studies of the external ears carried out in different countries, and ethnic groups...
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Fig. 1. Showing landmarks to measure position of auricle from anterior midline sn = subnasal, t= tragion

Fig. 2. Showing landmarks to measure position of auricle from posterior midline o = external occipital protuberance, r = midpoint of posterior attachment of auricle

the auricle length and width are the most commonly measured parameters. Many of these previous studies have mentioned that the auricle length and auricle width values are greater in males than in females in almost all age groups. In the present study too, there was a statistically significant sex difference in auricle length and auricle width [p=0.000, which is less than 0.025] as well as other parameters. [Table 1]

The present study also shows that the mean auricle length in males is 6.1% more than that in females and confirms the finding by most of the previous reports that the males have a longer auricle length as compared to the females.

The 'prominent ear' has been defined by many research workers as having the projection distance more than 2 cm. In the present study, the number of prominent ears was 49.14%. The prominent ears were found more in males – i.e. 60%, while in the females this value was 42.33%. This is a statistically significant sex difference [p=0.020]. In the era of cosmetic awareness, prominent or protruding ears have not been accepted by many people as it may hamper the beauty of the face, hence the data as well as the gender differences may be of value for the plastic reconstruction of the face and ear. The other parameters - auricle attachment, face width, and face height also showed sexual dimorphism. [Table 1]

In the present study two new parameters were used, namely 'position of ear from anterior midline [PEA]' which was taken as the distance between subnasal- Sn [junction between lower border of nasal septum and cutaneous portion of upper lip] and tragion; and 'position of ear from posterior midline [PEP]' was taken as the distance between midpoint of posterior attachment of auricle and external occipital protuberance, to decide position of ear from the anterior midline of face and posterior midline of head respectively; both of which showed statistically significant difference in males and females [p=0.000]. The PEA was found to be higher in males than in females, which was statistically significant [p=0.000]; while PEP was greater in females than in males and was statistically significant [p=0.000]. [Table 1]

When different ear indices were calculated using these parameters, the 'PEP to FW' index was statistically significant [p=0.000], where it measured 85.0598 in males and 87.9680 in females; while 'PEA to PEP' index was also statistically significant [p=0.000], where it measured 97.4296 in males and 93.9149 in females. [Table 2]

Though the studies indicate that face height and width measurements are more in males than in females, face height-width ratio has not been proved as an effective tool for gender determination. As the
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Table 1: Sex-wise comparison of morphometric parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Male</th>
<th>Female</th>
<th>SD</th>
<th>SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean [cm]</td>
<td>5.9644</td>
<td>5.6006</td>
<td>0.4388</td>
<td>0.3703</td>
<td>0.000</td>
</tr>
<tr>
<td>Pinna length</td>
<td>3.1866</td>
<td>2.9892</td>
<td>0.2871</td>
<td>0.3622</td>
<td>0.000</td>
</tr>
<tr>
<td>Pinna width</td>
<td>4.6921</td>
<td>4.4027</td>
<td>0.4772</td>
<td>0.4683</td>
<td>0.000</td>
</tr>
<tr>
<td>Pinna root/attachment</td>
<td>2.1192</td>
<td>1.9708</td>
<td>0.5444</td>
<td>0.6012</td>
<td>0.020</td>
</tr>
<tr>
<td>Pinna projection</td>
<td>12.0699</td>
<td>11.4277</td>
<td>0.6127</td>
<td>0.6835</td>
<td>0.000</td>
</tr>
<tr>
<td>Face height</td>
<td>13.1642</td>
<td>12.4473</td>
<td>0.5907</td>
<td>0.6247</td>
<td>0.000</td>
</tr>
<tr>
<td>Face width</td>
<td>10.8518</td>
<td>10.2334</td>
<td>0.7280</td>
<td>0.6416</td>
<td>0.000</td>
</tr>
<tr>
<td>PEA</td>
<td>11.1773</td>
<td>10.9281</td>
<td>0.7027</td>
<td>0.7007</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 2: Sex-wise comparison of Ear Indices

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sex</th>
<th>Mean</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear width to Ear length index</td>
<td>Male</td>
<td>53.6385</td>
<td>0.846</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>53.5056</td>
<td></td>
</tr>
<tr>
<td>Ear root attachment to Ear length index</td>
<td>Male</td>
<td>78.8138</td>
<td>0.849</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>78.6627</td>
<td></td>
</tr>
<tr>
<td>Ear to face index</td>
<td>Male</td>
<td>49.4881</td>
<td>0.377</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>49.1279</td>
<td></td>
</tr>
<tr>
<td>PEA to face width [FW] index</td>
<td>Male</td>
<td>82.5150</td>
<td>0.715</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>82.3073</td>
<td></td>
</tr>
<tr>
<td>PEP to face width [FW] index</td>
<td>Male</td>
<td>85.0598</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>87.9680</td>
<td></td>
</tr>
<tr>
<td>PEA to PEP index</td>
<td>Male</td>
<td>97.4296</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>93.9149</td>
<td></td>
</tr>
</tbody>
</table>

'PEP to FW' and 'PEA to PEP' indices show statistically significant difference [Table 2], they may be of practical value in forensic identification of a gender. Further studies using larger sample may be useful to establish these facts.

The present study was carried out on the living subjects, and further work is necessary for correlation of the landmarks used in the present study with the bony landmarks on the skull such as distance between prostinion and porion\textsuperscript{24}, and distance between posterior margin of external acoustic meatus and external occipital protuberance for PEA and PEP respectively, with the hope that such studies would be helpful to make use of these indices for gender determination in dry skull as well.

Conclusion

The morphometric parameters of auricle of ear show higher values in males than in females. The position of auricle also shows a gender wise difference. Position of ear from anterior midline [PEA] to Face width [FW] index [85.0598 in males and 87.9680 in females], and Position of ear from anterior midline [PEA] to position of ear from posterior midline [PEP] index [97.4296 in males and 93.9149 in females] showed statistically significant difference, which may be helpful for the forensic identification of an individual. It may also have application in other fields like reconstructive surgery, cosmetology, anthropometry, artistic representation of face in different art forms, mannequin designing,
manufacturing of devices related with ear, head or face. With the help of corresponding landmarks, if these indices can be studied on the dry skull, it may be valuable for the sex determination on skeletal remains.

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References


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