Forensic Imaging 25 (2021) 200452

Contents lists available at ScienceDirect

Forensic Imaging

journal homepage: www.sciencedirect.com/journal/forensic-imaging

Human identification by the ear: Reproducibility and applicability in a Brazilian sample

Paulo Henrique Viana Pinto [a], Maria Clara Panciera [b], Aline Maria da Silveira Sousa [b], Igor A. Kuznetsov [c], Carlos Eduardo Palhares Machado [d], Roberto Cameriere [e], Ricardo Henrique Alves da Silva [f,*]

[a] Graduation Program (Ph.D. student), Department of Pathology and Forensic Medicine, Ribeirão Preto Medical School, USP-University of São Paulo, Ribeirão Preto, SP, Brazil
[b] Undergraduate Student, School of Dentistry of Ribeirão Preto, USP-University of São Paulo, Ribeirão Preto, SP, Brazil
[c] National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Moscow, Russia
[d] National Institute of Criminalistics, Brazilian Federal Police, Ministry of Justice, Brasília, Brazil
[e] AgEstimation Project, Department of Forensic Medicine, University of Sechenov, Moscow, Russia
[f] Associate Professor (Forensic Odontology), Department of Stomatology, Public Health and Forensic Odontology, School of Dentistry of Ribeirão Preto, USP-University of São Paulo, Ribeirão Preto, SP, Brazil

ARTICLE INFO

Keywords:
Forensic Sciences
Forensic Anthropology
Crime
Biometric Identification
Ear

ABSTRACT

Objective: This research aimed to test the reproducibility and applicability of the human identification method using photographs of the ears proposed by Cameriere et al. in a Brazilian sample.
Materials and Methods: Photographs of both ears of 115 participants were captured and evaluated by three different examiners. The data obtained were submitted to Kendall's Agreement Coefficient to assess interobserver agreement, in addition to descriptive statistics to assess the proportions of the areas of each ear. The Wilcoxon test was applied to determine the similarity of the proportions of the ear. To test the ability to identify a person based on the parameters of the ear, the k-dimensional tree algorithm was used.
Results: There was a high interobserver agreement, and the size and proportions obtained between the ears were similar, except for helix proportion. Thus, most of the parameters of an ear can be identified based on the parameters of the opposite ear, and that the parameters associated with the algorithm used can classify and group a set of ears based on the similarity of their measurements.
Conclusion: It can be concluded that the method proved to be reproducible and useful as a method of human identification in a Brazilian sample.

Introduction

The identification of living people is an increasing challenge due to the occurrence of social problems such as theft and murder [1,2]. In this context, images of good quality may comprise the only available and suitable material to be used for human identification [1,2].

As they have been also described as a useful tool for the exclusion of suspects in crime scene investigation [2], photographs of the ear can also be used in the *post mortem* identification as it is a body region that has individualizing characteristics that can remain preserved for some time after death [3–5], although its application depends on the quality of the material available for analysis [6–10].

Therefore, the use of ear images has been the subject of the research that employs automated analysis [11–14]. However, if, on the one hand, the use of computational tools makes the ear identification more reliable, on the other hand, its complexity can compromise its practicality [6].

The human identification through images or photographs should be performed by morphological comparison or superimposition individualizing anatomical features or structures [15]. Nevertheless, in 2011, Cameriere et al. [6] proposed a method of human identification by images, which has the principle of calculating the area of certain regions

* Corresponding author: Av. do Café, s/n – Campus da USP Ribeirão Preto, São Paulo, Brasil. CEP: 14040-904.
E-mail addresses: paulohenriquevp@usp.br (P.H.V. Pinto), m_clarapanciera@usp.br (M.C. Panciera), alinesousa302@gmail.com (A.M.S. Sousa), iakuznetsov@mephi.ru (I.A. Kuznetsov), palhares.cepm@dpf.gov.br (C.E.P. Machado), agestimationproject@gmail.com (R. Cameriere), ricardohenrique@usp.br (R.H.A. Silva).

https://doi.org/10.1016/j.fri.2021.200452
Received 5 September 2020; Received in revised form 23 March 2021; Accepted 7 April 2021
Available online 8 April 2021
2666-2256/

of the ear. Furthermore, the method proposed stood out for the specificity and reproducibility found in an Italian sample.

Although photo-anthropometry is not currently recommended in international guidelines, such as the one recommended by the Facial Identification Scientific Working Group [15], the method by Cameriere et al. [6] was tested in this article. Thus, this research aimed to test the reproducibility and applicability of the human identification method using photographs of the ear in a Brazilian sample.

Materials and methods

This study was approved by the Research Ethics Committee of the School of Dentistry of Ribeirão Preto-University of São Paulo (Protocol: 06635019.8.0000.5419) and all participants were invited and consented to participate. A total of 115 participants (43 male and 72 female) aged between 18 and 60 years were part of the sample, all healthy and without malformations or trauma history or pathologies in the ears. The photographs analyzed did not present shadows, blur, or distortions that would make it impossible to carry out the measurements.

To obtain the photographs, a camera EOS Rebel T6i (Canon® Inc., Tokyo, Japan) was positioned at a distance of two meters from the ear of each participant. Both ears were photographed, which totaled 230 photographs. Each participant was seated in a chair positioned in an environment with controlled lighting, which dispensed the use of the camera flash. Furthermore, each participant had their hair tied by a fabric strip, and the participants that were wearing earrings or piercings were asked to remove them. Profile photographs of the participants were obtained only once and in a standardized manner according to the following technical specifications: ISO speed of 1600, shutter speed 1/80, a focal length of the lens 35 millimeters, with automatic focus and area pattern. In addition to adequate ambient lighting, each photograph was saved in JPEG format with low compression to ensure the high quality of the images.

To conduct the analysis, the software ImageJ (https://imagej.nih.gov/ij/index.html) was used and each photograph was analyzed by three observers without previous experience with ear identification, where two of them were undergraduate students in Odontology, and the other one was a Forensic Odontologist and Ph.D. student. Each observer was trained, and according to the method [6], each ear was divided into four regions (helix, antihelix, concha, and lobe) based on the arrangement of two parallel lines in the horizontal direction and two parallel lines in the vertical direction (Fig. 1). Then, corresponding the areas to each of these regions were delimited and their values were obtained in pixels.

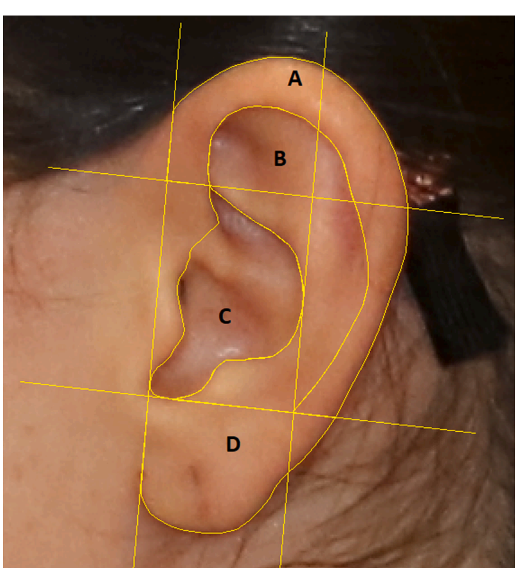

Fig. 1. Photograph of the left ear of a female participant divided into the [A] helix, [B] antihelix, [C] concha, and [D] lobe regions.

The data obtained were organized in Microsoft Excel® spreadsheets (Microsoft Corp., Redmond, WA, USA) and submitted to statistical analysis. Python™ programming language (Python Software Foundation, Beaverton, OR, USA) with a set of additional libraries was used to conduct the calculations. To assess the agreement between the observers, Kendall's Agreement Coefficient was applied. The proportions of the areas of each ear region were assessed using descriptive statistics (mean, standard deviation, minimum and maximum values). To determine the similarity of the ear proportions for a given person, the Wilcoxon test was applied. To identify a person by his ears parameters were used a *k-dimensional tree* algorithm (*KDT*) based on *N* nearest neighbors principle with Minkowski distance metric with *p*-value=2 (Euclidean metric). The *KDT* algorithm allows finding the *N*-size group of the most similar objects by given parameters [16,17]. Results accuracy evaluation was calculated using the Formula 1 developed in this research:

$$F(N) = \sum_{n=1}^{N} \frac{\sum_{k=1}^{K} 1\left(KDT_n\left(\bar{y}_k\right) = y_k\right)}{K}, N > 0, \quad (1)$$

Where:

KDT_n – function to determine the most similar n^{th} object and return id;

$\bar{y}$ – identifiable object parameters;

y – valid object id;

N – group size of similar objects;

K – number of objects in the dataset;

$1(x)$ – indicator function.

Results

The original dimensions of the measurements were used. Additionally, the proportions of the ear areas were used to identify the possibility of increasing the identification accuracy. Descriptive statistics for averaged ear area measurements obtained by the three different observers are shown in Table 1, and the proportions of the ears areas are shown in Table 2.

To determine agreement among observers was calculated Kendall's coefficient of concordance which ranges from 0 to 1, whichever is equal to 1 means high agreement. The coefficient of agreement between the three observers was described in Table 3.

To determine ears similarity for one person was calculated Wilcoxon signed-rank for original ear size and their proportions. The results in Table 4 shows that left and right ears for one person are mostly similar, except for values for helix proportion.

KDT algorithm allows to identify a person by ears parameters in two scenarios: by the similarity of the ears of one side (left ear per left ear); similarity of opposite ears (left ear per right ear).

Opposite ear identification

When the parameters of the ear are known, it is possible to identify the opposite (for the left ear, it is possible to identify the right and in the opposite direction). The following data were used in the experiment: Original size (mean)-average values by three observers with the original size of ear areas; Proportions (mean)-proportions of the ear areas; Original size (Observer 1)-values by first observer; Original size (Observer 2)-values by second observer; Original size (Observer 3)-values by third observer. The area proportions showed very close results compared to the original ones, for this reason, they were removed from the final table. In this research, it was possible to identify the right ear of each person by his left ear. The results of the experiment are shown in Table 5.

Table 1
Statistics parameters of the helix, antihelix, concha, and lobe for the whole sample averaged over three observers. The areas of regions are in pixels.

Area	Left				Right			
	Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum
Helix	8612.4	2937.2	5255.0	26437.0	8460.2	2881.9	4399.0	26313.0
Antihelix	10892.3	3794.9	3227.0	25584.0	11030.6	3695.0	5123.0	24354.0
Concha	6792.6	2230.8	3677.0	15928.0	6837.1	2181.2	3886.0	16002.0
Lobe	7612.5	2382.0	4256.0	21206.0	7553.7	2091.7	4323.0	17775.0

Table 2
Statistics parameters of area proportions of helix, antihelix, concha, and lobe, concerning the total ear area, for the whole sample**,** averaged over three observers. The area proportions of regions are in pixels.

Area	Left				Right			
	Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum
Helix	0.26	0.04	0.18	0.38	0.25	0.03	0.16	0.34
Antihelix	0.32	0.05	0.15	0.49	0.32	0.05	0.20	0.46
Concha	0.20	0.03	0.14	0.29	0.20	0.02	0.14	0.26
Lobe	0.23	0.04	0.15	0.31	0.23	0.03	0.14	0.32

Table 3
Kendall's coefficient of concordance between three observers.

Area	Left	Right
Helix	0.910	0.917
Antihelix	0.979	0.977
Concha	0.965	0.958
Lobe	0.924	0.871

Table 4
Ears similarity by wilcoxon signed-rank.

Area	Original size		Proportions	
	T	p	T	p
Helix	2664.0	0.061	2446.5	0.013
Antihelix	2992.5	0.339	2804.0	0.138
Concha	3029.5	0.394	2830.5	0.206
Lobe	3256.5	0.827	3188.0	0.800

Results in Table 5 shows that for experiment “Original size (mean)” ear identification accuracy for the first most similar ear will be 27.8%. The accuracy of these values was calculated using Formula 1. To increase the accuracy of identification it is necessary to increase the group size of similar objects. If there is a group size of similar objects equal to 20, then the accuracy that the observer will have to find the original object will be 90.4%. Full results are shown in Fig. 2.

Results in Fig. 2 shows that for data “Proportions (mean)” accuracy is worse than for the rest. The measurements between the left and right ear for the third observer deviated, but there was no such variance for the first and second observers.

One side ear identification by different observers

The same experiment was implemented for one side ear identification where identifying the left ear was measured by one observer and another observer. The results of the experiment are shown in Table 6.

The results in Table 6 shows that for the experiment “Original size-Observer 1 and Observer 2” between first observer and second observer ear identification accuracy for the first most similar ear will be 50.4%. The accuracy of these values was calculated using Formula 1. If there is a group size of similar objects equal to 20, then the accuracy that the observer will have to find the original object will be 98.3%. Full results are shown in Fig. 3.

Opposite ear identification by different observers

Another experiment was conducted to test the possibility of identification using the opposite ear by different observers. The results of the experiments are shown in Table 7.

The results in Table 7 shows that for the experiment “Original size-Observer 1 and Observer 2” identification between opposite-sided ear for different observers accuracy for the first most similar ear will be 20.0%. Full results are shown in Fig. 4.

The developed method aimed to find the most similar objects from the set for the target object. The resulting group of most similar objects will be sorted in descending order based on the similarity to the target object. Thus, the resulting sorted list can be used by a specialist for further processing in manual mode, which will reduce the total time of his work if it simply sequentially processed all objects. Thus, the developed method can be used as a decision support system in forensic sciences.

Table 5
Identification accuracy for the right ear based on the left ear.

Group size of similar objects	Accuracy				
	Original size (mean)	Proportions (mean)	Original size (Observer 1)	Original size (Observer 2)	Original size (Observer 3)
1	0.278	0.165	0.313	0.261	0.235
2	0.426	0.278	0.443	0.504	0.322
3	0.557	0.374	0.539	0.574	0.417
4	0.609	0.426	0.600	0.652	0.513
5	0.635	0.452	0.652	0.670	0.530
10	0.774	0.583	0.757	0.765	0.696
20	0.904	0.704	0.904	0.896	0.817
50	0.991	0.930	0.974	0.983	0.948

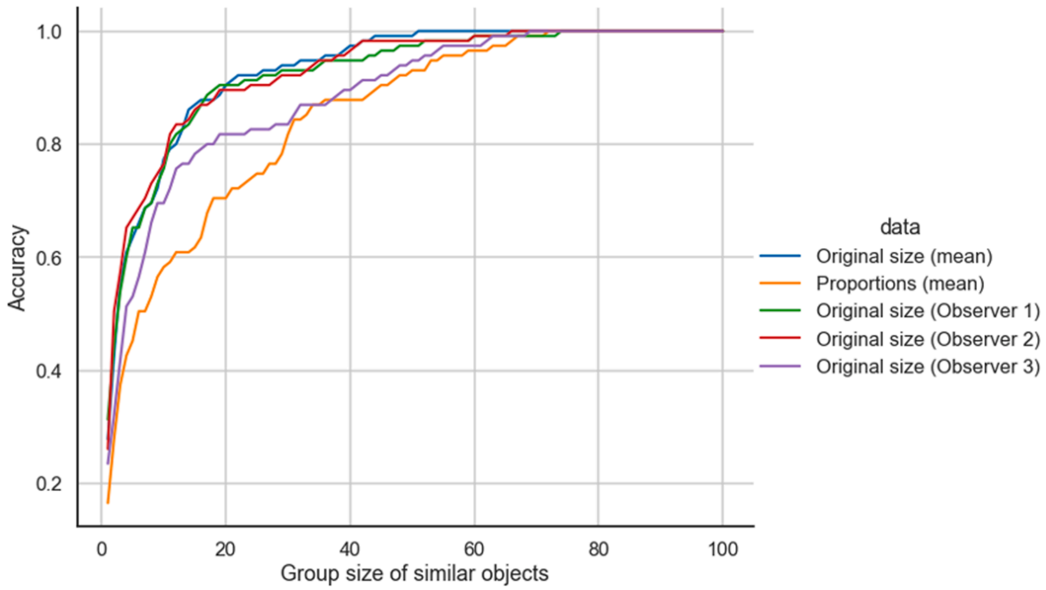

Fig. 2. Identification accuracy for the right ear based on the left ear.

Table 6
Identification accuracy on one side ear between different observers.

Group size of similar objects	Accuracy Original size – Observer 1 and Observer 2	Original size – Observer 1 and Observer 3	Original size – Observer 2 and Observer 3
1	0.504	0.287	0.348
2	0.652	0.452	0.504
3	0.722	0.522	0.565
4	0.765	0.548	0.609
5	0.809	0.574	0.661
10	0.930	0.678	0.791
20	0.983	0.843	0.913
50	0.991	0.991	1.000

Discussion

A method of photo-anthropometric analysis of the ear was proposed by Cameriere et al. [6] for human identification due to the individualizing morphology that the ear presents. The proposed method was tested in this article, although the authors have emphasized that a metric analysis associated with ear morphological analysis could be useful as a tool for human identification through images.

Table 7
Identification accuracy of the opposite-sided ear between different observers.

Group size of similar objects	Accuracy Original size – Observer 1 and Observer 2	Original size – Observer 1 and Observer 3	Original size – Observer 2 and Observer 3
1	0.200	0.165	0.157
2	0.348	0.226	0.270
3	0.409	0.330	0.339
4	0.470	0.374	0.400
5	0.548	0.409	0.417
10	0.704	0.539	0.591
20	0.817	0.670	0.739
50	0.965	0.939	0.922

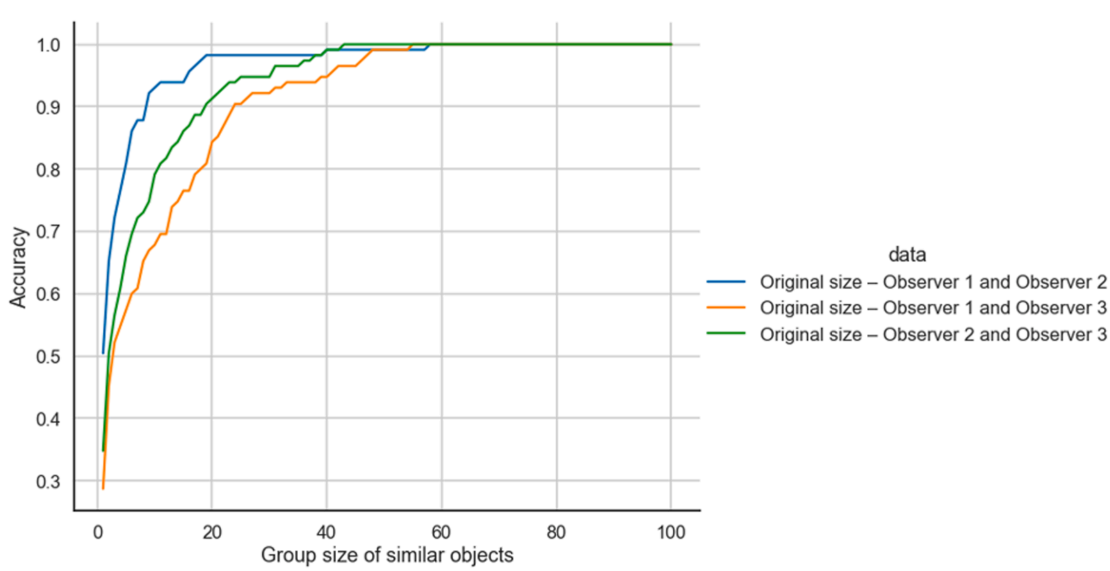

Fig. 3. Identification accuracy on one side ear between different observers.

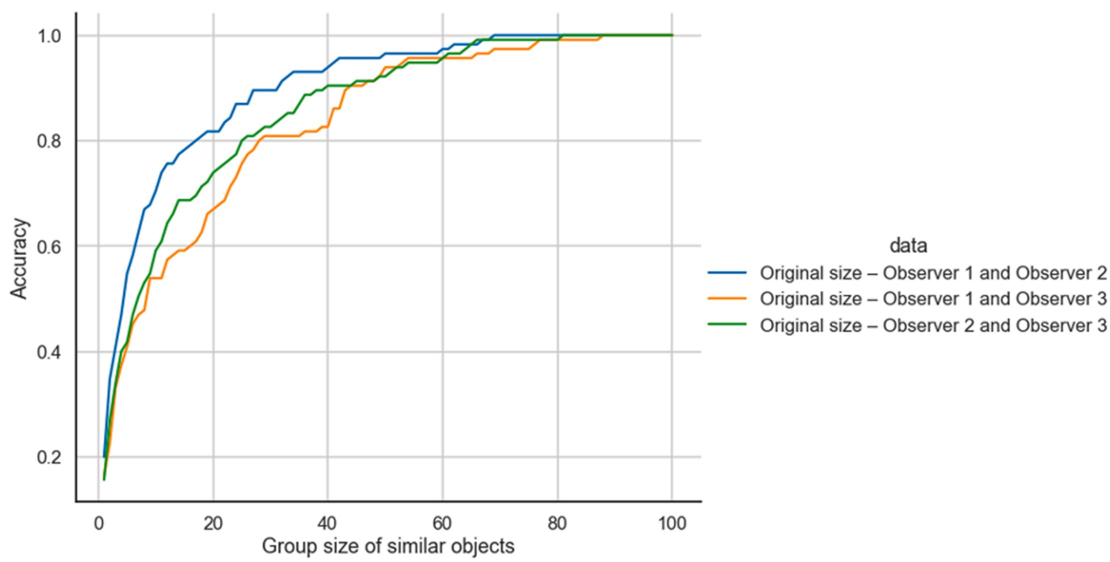

Fig. 4. Identification accuracy opposite-sided for different observers.

Thus, to test the reproducibility of the method, in this research, three observers independently measured photographs of both ears of 115 participants. Thus, concerning the reproducibility of the method, an interobserver agreement was found to be high among all regions assessed (Table 3). Additionally, the size and proportion in antihelix, concha, and lobe regions in both ears were similar (Table 4), which demonstrates that these regions from both ears can be used for human identification. However, the helix was an exception, since this region showed a statistically significant difference between both ears (Table 4). Possibly, the difference found for the helix region can be explained by the high miscegenation rate of the Brazilian population, due to the ill-defined contours that this region may present [6] or even by the difference in the values of the measurements found by the third observer (Fig. 2).

Although many studies have performed morphological analysis or population frequency of atrial characteristics such as the presence and location of Darwin's Tubercle [4,18–23], metric approaches can provide additional evidence, especially in human identification from images. Moreover, metric analyzes of the ear are particularly necessary when there are no pathologies, malformations, or deformities in the ear that could be useful in identifying by morphological comparison.

The evaluated parameters and the algorithm used in this research allow a person to be identified by similarity between ears on the same side or by the similarity of the most regions on opposite ears, where the accuracy in identifying a right ear based on the parameters of the left ear increases accordingly with the number of suspects (Table 5). This same result was observed among the three observers, although this accuracy was higher among observers 1 and 2 (Fig. 2). This means that, in a forensic scenario, when there is only one record of an ear of sufficient quality for comparison, the antihelix, concha, and lobe regions from both ears of the suspect can be used as evidence of materiality based on the assumption that there is symmetry in those regions between both ears [21,24].

However, when only the helix region has been available for analysis, the comparison between the questioned ear and the reference ear may consider whether they are on the same or opposite sides since the helix showed a statistically significant difference between the sides (Table 4). Therefore, the helix should be used with caution, although it is an important region because it is the most projected region of the ear, which can be visualized in images or printed on surfaces [18].

The same reasoning of identifying an ear based on images of the opposite ear was used to test the reliability of identifying a single ear (left ear) and opposite-sided ear when two observers perform the analyzes. As seen in Tables 6 and 7 (Figs. 3 and 4), the accuracy between two observers increased with the number of ears assessed.

Thus, if observers 1 and 2 apply the method proposed to identify a single ear from another, the probability of a correct answer will be 50.4% (Table 6). However, as Dinkar and Sambyal [23], the present approach can be useful when there are several suspects because it can screen and group the suspects with the most similar ears, which would reduce the time and effort of investigators. Therefore, if the same observers applied the method after an initial screening in a group of 5 people, the probability of identifying the suspect based on the image of his ear increases to 80.9% (Table 6).

This research was able to fill the gap presented by Chattopadhyay and Bhatia [20], that is the premise that the ears can be so different and distinguishable to the point that they can be used for human identification. Furthermore, Chattopadhyay and Bhatia [20] also questioned whether individuality can be established and proven from a partial ear impression. In this research, the original size of the ear areas and their proportions showed comparable results, which suggests that an isolated parameter of the ear such as the helix region can be useful for human identification, which justifies more research for this purpose. Additionally, the predictive model of ear identification can be improved by creating a complex algorithm based on the combination of the original sizes and proportions of the ear.

Thus, through the adopted methodology and the algorithm used in this research, an ear profile can be used to identify or exclude suspects independently or associated with other methods of human identification (face, voice, posture, etc.) [23,25]. Therefore, further research is encouraged, since the ear suffers little influence from facial expressions [11,23], can be analyzed with the naked human eye [23], may be able to differentiate monozygotic twins [26] and, despite the process of aging changes the dimensions of the ear until some point, its morphology remains the same unless trauma-related changes occur [21,23,24].

Conclusion

The human identification method based on photographs of the ear proposed by Cameriere et al. [6] proved to be reproducible in the Brazilian sample. Furthermore, Cameriere's method can be especially applied when there are many people in crime scenes or when there are many suspects to be analyzed, situations in which the method proved better accuracy. Despite that, in a practical viewpoint in real cases, it is possible that the ear side must be considered when only the helix region has been available to analyze.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-Brasil (CAPES)-Finance Code 001. Furthermore, the authors acknowledge the essential financial contribution of the CAPES notice (grant number: 25/2014-Pró-Forenses) for the financial support referring to the International Visitor researcher Roberto Cameriere.

References

[1] C. Cattaneo, Forensic anthropology: developments of a classical discipline in the new millennium, Forensic Sci. Int. 165 (2-3) (2007) 185–193, https://doi.org/10.1016/j.forsciint.2006.05.018.
[2] F. Ventura, A. Zacheo, A. Ventura, A. Pala, Computerised anthropomorphometric analysis of images: case report, Forensic Sci. Int. (146S) (2004) S211–S213, https://doi.org/10.1016/j.forsciint.2004.09.065.
[3] G.P. de Carvalho, Y.C.V. Bantim, Inmates beheaded in a Brazil prison riot: human identification by ear individual signs, J. Forensic Leg. Med. 68 (2019), 101870, https://doi.org/10.1016/j.jflm.2019.101870.
[4] K. Krishan, T. Kanchan, S. Thakur, A study of morphological variations of the human ear for its applications in personal identification, Egypt. J. Forensic Sci. 9 (2019) 11, https://doi.org/10.1186/s41935-019-0111-0.
[5] S. Duband, C. Bidat, A. Protte, M. Rochet, F.G. Barral, M. Péoc'h, M. Debout, Classification des méthodes utilisées en identification comparative en médecine légale illustrée par la casuistique [Classification of the methods used in comparative identification in forensic medicine illustrated by case mix], La Rev. Méd. Lég. 2 (4) (2011) 158–169, https://doi.org/10.1016/j.medleg.2011.10.005.
[6] R. Cameriere, D. DeAngelis, L. Ferrante, Ear identification: a pilot study, J. Forensic Sci. 56 (4) (2011) 1010–1014, https://doi.org/10.1111/j.1556-4029.2011.01778.x.
[7] D. Seckiner, X. Mallett, C. Roux, D. Meuwly, P. Maynard, Forensic image analysis-CCTV distortion and artefacts, Forensic Sci. Int. 285 (2018) 77–85, https://doi.org/10.1016/j.forsciint.2018.01.024.
[8] R. Moreton, J. Morley, Investigation into the use of photoanthropometry in facial image comparison, Forensic Sci. Int. 212 (1-3) (2011) 231–237, https://doi.org/10.1016/j.forsciint.2011.06.023.
[9] J.P. Davis, T. Valentine, R.E. Davis, Computer assisted photo-anthropometric analyses of full-face and profile facial images, Forensic Sci. Int. 200 (1-3) (2010) 165–176, https://doi.org/10.1016/j.forsciint.2010.04.012.
[10] K.F. Kleinberg, J.P. Siebert, A study of quantitative comparisons of photographs and video images based on landmark derived feature vectors, Forensic Sci. Int. 219 (1-3) (2012) 248–258, https://doi.org/10.1016/j.forsciint.2012.01.014.
[11] A. Tariq, M.A. Anjum, M.U. Akram, in: Proceedings of the Personal Identification using Computerized Human Ear Recognition System, 2011 International Conference on Computer Science and Network Technology, IEEE, 2012, pp. 50–54, https://doi.org/10.1109/iccsnt.2011.6181906n.
[12] A. Alemran, B.B. Rahmatullah, A. Hadi, Systematic review on ear identification, Int. J. Eng. Technol. 7 (4.31) (2018) 251–259, https://doi.org/10.14419/ijet.v7i4.31.23377.
[13] A. Kumar, C. Wu, Automated human identification using ear imaging, Pattern Recognit. 45 (3) (2012) 956–968, https://doi.org/10.1016/j.patcog.2011.06.005.
[14] B. Arbab-Zavar, M.S. Nixon, On guided model-based analysis for ear biometrics, Comput. Vis. Image Underst. 115 (4) (2011) 487–502, https://doi.org/10.1016/j.cviu.2010.11.014.
[15] FISWG. Facial identification scientific working group. Facial Comparison Overview and Methodology Guidelines. https://fiswg.org/documents.html, 2020 (accessed, 2020).
[16] J.L. Bentley, Multidimensional binary search trees used for associative searching, Commun. ACM 18 (9) (1975) 509–517, https://doi.org/10.1145/361002.361007.
[17] W. Hou, D. Li, C. Xu, H. Zhang, T. Li, in: Proceedings of the An Advanced k Nearest Neighbor Classification Algorithm Based on KD-tree, 2018 IEEE International Conference of Safety Produce Informatization (IICSPI), Chongqing, China, 2018, pp. 902–905, https://doi.org/10.1109/iicspi.2018.8690508.
[18] O. Rubio, V. Galera, M.C. Alonso, Anthropological study of ear tubercles in a Spanish sample, Homo 66 (4) (2015) 343–356, https://doi.org/10.1016/j.jchb.2015.02.005.
[19] O. Rubio, V. Galera, M.C. Alonso, Morphological variability of the earlobe in a Spanish population sample, Homo 68 (3) (2017) 222–235, https://doi.org/10.1016/j.jchb.2017.03.007.
[20] S.Bhatia P.K.Chattopadhyay, Morphological examination of ear: A study of an Indian population, Leg. Med. 11 (2009) S190–S193, https://doi.org/10.1016/j.legalmed.2009.02.057. Tokyo.
[21] P. Verma, H.K. Sandhu, K.G. Verma, S. Goyal, M. Sudan, A. Ladgotra, Morphological variations and biometrics of ear: an aid to personal identification, J. Clin. Diagn. Res. 10 (5) (2016), https://doi.org/10.7860/JCDR/2016/18265.7876. ZC138-ZC142.
[22] S. Makaju, S. Chaudhary, K. Iyer, Evaluation of morphological variations of external ear between the Nepalese and Indian students of a medical college, JNMA J. Nepal Med. Assoc. 56 (214) (2018) 936–939, https://doi.org/10.31729/jnma.3912.
[23] A.D. Dinkar, S.S. Sambyal, Person identification in ethnic Indian goans using ear biometrics and neural networks, Forensic Sci. Int. 223 (1-3) (2012), https://doi.org/10.1016/j.forsciint.2012.08.032, 373.e1–373.e13.
[24] C. Sforza, G. Grandi, M. Binelli, D.G. Tommasi, R. Rosati, V.F. Ferrario, Age-and sex-related changes in the normal human ear, Forensic Sci. Int. 187 (1-3) (2009), https://doi.org/10.1016/j.forsciint.2009.02.019, 110.e1–110.e7.
[25] D. Gibelli, Z. Obertova, S. Ritz-Timme, P. Gabriel, T. Arent, M. Ratnayake, D. De Angelis, C. Cattaneo, The identification of living persons on images: a literature review, Leg. Med. 19 (2016) 52–60, https://doi.org/10.1016/j.legalmed.2016.02.001. Tokyo.
[26] M. Atsuchi, A. Tsuji, Y. Usumoto, M. Yoshino, N. Ikeda, Assessment of some problematic factors in facial image identification using a 2D/3D superimposition technique, Leg. Med. 15 (5) (2013) 244–248, https://doi.org/10.1016/j.legalmed.2013.06.002. Tokyo.