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Research Article

Age-Related Metric Changes in Ear Size and Position

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Abstract: **Objective:** In the field of identification, the effects of age on the face have always been an interesting subject, especially concerning age estimation. Although there are many studies on this subject with front face images, the profile (side face) images, especially the ear studies, are insufficient, which remained under-researched., in this study, we aimed to examine the changes in human face profile and ear with age and contribute to future age estimation studies in the literature.

Materials and Methods: Data regarding human face profile and ear that provide statistically significant results were included in this study. Within the statistically significant data, the values that showed a continuous increase/decrease with age focused on seeing how the effects of age on the face are. Linear regression analysis was performed using 19 anthropometric points (landmarks) together with profile face and ear area measurements.

Results: A total of 369 volunteers' profile images and ear images (166 female, 203 male) were gathered in this study. Profile face and ear measurements were taken and analyzed in ImageJ. It was observed that the continuous increase in profile and ear measurements was in the ear in women. Similar to women, an increase in ear size was observed in men, as well as an enlargement in the auricle.

Conclusion: According to the data, the findings suggest that in a forensic case, when the age is estimated from the human facial images, the profile image and the ear image can be helpful in cases where the front image cannot be obtained. If more data and parameters are used in future studies, more successful results can be obtained.

Keywords: Age Estimation; Forensic Sciences; Anthropometry; Biometry; Ear; Identification.

Öz: **Amaç:** Kimliklendirme alanında özellikle yaş tahmini açısından yaşın yüze etkisi her zaman ilgi çekici bir konu olarak görülmektedir. Konuyla ilgili ön yüz görüntüleriyle yapılmış çok sayıda çalışma bulunmasına rağmen profil ve özellikle kulak ile ilgili çalışmalar yetersiz kalmaktadır. Dolayısıyla bu çalışmada, insan yüz profilinde ve kulakta yaşla birlikte meydana gelen değişikliklerin metrik olarak incelenmesi ve ileride yapılacak yaş tahmin çalışmalarına katkı sağlanması amaçlanmıştır.

Gereç ve Yöntem: Elde edilen değerlerden istatistiksel olarak anlamlı sonuç verenler çalışmaya dahil edildi ve bunların içinde, yaşın yüze etkisinin ne yönde olduğunu görebilmek için yaşla birlikte sürekli artma/azalma gösteren değerlere odaklanıldı. Yan yüz ve kulak alan hesaplamalarıyla birlikte, 19 antropometrik nokta kullanılarak doğrusal mesafe ölçümleri alındı.

Bulgular: Çalışmada 166 kadın, 203 erkek olmak üzere 369 gönüllünün yan yüz ve kulak görüntüleri üzerinden ImageJ programıyla ölçüler alındı. Kadınlarda yan yüz ve kulak üzerinden alınan ölçüler içinde sürekli artışın kulakta olduğu gözlendi. Erkeklerde de kadınlara benzer şekilde kulak boyutunda artış gözlenmekle birlikte kulak kepçesinde de genişlenme olduğu belirlendi.

Sonuç: Çalışmada elde edilen verilere göre, adli bir vakada kişilerin yüz görüntüsü üzerinden yaş tahmini yapılırken, ön yüz görüntüsünün elde edilemediği durumlarda profil görüntüsü ve kulak için yardımcı olabilecek nitelikte oldukları söylenebilir. Gelecek çalışmalarda veri sayısının ve parametrelerin artırılması halinde daha başarılı sonuçlar elde edilebilir.

Anahtar kelimeler: Yaş Tayini; Adli Bilimler; Antropometri, Biyometri; Kulak; Kimliklendirme.

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Conflict of Interest

The authors declare that they have no conflict of interests regarding content of this article.

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The author's doctoral thesis received financial support from Istanbul University-Cerrahpasa, Medical Faculty Clinical Research Ethics Committee (Project No: 51199). Through to this support, the purchase of basic materials such as paraflash sets, tripods and camera for the establishment of an amateur studio was provided.

Ethical Declaration

Permission was obtained from the Istanbul University Cerrahpasa, Medical Faculty Clinical Research Ethics Committee for this study, and Helsinki Declaration rules were followed to conduct this study.

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1. Introduction

Human shows different forms of aging on different ages. However, there are general changes and similarities during aging. Skin aging is the most understandable change in aging. During the first growth and development of the face, the biggest change consists of the craniofacial region (1).

When a person's age is found suspicious by legal authorities, they can ask age estimation. Nowadays, any age estimation method can accurately detect the chronological age (2). Since the difference between calendar age and medical age increases as the person gets older, the error rate can be up to 10 years (3).

Whether or not identification can be made from a visible part of a person's body is an issue that has been explored for years (4). Ear is a significant feature because it has been used in forensic science for years due to its shape, cartilaginous structure, and specificity of the auricle tissue (5,6). Since ear does not change much with facial expression and head movements, it has some advantages over identification concerning the face (7).

The most common method used in studies is ear images. The human ear grows comparatively throughout life. Although ear shape applications are not widely used, it is interesting for crime research. On the other hand, there is no standardized and generally accepted description used for the ear, unlike the face. We can remember people from their faces, but it is quite difficult to remember from their ears (8).

The effect of age on the face is an interesting subject for years. Different methods have been used for this subject. Although many studies are conducted with the front face images, the profile and especially the ear research are insufficient. Thus, in this study, we examined the changes that occur with age on the human face, especially on the ear.

2. Materials and Methods

2.1. Sample Group

Ethical Declaration

Permission was obtained from the Istanbul University Cerrahpasa, Medical Faculty Clinical Research Ethics Committee for this study, and Helsinki Declaration rules were followed to conduct this study.

The data obtained in this study were from166 female, 203 male, 369 participants who were randomly selected from the Marmara Region. Height and weight information and Body Mass Index (BMI) of the 369 volunteers were measured, and the participants in the obesity group, they were excluded from this study. After that, this study was completed using the data of a total of 345 participants, including 151 female participants and 194 male participants. Volunteers ages were divided into five groups, as follows: 18-28, 29-38, 39-48, 49-58, 59-68+. The number of people in these age groups is given in Table 1 with their gender information.

2.2. Methods

Volunteers' front and profile photos were taken in the amateur studio by one of the researchers in this study. The tools used in the studio were as follows: Elinchrom D-Lite-4 for lighting in the studio; Fancier 532 tripod to fix the camera; a white curtain to create white background; Nikon D5100 (18-55 mm lens) to take the photographs of the volunteers; hydraulic rotating stool, so that they could sit down during the photo shoot; digital scale with height meter for weight and height measurements. The purpose of this study was explained to the volunteers, and to record the information, the questionnaire form was filled, and informed consent forms were signed. Volunteers' height and weight measurements were taken first; then, the face photos were taken at a distance of 1 m, with 800 ASA and 50 mm flat lighting. Measurements on the images were taken by the ImageJ 1.50i (9).

Anthropometric Landmarks and Field Information Used in this Study

Otobasion superius (Obs): It is the connecting point of the helix in the temporal region and determines the upper border at which the ear meets the face (10).

Otobasion inferius (Obi): It is the point of attachment of the ear lobe to the cheek. Determines the lower border at which the ear meets the face (10).

Nasion (N): The point where the nasal bone meets the median sagittal line and forehead bone (11).

Gnathion (Gn): The lowest point in the median sagittal line in the lower jaw (11).

Pronasal (Prn): The most protruding point of the nose tip on the median sagittal line to the front (11).

Glabella (Gl): The point between the two eyebrows that protrudes forward in the median sagittal line (11).

Supramental (Sm): The deepest point of the concavity extending from the bottom of the lower lip to the chin (12).

Tragus (T): The part protruding in front of and above the auditory canal (13).

Superaurale (Sa): The highest point of the auricle (11).

Subaurale (Sba): The lowest point of the auricle (11).

Postaurale (Pa): The most outer point of the curvature of the auricle backwards (11).

Preaurale (Pra): The front of the ear. Positioned at the level of helix attachment to the head (14).

Intertragic notch (İntno): Deep notch between the Tragus and antitragus (intertragic notch) (15).

Ear rectangular area (ERA): Using the 'rectangular' selection tool in the ImageJ, using Obs and Obi landmarks, whichever is more external; Sa above; on the outside Pa; Sba points at the bottom are accepted as the boundary, the ear is placed in the frame and the area is calculated.

Ear polygon area (EPA): Obs, Sa, Pa, Sba, Obi and T landmarks on the ear were used for polygonal calculation. The area of the polygon obtained with the lines drawn between the placed points was calculated.

Linear distance measurements taken using the given anthropometric landmarks were handled in four different groups:

Distance between profile landmarks and Tragus: T-Gl, T-N, T-Prn, T-Sm, T-Gn (Figure 1).

Distance between the landmarks on the ear and Tragus: T-Obs, T-Sa, T-Sba, T-Obi (Figure 2).

Distances between the landmarks on the ear: Obs-Obi, Sa-Sba, Sa-Pa, Pa-Sba, Obi-Sba, Obi-Pa, Intno-Obi, Intno-Sba, Pra-Pa (Figure 3).

Ear area measurements: Ear Rectangle Area (Figure 4) and Ear Polygon Area (Figure 5).

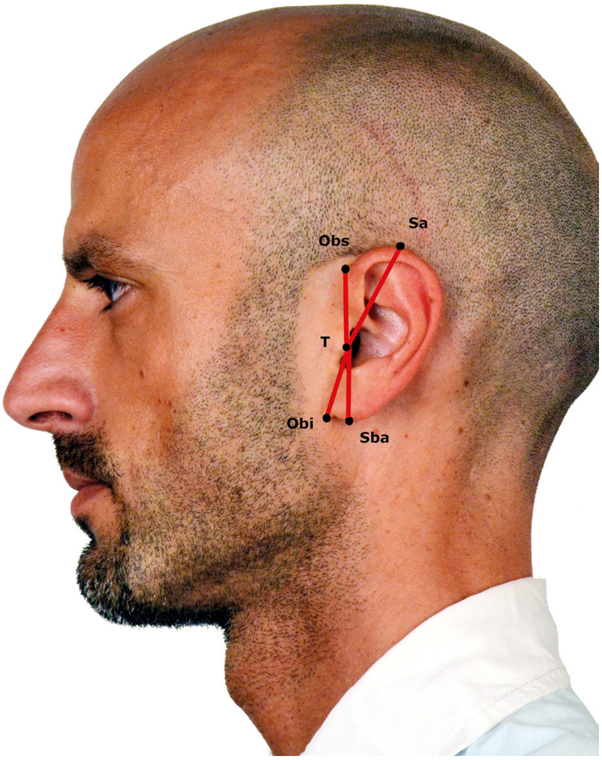

Figure 2. T-Obs, T-Sa, T-Sba, T-Obi (Distance between the ear and Tragus) [Published with the permission of the participant]

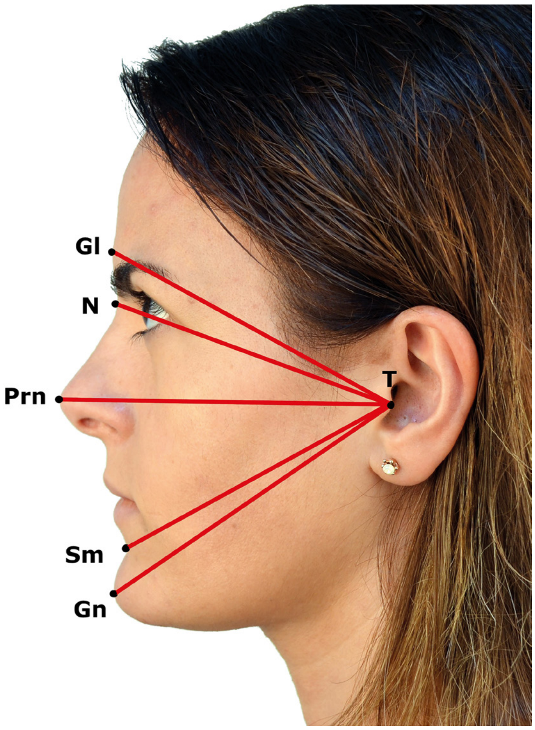

Figure 1. T-Gl, T-N, T-Prn, T-Sm, T-Gn (Distance between profile points and Tragus) [Published with the permission of the participant]

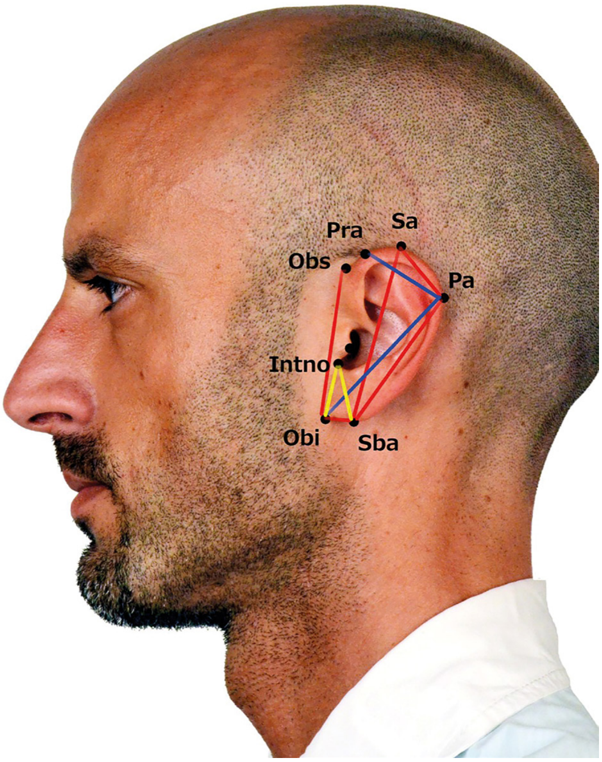

Figure 3. Obs-Obi, Sa-Sba, Sa-Pa, Pa-Sba, Obi-Sba, Obi-Pa, İntno-Obi, İntno-Sba, Pra-Pa (In-ear measurements) [Published with the permission of the participant]

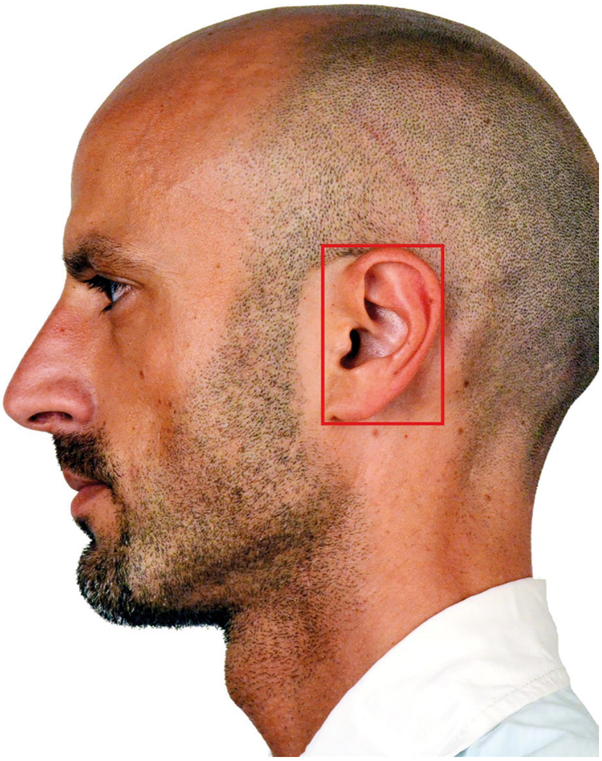

Figure 4. Ear Rectangle Area [Published with the permission of the participant]

Figure 5. Ear Polygon Area [Published with the permission of the participant

2.3. Statistical Analysis

ANOVA analysis was performed to compare measurement averages together with descriptive analyzes giving the number of volunteer participants in age groups. Post hoc tests for the groups that differed by ANOVA analysis were completed using the Tukey test. SPSS 20.00 (Statistical Package for the Social Sciences) was used for statistical analysis.

3. Results

In this study, after excluding data from a group of volunteers due to obesity, the information of 151 female, 194 male, a total of 345 volunteers was included, and the age groups and gender distribution are shown in Table 1.

Table 1. Distribution of participants by age groups and genders

Age groups	Female		Male	
	N	%	N	%
18-28	35	23,2	36	18,6
29-38	32	21,2	43	22,2
39-48	28	18,5	45	23,2
49-58	27	17,9	33	17,0
59-68+	29	19,2	37	19,1
Total	151	100,0	194	100,0

The average height of female volunteers was 161,77 cm, the average weight was 64,30 kg; the average height of male volunteers was 174,70 cm and the average weight was 81,90 kg (Table 2).

Table 2. Height and weight information of the volunteers with gender

	Height		Weight	
	Mean	S.D.	Mean	S.D.
Female	161,77	6,292	64,30	11,414
Male	174,70	7,425	81,90	12,471

The averages of female volunteers' measurements by age groups are given in Table 3. No statistical significance was observed in Profile-Tragus measurements in female (P<0,05) participants. However, all measurements in the Ear-Tragus, in-ear points and ear areas groups differed by age groups (Table 3).

In the measurements taken from male volunteers, there was a significant difference (P <0,05) in all measurement groups (Profile-Tragus, Ear-Tragus, In-ear measurements, Ear area) by age groups (Table 4).

Results related to measurements between Profile-Tragus Landmarks

There was no significant difference found in female all measurements, but a significant difference was found in all measurements in male participants (Table 4). In post hoc analysis, for male, 59-68+ age group were not different from the age group of 49-59 (P=0,583) in the measurements between Tragus-Supramental, and higher than all the other groups (age groups from young to adult, P= 0,004; 0,019; 0,007, respectively). Again, in the 59-68+ age group, it was observed that it was higher than for the distance between Tragus and Gnathion from 39-48 age group (P=0,038), for the distance between Tragus and Pronasal, from both 18-28 (P=0,018) and 39-48 age group (P=0,030), for the distance between Tragus and Glabella only from 18-28 age group (P=0,048) (P<0,05). Although in ANOVA analysis, there was a difference in the measurements between Tragus and Nasion, there was no difference between groups in post hoc analysis (Tables 3, 4).

Results related measurements between Ear-Tragus Landmarks

18-28 age group values were significantly (P<0,05) lower than 59-68+ age group in female (P=0,012) and 49-58 age group in male (P=0,029) participants for the distance between Tragus and Superaurale. There was no difference between other age groups in both genders.

It was found that the measurement between Tragus and Subaurale in 59-68+ age group in female participants was significantly higher than all age groups (P=0,000 in all other age groups) (P<0,05) except the 49-58 age group (P=0,078). Again, the 49-58 age group was higher than the groups under 38 in both genders (P=0,000; 0,003 in female; P=0,000; 0,002 in male) (P<0,05).

59-68+ age group in female participants was higher than 18-28 (P=0,000) and 39-48 (P=0,002) age groups; 59-68+ age group in males was higher than all the age groups in the measurements between Tragus-Otobasion superior landmarks. Also, in male, the 49-58 age group measurements were higher in the 18-28 (P=0,000) and 39-48 age groups (P=0,043) (P<0,05).

59-68+ age group in female was higher in the measurements between Tragus-Otobasion inferior landmarks from all the other groups (P=0,000; 0,001; 0,031; 0,032, respectively) (P<0,01-0,05). Groups over the age of 39 did not differ among themselves; however, they were found higher than the age groups 18-28 (P=0,000) and 29-38 (P=0,014) in male (P<0,01 – 0,05) participants.

Results Related Measurements between the In-ear Landmarks

Distances between the Otobasion inferior-Otobasion superior and Otobasion inferior-Intertragic notch in the 59-68+ age group (P=0,000; 0,001; 0,003; 0,002, respectively for Obs-Obi and P=0,000; 0,000; 0,001; 0,012, respectively for Intno-Obi) was higher than all age groups

Table 3. Average values and standard deviations of ear measurements by age in female

Measurements groups	Measurements	18-28		29-38		39-48		49-58		59-68+		P
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
PROFILE-TRAGUS	T-Gl	151,34	10,47	150,13	10,91	151,73	11,10	153,31	11,27	154,26	11,89	0,633
	T-N	138,53	11,28	136,76	10,18	139,33	12,33	142,20	12,39	141,76	11,86	0,345
	T-Prn	162,60	12,97	158,24	12,04	160,80	13,58	163,11	13,78	162,70	11,93	0,548
	T-Sm	148,85	12,44	142,13	12,06	144,02	12,95	147,54	11,64	147,88	11,91	0,145
	T-Gn	157,10	12,59	151,88	13,14	153,60	12,84	156,75	11,05	158,08	12,94	0,259
EAR-TRAGUS	T-Obs	35,86	3,81	37,36	3,07	36,15	3,37	37,39	4,17	40,25	5,39	0,000
	T-Sa	50,91	4,93	51,59	3,44	51,29	4,05	54,54	4,62	54,76	5,61	0,001
	T-Sba	32,38	3,65	33,94	3,91	35,51	4,78	37,98	3,76	40,85	4,60	0,000
	T-Obi	27,16	4,57	28,39	4,57	29,54	5,48	29,51	4,94	33,44	5,55	0,000
IN-EAR	Obs-Obi	60,48	6,29	62,42	6,01	62,77	6,70	62,50	9,30	70,16	8,87	0,000
	Sa-Sba	80,72	6,93	83,03	6,05	84,09	7,65	89,89	6,88	94,09	8,44	0,000
	Pa-Sba	37,97	7,17	37,57	7,57	35,67	3,96	38,97	6,32	43,55	6,77	0,001
	Obi-Sba	10,02	3,32	10,53	3,71	10,52	3,93	13,21	4,37	13,16	5,24	0,003
	Obi-Pa	62,22	7,29	64,34	8,30	65,80	8,33	68,27	9,93	70,43	8,02	0,002
	Intno-Obi	19,55	3,68	20,82	4,61	21,64	4,65	22,49	4,27	26,56	6,06	0,000
	Intno-Sba	26,08	2,97	28,28	3,60	28,51	4,39	31,10	3,32	34,14	4,81	0,000
	Pra-Pa	47,30	3,94	48,61	5,42	46,56	5,14	48,99	4,76	52,66	6,58	0,000
EAR AREA	ERA mm2	4113,63	613,97	4378,51	590,75	4437,04	773,55	4995,76	779,88	5265,96	899,25	0,000
	EPA mm2	2377,39	319,87	2469,08	283,26	2526,57	420,22	2761,97	374,82	2954,23	562,20	0,000

in female participants and there was no significant difference between the other age groups (P<0,05). The distance between Preaurale and Postaurale was only in the 59-68+ age group from other groups in female (P=0,001; 0,028; 0,000, respectively); it was higher than the groups under the age of 39 in male (P=0,000; 0,027, respectively) participants.

In both genders, distances between Intertragic notch-Subaurale was different in the 59-68+ age group (P=0,000; 0,000; 0,000; 0,029, respectively in female; P=0,000; 0,000; 0,003 respectively in male); the distance between Superaurale and Subaurale was different in all groups under the age of 49 (P=0,000 in both genders). Also, it was higher than the 49-58 age group in female in all groups except the 59-68+ age group (P=0,000; 0,004; 0,036, respectively); in male, in the groups under the age of 39 (P=0,000; 0,013) (P<0,05).

In the female participants, the measurements between Postaurale and Otobasion inferior, in 49-58 age group was higher than 18-28 age group (P=0,045); 59-68+ age group was higher than the groups under the age of 39 (P=0,002; 0,044, respectively) (P<0,005 – 0,05).

In the male participants, the distance between Otobasion superior-Otobasion inferior was lower in the 18-28 age group than all age groups (P=0,045, respectively, and P=0,000 in the other three groups); in the 29-38 age group, it was lower than the two groups over the age of 49 (P=0,003; 0,004, respectively) (P<0,005 – 0,05). While the distances between Superaurale- Subaurale (P=0,000 in two groups over the age of 49 in the age group 18-28; P=0,013; 0,000 in the age group of 29-38, respectively), Intertragic notch-Otobasion inferior (18-28 age group in all groups above the age of 39 P=0,000; 29-38 age group above the age of 39 P=0,013; 0,001; 0,003, respectively) and Intertragic notch-Subaurale were smaller in the 18-28 age group than the older groups (P=0,000) and in the 29-38 age group was smaller than over the age of 49 (P=0,000) (P<0,005 – 0,05), no difference was found between the groups above the age of 49 (P<0,05). For this last measurement, the 59-68+ age group was higher than the 39-48 age group (P=0,003) (P<0,05).

In female, the distance between Otobasion superior and Otobasion inferior was higher in the 59-68+ age group compared to other groups (P=0,000; 0,001; 0,003; 0,002, respectively). In 59-68+ age group, the distance between Superaurale and Subaurale was higher than the all groups except 49-58 age group (P=0,000); in the 49-58 age group, it was higher in all younger groups (P=0,000; 0,004; 0,036, respectively). In the 59-68+ age group, the distance between Intertragic notch-Otobasion was inferior compared to all other groups (P=0,000; 0,000; 0,001; 0,012, respectively); the distance between the Intertragic notch-Subaurale in the 49-58 age group from the under the age of 39 (P=0,000; 0,045, respectively); in the 59-68+ age group, it was higher than all groups (P=0,000; 0,000; 0,000; 0,029, respectively) (P<0,05).

The distance between Otobasion inferior-Subaurale in female was higher in both groups over the age of 49

Table 4. Average values and standard deviations of ear measurements by age in male participants

Measurements groups	Measurements	18-28		29-38		39-48		49-58		59-68+		P
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
PROFILE-TRAGUS	T-Gl	153,26	13,39	154,29	11,90	154,32	11,68	159,68	11,27	160,93	10,65	0,012
	T-N	140,75	12,70	142,03	11,56	142,61	11,16	146,46	11,25	147,82	10,10	0,042
	T-Prn	163,10	13,58	165,06	13,23	164,16	11,37	169,85	12,84	172,51	12,98	0,006
	T-Sm	148,47	12,07	150,18	12,10	149,41	10,18	154,30	12,15	158,50	13,22	0,001
	T-Gn	161,10	11,12	161,90	12,92	161,17	10,45	165,92	11,75	168,69	12,60	0,017
EAR-TRAGUS	T-Obs	39,47	3,94	41,86	3,03	41,78	3,77	44,11	3,38	43,72	3,86	0,000
	T-Sa	54,47	5,18	56,04	3,90	54,96	4,94	57,95	4,76	57,52	5,58	0,008
	T-Sba	34,16	3,55	35,32	4,21	37,96	4,35	39,45	4,54	42,97	6,21	0,000
	T-Obi	27,65	4,89	28,99	4,50	32,48	5,06	32,45	4,94	32,50	4,99	0,000
IN-EAR	Obs-Obi	63,43	6,50	67,61	6,23	71,00	7,04	73,25	6,58	72,98	6,67	0,000
	Sa-Sba	85,89	6,83	88,90	6,41	90,10	8,12	94,65	7,42	98,60	9,28	0,000
	Pa-Sba	67,58	10,63	68,64	8,92	69,73	9,48	73,13	11,12	76,41	8,56	0,001
	Obi-Sba	10,86	3,09	10,94	3,19	10,69	3,78	12,98	3,97	14,72	5,31	0,000
	Obi-Pa	67,83	9,68	69,40	8,42	71,03	8,53	74,24	10,42	74,53	7,35	0,004
	Intno-Obi	20,14	4,42	21,56	4,69	24,67	4,85	25,73	5,01	25,30	3,34	0,000
	Intno-Sba	27,48	3,43	29,05	3,66	31,46	3,79	33,27	4,53	34,90	5,66	0,000
	Pra-Pa	46,47	6,36	48,83	6,40	49,28	5,79	50,79	6,62	53,10	6,45	0,000
EAR AREA	ERA mm2	4544,29	697,10	4786,64	740,18	4935,57	943,22	5509,41	833,82	5690,62	967,50	0,000
	EPA mm2	2600,99	424,93	2734,12	425,34	2793,18	463,83	3115,75	538,64	3209,55	545,24	0,000

compared to the 18-28 age group (P=0,025; 0,024, respectively); the distance between Postaurale-Subaurale was higher in both groups over the age of 49 compared to the 18-28 age group (P=0,005; 0,001, respectively) (P<0,005 – 0,05). In the distance between Postaurale and Otobasion inferior, two groups over 49 were higher than the 18-28 age group (P=0,045; 0,002, respectively); it was also higher in above the age of 59 than the age group of 29-38 (P=0,044) (P<0,05). In the distance between Preaurale and Postaurale, for the 18-28, 29-38 and 39-48 age groups were smaller than the 59-68+ age group (P=0,002; 0,028; 0,000, respectively) (P<0,05-0,005).

The distance between Otobasion inferior-Subaurale was higher than all groups (P=0,000) above the age of 59, except the 49-58 age group in male. The distance between Postaurale- Subaurale was higher above 59 years of age than all groups (P=0,001; 0,004; 0,020, respectively) except the 49-58 age group. The distance between Postaurale and Otobasion inferior was lower in the 18-28 age group than over the age of 49 (P=0,025; 0,013). In the same way, the distance between Preaurale and Postaurale as lower in the 18-28 age group than over the age of 49 (P=0,040; 0,000) and also over the age of 59 was bigger than 29-38 age group (P=0,027) (P<0,05).

Results of the Ear Area Measurements

There were no differences in the ear polygon and ear rectangular area measurements for both female and male participants in two groups over the age of 49, and the values in these two groups were larger than the other age groups (P<0,05 – 0,001). The the female ear rectangular area in the 59-68 age group was larger than other groups, except the 49-58 age group (P=0,000); in the 49-58 age group, it was also larger than other groups, except over the age of 59 (P=0,000; 0,014; 0,047). The ear polygon area was also larger in the 59-68 age group than the other groups, except the 49-58 age group (P=0,000; 0,000; 0,001, respectively); in the 49-58 age group, it was larger than the other groups, except over the age of 39 (P=0,002; 0,047, respectively). The male ear rectangular area was larger in the 59-68 age group, except for the 49-58 age group (P=0,000; 0,000; 0,001, respectively); in the 49-58 age group, it was also larger than the other groups, except over the age of 59 (P=0,000; 0,003; 0,028, respectively). The ear polygon area was larger in the 59-68 age group than the other groups, except the 49-58 age group (P=0,000; 0,000; 0,001, respectively), in the 49-58 age group was also larger than the other groups, except over the age of 59 (P=0,000; 0,007; 0,030, respectively) (P<0,05).

4. Discussion

In regional studies on human face images, the ear is an important parameter because it is unique, it can be used with different methods (e.g., earprints and ear images) and it can be used concerning identification on the faces that are tried to be hidden in the security cameras and on the face viewed from the side.

For the first time in the 18th century, Lavator started to examine the ear by illustrating the ears of the people in his reports. In 1894, Bertillon used the earprint for identification and tried to reveal the characteristic features of the ear with anthropometric measurements. In 1906, Dr. Imhofer revealed all the characteristic features of the ear and permission of the earprint to be used in identification. The ear was used for the identification of a criminal for the first time in 1965. Iannarelli compared ten thousand earprints in 1989 and determined that they were different from each other. In later years, especially in forensic cases, the ear continued to be used as a parameter (16).

Today, such studies are tried to be developed by producing novel methods with technology. The importance of ear in forensic science has been increasing in recent years. Thus, in this study, especially by taking many measurements on the ear, its relationship with age was examined and tried to contribute to the literature.

Nabiyev (17) defended that the success rate in identification will increase when information about ear used with other features, such as nose, lips and forehead. Sforza et al. (18) stated that age-related growth/enlargement was observed more frequently in the ear during the aging process.

In this study, similarly, the statistical significance rates (P<0,05) of ear measurements resulted better than face profile measurements. While the *Tragus* was fixed point, the lateral measurements (Profile-Tragus) taken from the profile did not show any statistical significance with age in female participants, but the difference was observed in all age groups in male (P<0,05) participants. An increase was observed with age in profile dimensions, especially due to soft tissue sagging. It can be seen that the ear moves downward with age by the increase in the Glabella-Tragus and Nasion-Tragus distances of the profile (lateral measurements) in male.

Sforza et al. (18) stated that the ear length in 15-17 age group girls was slightly higher than the adult group values and found that the ear length in both genders developed more than the ear width. Gualdi-Russo (19) stated that the ear size and ear area develop faster than ear width. In the study conducted in the Caucasians, the ear length was found to be 65 mm on average in males between the ages of 21-65 (20), Özkoçak (21) stated that ear length is higher than Caucasians and increases with age.

In this study, in female, there is a significant difference observed in the ear length, ear lobe length and ear width in their 60s age compared to other age groups. While ear lobe length did not differ among female in young age groups, it increased in 60s ages compared to other groups. The ear length and ear lobe length increased up to the age of 50s, after which this increase almost stopped in male. Moreover, ear width has increased from the age of 60s compared to other age groups. While there is a continuous increase in the measurements that Tragus-Subaurale, Intertragic notch-Otobasion inferius and Intertragic notch-Subaurale taken from the ear lobe, as the reason for not being seen only in the Otobasion inferius-Subaurale, the Otobasion inferius is thought to be moving downward with age like Subaurale.

The auricle is one of the few organs that continue to develop during its lifetime (22). Aroral noted that the size of the auricle increases with age, even after full development and the values are higher in older individuals. This increase may be due to the elastic fibers in the ear cartilage (23). It has been stated in other studies that the increase in ear size is also related to the decrease of the elasticity of the skin and gravity (24). Also, in a study of age-related morphological changes in adult human auricle elastic cartilage, it was observed that the auricle significantly increased with age in both genders. It has been suggested that this situation is associated with changes in elastic fibers after childhood (25). Another study stated that almost all linear dimensions of the auricle increased with age in both genders. It has been stated that this increase can be associated with decreasing tensile strength or decreasing elasticity of gravity with age (26).

Gender and age are the main factors affecting earlobe length in the adult population. Ethnicity, skin structure, gravity and BMI are not complicated (27). Shireen (2015) stated that an aging deformity that may develop with aging could cause the ear lobe to extend, and this is attributed to the loss of elastic fibers and gravity (28,29,30,31). Azaria stated that ear lobe length increased with age in both genders. In multiple regression models, age was seen as the most important factor affecting ear lobe length and affecting female twice as much as the male. It has been stated that the ear lobe length increased by 30-35% from the youngest group (the group of age 20-40) to the oldest group (age of 60). These changes have been linked to a decrease in the tensile strength of the connective tissue over time, similar to other studies mentioned (32). Extension of the ear lobe slows down significantly in the female after the age of 40. It has been stated that earrings increase the weight on the ears as a reason for the increase in female, which affects the lobe length. It has also stated that the width of the auricle continues to older ages in male and that gender differences may be affected by genetic factors (27,28). Eboh stated that ear lobe length was statistically significantly higher in girls than in boys, which was linked to population-specific factors (32).

Verma (2016) observed that ear measurements increased significantly with age in both genders and suggested that this change was related to changes in elastic fibers, which are seen faster in male than in female (29). Differences between studies on ear morphology can be affected by various factors, such as geographic location, ethnicity and genetics (32).

The projection at the levels of Superaurale and Tragus showed a decreasing trend with increasing age. It is stated that this decrease may be due to possible sleep position and skin elasticity (26).

When the in-ear measurements are examined, no comparison can be made due to the lack of similar measurements in the literature. However, it has been observed that the upper ear length has increased since the 60s for female and the 50s for male, and the lower ear length has increased since the 50s for both genders. This is thought to be due to the soft tissue sagging that occurs because the ear lobe does not contain bone and cartilage tissue, and the lower part of the ear is more prominently affected by aging. It was observed that, especially in the Tragus-Otobasion inferior, distance developed in the male until the 40s, unlike the female, and did not show any significant difference afterwards. It is thought that the ear lobe may be deformed female more than male due to the use of accessories; however, this analysis has not been strengthened.

Azaria (2003) stated that body mass index significantly affects ear lobe length in female, and in male, the weight, height and body mass index are not statistically significant ($P<0,05$) to ear lobe length (27). Due to the studies about the effects of obesity on ear measurement values, obese volunteers were not included in this study by looking at their BMI values.

5. Conclusion

Studies on identification in forensic science are gaining importance day by day as security issues are experienced due to the increasing number of people. This study is also important in the field of identification, to reach an age, especially in terms of emphasizing the ear. In security cameras, such studies constitute a statistical basis for age estimation, especially since the information on the side and ear is important when the person is viewed from the side.

The ear is an important biometric field of identification, as it is personal. When its own measurements and its relationship with the face are determined, it will enable the production of more practical studies in terms of identification in forensic cases in the future. Metric and morphological knowledge and evaluation of each biometrics on the face are not only for forensic cases; they are also important for biometric technologies that include facial identification.

In a forensic case, when we evaluate the averages of the side and/or ear images at hand, within the age ranges, we can make an estimate of the age group of the person in the image. In future studies, more parameters should be used with a wider age group to obtain better results.

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