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Morphological markers of ear print in Iraqi population

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Abstract---The outer ear is an emerging biometric that has drawn the attention of the research community for more than a decade. Empirical studies confirm, that the shape of the outer ear is unique, and it is also assumed to be stable throughout a human life time. An ear print is a two-dimensional depiction of the external ear pieces that have got into contact with a surface. In 1965, the first criminal ear print identification was made in Switzerland. The variation in shape and size of ear features makes it richer biometric tool than face. Material and method: The study performed a qualitative discrimination of the external ear shape of 143 individuals, including lobe size, lobe attachment, helix rolling, ear protrusion, and antihelix folding, by using ear photographs. Results: Six landmarks were evaluated for auricle morphometry in both sexes. There was variation in the morphological features of the external ear of the sampled subjects. The external ear features vary in both sexes. All variables were statistically significant ($p \leq 0.05$). The triangle-shaped ear was prevalent in females and males had an oval shape. In helix females had a higher percentage of concave shapes than males, who had a higher percentage of wide shapes. Females more significant than males in shape of earlobe, thickness of earlobe and shape of tragus. In the other hand, the males are more significant than females in attachment. Conclusion: the present study shows that the individualistic characteristics of the ear can provide very useful information for personal identification in forensic examinations by the identification of landmark variations in different ethnic groups.

Keywords---ear print, human identification, forensic science, Iraq.

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Introduction

The human ear is one of the key body parts that has recently attracted the attention of the forensic community for human identification [1]. Biometric is an automatic method of the identity of an individual based on morphological and structural characteristics. An ideal biometric needs to be universal, unique, permanent, and collectible [2]. The variation in shape and size of ear nature, reduced space-related resolution, more uniform of color distribution and no effect of expression change on ear makes it an enriched biometric tool than other facial features [3]. An ear print is a two dimensional depiction of the external ear pieces that have got into contact with a surface. In 1965, the first criminal ear print identification was made in Switzerland. When burglars examine to see if the house is vacant, they may leave ear prints on windows or doors [4]. The anatomical landmarks used for this study were, shape of external ear traits lobe size, lobe attachment, helix rolling, ear protrusion, and antihelix folding. Although the ear print can reflect a wide genetic diversity in the heritage of genetic population discrimination and genetic ear diseases and become a tool for human identification, there is controversy about the accuracy of the genetic information extracted to draw a picture of the ear with a high resolution for phenotypic traits that many researchers have yet to address.

Materials and Methods

Subjects

In this study, 143 Iraqi subjects were included (70 females and 73 males), aged 18 to 65 years. This study was approved by the ethics committee of Al-Muthanna University. Individuals with dysmorphologies, a history of facial surgery or trauma, and a BMI of over 33 were excluded (due to the effect of obesity on facial features). All participants provided written informed consent.

Morphology and organization of ear

The study of ear morphological traits was assessed in order to set population data for the unique ear markers. Digital photograph of the face were captured: left side (90°), left angle (45°), frontal (0°), right angle (45°) and right side (90°) were taken by camera (Nikon D90) at the same distance of all subjects (~ 1.5). Other phenotypes including age, gender, Ethnicity, systemic illness and any ear disorders were detected for the participanst. The bilateral profile images were taken for confirmation and to avoid bias ,it is valid to compare the right and left ears in the same person for bilateral symmetry match [5]. The major landmarks of the external ear are shown in figure 1, as described by Singh and purkait [6].

- Helix (normally rolled, wide covering scapha, flat, concave marginal)
- Tragus (long, knob, round)
- Shape of earlobe (tongue, triangular, arched, square)
- Earlobe attachment (free, partially attached, attached)
- Thickness of ear lobe (thin, thick, medium)

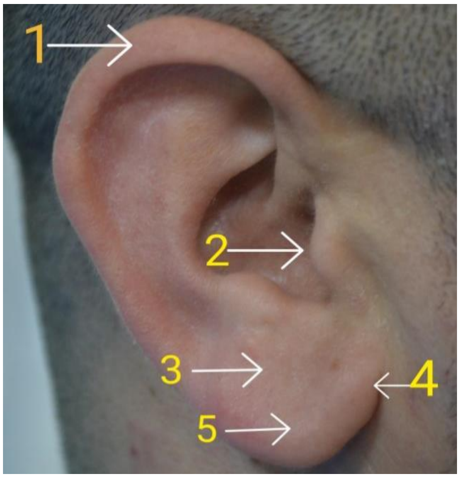

Fig 1. shows the shape and location of different anatomical landmarks of ear: 1.helix, 2.tragus, 3. shape of earlobe, 4.earlobe attachment, 5.thickness of ear lobe

Statistical analysis

The collected data was statistically analyzed using ANOVA, chi-square Fisher Exact test with significance values of $P \leq 0.05$ and $P \leq 0.001$.

Results and Discussion

The current study demonstrates that the ear's distinctive traits can be really valuable in forensic exams for human identification. The shape of the ear, tragus, helix, and earlobe showed morphological variations among individuals. The earlobe showed different characteristics in different individuals. In nearly half of the cases (53%), the earlobe was found to be attached to the face; in other cases, it was free in 38% and partially attached in 9%. The shape of the earlobe showed variations of the tongue at 21%, arched at 26%, square 51%, and triangular 2%. The helix showed a variety of structures with round 43%, wide-covering 32%, concave marginal 22%, and flat 3%. Variations in the thickness of the earlobe showed a thick 33%, a thin 5% and a medium 62%. From an anthropological and forensic standpoint, knowing the normal human ear size and morphological features of distinct populations can help offer data techniques for the inclusion and exclusion of people for identification based on ear variances [1].

Furthermore, data from population-based ear morphological studies will offer plastic surgeons a foundation for ear reconstruction. As a result of the external ear's intricacy, different anatomical landmarks of the external ear have been noted in this study. The variations of human ears might help with identification. Ear dimensions have been studied in numerous ethnic groups using direct and indirect anthropometry and photography in recent years [7]. The morphological features were studied for the data collected and evaluated between sexes. The helix has a variety of shapes and is one of the features that will almost always leave a print when an ear is pressed against a surface. Fig. 2 shows the location of the helix and subclassification (normally rolled, wide-covering scapha, flat, concave marginal).

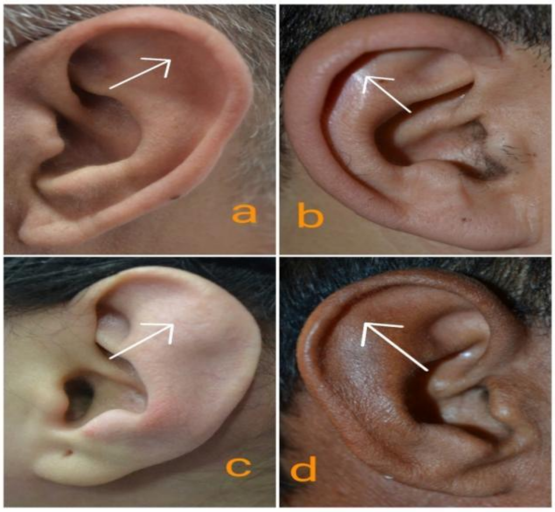

Figure 2. Photographs showing the different forms of the helix: a.normally rolled, b.wide covering scapha, c.flat, d.concave marginal

The results of the current study showed the percentages of females were higher in concave and then flat, in contrast to males, who had a higher percentage in wide and then normal shapes. (Table 1). A highly significant relationship was observed between the genders of subjects by using Chi square.

Table 1
Distribution of gender according to helix. Significant difference was calculated using Chi square

Gender	Helix				
	Wide	Normally	Concave	Flat	Total
Female	19 (41.30%)	28 (45.90%)	20 (64.52%)	3 (60.00%)	70
Male	27 (58.70%)	33 (54.10%)	11 (35.48%)	2 (40.00%)	73
P. value	0.0102	0.0221	0.0321	0.0125	
Total	46 (32.17%)	61 (42.66%)	31 (21.68%)	5 (3.50%)	143 (100%)
The chi-square statistics showed *P* value ≤ 0.05					

In terms of helix structure variability, the helix exhibits a wide range of structures. Nearly 43% of the participants in this study have routinely rolled helixes. Nevertheless, the Farkas study reported 76–79% of normally rolled helix in Americans [8], and Singh and Purkait found 56–60% of normally rolled helix in Central Indian respondents [6]. The concave marginal type was detected in roughly 22% of the participants in this study; nevertheless, Singh and Purkait observed this character in 10–11% of the study group [6], and North Americans also have this character on a rare basis (25%). Wide-covering scapha was found to be 32% more common in this study than in North American males (5.20%) [8] and Central Indians (6.42%) [6]. The frequency of the flat helix was found to be quite comparable among Central Indians and Americans. A common way of classifying the shape of the ear is by defining it as either oval, round, rectangular, or triangular. As in fig.3,

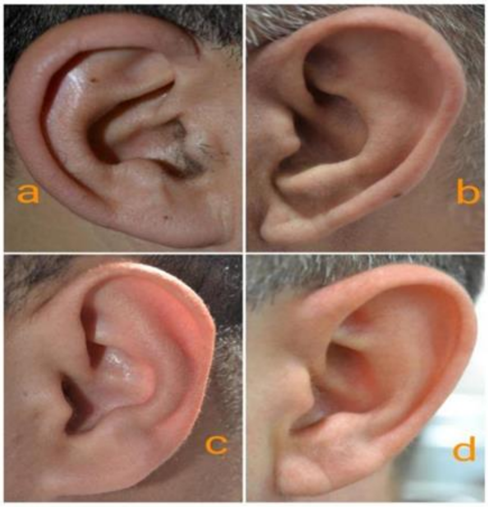

Figure 3. Photographs showing the shape of the ear: a.oval, b.triangular, c.rectangular, d.round

The highest percentage of females is in triangles at 66.67% and then round at 44.44%, in contrast to males, who had a higher percentage of ovals at 60.78% and then round shapes at 55.56% (Table 2). By using Chi square, a significant relationship was observed between the shape of the ear and the gender of the subject.

Table 2
Distribution of gender according to shape of external ear. Significant difference was calculated using Chi square

Gender	Shape				
	Rectangle	Oval	Round	Triangle	Total
Female	20 (58.84%)	26 (39.22%)	20 (44.44%)	4 (66.67%)	70
Male	14 (34.15%)	32 (60.78%)	25 (55.56%)	2 (33.33%)	73
P. value	0.0491	0.0326	0.0452	0.0362	
Total	34 (23.78%)	58 (40.55%)	45 (31.47%)	6 (4.20%)	143 (100%)
The chi-square statistics showed P value ≤ 0.05					

The ear is classified into four shapes: triangular, rounded, oval, and rectangular [9]. The most common shape in north India was the oval shape, in contrast to the round that had the lowest percentage [1]. In Farhan's study, the ear shape showed the highest percentage of triangular shapes among Iraqis, in contrast to our results that showed the lowest percentage of triangular shapes [10]. A study of Nigerian subjects agreed with our results, reporting that the highest percentage of ear shapes was oval and the lowest percentage was triangular shapes. The same study claimed there was no difference in ear shape and gender, which disagreed with our findings [11]. The shape of the earlobe was expressed differently in the sampled individuals as tongue, triangular, arched, or square.

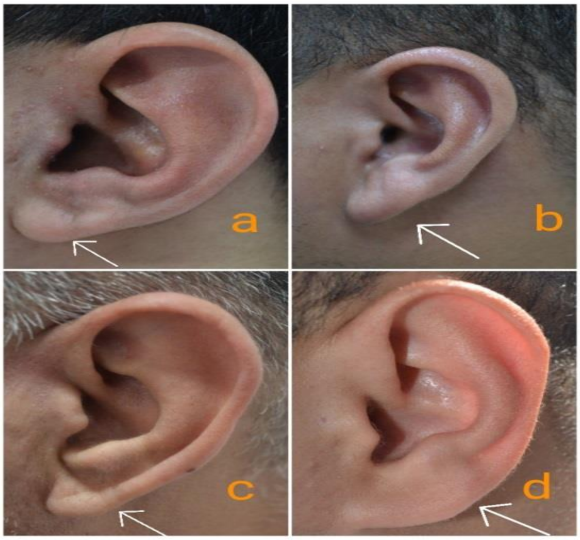

Figure 4. Photographs showing the different shapes of the earlobe: a.tongue, b.triangular, c.arched, d.square

Table 3
Distribution of gender according to shape of earlobe. Significant difference was calculated using Chi square

Gender	Shape				
	Tongue	Arched	Square	Triangular	Total
Female	12 (40.00%)	20 (54.05%)	36 (49.32%)	2 (66.67%)	70
Male	18 (60.00%)	17 (45.95%)	37 (50.68%)	1 (33.33%)	73
P. value	0.0112	0.0324	0.0242	0.0125	
Total	40 (20.98%)	37 (25.87%)	73 (51.05%)	3 (2.10%)	143 (100%)
The chi-square statistics showed P value ≤ 0.05					

In the distribution of the shapes of the earlobes [5], the arch shape, with 55.3% right ear and 52.6% left ear among the males; and 51.4% right ear and 47.3% left ear among the females, is the most frequent in both sexes of the population. The triangular shape was found to be the least common in all sampled subjects. In the present study, our population showed a higher percentage in square shapes, with 51% among males and 50% among females, while the lowest percentage was in triangular shapes, with 2% in both sexes. Fig. 5 shows forms of the earlobe attachment. The earlobe attachment can be either of the three forms: free, partially attached, or fully attached to the skin of the scalp or the upper cheek. The male partially attached earlobe was discovered to be 69.23%, while the female free earlobe was determined to be 61.11% (Table4). An assessment of relations between lobule status and gender was done using the Fisher Exact test and significant differences were found.

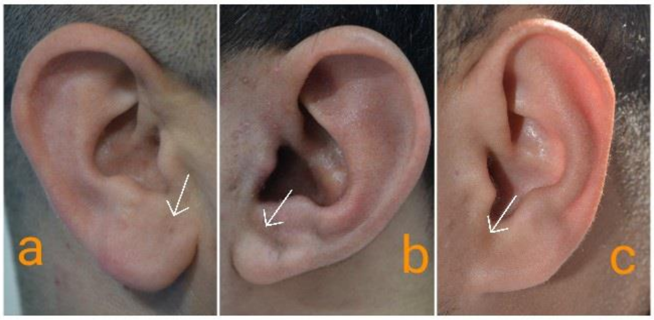

Figure 5. Photographs showing the different forms of the earlobe attachment: a.free, b.partially attached, c.attached

Table 4
Relation between gender and lobule attachment using Fisher's Exact Test

Gender	Attachment			
	Free	Partially	Attached	Total
Female	33 (61.11%)	4 (30.77%)	33 (43.42%)	70
Male	31 (38.89%)	9 (69.23%)	43 (56.58%)	73
P. value	0.0426	0.0445	0.0138	
Total	54 (37.76%)	13 (9.09%)	76 (53.15%)	143 (100%)
Fisher's Exact Test showed P value ≤ 0.05				

The earlobe trait is considered a marker in population genetics [12]. Farhan's study found the free lobule (59.8%) and an attached lobule (40.2%), while our results demonstrated an attached lobule (53%) and a free lobule (38%) [10]. The present study showed a higher percentage of attached ear lobes among both males and females. The variant of the ear lobe attach trait might be attributed to the different ethnic and genetic origins that were reported in previous studies [13, 14, 1]. The thickness of the earlobe is found in three forms: thick, thin, and medium.

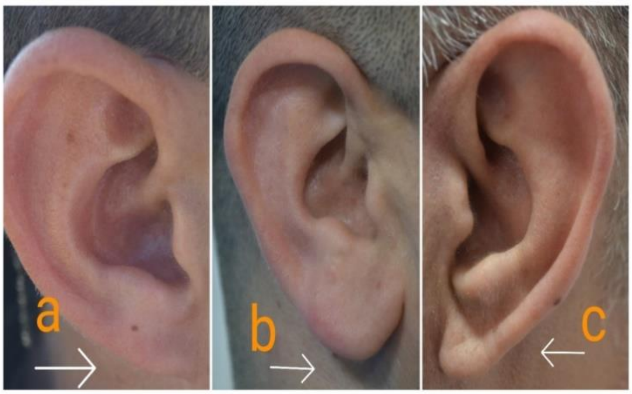

Figure 6. Photographs showing the thickness of the earlobe: a.thin, b.thick, c.medium

Table 5
Relationship between gender and lobe thickness utilizing Fisher's Exact Test

Gender	Thickness			
	Thin	Thick	Medium	Total
Female	6 (85.71%)	14 (29.79%)	50 (56.18%)	70
Male	1 (14.29%)	33 (70.21%)	39 (43.82%)	73
P. value	0.0110	0.0256	0.0154	
Total	7 (4.90%)	47 (32.87%)	89 (62.24%)	143 (100%)
Fisher's Exact Test showed P value ≤ 0.05				

The thickness of the earlobe is an important characteristic that may be considered an individualistic feature of the person. The medium thickness of the earlobe was common (64.4% in males and 67.8% in females for the left ear; 66.7% in males and 67.8% in females for the right ear) among the subjects in both sexes [15]. That agrees with our study that a higher percentage (71% in females and 53% in males). The shape of the ear tragus is presented in fig. 7. There are three forms of ear tragus observed in the study, which are knob, round, and long. Overall, the knob shape is the most common of the three shapes in males and the round shape in females (Table 6).

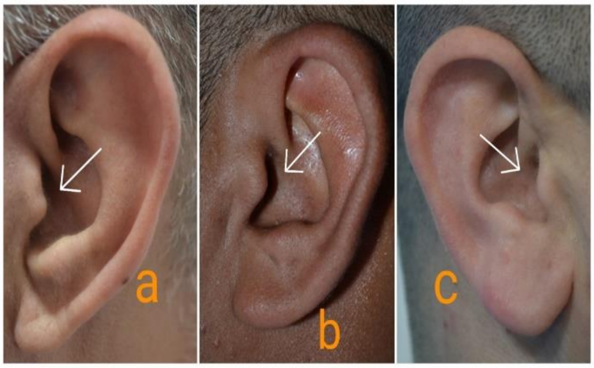

Fig 7. Photographs showing the different shapes of the ear tragus: a long. b knob. c round

Table 6
Relation between gender and tragus using chi-square

Gender	Tragus			
	Long	Round	Knob	Total
Female	33 (45.21%)	35 (63.64%)	2 (13.33%)	70
Male	40 (54.79%)	20 (36.36%)	13 (86.67%)	73
P. value	0.0291	0.0300	0.0012	
Total	2 (51.05%)	55 (38.46%)	15 (10.49%)	143 (100%)
The chi-square statistics showed P value ≤0.05				

The knob shape is the most common of the three shapes. In the Hausa population, the knob-shaped ear tragus is 63.1% right ear and 57.9% left ear in the males; and 47.1% right ear and 54.9% left ear in the females. Among the Yorubas, the knob ear shape is found in 81.8% of the right ear and 76.4% of the left ear of males; and 58.8% of the right ear and 72.5% of the left ear of females. The long ear tragus was the lowest percentage among samples [5]. In our study, the most common shapes are long (55% among males) and round (50% among females). The knob has the lowest percentage in both sexes. Some traits in females and males and for different shapes showed significant differences by ANOVA test (Table 7). At P≤0.05, traits are significantly different from one another. In this table, we find the females more significant than the males in terms of shape of earlobe, thickness of earlobe, and shape of tragus. In contrast, the males are more significant than the females in attachment.

Table 7
Ear morphology for males and females differs according to the shape of the auricle. The results were expressed as mean ±SD, with significance indicated by a * (P≤ 0.05)

Features	Sub-classification	gender	Rectangle	Oval	Round	Triangle
helix	Wide	Female	9±0.32	4±1.02	3±0.15	3±0.52
		Male	8±0.18	9±0.12	9±2.22	1±0.01
	Normal	Female	6±0.78	12±3.52	10±3.04	0
		Male	2±0.33	20±4.02	10±2.69	1±0.01
	Concave	Female	5±0.85	8±0.75	7±0.44	0
		Male	4±0.32	2±0.56	5±0.59	0
	Flat	Female	0	2±0.32	0	1±0.02
		Male	0	1±0.21	1±0.01	0
Earlobe	tongue	Female	3±0.55	8±0.69	1±0.02	0
		Male	1±0.01	12±2.39	4±0.15	1±0.01
	Arched	Female	0	6±0.55	12±0.99	2±0.12
		Male	4±0.62	6±0.74	6±0.36	1±0.01
	square	Female	17*±3.12	11±1.09	7±1.09	1±0.01
		Male	9±0.51	13±2.66	15±5.21	0
	triangular	Female	0	1±0.01	0	1±0.03
		Male	0	1±0.01	0	0
Attachment	free	Female	8±0.15	14±0.47	11±3.26	0
		Male	4±0.11	12±3.33	4±0.41	1±0.01
	partially	Female	1±0.14	1±0.02	1±0.03	1±0.01
		Male	2±0.32	4±0.15	2±0.15	1±0.01
	attached	Female	11±2.39	11±0.39	8±0.78	3±0.23
		Male	8±0.58	16±2.32	19*±8.32	0
thickness	thin	Female	1±0.05	1±0.01	4±0.68	0
		Male	0	0	1±0.01	0
	thick	Female	8±0.99	4±0.36	1±0.01	1±0.02
		Male	7±0.35	14±4.92	11±5.21	1±0.12
	medium	Female	11±0.99	21*±6.23	15±3.69	3±0.09
		Male	7±0.39	18±1.99	13±4.02	1±0.01
tragus	long	Female	12*±3.35	12±1.52	7±0.79	2±0.08
		Male	8±0.89	17±2.62	14±6.52	1±0.01

	round	Female	8±1.38	14±2.01	13±7.62	0
		Male	2±0.15	11±3.15	6±0.95	1±0.02
	knob	Female	0	0	0	2±0.05
		Male	4±0.39	4±0.36	5±0.11	0

ANOVA test for the ear trait *P≤ 0.05

The results of the present study show that every ear is unique in shape and size with respect to various other morphological features. The individuality of the ear can be judged by the variable structure of the ear. The study provides new information on the morphological ear variability that will add to the anthropological knowledge and morphological variability of the ear in the Iraqi population, particularly in the identification process involving facial and ear images.

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