International Journal of Research in Medical Sciences
Maitreyee M. Int J Res Med Sci. 2017 Sep;5(9):3843-3846
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20173640

Original Research Article

Pinna of ear: a potential biometric identifier

Maitreyee M.*

Department of Anatomy, Dr. D Y Patil Medical College, Pune, Maharashtra, India

Received: 19 July 2017
Accepted: 22 July 2017

***Correspondence:**
Dr. Maitreyee M.,
E-mail: maitreyeemadhav@gmail.com

ABSTRACT

Background: Individual differences in morphometric and somatoscopic observations of pinna of ear were studied to explore the potential of pinna of ear as a biometric tool.
Methods: Morphometric and somatoscopic data of right ear of 350 Indian individuals (Age: 17-25 years) was collected. Measurements of pinna length, pinna width, pinna root, pinna projection, intertragic distance, ear lobe length, and ear lobe width were taken. Observations were done for presence or absence of Darwin tubercle, flat or rolled helix, and attached or free ear lobe. Probability statistics was extrapolated to assess the variations in ear pinna characters.
Results: All measurements showed a wide range. There was statistically significant difference between male and female pinna measurements. The somatoscopic observations showed 82.9% individuals with presence of Darwin tubercle, 99.1% with rolled helix, and 65.4% with free ear lobes. On the basis of extrapolation of ten different morphometric and somatoscopic parameters, the statistics showed the probability of any two individuals having exactly same observations to be 0.0008%.
Conclusions: The wide range of measurements in the present study suggested a high possibility of variations amongst the population. If all the parameters including both morphometric and somatoscopic, are taken into consideration, the pinna of ear of each individual is a very distinctive structure, which makes it a potential biometric identifier and with the use of proper technologies, it will be a widely used biometric tool in the future.

Keywords: Auricle, Biometric, Ear, Identifier, Pinna

INTRODUCTION

Pinna of ear is a cartilaginous projecting portion of the external ear. Different parts of the pinna are: Helix, antihelix, triangular fossa, scapha, tragus, antitragus, concha, and ear-lobe (Figure 1). Many times, there is a small expansion of the helical fold at the junction of the superior and descending portions of the helix which is called Darwin tubercle. The lateral surface of the pinna is irregularly concave, faces slightly forwards, and displays numerous eminences and depressions due to the unique arrangement of the parts of the pinna mentioned above. In 1896, a French police officer/criminologist Bertillon stated in his book - "The ear, thanks to these multiple small valleys and hills which furrow across it, is the most significant factor from the point of view of identification. Immutable in its form since birth, resistant to the influences of environment and education, this organ remains during the entire life like the intangible legacy of heredity and of the intra-uterine life."[1] Bertillon was one of the pioneers who used external ear biometric for identification of criminals.[2]

For any ideal biometric tool/identifier, certain prerequisites should be fulfilled to achieve the highest precision of personal identification. These include universality (every person using a system should possess the trait), uniqueness/distinctiveness (sufficiently different characteristics for any two individuals), permanence (of features and characters of the trait over long period of time), measurability/collectability (ease of acquisition or measurement of the trait), performance (recognition accuracy and speed), acceptability (willingness of people for the use of a particular biometric identifier in their daily lives), and circumvention (actually absence of it so that it resists any fraudulent attempt).[3] Pinna of ear fulfills all the criteria of biometric identifier – like: all individuals possess ears (universality); features of pinna for each individual are unique; and its size and shape remains same for maximum period of life (permanence). It also fits into the criteria of measurability, accuracy, acceptability, and circumvention.

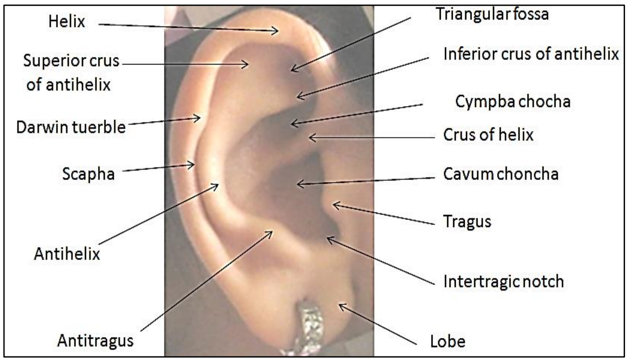

Figure 1: Anatomy of pinna of ear.

Although fingerprints are the most popular means of biometric for a long period of time, retinal patterns or shape of hand or iris patterns and even face biometric have also been in use at some of the places. But still their use is limited as they have their own inadequacies e.g. retinal scans cannot be done from a distance or facial biometric cannot be accurate due to factors such as changeability of facial expressions and use of cosmetics. While iris is a comparatively better means of biometric, its small size is its drawback.[4,5]

Exploration of external ear as a biometric tool has been going on for more than 120 years.[2] But as the accuracy and robustness of fingerprints for personal identification consistently increased, it did not happen for the ear. It may be because the technology to use ear as a biometric was insufficient in the past. However, in the recent past with increasing computerization and development of different types of sensors, the possibility of using ear biometrics is now on its way.

In the present study, morphometric and somatoscopic data of right ear of 350 Indian individuals was collected, and the likelihood of using pinna of ear as a biometric identifier was explored by extrapolating the probability statistics.

METHODS

Inclusion criteria

- Individuals within the age group of 17-25 years.

Exclusion criteria

- Individuals whose normal external ear morphology has been altered by trauma, accidents or surgery.

Equipments: Digital caliper, spreading caliper.

After the ethical committee approval, the informed consent was obtained from the individuals participating in the present study.

Observations were taken on the right ear of 350 healthy Indian individuals including 135 males (38.6%) and 215 females (61.4%). All the observations were done on the right ear as the literature mentions a good symmetry and no statistically significant difference in right and left ears.[6,7]

Total 7 morphometric characteristics were included - pinna length, pinna width, attachment/root of ear, pinna projection, ear lobe length, ear lobe width, distance between tragus and antitragus (intertragic distance). The measurements were recorded in centimetres and data was tabulated and analyzed statistically. The measurements were based on following landmarks.

Pinna length

Maximum length measured from the superior to the inferior aspect of the external ear

Pinna 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

Attachment/root of ear

Distance between otobasion superior- Obs (most cranial attachment of pinna to head) and otobasion inferior- Obi (most caudal attachment of earlobe to face)

Pinna projection

Distance of the outer edge of the helix of the ear to mastoid

Ear lobe length

From lowermost point of intertragic notch to inferior aspect of the external ear

Ear lobe width

Maximum transverse distance across the lobe.

Total 3 Somatoscopic parameters were included - Presence or absence of Darwin tubercle, Helix - flat/rolled, Attached (to cheek) or free Ear lobe.

RESULTS

Morphometric parameters included pinna length, pinna width, pinna projection, pinna root, ear lobe length, ear lobe width, and intertragic distance. Range for all the parameters was large. Mean values and range of all morphometric parameters are shown in Table 1.

Table 1: Mean values and range of all morphometric parameters, N=350.

Parameters	Mean	Range
Pinna length	5.78	4.71-7.16
Pinna width	3.08	2.33-4.32
Pinna root/attachment	4.54	3.06-6.03
Projection	2.04	0.40-2.80
Lobe length	1.74	1.40-2.06
Lobe width	1.85	1.70-2.11
Distance between tragus and antitragus	0.74	0.57-1.02

There was significant statistical difference in the morphometric values of pinna between the males and females. These values of pinna are shown in Table 2.

Table 2: Pinna: Mean values and range in males and females.

	Male	Female
Parameters	**Mean**	**Mean**
Pinna length	5.96 (5.09 - 7.16)	5.60 (4.71-7.07)
Pinna width	3.18 (2.61-4.32)	2.98 (2.33-3.91)
Pinna root/ attachment	4.69 (3.08-6.03)	4.40 (3.06-5.88)
Projection	2.11 (0.46-2.80)	1.97 (0.40-2.60)
Lobe length	1.78 (1.42-2.06)	1.71 (1.40-1.95)
Lobe width	1.90 (1.78-2.11)	1.84 (1.70-2.05)
Distance between tragus and antitragus	0.76 (0.60-1.02)	0.72 (0.57-0.91)

Somatoscopic parameters included presence or absence of Darwin tubercle, Helix - flat/rolled, and ear lobe attachment to cheek.

The present study found 82.9% individuals with presence of Darwin's tubercle and 17.1% with absence of it. (Table 3).

Table 3: Presence or absence of Darwin tubercle.

Parameter	Detail	Sex		Total
		Male	Female	
Darwin's tubercle	Absent	26	34	60
	Present	109	181	290
Total		135	215	350

Rolled helix (99.1%) was seen to have much common occurrence as compared to the flat helix (0.9%) (Table 4).

Table 4: Types of helix.

Parameter	Detail	Sex		Total
		Male	Female	
Helix	Rolled	132	215	347
	Flat	3	0	3
Total		135	215	350

The attached ear lobe was found to be present in 34.6% subjects, while it was free in 65.4% subjects (Table 5).

Table 5: Types of ear lobe.

Parameter	Type	Sex		Total
		Male	Female	
Ear lobe	Attached	45	76	121
	Free	90	139	229
Total		135	215	350

Considering these 10 parameters (both morphometric and somatoscopic) in the given sample, the calculation of probability statistics of any two individuals having exactly same observations was found to be 0.0008%. (Table 6).

DISCUSSION

The observations in the present study reiterated the tremendous diversity in the different characteristics of pinna of ear, which is the key to the uniqueness of any biometric identifier. If we have a look at the range of the morphometric parameters in the present data e.g. Pinna length (4.71-7.16), pinna width (2.33-4.32), pinna root (3.06-6.03), projection (0.40-2.80), they are very wide, which suggests infinite possibilities of variations of pinna. The statistics made it evident that even with these 10 parameters, the probability of matching of pinna of two different individuals in the given population is 0.0008%. Thus, it is pertinent that inclusion of more number of morphometric measurements and somatoscopic parameters having more variable characteristics, the probability will be almost zero. For the helix of ear, we only considered two variables i.e. rolled and flat. But the curve of helix shows many variations. So, if one considers inclusion of those variations in the database, it will improve the performance of pinna as a biometric identifier. In a study where similar parameters were used to make simplified algorithms proved that it helped 100% personal identification in the given sample size. The same study also mentioned that the curve of helix is a reliable anatomical structure for the identification of a person.[8]

Table 6: Probability statistics of any two individuals having exactly same observations with the 10 parameters.

Parameter	Division	Probability
Ear lobe	Attached	50%
	Free	
Helix	Rolled	50%
	Flat	
Darwin Tubercle	Present	50%
	Absent	
Pinna length	Range 4.71-7.16 (divided into six categories)	16.66%
Pinna width	Range 2.33-4.32 (divided into five categories)	20%
Pinna projection	Range 0.40-2.80 (divided into six categories)	16.66%
Pinna root	Range 3.06-6.03 (divided into seven categories)	14.28%
Ear lobe length	Range 1.40-2.06 (divided into two categories)	50%
Ear lobe width	Range 1.70-2.11 (divided into two categories)	50%
Intertragic distance	Range 0.57-0.74 (divided into three categories)	33.33%
Probability of any two individuals having exactly same observations		0.0008%

Automatic ear detection methods have been coming up, and from the beginning of this century many researchers are trying to find out a perfect method either with 2D or 3D images. These methods have been trying to overcome the limitation of ear biometric e.g. occlusion of ear by hair or use of ear ornaments.[9]

CONCLUSION

The data of 350 individuals in the present study will help in providing a database of Indian population. If all the morphometric and somatoscopic observations are taken into consideration, the pinna of ear of each individual seems to be very distinctive structure, which makes it a very good biometric identifier and with the use of proper technologies, it will be a widely used biometric tool in the future.

ACKNOWLEDGEMENTS

Authors would like to acknowledge the individuals who cooperated and participated in the present study.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Hurley DJ, Arbab-Zavar B, Nixon MS. The ear as a biometric. Handbook of Biometrics; 2007:25-29.
2. Abaza A, Ross A, Herbert C, Harrison MAF, Nixon M. A survey on ear biometrics; 2011. Accepted at ACM Computing Surveys. Available at http://eprints.ecs.soton.ac.uk/22951/. Accessed on 18 July 2017.
3. Jain AK, Ross A, Prabhakar S. An introduction to biometric recognition. IEEE transactions on circuits and systems for video technology. 2004;14(1):4-20.
4. Burge M, Burger W. Ear Biometrics, Chapter 13. In: Jain A, Bolle R, Pankanti (Hrsg.) S, eds.Ear Biometrics – Personal Identification in a Networked Society, Kluwer Academic Publishers; 1999. Retrieved at http://www.hagenberg.at/burger /publications/index.html. Accessed on 19 July 2017.
5. Suryawanshi S. The ear as a biometric. Int J Comp Sci Mob Comput. 2015;4(2):61-5.
6. Barut C, Aktune E. Anthropometric measurements of the external ear in a group of Turkish primary school students. Aesth Plast Surg. 2006;30:255-9.
7. Alexander KS, Stott DJ, Sivakumar B, Kang N. A morphometric study of the human ear. J Plast Reconstr Aesthet Surg. 2011;64(1):41-7.
8. Ragan EJ, Johnson C, Milton JN, Gill CJ. Ear biometrics for patient identification in global health: a cross sectional study to test the feasibility of a simplified algorithm. BMC Res Notes. 2016;9:484.
9. Pflug A, Busch C. Ear biometrics: a survey of detection, feature extraction and recognition methods. Biometrics IET. 2012;2:114-29.

Cite this article as: Maitreyee M. Pinna of ear: a potential biometric identifier. Int J Res Med Sci 2017;5:3843-6.