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Original Article

Morphometric evaluation of the relationship between the osseous orifice of the auditory tube and the other cranial base structures on the adult skulls

Erişkin kafataslarında östaki borusunun kemik parçasının kafatası tabanında yer alan diğer oluşumlar ile olan ilişkisinin morfometrik değerlendirilmesi

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Abstract

Background: The eustachian tube consists of cartilage, fibrocartilagenous part and osseous part anteriorly from lateral to medial. Functional evaluation of the auditory tube has become important in myringoplasty and tympanoplastic procedures and also 3-dimensional (3D) modeling. The aim of the study is to perform morphometric measurements of the bony part of the tube and relation with the other anatomical formations at the base of the skull and to give the descriptive values of these values.

Materials and Methods: In the study, measurements of 12 variables were carried out using 26 dry skulls belonging to the bone collection of Uludag University Faculty of Medicine, Department of Anatomy. Measurements were made with Somet Inox caliper and SPSS 22.0 program was used for statistical analysis.

Results: The mean values of the parameters are given. It was observed that the distances between the right and left lateral and medial edges of the osseous orifice of the auditory tube were in relation with each other. In addition, it was also determined that these distances and the bilateral medial pterygoid distance showed a high correlation.

Conclusion: As a result, data were provided for 3-dimensional functional models using the eustachian bone part and the correlation values between the variables were evaluated.

Key Words: Auditory tube, osseous part, cranial base, morphometry

ÖZ

Amaç: Östaki borusu, en dıştan içe doğru kıkırdak, fibrokartilaginöz ve kemik kısımlardan oluşmaktadır. Östaki borusunun işlevsel olarak değerlendirilmesi miringoplasti, timpanoplastik prosedürlerde ve ayrıca 3 boyutlu modellemelerde önemli hale gelmiştir. Çalışmanın amacı, östaki borusunun kemik kısmı ile ilgili morfometrik ölçümler gerçekleştirmek ve kafatası tabanında yer alan diğer anatomik oluşumlar ile bu değerlerin tanımlayıcı değerlerini vermektir.

Materyal ve metod: Çalışma, Uludağ Üniversitesi Tıp Fakültesi Anatomi Anabilim Dalı kemik koleksiyonuna ait 26 adet kuru kafatası kullanılarak belirlenen 12 değişkene ait ölçümler gerçekleştirilmiştir. Ölçümler Somet Inox sürme kumpas ile yapılmış ve istatistiksel analizler için SPSS 22.0 programı kullanılmıştır.

Bulgular: Ölçülen değerlere ait ortalama değerleri verilmiştir. Kemik alanın sağ ve sol lateral ve medial kenarları arasındaki mesafelerin birbiri ile ilişkide olduğu görülmüştür. Ayrıca yine bu mesafeler ile bilateral medial pterygoid mesafenin de yüksek korelasyon gösterdiği belirlenmiştir.

Sonuç: Sonuç olarak östaki kemik kısmı kullanılarak 3 boyutlu fonksiyonel modellemeler için veri sağlanmış olup ayrıca değişkenler arası korelasyon değerlerini değerlendirilmiştir.

Anahtar Kelimeler: Östaki borusu, kemik kısım, kafatası tabanı, morfometri

Introduction

The eustachian or auditory tube is a shape like a funnel channel that connects the middle ear and nasopharynx (1). The posterolateral part of the auditory tube is formed with the osseous part and its orifice, junctional or membrano-cartilginous part and the cartilaginous anteromedial part (1,2). The osseous portion of the canal is mainly located in the petrous part of the temporal bone. The cartilage part has a more complex structure, and it forms the functional part of the tube. The main function of the tube is the ventilation, protection and clearance of the middle ear (2,3). It is the part of the contiguous organs which includes the nose, middle ear, nasopharynx, and also mastoid air cells. Disruption in the systems cause problems with functional middle ear ventilation and this are the main cause of the chronic otitis media (4).

Magnetic resonance imaging (MRI) is an excellent method of evaluating anatomical points around the auditory tube. Although a small number of human cadavers are present in studies with temporal bones, some details still need to be discussed for example, 3D anatomy of the auditory tube and functional relationship with the tensor veli palatini muscle (5,6). The anatomy of the auditory tube and its related muscles has been described in the literature (7,8). The vectorial relationship between the tensor veli palatini muscle and the cranial base are structures that are important in determining the effectiveness of middle ear pressure regulation and are also necessary parameters for modeling the auditory tube function (9).

A method that shows the vector relationships between tensor veli palatini muscle, the anterior osseous orifice of the auditory tube and the cranial base from measurements on adult human skulls has been described (9,10). The aim of this study is to provide data for 3D computer-generated functional models of the osseous part of the auditory tube and to evaluate the correlation values.

Material and Method

The study was carried out on 26 adult dry skulls in xxx University Anatomy Department of the Medicine Faculty. The bones which have deformities or fractures were excluded from the study. For the measurements, Somet Inox brand mechanical caliper with 1/20 mm precision was used. A total of 12 parameters (Figure 1 and Figure 2) were evaluated in the study. The parameters are respectively;

1-The distance between lateral margins of the right and left osseous orifice of the auditory tube

2-The distance between medial margins of the right and left osseous orifice of the auditory tube

3-The distance between the right and left hamular process

4-The distance between the right and left basal lamina of the pterygoid process

5-The distance between the right and left medial pterygoid tubercle

6-The distance between the posterior nasal spine and the midpoint of the anterior margin of the foramen magnum

7-The distance between the center of the osseous orifice of the auditory tube and the basal lamina of the pterygoid process for the right and left sides

8-The distance between the center of the osseous orifice of the auditory tube and the medial pterygoid tubercle for the right and left sides

9-The distance between the osseous orifice of the auditory tube and the midpoint of the anterior margin of the foramen magnum for the right and left sides

10-The distance between the medial pterygoid tubercle and the midpoint of the anterior margin of the foramen magnum for the right and left sides

11-The distance between the basal lamina of the pterygoid tubercle and the midpoint of the anterior margin of the foramen magnum for the right and left sides

12-The distance between posterior nasal spine and the midpoint of the ala of the vomer

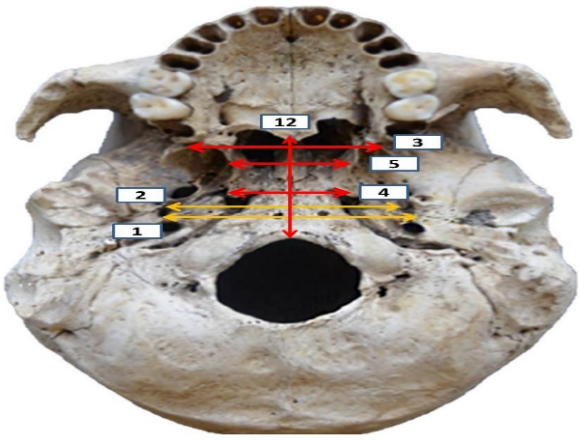

Figure 1. Parameters of the osseous orifice of the auditory tube

1. The distance between lateral margins of the OAE; **2.** The distance between medial margins of the OAE; **3.** The distance between the right and left HP; **4.** The distance between the right and left BPT; **5.** The distance between the right and left medial PT; **12.** The distance between PNS and the midpoint of the ala of the vomer

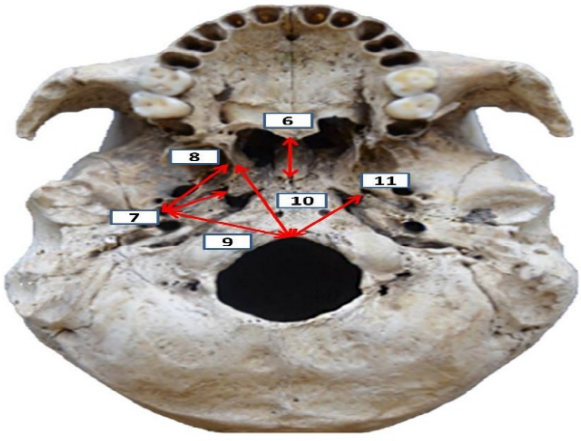

Figure 2. Parameters of the osseous orifice of the auditory tube (continue)

6. The distance between the PNS and FM; **7.** The distance between the center of the OAE and the BPP for the right and left side; **8.** The distance between center of the OAE and the medial PT for the right and left side; **9.** The distance between the OAE and FM for the right and left side; **10.** The distance between the medial PT and FM for the right and left side; **11.** The distance between the BPP and FM for the right and left side

Statistical analyses

The statistical analyses were performed with SPSS 22.0 software (IBM). For the determination of the relations of the variables, Spearman analysis was conducted ($p<0.05$).

Results

The mean and standard deviation values of the measurements were shown in Table 1 and no side difference was observed between the right and left sides. According to the Spearman correlation analysis, it was observed that the highest correlation coefficient value existed between the medial and lateral edges of the osseous orifice of the auditory tube (R=0.904). It was also determined that the distances between the lateral edges of the osseous orifice of the auditory tube and the medial edges have correlated with the distance between the right and left medial pterygoid tubercle (R=0.741 and R=0.782 respectively). The distance between the right and left hamular process and the distance between the right and left basal lamina of the pterygoid process showed a correlation (R=0.743). The distance between the right and left basal lamina of the pterygoid process and the distance between the right and left medial pterygoid tubercle showed a high correlation and the coefficient value was 0.834. It has been found that the distance between the posterior nasal spine and ala of the vomer was related to the distance between the midpoint of the anterior of the foramen magnum and basal lamina of the pterygoid tubercle for the right and left sides (R=0.817 and R=0.832 respectively). The coefficient values of the variables were shown in Table 2.

Table 1. Descriptive values of the parameters of the osseous orifice of the auditory tube

Parameters	Mean±S.D.	Range (mm)
1. The distance between lateral margins of the OAE	59.80±3.81	53.00-65.00
2. The distance between medial margins of the OAE	57.95±4.30	49.00-64.00
3. The distance between the right and left HP	36.31±4.38	31.00-45.00
4. The distance between the right and left BPT	27.22±4.02	22.00-35.00
5. The distance between the right and left medial PT	28.20±3.26	23.00-34.00
6. The distance between the PNS and FM	38.60±4.12	33.00-46.00
7. The distance between the center of the OAE and the BPP for the right side	16.78±2.65	12.00-21.00
The distance between center of the OAE and the BPP for the left side	16.28±3.55	16.00-22.00
8. The distance between center of the OAE and the medial PT for the right side	25.00±2.42	22.00-31.00
The distance between center of the OAE and the medial PT for the left side	23.88±3.02	19.00-33.00
9. The distance between the OAE and FM for the right side	31.61±2.88	27.00-38.00
The distance between the OAE and FM for the left side	31.06±2.69	27.00-36.00
10. The distance between the medial PT and FM for the right side	33.06±3.49	24.00-38.00
The distance between the medial PT and FM for the left side	32.80±3.26	26.00-39.00
11. The distance between the BPP and FM for the right side	26.00±2.76	21.00-32.00
The distance between the medial PT and FM for the left side	25.41±2.92	19.00-32.00
12. The distance between PNS and the midpoint of the ala of the vomer	21.50±3.81	13.00-27.00

* S.D.: Standart Deviation; OAE: Osseous orifice of the auditory tube; HP: Hamular process; BPP: Basal lamina of the pterygoid processus; PT: Pterygoid tubercle; PNS: Posterior nasal spine; FM: midpoint of the anterior margin of the foramen magnum

Table 2. Correlation values between variables (Spearman correlation analysis, $p<0.05$)

Parameters	R value
The distance between lateral and medial margins of the OAE	0.904
The distance between lateral margins of the OAEs and the distance between the right and left medial PT	0.741
The distance between medial margins of the OAE and the distance between the right and left medial PT	0.782
The distance between the right and left HP and the distance between the right and left BPT	0.743
The distance between the right and left BPT and the distance between the right and left medial PT	0.834
The distance between PNS and the midpoint of the ala of the vomer and right the distance between the BPP and FM	0.817
The distance between PNS and the midpoint of the ala of the vomer and the left distance between the BPP and FM	0.832

Discussion

The complex anatomical structure of the auditory tube makes it difficult to access the area of surgical and endoscopic imaging. The morphometry of the tube and its relationship with the neighboring anatomical structures play an important role in understanding the anatomy and also the pathology of the disorders (11). The study aims to analyze the osseous part of the auditory tube and its relation with the other structures on the skull base thus providing the data for the reconstruction of the area for the functional 3D remodeling. One of the functions of the auditory tube is the regulation of the air pressure between the middle ear and the nasopharynx (9). In healthy individuals, bolus gas transfer occurs by the contraction of the tensor veli palatini muscle which is the main dilator muscle of the auditory tube with aid of the levator veli palatini muscle (12). The study is aimed that show the relation of osseous structures of the auditory tube on the cranial base.

In the literature, there are few studies about the auditory tube with the skulls. Doyle and Swarts studied the auditory tube with 20 adult (10 male, 10 female) and 18 child skulls. While they reported that the bilateral anterior orifice osseous distance (lateral margins of the osseous orifice of the auditory tube) was 53.9 mm, in our study this distance was measured as 59.8 mm. Bihamulus distance (distance between the hamular process) was reported 32.2 mm in this study, and this was 36.3 mm in our study. The bilateral medial pterygoid distance was reported as 27.0 mm, in our study it was 28.2 mm. Doyle and Swart's study, the distance from the osseous orifice of the auditory tube to the medial pterygoid tubercle is defined as the inferior length of the junctional part of the auditory tube and its length was reported as 24.5 mm. This distance was 25 mm for the right and 23.88 m for the left side in our study. The distance from the posterior nasal spine to the foramen magnum was 41.5 mm, in this study it was 38.6 mm. Doyle and Swart also specified that there were no differences between the genders for these variables (9).

The junctional part of the auditory tube is attached to the osseous orifice of the tube and the medial pterygoid tubercle firmly (13). The tensor veli palatini muscle is the main dilator muscle of the eustachian tube. It plays a role in the relationship between the temporomandibular joint and the auditory system with the tensor tympani muscle. It is accepted that they are involved in mastication, chewing, swallowing and velopharyngeal movements (3). The tensor veli palatini is initiated from the scaphoid fossa posteriorly and sphenoid spine superiorly and probably the lateral lamina of the cartilage part of the auditory tube. It descends vertically then end in a tendon around the hamular process pass horizontally and insert into the palatal aponeurosis and the hard plate (11). When we compare our results with this study it has seen that the distance of the lateral margins of the osseous orifice of the auditory tube, the bihamular distance and the distance from the posterior nasal spine to the foramen magnum show the dramatic differences but the bilateral medial pterygoid tubercle distance shows no difference. It is brought to mind the idea that it might be due to racial differences because Doyle and Swarts studied with the American adult and child skulls (9). In the literature, it is stated that the length of the auditory tube varies with the race from 30 mm to 40 mm, but the mean length is described as 31-38 mm (3,10). A method for reconstructing the relationships between the tensor veli palatini muscle, fibrocartilaginous part and the cranial base was described previously (9).

Limitations

The study is the low number of samples and unknown gender. Also, it is recommended to examine the study with other age groups as well as the adult group.

Conclusion

The osseous part of the auditory tube and its relationship with the cranial base and the other anatomical structures especially the tensor veli palatini muscle is important for the reconstruction of the area. In the literature, there are not many studies about this topic, especially for the

Turkish population so with this study. We believe this study set an example for future studies.

Acknowledgement
We thank to all the individuals who have donated their bodies as cadaver because of belief in Science.

Ethical Approval

The authors declare that the study was performed in accordance with the ethical standards as mentioned in the 1964 Declaration of Helsinki. This study does not contain human participants or experiments on animals and the skulls are the donation of the cadavers and belong to the Anatomy department so there is no ethics committee decision

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