SciMedCentral

Annals of Forensic Research and Analysis

Research Article

Application of External Ear in Personal Identification: A Somatoscopic Study in Families

Ruma Purkait*

Department of Anthropology, University of Allahabad, India

***Corresponding author**

Ruma Purkait, Department of Anthropology, University of Allahabad, Allahabad, U.P. 211002, India, Tel: 919-455-228-39; Email: r.purkait@gmail.com

Submitted: 02 January 2015

Accepted: 17 April 2015

Published: 18 May 2015

Keywords

- Personal identification
- External ear
- Soft biometric trait
- Somatoscopic characters

Abstract

Human morphological features are used as 'Biometric' traits for establishing identity of a person. The present study investigates the potential candidature of external ear as a tool for identification even among genetically related persons. The study investigates its uniqueness, the degree of morphological similarity/dissimilarity of its features and identifies the most variant features of them. The knowledge of the ear features whose expressions are variable even in genetically related persons could be useful in establishing personal identity. The study sample included members of 90 general and 30 tribal families of Central India. A validation study was performed on members of 54 North Indian families. Adopting Somatoscopic method ten characters of the external ear were analyzed. To investigate the variability in ear features of the closest genetic relation 90 monozygotic twin pairs were also included in the study.

Analysis of the data found that none of genetic relations except one monozygotic twin pair shared all ten matching ear features. The shapes of ear, lobule and upper helix were found to be most variant characters among members of families and monozygotic twin pairs. Among various genetic relations in families the ear features exhibited maximum dissimilarity between grandparent-grandchild and were most similar among monozygotic twin pairs.

The study has proposed a classification of ear features for personal identification based on the seven most variant ear characteristics. The classification will benefit the Forensic Scientists in personal identification cases and Computer Scientist in improving the functionality of Ear Biometric system by using these as Soft Biometric traits.

INTRODUCTION

In the present electronic world the traditional methods of identification (identity card, password, magnetic cards) have given way to technologically and security wise more effective mode of identification, human physical and behavioral (Biometric) traits. Presently characteristics like, face, fingerprint, iris, signature etc. are widely recognized. Other morphological features, e.g. external ear, by virtue of great variability in form may find its use in the same field. For any trait to be used for identification purpose it is necessary to possess few desirable properties. One such property is uniqueness of the trait in all [1]. If one looks at the history of personal identification, the claim of external ear as a potential tool for individualization was made by many Scientists [2-6]. But still the question of its uniqueness though accepted as statement, '*nature creates things and shapes with large between individual variations*', was not empirically proved [7]. Against this backdrop, the author had conducted a preliminary study to test the uniqueness of external ear on a limited sample of 700 unrelated individuals [8] by metric method.

It is a fact that various features of external ear are under multiple genetic controls and are expected to behave in similar manner in genetically related persons. Hence for considering external ear as a probable Biometric trait it was felt necessary to test its uniqueness among genetic relatives and also to estimate the degree of similarity/variability of ear features existing in different genetic relations.

Few morphological characteristics e.g. skin colour, stature, hair colour have been incorporated in recent times in identification system to improve its function. These characteristics, 'Soft Biometric' traits, though exhibit low discriminating power reduces the error rate and computation time of the identification system [9]. The ear features which are highly variable even in genetically related persons can be used as 'Soft Biometric' characteristic and could be useful in personal identification study. Hence the present study sets out to identify those varying characteristics in the external ear.

MATERIALS AND METHODS

The study was conducted in Central India covering the districts of Sagar, Raisen and Ujjain. The data were collected over a period of 4 years, between 2008 and 2012.

Subjects

The study covered all cross section of people (general) and few tribal (Bhil and Saura) groups. In total, images were procured from 96 families belonging to general population and 34 families from tribal groups. While finalizing the data some of the members were found missing in few families, and hence were removed from the final analysis. The final sample for family study comprised of 90 and 30 families belonging to general and tribal populations respectively. Out of 90 families, 55 families included members from three generations while 35 families were restricted to two generations only. Similarly, among tribal groups 19 were 3 generation families and 11 families had members from 2 generations. Most of the families mentioned above were joint families. In total 648 members of general and 243 members of tribal families took part in the study. All the subjects were normal and healthy. None of them suffered from any auricular (congenital or traumatic) or maxillofacial deformity.

An additional sample consisting of monozygotic twins was collected to investigate the variation among the closest genetic relations. Ninety pairs of twins were examined from Central India and Allahabad district in North India.

Method

Bilateral images of subjects from a distance of 30cm were acquired with Kodak Easy Share CX7330, 3.2 Mega pixel digital cameras. During photography the head of the subject was oriented in Frankfurt horizontal plane and the focal plane of the camera was parallel to the longitudinal plane of the external ear. This negated any protrusion in external ear, thereby producing uniformly aligned images of subjects. The camera was fixed on a tripod (Flaxzy SW-F705A) so that it could be elevated to the level of ear of the subject. The images were acquired in daylight. The various parts of external ear are depicted in Figure 1. Ten Somatoscopic characters pertaining to eight features of external ear were analyzed in the study (Table 1), (Figures 2-7). The features were categorized as per the classification given by Lugt [10] and Farkas [11]. Few characteristics features, e.g. shapes

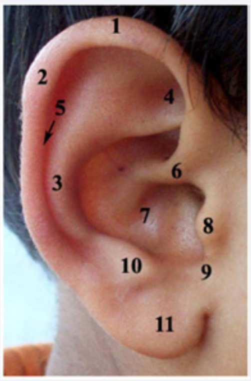

Figure 1 Features of external ear.
1. Helix 2. Darwin's tubercle 3. Antihelix 4. Triangular fossa 5. Scapha 6. Crux of helix 7. Concha 8. Tragus 9. Incisura intertragica 10. Antitragus 11. Lobule

Table 1: Somatoscopic characteristics describing the form of external ear.

Features	Characteristics	Classification
External ear	Shape	Triangular
		Round
		Oval
		Rectangular
Darwin's tubercle	Shape	Absent
		Nodosity
		Enlargement
		Projection
		Tubercle
Helical fold	Form	Flat
		Curved
		Normally rolled
		Wide covering scapha
	Shape of	Acute medial angle
	upper helix	Upper directed angle
		Obtuse medial angle
		Obtuse lateral angle
		Obtuse acute angle
		Double right angle
		Obtuse angle
		Circular
Tragus	Shape	Long
		Round
		Knob shaped
Anti-tragus	Shape	Prominent
		Medium
		Flat
Lobule	Shape	Tongue
		Triangular
		Rectangular
		Arched
		Round
	Attachment to	Attached
	cheek	Partially attached
		Free
Concha	Shape	Narrow
		Proportionate
		Broad
Anti helix-concha	Shape	Straight
border		Curved
		Round
		Laterally protruding

of upper helix, tragus, concha, antitragus and antihelix-concha border, shapes and attachment of lobule were categorized by the author. Somatoscopic features of each subject were observed and a ten character comparison was made with other members of the family who had genetic relation with him/her. For example, in a 3 generation family, a grandfather's characters were compared with his son/daughter and grandson/granddaughter but not with his daughter-in-law as they are genetically not related. Five categories of relations have been identified, grandparent and grandchild, parent and child, parental siblings and nephew/niece, among siblings and cousin (first and second) siblings. For

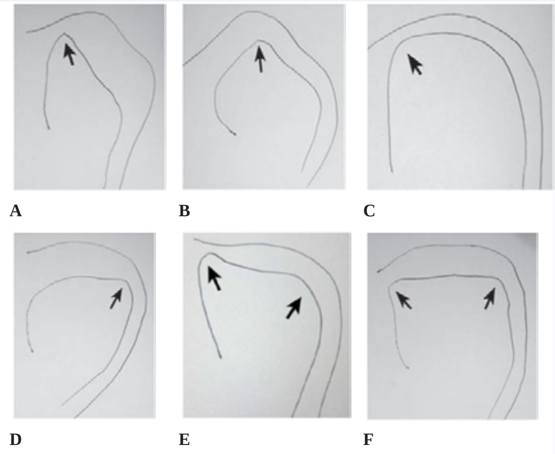

Figure 2 Forms of Upper helix.
A. Acute angle medial B. Angle upper directed C. Obtuse angle medial D. Angle laterally directed E. Obtuse acute angle F. Double right angle G. Double Obtuse angle H. Circular

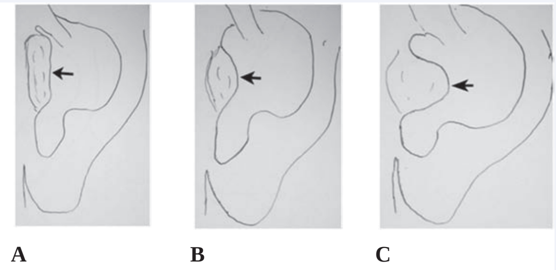

Figure 3 Shape of tragus.
A. Long B. Round C. Knob

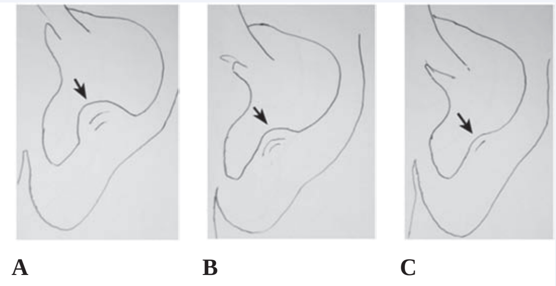

Figure 4 Shape of Anti tragus.
A. Prominent B. Medium C. Flat

uniqueness test members of each genetic pair were matched with each other and the pair which matched completely on all ten characters was further compared by image superimposition method. In non-matching pairs the dissimilarity in characters between paired relations was noted. The other part of the analysis concentrated on identifying the Somatoscopic features which exhibited highest frequency of dissimilarity in pair wise matching.

As a validation test the same study was carried out in Hamirpur district of Himachal Pradesh in North India. 54 families (36 three generation and 18 two generation) comprising of 378 members residing in the state formed the test sample.

Repetitive tests

It is a fact that reliance on the visual assessment of external ear morphology has the inherent disadvantage of lending an element of subjectivity in the study. Repetitive tests were performed to assess the level of this subjectivity. Two tests were undertaken involving variation in images and identification of features, both within (intra-observer) and between operators (inter-observer).

For testing variation in images, three tests were conducted, changing light condition, distance from camera and pose of the

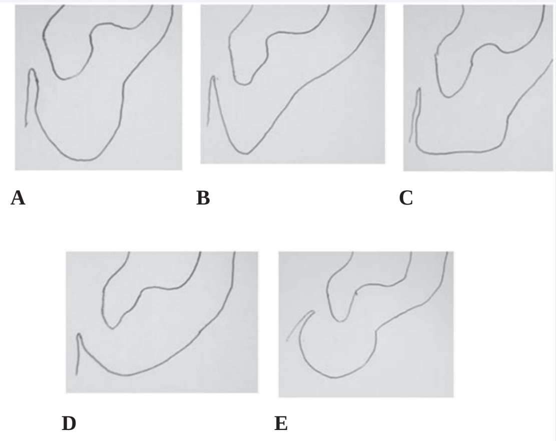

Figure 5 **Shape of Lobule.**
A. Tongue B. Triangular C. Rectangular D. Arched E. Round

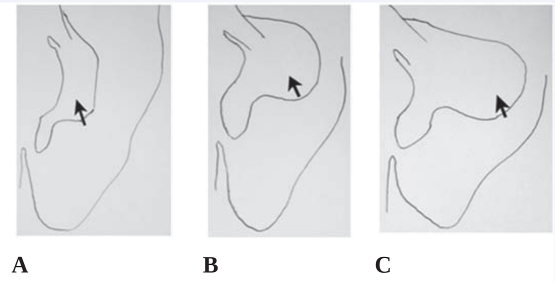

Figure 6 **Shape of Concha.**
A. Narrow B. Proportionate C. Broad

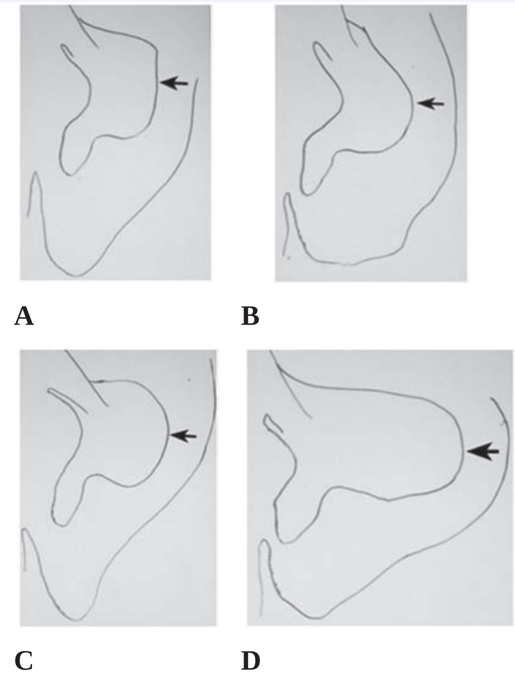

Figure 7 **Shape of Antihelix-concha border.**
A. Straight B. Curved C. Round D. laterally protruding

subject. Images of the same person were procured in sunlight, reflected/indirect sunlight and in room illuminated with 40watt tube light. The position and distance of camera and the pose of the subject was same as described above. Another set of images were acquired by varying the distance of the camera from the subject, at 30cm, 45cm and 60 cm. In the last test variation was made in the position of head e.g. parallel, rotated laterally (in horizontal axis) at 20 degrees and 30 degrees to the focal plane of camera. Only classification of upper helix was attempted on the images. The test was repeated on ten subjects. To determine the error rate in classifying ear features, five ear characteristics (shapes of ear, upper helix, lobule, tragus and anti tragus) were selected for the test.

Intra observer test was undertaken by the author for both experiments. To determine consistency in classification of ear features the test was repeated five times over a period of six months, with a week or more gap between each session. The classifications of all sessions were compared and agreement noted.

Similarly the inter-observer test was performed by ten volunteers. Representative images of each type of ear feature (e.g. triangular, round, oval and rectangular shapes for ear shape characteristic) were shown to the volunteer prior to starting the test. A series of ten ear images (covering all the classification subtypes) belonging to ten individuals were given as test images to volunteers for classification. The classifications given by all volunteers were compared and agreement noted. Kappa statistics [12-13] measured the extent of agreement.

In the present report the result of paired comparison of only left ear features in various genetic relations is presented. The result of right ear shows similar trend. Due consent was sought from the subjects before acquiring images. The study conformed to the guidelines set by the Ethical committee of Indian Council of Medical Research, New Delhi.

RESULTS AND DISCUSSION

The kappa statistic provides a measure of agreement among observers over the categories assigned to any subject [12-13]. Generally Kappa values ranges between 0 and 1, unity represents perfect agreement, indicating that the observers agree in their classification of every case. Zero indicates agreement no better than that expected by chance, as if the observers had simply "guessed" every rating [14-16]. In the present study, the intra and inter-observer agreement were fairly high for most of tests (Table 2). The pose variation experiment looked at how lateral rotation of ear affected performance of the observer. The kappa value of agreement in this case was quite low and is not likely to be practically meaningful.

Although Somatoscopic observations of the ear are not sufficient to establish the identity of a person, they may be used to exclude cases which are not matching at preliminary stage of investigation.

Testing uniqueness

The present study applies Somatoscopic method to test the phenomenon of uniqueness among genetically related individuals. During the investigation none of the paired relatives were found to match completely except for one twin pair (1.11%) (Table 3, columns 1 through 4). The matched twin pair when further subjected to direct image superimposition by SPAN [8] showed distinct points of dissimilarity in various parts of ear structure.

The observation in fact is interesting as the paired members are sharing common genes depending on the degree of closeness in the relation. Though Somatoscopic analysis is thought to give 'subjective' assessment of the ear structure the array of characteristic features so selected in the study seems to bring out the differences even in closely related member pair.

Variation/dissimilarity in genetic relations

The paired comparison was performed between generations (vertically) and laterally among relatives of same or other generation (Table 4). The mean dissimilarity in each paired relation was calculated and for convenience of comparison, mean, collectively representing a category was determined. When the mean ear feature dissimilarity was compared among various relations in families of Central India, the relation between first and third generation (grandparent-grandchild) was found to have highest dissimilarity while monozygotic twin pairs followed by siblings were closest having least. The result of validation test

Table 2: Kappa values for assessment of intra- and inter-observer agreement in image variation and classification of ear features.

Tests	Intra-observer Error		Inter-observer Error	
	Kappa value [17]	Agreement status	Kappa value [17]	Agreement status
Variation in imaging	*conditions:*			
Light	0.833	Substantial	0.679	Substantial
Camera distance	0.687	Substantial	0.561	Moderate
Ear position	0.174	Slight	0.133	Slight
Classification of ear features: Shape of :				
External ear	0.77	Substantial	0.592	Moderate
Upper helix	0.571	Moderate	0.679	Substantial
Lobule	0.531	Moderate	0.606	Substantial
Tragus	0.613	Substantial	0.581	Moderate
Anti tragus	0.479	Moderate	0.657	Substantial

Table 3: Somatoscopic analysis for testing Uniqueness and Variation in ear features in various genetic relations among family members.

Sample	Families	Total pairs of relation analyzed	No. of complete matching pairs	Feature showing Max. variation	Max. No. of mismatched pairs
General	90	1699	Nil	Shape of Ear	1176
Tribal	30	683	Nil	Shape of Lobule	506
Total sample of Central India	120	2382	Nil	Shape of Lobule	1625
Validation study in Northern India	54	1593	Nil	Shape of Ear	1104
MZ twins pairs	90	90	1	Shape of Upper Helix	49

Table 4: Somatoscopic analysis showing dissimilarity in ear features in pair wise comparison among family members of Central India.

Relationships	General population				Tribal population		
	Number of Cases	Total no. of dissimilarity in ear features	Mean dissimilarity		Number of Cases	Total no. of dissimilarity in ear features	Mean dissimilarity
Grandparent-grand child	307	1718	6.15		114	722	6.33
Parent-child	643	3416	5.31		226	1174	5.15
Parental sibling-Nephew/Niece	298	1763	5.62		163	1034	6.14
Among cousins	216	1138	5.37		34	156	4.86
Among sibling	235	1123	4.78		156	718	4.61
Monozygotic Twins	90	340	3.78		-	-	-

(Table 5) resembled the trend exhibited by general families of Central India.

The Cousin enigma

An interesting feature was witnessed in two relations, parent-child and among cousins. Both the relations show similar variation in ear structure (Table 4, parent-child is 5.31 while cousins is 5.37), when the former is first degree relation (sharing 50% of genes) and the latter is third degree one (sharing 12.5% of genes). Among tribal group (Table 4, column 7) the ear features exhibit closer relation among cousins (4.86) than parent-child (5.15).

The test performed on North Indian sample produced similar result (Table 5). In this sample though the parent-child similarity is more than between cousins, the latter relation is still closer than between grandparent-grandchild and parent siblings-nephew/niece relation. If one looks at the genetic aspect, the third degree relation showed more similarity than second degree ones. It is difficult to furnish any scientific reason for the aberrant behaviour of the 'cousin' category in dissimilarity test in both samples.

Based on his study of parents and children Iannarelli [6] commented that '*there was no appreciable similarity of ear configuration between the child and the parent. Though …., there was some likeness of ear form between children of the same parent.*' The outcome of the present study also finds that the siblings exhibited maximum closeness in ear structure though parent and child too exhibit similarity to some extent as empirically proved above. It is pertinent to mention here that the closeness in the ear structure among siblings does not preclude the uniqueness of individual ear.

Identification of variant ear features

The possibility of using external ear as a tool for identification is largely based on the concept that the form of ear features constituting the external ear varies from person to person. In other words it is to be investigated whether these features can play the same role as the ridge characteristics in fingerprint identification. Somatoscopic observation concerned with visual inspection is generally considered as 'soft' form or suitable for preliminary level of examination. The more Somatoscopic characteristics define any anatomical structure the assessment is generally graded higher on its objectivity. The human external ear presents few such features which can be defined by various Somatoscopic characteristics. In order to narrow down the subjectivity in the analysis, greater number of characteristics defining the ear has been selected in the study.

When ear features were compared among family members (columns 5 and 6 in Tables 3, Figs 8 and 9) the shape of ear, lobule, upper helix, tragus and antihelix-concha border had exhibited largest variation. Among twins the shape of upper helix was leading followed by shape of ear. The other variants, shape of lobule, antihelix-concha border, tragus and Darwin's tubercle had followed. While studying Darwin's tubercle among monozygotic

Table 5: Validation study: Dissimilarity in ear features in pair wise comparison among members of 54 families of Northern India.

Relationships	North India		
	Number of Cases	Total no. of dissimilarity in ear features	Mean dissimi-larity
Grandparent-grand child	303	1876	6.19
Parent-child	342	1971	5.76
Parental sibling-Nephew/Niece	387	2160	5.98
Among cousins	411	2214	5.89
Among sibling	165	843	5.11

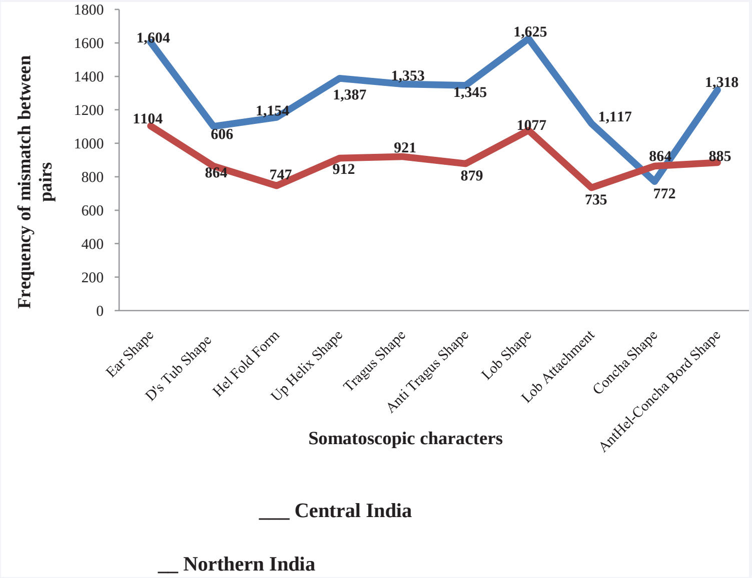

Figure 8 Frequency distribution of mismatch of Somatoscopic characters when compared among pair of family members in Central and Northern India.

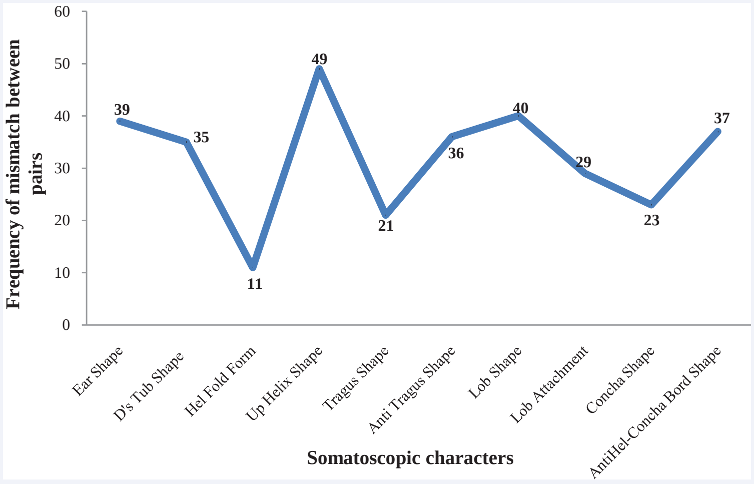

Figure 9 Frequency distribution of mismatch of Somatoscopic characters when compared among pair of MZ twins.

twins Quelprud [17] found the tubercle to be irregular in its presence, being unilateral in one and bilateral in the other twin and its size also varied. Quelprud [18] also commented on the variable shape and length of the ear lobe among monozygotic twins. Variation was also found in the degree of the folding of the helix [19] among identical twins. Our study on monozygotic twins supports the above observations except for the helical fold which scored low variation. It may be worth mentioning that the characteristics which are varying even in genetically identical individuals may also suggest a role of environmental factor in their phenotypic expression. The characteristics having such variant nature find profound use in personal identification study.

Proposal of New classification of ear variants

On identifying the most variant features of ear a Somatoscopic classification has been proposed in the present study. It includes shape of seven ear features with the same number of ear characteristics namely:

i. helical fold (shape of upper helix),
ii. lobule,
iii. external ear,
iv. tragus,
v. antihelix-concha border,
vi. anti tragus and
vii. Darwin's tubercle

Though the classification is based on the degree of variance of the ear characteristics it included all the features of ear.

Its application

Personal Identification: While comparing images of ear for identification in forensic cases, before proceeding for direct superimposition, one can visually compare the above ear shape characteristics to locate any variation. For example, if the lobule is triangular in the known subject and rectangular in 'questioned' subject, there may not be a requirement to proceed for further investigation on the 'questioned' subject. Moreover, these characteristics are related to different features of the ear, hence even if partial image is available as a 'questioned' ear the feature characteristics seen in the 'questioned' image can be compared to the known ear sample.

Soft Ear Biometrics: Biometrics or better 'Biometric authentication' is a method of identifying or verifying the identity of an individual based on the physiological and behavioral characteristics. A Biometric trait (e.g. face, fingerprint etc.) is distinct in every individual. During identification the machine automatically locates, extracts, encodes and matches distinctive characteristics from the biometric sample. This ultimately leads to identification of a person. Apart from other factors the performance of the system depends on the trait's uniqueness and computation time of the system. Few anthropological characteristics e.g. skin colour, stature, hair colour had been incorporated in recent times in Biometric system to improve its function for identification/verification. These characteristics called ***Soft Biometric traits***, though exhibit low discriminating power reduces the error rate and computation time of the system [9].

Though Somatoscopic characteristics are not unique to any individual, the information about the variant characteristics (showing high variability between individuals and are least affected by genetic relation) if stored in the system with primary biometric data, may improve the speed and search efficiency of the application software. For example, during the authentication of an individual with round ear shape, the system will automatically restrict the search area to the subjects with this profile enrolled in the database (ignoring individuals with triangular, rectangular or oval shaped ear) thereby reducing the search area and improving the computation time of the system.

Though the question of uniqueness was rarely addressed by Scientist before, several studies have attempted to test the utility of external ear as a tool for personal identification. Most of the studies were undertaken by Computer Scientists adopting diverse methods of analysis. To mention a few landmark studies Burge and Burger [20] made use of neighborhood graph from Voronoi diagram of the ear. They also proposed thermogram imagery to circumvent the problem of ear being hidden by hair. Victor et al. [21] and Chang et al. [22] adopted Principle component analysis to identify external ear. When the performance of face and ear was compared Victor et al. [21] found face to surpass ear while Chang et al. [22] found similar performance for both. Geometric automated and neural classifier techniques were used by Choras [23] and Moreno et al. [24] respectively for ear identification. Most of the above mentioned methods achieved high identification percentage. In India a novel approach of Haar wavelet transformation was used by Sana et al. [25] in which the images were decomposed and coefficient matrices of wavelet were computed. The method achieved 98% accuracy. The Somatoscopic features identified in the present study can be used in the preliminary stage of investigation.

CONCLUSION

The study explores the possibility of human external ear's suitability as a tool for identification. The Somatoscopic comparison of ear characteristics among the genetic relations revealed its unique nature. Even the ears of genetically closest relative, identical twins have similar but distinct morphology. Few ear characteristics were identified which despite genetic closeness exhibited marked dissimilarity in morphology.

Based on the variant nature of human ears a new Somatoscopic classification has been proposed in the study. The classification proposes its use for initial level pruning by Forensic Scientists before using other methods for in-depth analysis. These ear characteristics may be also used as 'Soft Biometric' traits to improve the functioning of a Biometric system.

Limitations of the study

The ear has nearly coplanar/flattened structure. With vertical or horizontal rotation of head the shape of various ear features may not be visible in the image for a faithful classification.

It is an established fact that various parts of external ear do exhibit changes with progression of age. The elongation of lobule contributes maximum to the overall increase of ear length, especially after 60 years of age [26-27]. This will necessitate Law enforcement agencies to frequently update the biometric database for all ages beyond 60 years.

ACKNOWLEDGEMENTS

The author is grateful to the subjects for their cooperation during the study and gratefully acknowledges the assistance of Dr. Nasir Ahemad and Mr. Sandeep Prasad Daksha in the field.

REFERENCES

1. Jain AK, Ross A. Introduction to Biometrics. In: Jain AK, Flynn P, Ross A, editors. Handbook of Biometrics, New York: Springer Science+Business Media. 2008.
2. Bertillon A. Identification anthropometrique: Insructions signaletiques. Paris: Masson. 1893.
3. Locard E. L'identification des recidivists. Paris: Maloine. 1909.
4. Fields C, Falls HC, Warren CP, Zimberoff M. The ear of the newborn as identification constant. Obstet Gynecol. 1960; 16: 98-102.
5. Lugt CV. Ear identification – State of Art. Infor Bull Shoeprint/Toolmark Examiners. 1998; 69-81.
6. Iannarelli A. Ear Identification. Forensic Identification series. Freemont, California: Paramount Publishing Company; 1989.
7. Moenssens AA. Ear identification research. Forensic-Evidence.com/UMKC School of Law. http://forensic-evidence.com/site/ID/ID00004_4.html;1999.
8. Purkait R, Singh P. A test of individuality of human external ear pattern: its application in the field of personal identification. Forensic Sci Int. 2008; 178: 112-118.
9. Jain AK, Dass SC, Nandakumar K. Can soft biometric traits assist user

recognition? Proceedings of SPIE Defense and Security Symposium. 2004; 5404: 561–572.

10. Lugt CV. Ear Identification. Bedrijifsinformatie's Gravenhage: Elsevier; 2001.

11. Farkas L. Anthropometry of the head and face in medicine. New York: Elsevier; 1981.

12. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas. 1960; 20: 37-46.

13. Fleiss J. Measuring nominal scale agreement among many raters. Psychol Bull. 1971; 76: 378-382.

14. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977; 33: 159-174.

15. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. Fam Med. 2005; 37: 360-363.

16. Shoukri MM. Measures of interobserver agreement. Florida: Chapman & Hall/CRC. Press. 2004.

17. Quelpred T. Zur Erblischkeit des darwinschen H?ckerschens Z Morph Anthropol. 1936; 34:343-63.

18. Quelpred T. Die ohrmuschel und ihre Bedeutung fur die erbbiologische Abstammungsprufung. Der Erbarzt 1935; 8121-25.

19. Geyer E. Studien am menschlichen Ohr: Stellung und Faltung der ohrmuschel.

20. Burge M, Burger W. Ear Biometrics. Biometrics: Personal identification in a Networked Society. In: Jain A, Bolle R, Pankanti S. editors. Boston: Kluwer Academic Publishers; 1999.

21. Victor B, Bowyer KW, Sarkar S. An evaluation of face and ear biometrics. Proceeding of International Conference on Pattern Recognition. 2002.

22. Chang K, Bowyer KW, Sarkar S, Victor B. Comparison and combination of ear and face images in appearance-based biometrics. IEEE T. Pattern Anal. 2003; 25: 1160-1165.

23. Choras M. Ear Biometrics based on Geometrical Feature Extraction. Electr L Comp Vision Image Anal. 2005; 5: 84-95.

24. Moreno B, Sanchez A, Velez JF. On the use of outer ear images for personal identification in security applications. Proceedings IEEE Conference of Security Technology. 1999.

25. Sana A, Gupta P, Purkait R. Ear Biometrics: A new Approach. Proceedings of Sixth International Conference on Pattern Recognition; Kolkata. New Jersey, USA: World Scientific. 2007.

26. Purkait R, Singh P. Anthropometry of the normal human auricle: a study of adult Indian men. Aesthetic Plast Surg. 2007; 31: 372-379.

27. Purkait R. Anthropometry of normal human auricle. In: Preedy VR. editors. Handbook of Anthropometry: Physical measures of human form in health and disease, London: Springer; 2012, 903-917.

Cite this article

Purkait R (2015) Application of External Ear in Personal Identification: A Somatoscopic Study in Families. Ann Forensic Res Anal 2(1): 1015.