VERIFICATION OF THE APPLICABILITY OF AURICULAR PARAMETERS IN DIFFERENTIATION BETWEEN ADULT EGYPTIANS AND MALAYSIANS

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ABSTRACT

Background: External ear morphoscopic and morphometric characteristics are valuable in clinical fields. In forensic practice, auricular parameters proved to be sexually dimorphic. However, the role of the external ear in ethnic determination gained limited attention. **Objectives**: Verification of the applicability of external ear parameters in differentiation between adult Egyptians and Malaysians. **Methodology:** The study included 160 adult subjects (80 Egyptians and 80 Malaysians) who were equally divided between both sexes. Seven measurements were obtained for the left auricle using a digital vernier caliper as follows: ear length, ear width, base of auricle, lobular length, lobular width, conchal length, and conchal width. Then, ear, lobular, lobule ear, and conchal indices were calculated. **Results:** Regarding males; ear length, ear width, base of auricle, lobular length, lobular width, conchal width, ear index, and conchal index were significantly higher in Egyptians. Ear width yielded the highest accuracy for population determination using logistic regression (81.3%) and Receiver Operator Characteristic (ROC) curve analyses (Area Under Curve 'AUC'=0.856). The best result was obtained when the eight significant parameters were included in one regression model (Accuracy = 86.3% and AUC = 0.923). While for females; ear length, ear width, base of auricle, lobular length, and conchal width were significantly higher in Egyptians. Only the lobular index was significantly higher in Malaysian females. Ear width achieved the highest accuracy using logistic regression (72.5%) and ROC curve analyses (AUC=0.773). The best result was obtained when the six significant parameters were included in one regression model (Accuracy = 76.3% and AUC = 0.828). **Conclusion:** The auricular parameters can be used as a valuable tool in differentiation between Egyptians and Malaysians with reasonable accuracies in both sexes.

Keywords: Forensic; Identification; Ethnicity; Auricular parameters; Egyptians; Malaysians.

INTRODUCTION

Identification is a fundamental task in forensic practice. Determination of biological profile includes identifying sex, age, stature, and race. This preliminary establishment of a biological profile restricts the individuals who need to be considered **(Sobh and Mohamed 2021)**.

Various morphometric methods have been adopted by forensic anthropologists. The morphometric techniques include obtaining measurements between two anatomical landmarks. Different anthropometric measurements were used to identify age, sex, and stature. However, less concern was paid to the distinguishment of the race using anthropometric tools **(Michael et al 2021)**.

Classically, there are three main racial categories; Caucasoid, Mongoloid, and Negroid. The literature reported that morphological traits and morphometric measurements of the skull are the most valuable parameters in differentiation between different races. Genetic variation constitutes the base of racial differences.

Also, environmental factors further generate population-specific anthropometric characters (**Saukko and Knight 2015)**.

Nowadays, the identification of race is challenged by crossbreeding. Thus, recent anthropometric studies are concerned with population-specific characteristics rather than pure racial differences (**Cole 2020)**.

From a medicolegal point of view, the determination of ethnicity either in living or dead individuals is crucial. In the last few years, there is an escalating demand for ethnic identification worldwide. There is a growing trend for migration to countries with higher economic standards. Also, the wars are responsible for compelled immigration of millions belonging to various races across boundaries (**Cole 2020; Keten 2020)**.

Ethnicity along with other biological profile items is accurately determined by DNA analysis. However, the high cost along with difficult DNA extraction techniques markedly limits its applicability. Thus, anthropometric parameters are a more convenient tool for identification when there are limited resources (**Latham and Miller 2019)**.

In forensic identification, the auricle could be useful because of its constant location on the lateral aspect of the face and its relatively large size in relation to other facial structures. Furthermore, the auricle has demonstrated the steadiness of features and orientation **(Krishan et al., 2019; Fakorede et al., 2021)**.

Anatomically, the auricle is composed of three main parts; the helix-antihelical complex, the lobule, and the conchal complex; additional morphological features are present that include the tragus and Darwin's tubercle. The ear is accessible, present bilaterally, and exhibits wide variations in morphology and morphometry. The ear parameters are genetically determined then modulated by environmental factors such as ear-piercing **(Fakorede et al., 2021; Rani et al., 2021)**.

The position, anatomical landmarks, and dimensions of the auricle are impressive features that are extensively used for sex identification **(Sullivan et al., 2003**; **Barut and Aktunc 2006; Sforza et al., 2009; Wang B et al., 2011; Taura et al., 2013; Murgod et al., 2013; Ahmed and Omer 2015; EL-Faresy et al.,2016; Abdel Aziz et al., 2017; Umar et al., 2017; Sehrawat et al., 2018; Asadujjaman 2019**; **Nigam and Kulshreshtha 2019; Farhan et al., 2019; Faakuu et al., 2020; Ma XF et al., 2020; Taura and Adamu 2021; Tanko et al., 2021; Chantajitr and Wattanawong 2021; Iswara 2022).** However, relatively limited studies investigated the utility of auricular parameters in differentiation between populations **(Alexander et al., 2011; Verma et al., 2016; Gupta. and Ambekar et al., 2017; Mumin A et al. 2018).** This study aimed to verify the applicability of various external ear parameters in differentiation between adult Egyptians and Malaysians.

SUBJECTS AND METHODS

A pilot study was conducted on 6 Egyptians and 6 Malaysians. Based on the results of the pilot study, the sample size was calculated using G. Power software considering power 80% and confidence level 95%. The minimum sample size for females was found to be 12 subjects per group and the minimum sample size for males was 7 subjects per group.

This research was conducted on 160 adult subjects (80 Egyptians and 80 Malaysians). The age limit of the participants was set between 18 and 30 years. Egyptian and Malaysian groups were equally divided between both sexes. The study included only those with confirmed sex, age, and ethnicity. Any subject with auricular anomalies, external ear diseases, or trauma was excluded.

Ethical approval was obtained from the Ethics Committee of Alexandria Faculty of Medicine (serial protocol number: 0305054, IRB number: 00012098, FWA number: 0018699). Informed consent was

obtained from all participants in the current study.

Each subject was instructed to sit in the Frankfurt plane with the head in the neutral position and looking forward with the lower orbital margins at the same horizontal plane of external auditory meatuses. Then, landmarks of the left auricle were identified, and certain auricular measurements were obtained. Also, auricular indices were calculated (**Murgod et al., 2013; Ahmed and Omer 2015).**

a. Left auricular landmarks: (fig. 1).

(A) Pre-aurale: the most upper point that attaches the auricle to the head.

(B) Super-aurale: the most distant point on the upper auricular margin.

(C) Post-aurale: the most distant point on the posterior auricular margin.

(D) Posterior lobule: the most posterior point on the ear lobule.

(E) Sub-aurale: the most distant point on the lower lobular margin.

(F) Anterior lobule: the lowest point that attaches the auricle to the head.

(G) Incisura intertragica inferior: the greatest depth on the intertragic notch.

(H) The furthest point back on the incisura anterior auris.

(I) Concha superior: the most upper point in the conchal cavity

(J) Strongest anithelical curvature: the most posterior point on the anithelical curvature.

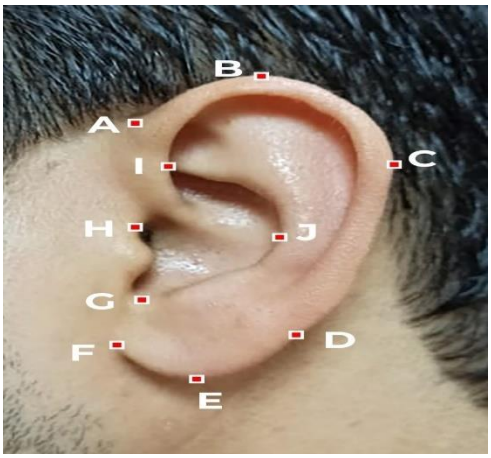

Figure (1): Anatomical landmarks of the left auricle.

b. Left auricular measurements between the previously determined landmarks: (Murgod et al., 2013; Ahmed and Omer 2015)

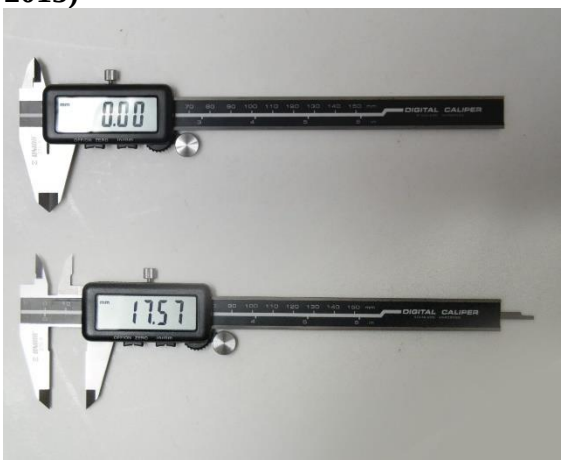

Figure (2): Digital Vernier caliper (UNIOR brand - 270A, SOShanger).

Digital Vernier caliper (UNIOR Digital vernier - 270A, SOShanger) was used to obtain ear measurements **(fig. 2).** All measurements were obtained in millimeters by the same investigator on 2 different occasions and the mean values were considered for further analysis.

1. **Ear length**: the distance between super-aurale (B) and sub-aurale (E).

2. **Ear width**: the distance between pre-aurale (A) and post-aurale (C).

3. **Base of auricle**: the distance between pre-aurale (A) and Anterior lobule (F).

4. **Lobular length**: the distance between incisura intertragica inferior (G) and sub-aurale (E).

5. **Lobular width**: the distance between the most anterior point on the lobule (F) and the most posterior point on the lobule (D).

6. **Conchal length**: the distance between the concha superior (I) and the incisura intertragica inferior (G).

7. **Conchal width**: the distance between the furthest point back of the incisura anterior auris (H) and the strongest antihelical curvature (J).

c. Calculated auricular indices: (Ahmed and Omer 2015)

1. **Ear index** = ear width/ ear length×100.

2. **Lobular index** = lobular width/

lobular length × 100.

3. **Lobule ear index** = lobular length/ear length × 100.

4. **Conchal index** = conchal width/ conchal length×100.

Statistical analysis:

Data analysis was done using SPSS, version 20 (Armonk, NY: IBM Corp). Kolmogorov-Smirnov test was used to verify the normality of the data distribution. Student t-test compared normally distributed quantitative variables. Multivariate binary logistic regression was carried out to differentiate Egyptians from Malaysians. Receiver operating characteristic (ROC) curve analysis determined the performance of the studied parameters. Arear under the curve (AUC) close to one is considered as perfect whereas; an area of 0.5 is considered a worthless test.

RESULTS

The age of Egyptian males ranged from 18 to 27 years with a mean of 21.94 ± 2.05 while that of Malaysian males ranged from 18 to 26 years with a mean of 22.15±2.41. No significant difference was present between the mean ages of Egyptian and Malaysian males (t= 0.424 and p=0.672) (**Table 1)**.

The age of Egyptian females ranged from 18 to 28 years with a mean of 22.63 ± 3.05 years while that of Malaysian females ranged from 21 to 24 years with a mean of 22.28 ± 0.88. There was no significant difference regarding mean age between Egyptian and Malaysian females (t=0.697 and p=0.489) (**Table 1)**.

Table (1): Comparison between Egyptians (n=80) and Malaysians (n=80) according to age

Age (Years)	Egyptians (n = 80)	Malaysians (n = 80)	t	p
Males	**(n=40)**	**(n=40)**		
Min. – Max. **Mean ± SD**	18.00 – 27.00 21.94 ± 2.05	18.00 – 26.00 22.15±2.41	0.424	0.672
Females	**(n=40)**	**(n=40)**		
Min. – Max. **Mean ± SD**	18.00 – 28.00 22.63 ± 3.05	21.00 – 24.00 22.28 ± 0.88	0.697	0.489

t: Student t-test

Ear parameters among Egyptian and Malaysian males

A-Comparison of auricular measurements and indices:

Table (2) compared the studied ear parameters between the Egyptian and Malaysian males. Six out of the seven measurements were significantly higher in Egyptian males than Malaysian males (ear length, ear width, base of auricle, lobular length, lobular width, and conchal width) with p values <0.001, <0.001, 0.002, 0.016, <0.001 and <0.001 respectively. Only conchal length showed no statistically significant difference between the two populations (p=0.751). Regarding the indices, ear index and conchal index were significantly higher in Egyptian males (p=0.001 and <0.001 respectively). However, there was no statistically significant difference in comparing lobular index and lobule ear index among the two groups with p values 0.242 and 0.588 respectively.

B-Logistic regression and ROC curve analyses

The six significant measurements and two significant indices were included in logistic regression and ROC curve analyses to allow differentiation between Egyptian and Malaysian males using ear parameters **(Tables 3 and 4)**

Table 3 reveals the significant logistic regression equations for ear parameters; six for auricular measurements and two for auricular indices. Regarding the auricular measurements, the highest accuracy for determination of the population was achieved by using ear width (81.3%), whereas the least accuracy was achieved from lobular length (67.5%). Considering auricular indices, a regression model using the conchal index predicted population with 70% accuracy, whereas the ear index predicted the population with 68.8% accuracy.

Similar results were obtained when ROC curve analysis was adopted for all significant ear parameters. The ear width yields the best results as Egyptian male was predicted at cut-off>35.15 mm (AUC=0.856, sensitivity 85.0, specificity 77.50, P<0.001). whereas lobular length predicted Egyptian male at cut off >17.7 mm (AUC=0.670, sensitivity 87.5, specificity 47.50, P<0.009). Considering auricular indices, conchal index identified Egyptian male at cut off >63.53 (AUC=0.733, sensitivity 90.00, specificity 50.00, P<0.001) while ear index identified Egyptian male at cut off >54 (AUC=0.698, sensitivity 82.5, specificity 50.00, P<0.001) **(Table 4)**.

Table (2): Comparison between Egyptian (n = 40) and Malaysian (n = 40) males according to different ear parameters

Parameters	Egyptian males (n = 40)	Malaysian males (n = 40)	t	p
1-Auricular measurements				
Ear length				
Min. – Max. **Mean ± SD**	60.94 – 75.51 66.29 ± 3.28	57.28 – 69.88 62.53 ± 3.99	4.608*	<0.001*
Ear width				
Min. – Max. **Mean ± SD**	32.62 – 42.18 37.47 ± 2.31	22.33 – 39.94 33.27 ± 3.29	6.609*	<0.001*
Base of auricle				
Min. – Max.	41.40 – 60.09	41.81 – 60.40	3.166*	0.002*
Mean ± SD	51.74 ± 4.29	48.43 ± 5.03		
Lobular length				
Min. – Max.	13.73 – 29.73	14.45 – 24.35	2.460*	0.016*
Mean ± SD	19.78 ± 2.74	18.41 ± 2.21		
Lobular width				
Min. – Max.	14.62 – 27.15	13.32 – 26.65	3.802*	<0.001*
Mean ± SD	22.99 ± 2.35	20.74 ± 2.91		
Conchal length				
Min. – Max.	17.00 – 31.14	20.78 – 32.97	0.319	0.751
Mean ± SD	26.52 ± 2.76	26.71 ± 2.51		
Conchal width				
Min. – Max.	16.00 – 24.05	13.61 – 21.17	5.474*	<0.001*
Mean ± SD	19.59 ± 1.95	17.37 ± 1.67		
2- Auricular Indices				
Ear index				
Min. – Max.	49.76 – 62.42	33.49 – 60.15	3.352*	0.001*
Mean ± SD	56.58 ± 3.31	53.32 ± 5.18		
Lobular index				
Min. – Max.	67.72 – 164.60	72.55 – 153.69	1.179	0.242
Mean ± SD	118.24 ± 19.57	113.48 ± 16.46		
Lobule ear index				
Min. – Max.	22.15 – 44.13	24.02 – 35.40	0.544	0.588
Mean ± SD	29.81 ± 3.57	29.42 ± 2.69		
Conchal index				
Min. – Max.	60.29 – 117.00	49.31 – 81.71	4.122*	<0.001*
Mean ± SD	74.75 ± 11.68	65.50 ± 8.05		

t: Student t-test ***: Statistically significant at p ≤ 0.05**

Table (3): Logistic regression analysis for differentiation between Egyptian (n = 40) and Malaysian (n = 40) males using ear parameters

Parameters	Regression Equation	Cut off	Accuracy	p	R^2
1- Auricular measurements					
Ear length	-17.977 +0.79*Ear length	>61.24	75.0%	<0.001*	0.281
Ear width	-20.307 + 0.572*Ear width	>35.15	81.3%	<0.001*	0.493
Base of auricle	-7.557 + 0.151*Base of auricle	>48.36	75.0%	0.004*	0.150
Lobular length	-4.527 + 0.238*Lobular length	>17.7	67.5%	0.022*	0.098
Lobular width	-7.541 +0.343*Lobular width	>22.4	77.5%	0.001*	0.212
Conchal width	-13.778 + 0.748*Conchal width	>18.41	76.3%	<0.001*	0.379
2- Auricular Indices					
Ear index	-11.188+ 0.203*Ear index	>54	68.8%	0.003*	0.181
Conchal index	-7.668+ 0.110*Conchal index	>63.53	70.0%	0.001*	0.257
3- All significant auricular parameters	-9.306+ -0.349*Ear length+ 1.354*Ear width+ 0.099*Base of auricle+ -0.246*Lobular length+ 0.214*Lobular width+ 0.190*Conchal width+ -0.614*Ear index+ 0.130*Conchal index	>0.39	86.3%	<0.001*	0.661

Cut-off for Egyptian male ***: Statistically significant at p ≤ 0.05**

Table (4): ROC Curve analysis for the performance of ear parameters in differentiation between Egyptian (n = 40) and Malaysian (n = 40) males.

Measurements	Sensitivity	Specificity	p	AUC	Cut off
1- Auricular measurements					
Ear length	97.50	52.50	<0.001*	0.748	>61.24
Ear width	85.00	77.50	<0.001*	0.856	>35.15
Base of auricle	87.50	62.50	0.001*	0.723	>48.36
Lobular length	87.50	47.50	0.009*	0.670	>17.7
Lobular width	77.50	77.50	<0.001*	0.752	>22.4
Conchal width	72.50	80.00	<0.001*	0.816	>18.41
2-Auricular Indices					
Ear index	82.50	55.00	0.002	0.698	>54
Conchal index	90.00	50.00	<0.001*	0.733	>63.53
3- All significant auricular parameters	90.0	82.5	<0.001*	0.923	>0.39

Cut-off for Egyptian male ***: Statistically significant at p ≤ 0.05**

The best result was achieved by the inclusion of the eight significant parameters (six auricular measurements and two indices) in regression and ROC curve analyses where the accuracy reached 86.3%, Egyptian males Could be identified at cut off >0.39 (AUC=0.923, sensitivity 90.0, specificity 82.5, P<0.001) **(figure 3)**.

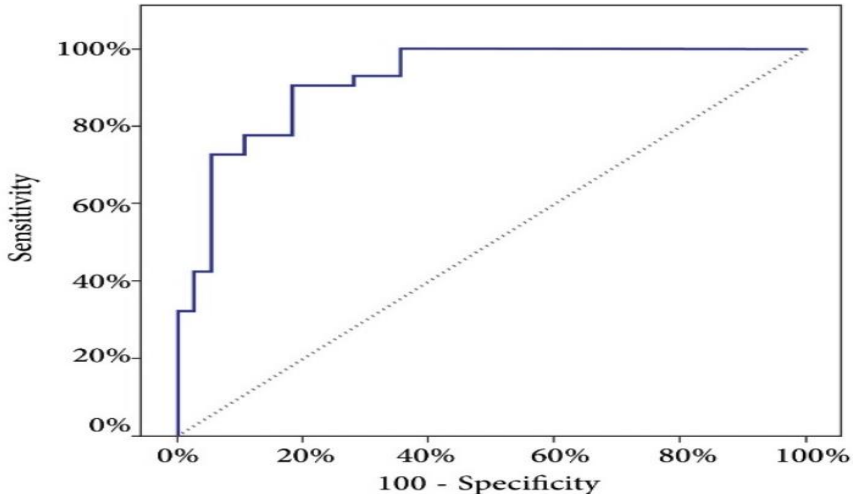

Figure (3): ROC curve for the performance of all significant auricular parameters in differentiation between Egyptian and Malaysian males (AUC=0.923, sensitivity 90.0, specificity 82.5, considered Egyptian if >0.39)

Ear parameters among Egyptian and Malaysian females

A-Comparison of auricular measurements and indices:

Table (5) compared the studied ear parameters between the Egyptian and Malaysian females. Five out of the seven measurements were significantly higher in Egyptian females than Malaysian females (ear length, ear width, base of auricle, lobular length, and conchal width) with p values <0.001, <0.001, 0.025, <0.001, and 0.015 respectively. However, lobular width and conchal length showed no statistically significant differences between the two populations (p=0.273 and 0.086 respectively). Regarding the indices, only the lobular index was significantly higher in Malaysian females with p=0.022. Whereas, ear index, lobule ear index, and conchal index revealed insignificant differences among the two groups (p=0.099, 0.070, and 0.365 respectively).

B-Logistics regression and ROC curve analyses

The five significant auricular measurements and the lobular index were included in logistic regression and ROC curve analyses to allow differentiation between Egyptian and Malaysian females using ear parameters **(Tables 6 and 7).**

Table (6) reveals the significant logistic regression equations for ear parameters; five for auricular measurements and one for the lobular index. Regarding the auricular measurements, the highest accuracy for the determination of the population was achieved by using ear width (72.5%), whereas the least accuracy was achieved from the base of auricle (60%). Considering auricular indices, a regression model using lobular index predicted population with 67.5% accuracy.

Similar results were obtained when ROC curve analysis was adopted for all significant ear parameters. The ear width yields the best results as Egyptian female was predicted at cut-off >31.7 mm (AUC=0.773, sensitivity 77.5, specificity 67.50, P<0.001). whereas the base of auricle predicted Egyptian female at cut off >42.31 mm (AUC=0.632, sensitivity 67.50, specificity 52.50, P=0.043). The lobular index identified Egyptian females at cut-off ≤113.18 (AUC=0.643, sensitivity 52.50, specificity 82.50, P=0.028). **(Table 7)**

Table (5): Comparison between Egyptian (n = 40) and Malaysian (n = 40) females according to different ear parameters

Parameters	Egyptian females (n = 40)	Malaysian females (n = 40)	t	p
1- Auricular measurements				
Ear length				
Min. – Max.	52.96 – 75.07	50.99 – 64.22	3.931*	<0.001*
Mean ± SD	61.37 ± 4.23	58.03 ± 3.31		
Ear width				
Min. – Max.	30.44 – 41.16	25.22 – 36.86	4.835*	<0.001*
Mean ± SD	33.85 ± 2.39	31.01 ± 2.85		
Base of auricle				
Min. – Max.	31.38 – 62.34	33.69 – 49.05	2.286*	0.025*
Mean ± SD	44.83 ± 5.31	42.48 ± 3.73		
Lobular length				
Min. – Max.	16.09 – 23.90	12.99 – 21.56	3.699*	<0.001*
Mean ± SD	18.87 ± 2.01	17.14 ± 2.15		
Lobular width				
Min. – Max.	15.37 – 27.51	14.17 – 25.51	1.104	0.273
Mean ± SD	21.74 ± 2.85	21.06 ± 2.67		
Conchal length				
Min. – Max.	21.63 – 33.43	21.31 – 30.41	1.741	0.086
Mean ± SD	26.07 ± 3.05	25.07 ± 1.95		
Conchal width				
Min. – Max.	14.24 – 22.34	14.07 – 21.57	2.498*	0.015*
Mean ± SD	18.44 ± 2.31	17.25 ± 1.91		
2- Auricular Indices				
Ear index				
Min. – Max.	47.54 – 62.02	40.89 – 70.80	1.675	0.099
Mean ± SD	55.27 ± 3.54	53.56 ± 5.37		
Lobular index				
Min. – Max.	82.03 – 148.91	92.49 – 162.21	2.340*	0.022*
Mean ± SD	115.80 ± 15.08	123.54 ± 14.49		
Lobule ear index				
Min. – Max.	26.42 – 40.86	22.03 – 34.82	1.837	0.070
Mean ± SD	30.78 ± 2.97	29.53 ± 3.12		
Conchal index				
Min. – Max.	49.93 – 97.87	52.44 – 94.83	0.912	0.365
Mean ± SD	71.57 ± 11.64	69.33 ± 10.32		

t: Student t-test ***: Statistically significant at p ≤ 0.05**

Table (6): Logistic regression analysis for differentiation between Egyptian (n = 40) and

Malaysian (n = 40) females using ear parameters

Measurements	Regression Equation	Cut off	Accuracy	p	R^2
1- Auricular measurements					
Ear length	-15.086+ 0.253*Ear length	>59.25	68.8%	0.001*	0.228
Ear width	-14.201+ 0.438*Ear width	>31.7	72.5%	<0.001*	0.312
Base of auricle	-5.210+ 0.119*Base of auricle	>42.31	60.0%	0.032*	0.086
Lobular length	-7.297+ 0.406*Lobular length	>17.13	70.0%	0.001*	0.198
Conchal width	-4.720+ 0.265*Conchal width	>18.8	66.3%	0.019*	0.098
2- Auricular Indices					
Lobular index	-0.036+ 4.364 *Lobular index	≤113.18	67.5%	0.028*	0.088
3- All significant auricular parameters	-21.516+ 0.120*Ear length+ 0.359*Ear width+ -0.037*Base of auricle + 0.212*Lobular length+ 0.148*Conchal width+ -0.018*Lobular index	>0.25	76.3%	<0.001*	0.435

Cut-off for Egyptian female ***: Statistically significant at p ≤ 0.05**

Table (7): ROC Curve analysis for the performance of ear parameters in differentiation between Egyptian (n = 40) and Malaysian (n = 40) females

Measurements	Sensitivity	Specificity	p	AUC	Cut off
1-Auricular measurements					
Ear length	72.50	65.00	<0.001*	0.733	>59.25
Ear width	77.50	67.50	<0.001*	0.773	>31.7
Base of auricle	67.50	52.50	0.043*	0.632	>42.31
Lobular length	82.50	57.50	0.001*	0.711	>17.13
Conchal width	52.50	80.00	0.019*	0.653	>18.8
2- Auricular indices					
Lobular index	52.50	82.50	0.028*	0.643	≤113.18
3- All significant auricular parameters	97.50	55.0	<0.001*	0.828	>0.25

Cut-off for Egyptian female ***: Statistically significant at p ≤ 0.05**

The best result was achieved by the inclusion of the six significant parameters (five auricular measurements and the lobular index) in regression and ROC curve analyses where the accuracy reached 76.3%, Egyptian females Could be identified at cut off >0.25 (AUC=0.828, sensitivity 97.5, specificity 55, P<0.001) **(figure 4)**.

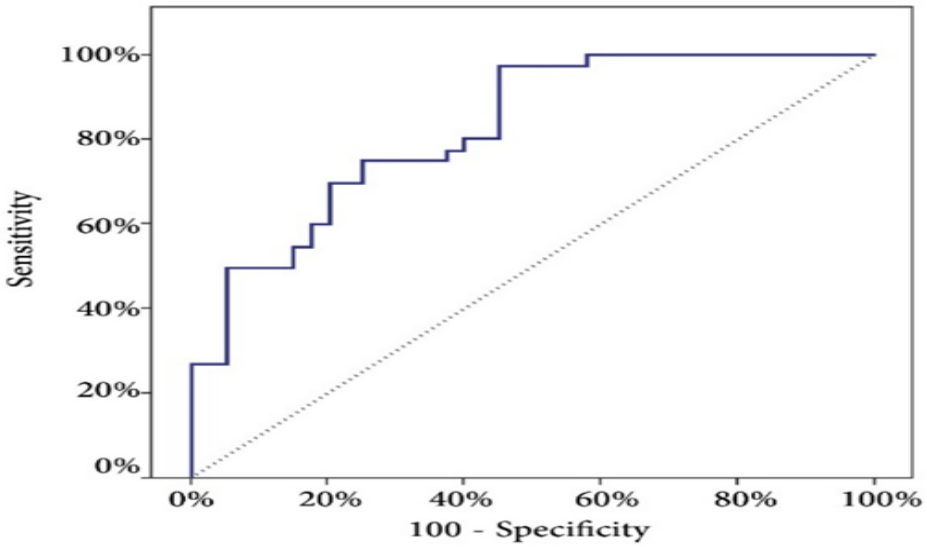

Figure (4): ROC curve for the performance of all significant auricular parameters in differentiation between Egyptian and Malaysian females (AUC=0.828, sensitivity 97.5, specificity 55, considered Egyptian if >0.25).

DISCUSSION

Determination of population is main step in the creation of the biological profile. Recently, the identification of ethnicity gained a lot of attention due to the high rate of migration worldwide. In clinical forensics, ethnicity was successfully determined with reasonable accuracies using fingerprints **(Gutiérrez-Redomero et al., 2013; Orike et al., 2016)**, Hand Anthropometry **(Numan et al., 2013)**, foot anthropometry **(Hisham et al.,2012)**, lip dimensions **(Saxena et al., 2010)**, palatal shape and dimensions **(Ferrario et al., 2000)**, dental parameters **(Rawlani et al., 2017)** and hair structure **(Nasir et al., 2020)**

The external ear was extensively studied as a sex predictor in populations of different countries. In Africa, sexual dimorphism of ear measurements was investigated in Egypt (**EL-Faresy et al.,2016; Abdel Aziz et al., 2017),** Sudan **(Ahmed and Omer 2015),** Nigeria **(Taura et al., 2013; Taura and Adamu 2021; Tanko et al., 2021),** and Ghana **(Faakuu et al., 2020)**. In western countries, ear dimensions as sex predictors were investigated in the USA **(Sullivan et al., 2003)**, Italy (**Sforza et al., 2009),** and Turkey (**Barut and Aktunc 2006)**. In Asia, ear parameters were similarly studied in Iraq (**Farhan et al., 2019**), Pakistan **(Umar et al., 2017)**, China (**Wang B et al., 2011; Ma XF et al., 2020**), Thailand **(Chantajitr and Wattanawong 2021)**, Indonesia **(Iswara 2022)**, Bangladesh **(Asadujjaman 2019)** and India **(Murgod et al., 2013; Sehrawat et al., 2018; Nigam and Kulshreshtha 2019)**.

Anthropological data is population specific. Egypt is a North African country currently inhabited by more than 102 million (**CAPMAS 2022)**. Whereas Malaysia is a south Asian country occupied by more than 33 million **(DOSM 2022)**. In the last few years, Egyptian universities received an increasing number of Malaysian students. On the other hand, Egyptians travel to Malaysia and other Asian countries for different purposes **(Abass et al., 2015)**. The differences in auricular measurements might be used to determine ethnicity (**Mumin et al., 2018)**. Therefore, the current study investigated the utility of different external ear parameters in differentiation between adult Egyptians and Malaysians.

The current study included 80 Egyptians and 80 Malaysians equally divided between both sexes. Each group included 40 subjects to increase the power of the study and enhance the reliability of

the results.

This study was concerned with differentiation between adult Egyptians and Malaysians using their auricular measurements. The age of eighteen was assigned as a lower limit to ensure maturity of various auricular features **(Japatti et al., 2018)**. Whereas the age of 30 was set as an upper limit in inclusion criteria to eliminate the age-related changes in the studied auricular parameters **(Sullivan et al., 2003)**.

Volunteers with ear anomalies, diseases, or trauma were excluded. A digital vernier caliper was used to obtain auricular measurements in millimeters. The used caliper is an efficient tool for recording highly accurate anthropometric measurements. Auricular indices were calculated from the obtained ear measurements. Statistical analysis revealed the normal distribution of the studied parameters. There was no significant difference between the mean age of Egyptians and Malaysians in both sexes.

In males, six out of the seven measurements were significantly higher in Egyptians than Malaysians (ear length, ear width, base of auricle, lobular length, lobular width and conchal width). Only conchal length showed no statistically significant difference between the males of the two populations. considering the indices, the ear index and conchal index were significantly higher in Egyptians. On the other hand, there was no statistically significant difference in comparing lobular index and lobule ear index among the two groups.

Each significant parameter either a measurement or an index was included in logistic regression and ROC curve analyses. Among the external ear measurements, the ear width was the best population determinant with an accuracy of 81.3% and AUC 0.856. Regarding indices, the conchal index predicted population with 70% accuracy and AUC 0.733. The accuracy of differentiation between Egyptian and Malaysian males increased to 86.3% with AUC 0.923 when the eight significant parameters were included in the same statistical model.

It is worth mentioning that lip prints **(Abdel Aziz et al., 2016)** and palatal rugae (**Hussein and Rady 2021)** were previously investigated in Egyptian and Malaysian males. Both studies successfully distinguished between Egyptian and Malaysian males with 65% accuracy.

In females, five out of the seven measurements were significantly higher in Egyptians than Malaysians (ear length, ear width, base of auricle, lobular length, and conchal width). Regarding the indices, ear index, lobule ear index, and conchal index revealed insignificant differences among the two populations.

Interestingly, the lobular index is the only parameter that is significantly higher in Malaysian females in relation to their Egyptian counterparts. The lobular index is calculated by dividing lobular width by lobular length. Selectively higher lobular index among Malaysian females could be explained by the non-significant difference in the mean lobular width in the presence of higher lobular length among Egyptian females. Other than genetic factors, the marked increase in the lobular length in Egyptian females could be augmented by their piercing habit and using heavy earrings **(Fakorede et al., 2021).**

A statistical model was adopted for each significant parameter to differentiate Egyptian and Malaysian females. The ear width determined the population with the highest accuracy (72.5%) and AUC was 0.773. Whereas, auricular indices, lobular index predicted population with 67.5% accuracy, and AUC was 0.643. Inclusion of all significant ear parameters improved the accuracy to reach 76.3% with AUC=0.828.

In 2016, **Abdel Aziz et al** used lip prints to distinguish Egyptian and Malaysian females with 66.7% accuracy. five years later, palatal rugae were provided as a useful tool for differentiation between Egyptian and Malaysian females with 54.4% accuracy (**Hussein and Rady 2021).**

It is worth mentioning that hand

measurements were studied by **Gheat H et al. (2020)** in differentiation between Egyptian and Malaysian populations with an accuracy of 71.7% when sex was considered in regression analysis as a confounding factor.

Other than the medicolegal perspective, investigation of ear characteristics becomes a rich media for research in the clinical field. The morphology of the ear is included in the diagnosis of congenital anomalies such as microtia, macrotia, first arch disorders, and Down's syndrome **(Mumin A et al. 2018)**. Besides, the number of persons who ask for otoplasty are escalating worldwide. Accurate consideration of external ear features regarding gender, age, and ethnicity is required for pre-operative planning **(Hammoudeh 2016; Oliveira et al., 2017)**. Also, the designing of hearing aids necessitates careful consideration of morphoscopic and morphometric features of the auricle (**Lee et al., 2018; Fu and Luximon 2020**). Subsequently, auricular dimensions of each population attract the concern of medical personnel other than forensic practitioners.

CONCLUSIONS

This study pointed for the first time to auricular parameters as useful tools for differentiation between adult Egyptians and Malaysians. Regarding males, ear width had the best accuracy for population determination (81.3%) which increased to 86.3% when all significant parameters were included in one statistical model. In females, ear width achieved the highest accuracy (72.5%) which increased to 76.3% when all significant parameters were included in the statistical analysis.

RECOMMENDATIONS

The current study pointed to the external ear parameters as a valuable tool for differentiation between adult Egyptians and Malaysians with reasonable accuracies. However, further studies on Egyptians and Malaysians are recommended using a larger sample size. Also, the conduction of a similar study on other populations is advisable.

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CONFLICTS OF INTEREST:

The author declares that there are NO conflicts of interest.

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الملخص العربي

التحقق من قابلية تطبيق المعلمات الأذنية في التفريق بين البالغين المصريين والماليزيين

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الخلاصة:

تعتبر خصائص الأذن الخارجية ذات قيمة في شتى المجالات الإكلينيكية. وفيما يتعلق بالطب الشرعي، فقد أثبتت الدراسات أن المعلمات الأذنية استخدمت في التمييز بين الذكوروالإناث. لكن دور الأذن الخارجية في التمييز بين الأعراق المختلفة لم يتم دراسته بشكل موسع حتى الآن. لذلك فقد هدفت الدراسة الحالية للتحقق من قابلية تطبيق معلمات الأذن الخارجية في التفريق بين البالغين المصريين والماليزيين. وقد شملت الدراسة 160 شخصاً بالغاً (80 مصرياً و 80 ماليزيا) والمقسمين بالتساوي بين الجنسين. وفي جميع المشاركين، تم قياس سبعة قياسات للأذن اليسرى باستخدام الفرجار الرقمي على النحو التالي: طول الأذن، عرض الأذن، طول قاعدة صوان الأذن، طول شحمة الأذن، عرض شحمة الأذن، طول محارة الأذن، وعرض محارة الأذن. ثم تم استخدام هذه القياسات في حساب مؤشرات الأذن و الشحمة والشحمة للأذن والمحارة. وقد أسفرت الدراسة الحالية أنه فيما يتعلق بالذكور، كان طول الأذن، وعرض الأذن، وقاعدة صوان الأذن، وطول الشحمة، وعرض الشحمة، وعرض محارة الأذن، ومؤشر الأذن ، ومؤشر المحارة أعلى في المصريين وقد كان الفارق ذو دلالة إحصائية. وكان لعرض الأذن أعلى دقة للتمييز بين المصريين و الماليزيين وذلك باستخدام الانحدار اللوجستي (81.3٪) وتحليل منحنى (ROC) لتقييم القدرة التنبؤية (المنطقة الواقعة تحت المنحنى = 0.856). وعندما استخدمت جميع المعلمات ذات الدلالة الإحصائية معاً فإن الدقة بلغت 86.3٪ و المنطقة الواقعة تحت المنحنى أصبحت 0.923. بينما للإناث ؛ كان طول الأذن، وعرض الأذن، وقاعدة صوان الأذن، وطول الشحمة، وعرض محارة الأذن أعلى بفارق ذو دلالة إحصائية عند المصريات. فقط مؤشر شحمة الأذن كان أعلى بفارق ذو دلالة إحصائية في الماليزيات. وكان لعرض الأذن أعلى دقة باستخدام الانحدار اللوجستي (72.5٪) وتحليل منحنى ROC (المنطقة الواقعة تحت المنحنى = 0.773) . وباستخدام كل المعلمات ذات الدلالة الإحصائية سوياً فإن الدقة بلغت 76.3٪ و المنطقة الواقعة تحت المنحنى أصبحت 0.828. وخلصت الدراسة الحالية أن المعلمات الأذنية يمكن الاعتماد عليها في التمييز بين المصريين والماليزيين البالغين في كلا الجنسين.