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Assessment of ear metric properties in young Turkish adults

Genç Türk erişkinlerde kulak metrik özelliklerinin değerlendirilmesi

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Abstract

Aim: The ear is a critical component of the human face functionally and aesthetically. Studies in recent years have reported that the morphological properties of the outer ear show substantial differences based on sex and ethnic group. The data obtained in these studies are guiding for plastic surgeons.

Methods: This cross-sectional study was carried out on a Turkish population. Ear axis, antihelix angle, ear length, ear width, earlobe length and earlobe width measurements were made on 191 healthy adult volunteers (106 women, 85 men) between the ages of 18-25 years. Ear metric values mentioned above were compared between the genders, and correlation analysis was conducted for all.

Results: All values except the antihelix angle were larger in males (P=0.0486; P<0.001; P=0.004; P<0.001; P=0.038 for ear axis, length, width, ear lobule length and width respectively). The ear axis was positively correlated with the antihelix angle, the ear width and the ear lobule width and the ear length was positively correlated with the ear width and ear lobule length (P<0.001 for both).

Conclusion: Although our study has some limitations it includes noteworthy data about outer ear metric values of the young adult Turkish population which we believe is going to be beneficial to standardization and optimization in ear surgery.

Keywords: Pinna, Metric, Aesthetic, Anatomy

Öz

Amaç: Kulak, fonksiyonel ve estetik olarak insan yüzünün son derece önemli bir bileşenidir. Son yıllarda yapılan çalışmalar dış kulağın morfolojik özelliklerinin cinsiyete ve etnik gruba göre makul farklılıklar gösterdiğini raporlamıştır. Bu çalışmalardan elde edilen veriler plastik cerrahlar için yönlendiricidir.

Yöntemler: Çalışmamız Türk popülasyonu üzerinde gerçekleştirilmiştir. 18-25 yaşları arasında 191 sağlıklı yetişkin gönüllünün (106 kadın, 85 erkek) kulak ekseni, antiheliks açısı, kulak uzunluğu, kulak genişliği, kulak memesi uzunluğu ve kulak memesi genişliği ölçümleri yapılmıştır. Tüm parametreler cinsiyetler arasında karşılaştırılmıştır ve hepsi için korelasyon analizi yapılmıştır.

Bulgular: Anti heliks açısı dışında tüm değerler erkeklerde kadınlara göre daha büyük bulundu (P=0,0486; P<0,001; P=0,004; P<0,001; P=0,038 sırasıyla kulak ekseni, uzunluğu, genişliği, kulak memesi uzunluğu ve genişliği için). Kulak ekseni, antiheliks açısı, kulak genişliği ve kulak memesi genişliği ile pozitif korelasyon gösterdi ve kulak uzunluğu, kulak genişliği ve kulak memesi uzunluğu ile pozitif korelasyon gösterdi (her ikisi için P<0,001).

Sonuç: Çalışmamızın bazı sınırlılıkları olmakla birlikte, kulak cerrahisinde standardizasyon ve optimizasyon için faydalı olacağına inandığımız genç erişkin Türk popülasyonunun dış kulak ölçüm değerleri hakkında dikkate değer veriler içermektedir.

Anahtar kelimeler: Pinna, Metrik, Estetik, Anatomi

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Introduction

Reconstruction of the auricle (pinna) is technically difficult due to some factors. Before changing the shape of the ear, plastic surgeons need to have normal anatomical data that determine the normal shape, size, and direction limits of the ear. The auricle is one of the descriptive properties of the face. It is not a focus of beauty itself, but deviations in its symmetry, direction or projection may be easily noticed and divert a face from a sense of aesthetics [1]. Accordingly, some studies conducted recently have reported that every part of the outer ear is morphologically unique and shows substantial differences in individuals and population groups [2-4]. Additionally, the lateral notch found in its three-dimensional topography is a unique structure that contributes to a normal outer ear with its vertical placement and characteristic contour structure [1,2]. This unique structure of the ear may be helpful in determining the identity of individuals and in terms of anthropology and forensic medicine [4, 5].

A deformation in the shape and size of the auricle may indicate a possible congenital anomaly or syndrome in the patient [3]. The auricle is a flexible structure consisting of five main anatomical regions as the concha, helix, antihelix, tragus, and lobule formed by skin, cartilage and fat tissues [6]. A cartilaginous notch on the helix is known as “Darwin’s tubercle”, and it is a vestigial residue corresponding to the tip of the ear of some animals [4]. The contour of the auricle is determined by the configuration of the elastic cartilage frame [1, 4]. The skin of its lateral and medial surfaces contains hair with both sebaceous and sudoriferous glands. While the skin is laterally tightly connected to the perichondrium, medially, it is only loosely connected. The cartilage of the auricle is an extension of the meatus acusticus externus cartilage, and it is fixed on the cranium with a few ligaments and muscle connections [1].

Embryologically, the outer ear starts to form within 6 weeks of pregnancy and completes its formation up to the 18^{th} week. Six tissue elevations known as the hillocks of His develop. Each of these elevations shape different parts of the outer ear. The first three elevations originate from the first branchial arch and combine to form the tragus, helix, and antitragus, whereas the next three elevations originate from the second branchial arch and form the antihelix and concha. The ear lobule (lobule) does not originate from these elevations [6]. Tragus, on the other hand, does not contain cartilage tissue although it develops from the first branchial arch. Incomplete fusional conglomerations of the branchial arches lead to malformations of the outer ear. During arrangement of the formed deformities with otoplasty, instead of individual aesthetical perceptions, some ratios need to be used. Therefore, measurements that will provide reconstruction and aesthetical perception compatible with the social population are required. In many studies, the structure of the ear has been examined metrically to reveal societal differences. Most of such studies have reported that ear dimensions are metrically variable in individuals and populations, ear measurement parameters are larger in men than women, and the ears show bilateral asymmetry [2,4]. It may be stated that data obtained from studies making metric observations provide evidence-based indicators regarding the ratios of an aesthetically pleasing ear. In summary, ear morphology is aesthetically important and shows differences between ethnic groups and genders [2,3]. For this reason, in our study, which we want to become a significant guide for the Turkish population in auricular surgery, in Turkish male and female individuals, ear axis, antihelix angle, ear length, ear width, lobule length and lobule width measurements were made, and they were compared between the genders. Correlation analysis was conducted for all parameters.

Materials and methods

All authors declare that the study was carried out in accordance with the World Medical Association Helsinki Declaration "Ethical Principles for Medical Research on Human Subjects".

Participants

This cross-sectional study was conducted with 191 healthy adult volunteers (106 women, 55.497%; 85 men, 44.503%) between the ages of 18-25 years after obtaining approval from the Ethics Board of Cukurova University (Ethical permission no:2020/95). Participants were informed about the study and gave individual consent. It was aimed to include healthy individuals in the study. For this reason, the inclusion criteria were determined as not having had any facial surgical operation and not having a history of any neurological disease. Among the 200 volunteers who were included at the beginning of the study, 9 volunteers who later refused to participate were excluded.

Measurements

The photographs of the participants which covered their entire profile were taken with a Digital SLR camera with constant photographing values (Canon EOS 80D; ISO 100 f / 4.5). The photography system was set up by fixing the camera with an adjustable tripod. The tripod height was adjusted based on the height of each individual. In the photography procedure, each individual was firstly asked to stand up and relax, and they were then put into the Frankfurt Horizontal Plane (FHP) position, which is the natural head position. FHP is considered the natural anatomical position of the human skull. This plane passes through the lower edge of the orbita and the upper edge of the external auditory meatus and is a significant reference for surgeons [7]. Reports have stated that FHP is an adequately reliable reference plane for different treatments and studies [8]. For this reason, in our study, we preferred to use FHP while making the measurements. The images taken on this plane were then transferred to a computer. The ear axis, antihelix angle (angle between the antihelix and the vertical), ear length, ear width, lobule length and lobule width were measured by using the Image J 1.52a program. The physiognomic ear length was measured by following the long axis of the ear as the direct distance between the supra-auricula and sub-auricula. While measuring the ear length, the distance between the very tip of the lobule to the farthest point of the auricle was used. The physiognomic ear width was measured as the direct distance between the pre-auricula and post-auricula. The ear width was measured in two ways as a and b (Figure 1). The lobule length was measured as the direct distance between the incisura intertragica and the deepest point in the sub-auricula. The lobule

width was measured at the center point of the lobular length as the distance between the anterior lobule and posterior lobule. The ear axis angle was considered the angle between the axis where the ear length measurement was made and the vertical plane. The measurements were made with a precision of 1/100 mm.

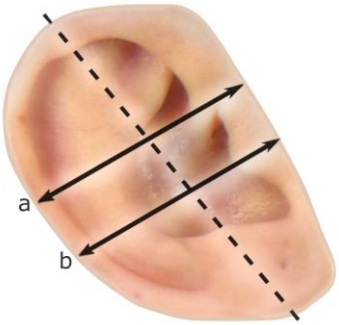

Figure 1: Presentation of ear width a and b measurement method on a volunteer

Statistical analysis

For the statistical analysis of the measurement results, the SPSS Windows version 24.0 package software was used. As n>30, Student's t-test was used to compare the variables between genders. The values are presented as mean (standard deviation). As n>30, the Pearson's correlation coefficient was used for correlation analysis. In all analyses, $P<0.05$ was considered statistically significant.

Results

In the comparison of the metric properties of the ear between the genders, almost all parameters turned out to be larger in the males than the females: The ear axis, ear length, ear width a and b, lobule length and width were all significantly higher in males ($P=0.049$, $P<0.001$, $P<0.001$, $P=0.004$, $P<0.001$ and $P=0.039$, respectively). There was no statistically significant difference between the genders in terms of the antihelix angle (Table 1).

Correlation analyses between ear metric properties yielded that there was a positive strong correlation between the ear axis and antihelix angle (r=0.417, $P=0.001$), the ear axis and ear width b (r=0.307, $P=0.001$) and the ear axis and lobule width (r=0.270, $P=0.001$). There was a significant positive correlation between the antihelix angle and ear width b (r=0.168, $P=0.020$), the ear length and ear width a (r=0.153, $P=0.034$), a positive strong correlation between the ear length and ear width b (r=0.660, $P=0.001$), ear length and lobule length (r=0.603, $P=0.001$) and ear length and lobule width (r=0.286, $P=0.001$). There were positive, strong and significant correlations between the ear width b and lobule length (r=0.361, $P=0.001$), ear width b and lobule width (r=0.530, $P=0.001$) and lobule length and lobule width (r=0.437, $P=0.001$) (Table 2).

Table 1: Comparison of ear metric properties between sexes

	Male (n=85)		Female (n=106)		*P*-value
	Mean	SD	Mean	SD	
Ear axis (°)	16.29	2.203	15.62	2.416	0.049
Antihelix angle (°)	61.95	8.586	60.76	9.152	0.360
Ear length (cm)	74.19	6.714	68.75	7.01	<0.001
Ear width a (cm)	41.04	4.584	37.6	3.987	<0.001
Ear width b (cm)	31.69	3.848	30.13	3.492	0.004
Ear lobule length (cm)	18.18	3.083	16.45	2.652	<0.001
Ear lobule width (cm)	22.32	3.848	21.21	3.306	0.039

SD: Standard deviation, cm: Centimeters

Table 2: Correlation analysis between ear metric properties

Variable 1	Variable 2	r	*P*-value
Ear axis (°)	Antihelix angle (°)	0.417	<0.001
Ear axis (°)	Ear width b (cm)	0.307	<0.001
Ear axis (°)	Earlobe width (cm)	0.270	<0.001
Antihelix angle (°)	Ear width b (cm)	0.168	0.020
Ear length (cm)	Ear width a (cm)	0.153	0.034
Ear length (cm)	Ear width b (cm)	0.660	<0.001
Ear length (cm)	Earlobe length (cm)	0.603	<0.001
Ear length (cm)	Earlobe width (cm)	0.286	<0.001
Ear width b (cm)	Earlobe length (cm)	0.361	<0.001
Ear width b (cm)	Earlobe width (cm)	0.530	<0.001
Earlobe length (cm)	Earlobe width (cm)	0.437	<0.001

cm: Centimeters, r: Correlation coefficient

Discussion

Knowing about the morphological properties and normal anatomical dimensions of the auricle is important in the diagnosis and surgical planning of congenital and acquired malformations [5]. The objectives of ear surgery include basing the ratios of an aesthetically pleasing ear on not the personal aesthetical views of surgeons but evidence-based data. Therefore, it is important to create standard measurements. Human auricles have a unique shape and are a well-known part of our auditory system. The shape of the outer ear is far from random, and it has developed to allow spatial localization of sounds. As it performs shape-specific filtering, it mediates monoaural cues, while it mediates binaural cues due to the bilateral localizations of the right and left ears [9]. The distance of the ear to the lateral orbital edge is approximately the same as the height of the ear [6]. The apex of the ear should be on the level of the eyebrows. The auriculocephalic angle is ideally between 25 and 35 degrees, while angles of larger than 45 degrees are considered too high. A scapha-conchal angle of lower than 90 degrees is ideal, and an angle larger than 90 degrees leads to a less aesthetical appearance by causing the scapha and fossa triangularis to protrude anteriorly rather than laterally. The helical edge needs to protrude from the head by 15 to 20 mm [1].

According to published reports, the average length of an ear is 55 to 65 mm, and the average width is 55% of the length [1]. Moreover, it is known that the morphology of the ear differs between genders [2,3]. In their study which investigated the dimensions of the auricle based on the factor of gender, Verma et al. [5] found that the two ears were symmetrical, and measurements (upper-tragus ear length, lower-tragus ear length, ear width, concha length, concha width, lobular height, lobular width) were higher among men than women [5]. In our study with healthy Turkish volunteers between the ages of 18-25 years, similar to previous studies, the ear axis, ear length and ear width were larger in the males than females. On the other hand, Senthil Kumar and Selvi [3] found that, although the total ear length was larger in men, the lobule length and width were almost the same between men and women [3]. In our study, the lobule length and width were significantly larger in males than females. It is possible that this significant finding could have been caused by the differences in ethnic groups and ages. However, it should still be kept in mind looking at our findings that the difference between the genders was larger in terms of the ear length and ear width a. As it was previously reported that there is no significant relationship between head size (height /width) and ear size (length / width) [2], our study did not assess head dimensions.

Previous studies have observed that the antihelix angle does not vary based on the ethnic group, but there is a statistically significant reduction by increasing age in both men and women. It is thought that the elongation of the ear might affect this [2]. The results of our study also showed that difference in genders does not create a significant difference in terms of the antihelix angle. Not finding a significant difference between ethnic groups and gender in this parameter may be related to the fact that the antihelix angle shows a large variation among individuals. Consequently, the data suggest that the antihelix angle plays an exceedingly small role in defining a normal ear. In addition to this, another significant aspect of the shape of the outer ear is its uniqueness from one person to another on the level seen in fingerprints and facial properties [9]. Considering that, in the embryonic period, the antihelix and concha develop from different tissue elevations than the tragus, helix and antitragus [6], we recommend the necessity to investigate the place of the antihelix in more detail in terms of the significance of the ear in identification in forensic cases. The correlation between the ear axis and the antihelix suggests that antihelix characteristics may be also important for the function of sound localization.

The auricle grows based on age. The auricle grows fast in the first 3 years of life and reaches approximately 85% of the adult size at ages 6 to 8 and 95% at ages 8 to 10 [1]. The auricle reaches its adult size at the age of 13 in men and 12 in women [3]. In the last few years, ear dimensions in different ethnic groups have been investigated in various studies where direct and indirect anthropometrics and photography were used [10]. Although there are ethnic differences, all these studies have reported that the auricle's dimensions significantly increase by age in both men and women due to changes in elastic fibers after adulthood (even after reaching skeletal maturity) [3,10]. Previous studies showed that age-related dimensional changes are not the same for all variables; the ear length continues to increase faster and for a longer time in comparison to the ear width [10]. While our study provides findings on young adults, considering this continuing development of the ear, it will be important to collect data from different age groups to create a broad guide for Turkish plastic surgery. Our study showed a correlation between ear length and ear width. The further increase in the ear length in further years than the ear width may reduce this correlation.

The RoB 2 tool (22 August 2019 version) was used to estimate potential bias. Analysis showed low risk for randomization process, deviations from intended interventions, missing outcome data and some concerns for measurement of the outcome. The low risk for overall bias can be counted among the strengths of this study.

Limitations

The auricle reaches its adult size at the age of 12-13 [3]. However, the ear length and width continue to increase by age [10]. In our study, measurements were made only in a certain age group, and the lack of age-related comparisons are an important limitation. Besides, body mass index, which is an indicator of body fat level, was associated with soft tissue thickness and positively correlated with ear length and width [11]. Body mass index of the volunteers was not calculated in this study. This prevents the study from providing more extensive information. Furthermore, the contribution of the outer ear to the aesthetic perception is not limited to its own metric properties. The distance of the outer ear to the eyes, the location on the head, the auriculocephalic angle, scapha-conchal angle are also critical parameters for aesthetic perception. Although our data give clues about aesthetic appearance, we do not deal with all aspects of aesthetic perception in the absence of this information.

If future studies are designed to overcome the limitations of our study in more comprehensive groups, it will be possible to create a more consistent and useful atlas for ear surgeries. In addition, there is a need of literature for studies examining the contribution of the outer ear shape to hearing function. The morphology of the external auditory canal has previously been studied radiologically [12]. The evaluation of the features of the outer ear shape and the outer ear canal can be an interesting and unexpected study.

Conclusions

Studies on the ears usually aim at treatment of congenital deformities and development of surgical techniques for reconstruction of ears that are traumatically injured. Every individual wants to have ears that look normal and aesthetically pleasing, and this demand is the highest among individuals with congenital or acquired deformities of the ear. Achievement of good functional and aesthetical rehabilitation does not only increase the self-confidence of the person, but it also means better social acceptance. The dimensions of the outer ear and its various parts vary in different ethnic groups, and this requires surgeons to base their reconstructions on data collected from each ethnic group. In this sense, we believe our study includes noteworthy data regarding the young adult Turkish population.

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