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Morphological Variation of ear for Individual Identification in Forensic Cases: A study of an Indian Population

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Abstract

The main aim of the current study is to presents the significance of morphological or morphometric variation of ears for individualization, to provide data procedures for the inclusion and exclusion of persons for identification on the basis of ear variation collected from peoples and represents anatomical ear variationsto forensic point of view. It was observed that in most of the parameters which were statistically significant when subjected to determination of identification, they showed a high percentage of differences between males. Studies presented in this research indicate that comparison of ear based on morphological examination and morphometric variations can be used as supportive tool and have a role in forensic science field by the identification of landmarks variations in peoples.

Keywords: Individualization, forensic science, landmarks variation.

Introduction

The use of forensic science in most countries is often hampered by unprepared and ill-equipped institutions. Only a limited number of countries have the requisite infrastructure, knowledge, expertise and training to properly investigate and prosecute crimes. The use of ear morphology and the variations created by its anatomical form are implemented principally for identification of perpetrators. Features pertaining to the human ear that may be used for identification include piercings, localized tattoos, pathologies or abnormalities, trauma, and surgery[1]. Meijer man et al., added that final individualization may further depend on characteristic ear minutiae, such as the position, size, or pattern of creases, papules, moles, scars, hillocks, and features along the inner rim of the helix[2-4]. This assists in the reinforcement of such a trait as individualistic; however, debates with regard to this issue are ongoing[5].

The anatomical structure of the external ear is utilized for personal identification of living subjects in relation to criminal activity. There have been claims in recent years that the external ear may be utilized for personal identification of both living and deceased individuals[1, 6]. There are a vast number of cases that present this type of evidence as well as several that have obtained a conviction dependent on analysis of the trait[7-8].

The human ear is the most defining feature of the face. Several studies have been attempted for individual identification from morphological features of ears. Studies on various landmarks like ear length, ear length above tragus, ear length below tragus, tragus length, ear breadth, concha length, concha breadth, lobule height, lobule width of the external ear have been identified with high accuracy. The anatomy of the external ear has been described in many texts,[9-12] yet the information about the morphometric variation between peoples has been lacking, which is essential for the identification purpose[13-17] and also for medico legal importance. However, no studies are being carried out regarding the individual features of the external ear, though; various parameters of the external ear have been evaluated.

Over the past few years, investigation of these parameters has primarily been conducted by Meijer man and his team as well as the development of the Forensic Ear Identification (FEARID) research project. Imhofer also stressed the possibility of using ear characteristics for assessing familial relationships, because the morphology of ears tends to be hereditary. Oepen studied the external ear from an anthropological point of view and gathered data from the ears of 500 male and 500 female subjects[18, 19].

Earology" was first reported by Johann Casper Lavater and was used by individuals such as Haken Jorgensen who established a system of recording the morphology of the ear using ear measurements and ear moulds from criminals in Denmark at the turn of the last century. Several attempts, notably by Alphonse Bertillon in 1862 and Alfred Iannarelli in the 1940s [20, 21], have been made to establish a classification system for the ear with varying success. Bertillon and the prominent forensic scientists at that time considered the ear to be the most distinctive part of the body[22-27]. There is however, no published data that establishes each individual's ear is different and distinct, and that an individual can be identified conclusively from comparison of the ear or too little data exist to establish the accuracy of this controversial hypothesis and more evidence-based research is required[28-32].

Alfred V. Iannarelli devoted most of his career to the study of the ear as an identifying organ. Van der Lugt reported on a study carried out by him in 1987[33,34]. A collection of photographs from the right and left ears of 500 men was classified according to defined measures i.e. ear length, ear width, length of the lobe, distance between the tragus and the antitragus and morphological features i.e. general shape, knob of Darwin, curving of the antihelix, size of the tragus and antitragus, form of the antitragic notch.

Kritscher et al.[35] dealt also with a case where the offender had been identified after comparing the ear image captured on a video system with ear photographs taken from a suspect. In a case report presented by Hammer, the probability for the random occurrence of four concordant features was estimated to be 1 in 7800[36]. Already at 1906 Imhofer[37] found that in the set of 500 ears only 4 characteristics was needed to state the ears unique[38]. The most famous work among ear identification is made by Alfred Iannarelli at 1989, when he gathered up over 10.000, ears and found that they all were different. Further research in the quantification and frequencies of occurrence of various ear features in human populations are ongoing, for example, the studies of American[21] and Dutch populations[39].

It was previously reported in a case study that characteristics of the pinna can be used successfully in the identification of disaster victims[40]. In India, morphology of ear was used to confirm the identity of Veerappan, the sandal wood smuggler who was killed by Special Task Force in 2004. Veerappan, a wood smuggler killed by special task forces in India was also reportedly identified by several morphological features of his ear, including a flat tragus being contiguous with the curved portion of the helix and an enlarged and squarish lobule[41]. Ear piercing, which often occurs on the lobe, is also a useful attribute for forensic identification[42]. Recent work pertains mainly to the development, quantification, and validation of hereditary variation of ears for utilization in a judicial environment now that it has been illustrated as a viable technique for identification.

The anatomical appearance of the auricle varies from individual to individual and between ethnic races[43]. The pattern of the free lobule was proposed also by Altmann to be a dominant trait with the attached lobule representing the recessive trait. Subsequent studies appeared to confirm the patterns of inheritance[44-45].

Material and Methods

This study was carried out on 100 men volunteers with age range 20 to 60 (mean age 40 years). All volunteers were auto rickshaw drivers of Greater Noida, Uttar Pradesh, India. Informed consent of the persons was obtained. Age and anatomical landmarks of each person were recorded. The major landmarks of the external ear are shown in figure 1. There is a wide range of normal variation in the shape of the external ear.

Figure 1 shows the shape and location of different anatomical landmarks of Ear

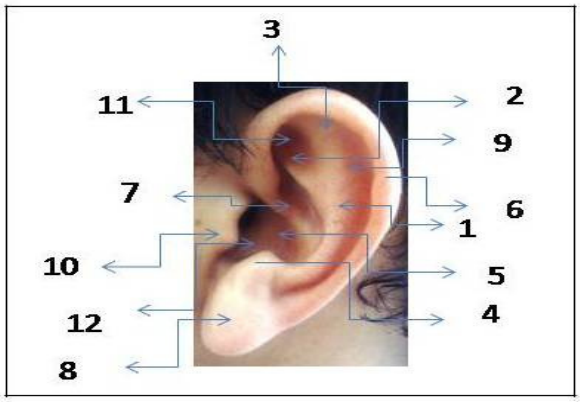

Figure-1
Shows the shape and location of different anatomical landmarks of Ear

The anatomical landmarks used for this research study were: i. Ear length, ii. Ear breadth, iii. Ear length above tragus, iv. Ear length below tragus, v. Tragus length, vi. Concha length, vii. Concha breadth, viii. Lobule height, ix. Lobule width

The Standardized measurements of the following parameters were taken carefully. In the present study, each of the above parameter andlandmark points distance was calculated in mm with standard caliper. The parameters shown below in figure-2 :

Figure 2 shows external ear landmarks parameter for distance calculation

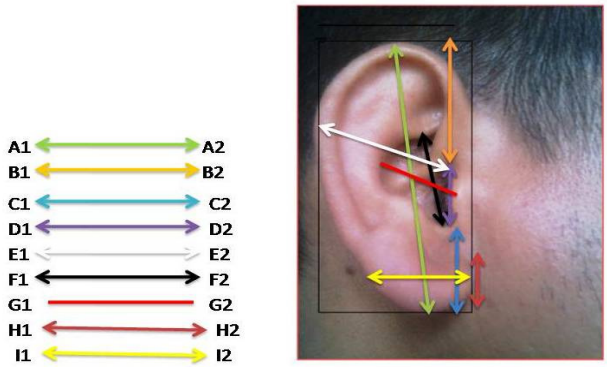

Figure-2
Shows external ear landmarks parameter for distance calculation

The parameters shown in figure-2 are as follows: i. Ear length: Uppermost of pinna to the lowermost point of lobule (A^1-A^2), ii. Ear length above tragus: Uppermost point of pinna to tragion (B^1-B^2), iii. Ear length below tragus: From intertragic incisure to the lower most point of lobule (C^1-C^2), iv. Tragus length: From tragion to intertragic incisure (D^1-D^2), v. Ear breadth: From root of the ear to maximum convexity of the

helix (E^1-E^2), vi. Concha length: From cymba concha to intertragic incisure (F^1-F^2), vii. Concha breadth: Posterior margin of the tragus to the maximum concavity of the antihelix (G^1-G^2), viii. Lobule height: From lower point of attachment of the external ear to the head (otobasion inferior) to the caudal extension of the ear lobe free margin (subaurale) (H^1-H^2), ix. Lobule width: From the most caudal attachment of the ear lobule to the head and to the outermost maximum transverse width of the ear lobule (I^1-I^2)

Results and Discussion

The anatomy of the various components of the ear is described below, and illustrations are shown each time in the section describing the various features of the components. Table 1 shows measurements of ear of the Rickshaw drivers. Table 3 Position of the ear. Table 4 Ear lobe types among the Rickshaw drivers. Table 5 Ear types among the Rickshaw drivers. Figure-3 shows long and narrow ears. Figure 4 shows Medium size ear. Figure 5 shows short and broad size ear. Figure 6 shows position of the ear at about the middle of the head. Figure 7 shows free ear lobe (Left Side Ear). Figure 8 shows attached ear lobe (Right side). Figure 9 shows the values of Anatomical landmarks of the external ear below:

Figure-3
Shows long and narrow ears

Figure-4
Shows Medium size ear

Figure-5
Shows short and broad size ear

Figure-6
Shows position of the ear at about the middle of the head

Figure-7
Shows free ear lobe (Left Side Ear)

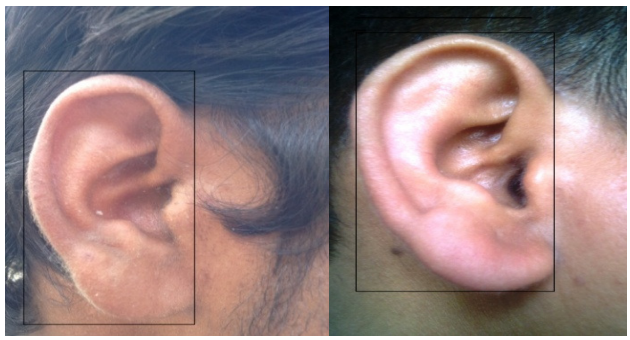

Figure-8
Shows attached ear lobe (Right side)

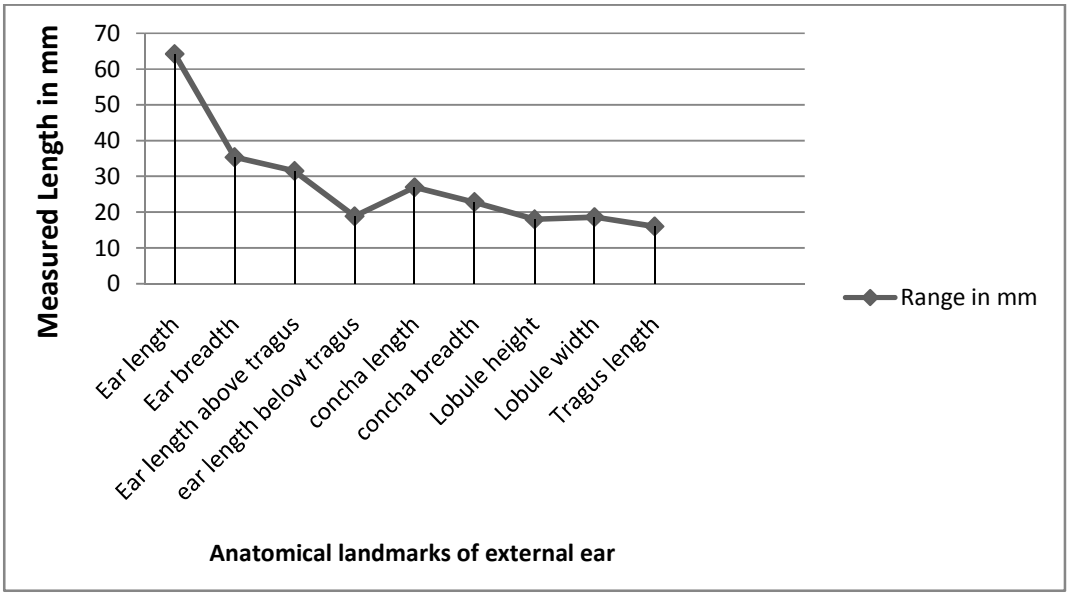

Figure-9
Shows the values of Anatomical landmarks of the external ear. All values are expressed the mean value in the morphological examination

The legal system typically requires two different types of corroborative evidence in order to confirm the identity of a person. A benefit to the collection of external ear morphological landmarks variations along with other procedure for identification purposes in its use as more economical and confirmatory data in legal procedures. The need for objective, scientifically based criteria for determining identifications have never been more important and it will take researchers and practitioners working together to move forensic science in the proper direction. Forensic science practitioners and researchers have the responsibility to incorporate many recent advances in science to provide valid, objective results.

A forensic anthropologist will frequently be presented with the task of identifying deceased remains; however, expertise pertaining to this field is increasingly called on to investigate situations involving living individuals (Iscan 2001).

To strengthen the scientific basis for ear variations for individualization, we must understand more about how to select and use ear morphological features and know more about the factors that determine the range of individual variation. Valvoda presented image-processing algorithms to extract features from the anthelix area[32]. More recently, Rutty et al. presented their concept of a computerized ear identification system and made use of a database containing 800 different ears.

In the morphological examination or comparison of ears, you'll need to rely on individual ear variations or traits for comparison, if visible. Look at the shape and the curves and lines of the ears of each person, these formative structures of the ear are entirely unique to each person. Ears may be oval, round, triangular or rectangular and variations of those shapes. The intertragal notch may be wider or higher from one person to another. Also look at the lobes to see whether they are attached or free. Lobes can be narrow, wide, pointed, squared, flat, creased etc.A limited number of studies reported data on ear position, notwithstanding the importance of this information[5, 41, 46- 49]. Similar studies were carried out in this research.Summary and graphical comparison of various ear studies by different scientist shown below in table 2 and figure 10:

Table-2
Summary of various ear studies

S. No.	Source (s)	Male ear length (mm)	Male ear width (mm)
1	Purkait [41]	57.7	33.1
2	Alexander and Laubach, 1968[46]	67.0	34.5
3	Chattopadhyayand Bhatia[5]	62.5	33.5
4	**Our study**	**64.2**	**35.335**
5	Burkhard and Sachs, 1975[47] (median values)	68.5	37.7
6	Dreyfus, 1967[48]	63.5	35.5
7	Algazi et al., 2001 (overall means)[49]	64. 1	29.2

1. Antihelix	**7.** Helix, Crus
2. Antihelix, Inferior Crus	**8.** Lobes
3. Antihelix, Superior Crus	**9.** Scapha
4. Antitragus:	**10.** Tragus
5. Concha	**11.** Triangular Fossa
6. Helix	**12.** Incisura

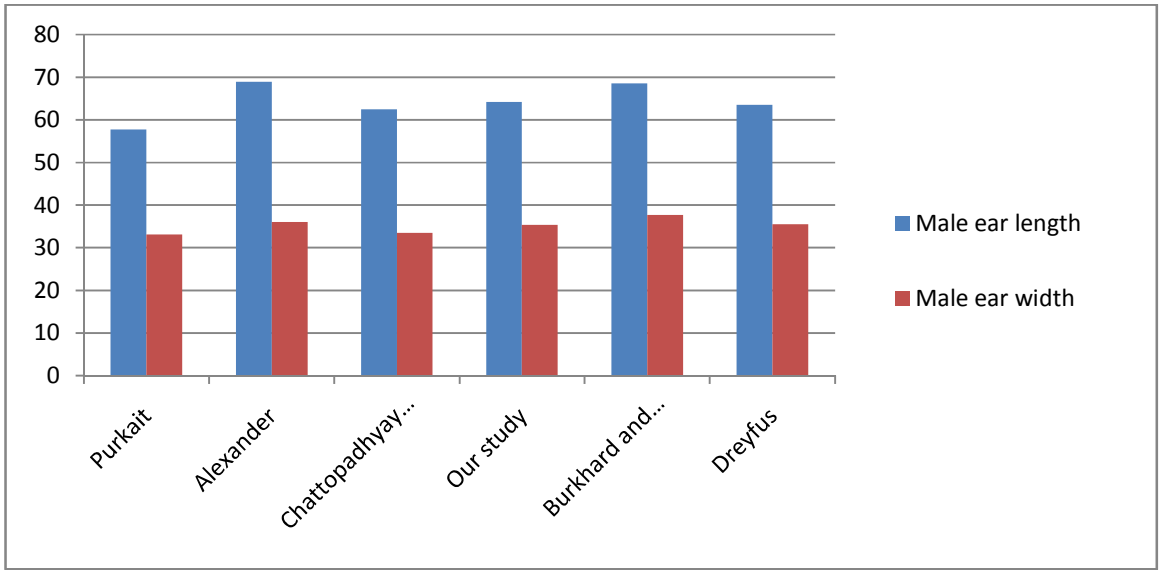

Figure-10
Graphical summaries of various ear studies

According to a 1995 British study with several other physicians and hundreds of subjects aged 30-93, James A. Heathcote, concluded that our ears grow at an average rate of about .22mm (.01 inches) per year. This study was confirmed by a Japanese study of 400 people in 1996[50]. While average growth rates vary from person to person and may vary during different stages in a person's life, we can assume that an individual with a 2" long ear at age 30 would, by age 80, have achieved about a 25% growth rate, resulting in about a 2-1/2" long ear[51-52].

Ears can protrude from the head to varying degrees or may be set close and flat to the head, some set so deeply that the concha is almost recessed into the head. The concha area can be wide or narrow, deep or shallow. Ears may be positioned at different levels on the head, normal being when the upper rim of the helix is even with the eyebrow. The helix of the ear will never be the exact same shape in any two people, not even people who are closely related. Also note that on any given head, one ear may look different than the other or it may be placed a little higher/lower on the head. So always look very closely at all of these details when they are visible.

The anatomy of the external ear is complex[53] and remarkably inaccurately described by most authors. The major landmarks of the external ear are shown in figure 1. There is a wide range of normal variation in the shape of the external ear. The anatomy of the various components of the ear is described below, and illustrations are shown each time in the section describing the various features of the components.

Conclusion

The present study represents anatomical Ear variations to forensic point of view as an important step or supportive tool in forensic identifications. Taking information from the ear is an attractive alternative for identification purposes and researchers from universities, forensic labs and national police training centers adapt existing technologies and find new methods for identification using ear as supportive evidence. The main aim of the current study is to presents the significance of morphological or morphometric variation of ears for individualization, and to provide data procedures for the inclusion and exclusion of persons for identification on the basis of ear variation collected from criminals. The anatomical landmarks of the external ear used for this research study.It has been observed from table1 that when all the parameters were statistically analyzed to find the range, mean and standard error, most of the parameters were varied. Ear length below tragus, lobule height and lobule width were vary for person to person.

It was observed that in most of the parameters which were statistically significant when subjected to determination of identification, they showed a high percentage of differences between males. As seen in table 1, the ear length of males was in the range of 54.21-74.19. However, ear length below tragus, lobule height and lobule width were statistically significant. As seen in table 3 positions of the ears among the rickshaw drivers were statistically varied. 60.21% of the ears positioned at middle of the head, while 39.78% positioned posterior 1/3 of the head. Types of Ear lobe among the rickshaw drivers were also statistically varied. 66.46% ears lobe is free and 33.53% is attached and shows high statistical variations for person to person s seen in table 4. Ear types among the rickshaw drivers were also statistically varied. 17.23% ears is long and narrow, 66.49% ears is medium and 16. 27% ears are short and broad as seen in table 5.

Table-1
Shows measurements of ear of the Rickshaw drivers

S. No.	Parameters	Sex	Calculated range	Mean	Standard Error	(p-values)
1)	Ear length	M	54.21-74.19	64.2	0.41	(p< 0.001)
2)	Ear breadth	M	29.52-41.15	35.335	0.23	(p< 0.001)
3)	Ear length above tragus	M	23.72-39.31	31.515	0.32	(p< 0.001)
4)	Ear length below tragus	M	11.25-26.48	18.865	0.31	(p< 0.001)
5)	Tragus Length	M	5.42-26.61	16.015	0.33	(p< 0.001)
6)	Concha length	M	20.12-33.82	26.97	0.23	(p< 0.001)
7)	Concha breadth	M	15.91-29.77	22.84	0.28	(p< 0.001)
8)	Lobule height	M	10.82-25.16	17.99	0.30	(p< 0.001)
9)	Lobule width	M	9.71-27.54	18.625	0.32	(p< 0.001)

Table-3
Position of the ear

No.	Posterior 1/3 of the head ± SE	Middle of the head ± SE
100	36.61% ± 0.7%	63.38% ±0.5%

Table-4
Ear lobe types among the Rickshaw drivers

No.	Free	Attached
100	65.14%	34.85%

Table-5
Ear types among the Rickshaw drivers

No.	Long and narrow	Medium	Short and broad
100	18.37%	69.13%	12. 49%

The present research is an attempt to study the individualal identification parameter on the basis of morphological features in the area of forensic science. Studies presented in this research indicate that comparison of ear based on morphological examination and morph metric variations can be used as supportive evidence and have a role in forensic field by the identification of landmarks variations in peoples.

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