Kocatepe Tıp Dergisi
Kocatepe Medical Journal
24:30-35 / Ocak 2023 Sayısı

ARAŞTIRMA YAZISI / RESEARCH ARTICLE

MEATUS ACUSTICUS INTERNUS MORFOMETRİSİ VE HACMİNİN BELİRLENMESİ

DETERMINATION OF MORPHOMETRY AND VOLUME OF THE INTERNAL AUDITORY CANAL

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ÖZET

AMAÇ: İç kulak yolu olarak da bilinen meatus acusticus internus (MAI), iç kulağı fossa cranii posterior'a bağlayan bir kemik kanaldır. Ortalama uzunluğu yaklaşık 1 cm'dir. MAI'nin kenarına porus acusticus internus (PAI) denir ve bu açıklığın kenarı künt ve yuvarlaktır. Nervus (n) facialis, n. vestibulocohlearis, arteria ve vena labirinti gibi önemli oluşumlar MAI'nin içinden geçer. Ayrıca MAI, temporal lob üzerindeki cerrahi müdahalelerde morfometrinin doğru belirlenmesinde hayati önem taşımaktadır. Bu nedenle bu çalışmada MAI'nin morfometrisinin ve hacminin belirlenmesi amaçlanmıştır.

GEREÇ VE YÖNTEM: Çalışma, 10-90 yaş arası normal popülasyondan rastgele 210 kişinin BT görüntüleri üzerinde gerçekleştirildi. MAI'nin morfometrik ölçümleri (lateral açı (LA), anteroposterior (AP) kanal uzunluğu, PAI çapı, PAI'den aquaductus vestibularis'e kadar olan mesafe (AV)) yapıldı. Ayrıca bu çalışmada MAI'nin şekli ve hacmi belirlendi. Olgular yaşlarına göre 10-14, 15-20, 21-30, 31-40, 41-50, 51-60 ve 61 yaş olmak üzere 7 farklı alt gruba ayrıldı.

BULGULAR: Bu çalışmada 210 hastanın BT görüntüleri analiz edildi. MAI'nin ortalama uzunluğu 9.5±1.6 mm, AP çapı 6.3±1.5 mm, giriş kısmından AV'ye olan mesafe 15.1±6.64mm, volüm 290±120 mm^3 ve LA 50±14º idi.

SONUÇ: Sonuç verileri cinsiyete göre karşılaştırıldığında, erkeklerde sağ AP çapının, kadınlarda sağ MAI uzunluğunun ve her iki taraf LA'nın daha yüksek olduğu istatistiksel olarak anlamlı bulundu. Ayrıca MAI hacimleri yaş gruplarına göre karşılaştırıldığında 10-14 yaş grubunun diğer yaş gruplarına göre daha küçük olduğu belirlendi.

ANAHTAR KELİMELER: Meatus acusticus internus, Anatomi, Radyoloji, Lateral açı

ABSTRACT

OBJECTIVE: The internal auditory canal (IAC) also known as internal acoustic meatus is a bone channel that connects the internal ear to the posterior cranial fossa. The mean length is approximately 1 cm. The edge of the IAC is called internal acoustic pore (IAP), and the edge of this aperture is blunt and rounded. Important formations such as facial nerve, vestibulocochlear nerve, labyrinth artery and labyrinth vein pass through the IAC. In addition, on the precise determination of the morphometry in surgical interventions on the temporal lobe, MAI is vital. Therefore, in this study, it was aimed to determine the morphometry and volume of MAI.

MATERIAL AND METHODS: The study was carried out on the CT images of 210 individuals randomly from the normal population between the ages of 10-90. Morphometric measurements of IAC (lateral angle (LA), canal length, anteroposterior (AP), diameter of IAP, distance from IAP to vestibular aqueduct (VA)) were performed. In addition, the shape and volume of IAC was determined in this study. Cases were divided into 7 different subgroups, 10-14, 15-20, 21-30, 31-40, 41-50, 51-60 and 61 years old, depending on their age.

RESULTS: In this study, CT images of 210 patients were analyzed. The mean length of the MAI was 9.5±1.6mm, the AP diameter was 6.3±1.5mm, the distance from the entrance part to the VA was 15.1±6.64mm, the volume was 290±120mm^3, and the LA was 50±14º.

CONCLUSIONS: When the outcome data were compared by gender, it was found statistically significant that the right AP diameter was higher in men, the length of the right MAI and both sides LA were higher in women. In addition, when the volumes of MAI were compared by age groups, it was determined that the 10-14 age group was smaller than the other age groups.

KEYWORDS: Internal auditory canal, Anatomy, Radiology, Lateral angle

Geliş Tarihi / Received: 22.11.2021
Kabul Tarihi / Accepted: 01.03.2022
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INTRODUCTION

The internal auditory canal (IAC) also known as internal acoustic meatus is a bone channel that connects the internal ear to the posterior cranial fossa. In the petrous part of the temporal bone, IAC extends laterally to the back in the anterior upper part of the jugular foramen, perpendicularly to the sagittal plane of the skull and parallelly to the long axis of the external acoustic meatus (1). IAC, with a mean length of 1 cm, forms an angle of about 45 degrees with the long axis of petrous part (2). The edge of the IAC is called internal acoustic pore (IAP), and the edge of this aperture is blunt and rounded. Important formations such as facial nerve, vestibulocochlear nerve, labyrinth artery and labyrinth vein pass through the IAC (1, 3, 4).

The anatomic location of the IAC is of great importance for surgical interventions to the posterior cranial fossa. The majority of surgical interventions to the temporal bone are performed on the posterior surface of the petrous part (5). Considering the surrounding structures and functions of them, tumor, trauma, inflammatory disease, infection and surgical interventions that may occur in this region poses a great risk for IAC (6 – 8). Therefore, the anatomical structure of IAC, the distance of IAP to various parts in the cranium, the morphological appearance of IAC and the volume it occupies are very important in terms of clinical approaches (9, 10). However, there is not sufficient anatomical data in literature in this regard. The most of the data obtained is based on research on clinical cases. In some studies, only dry skulls or dry temporal bone samples were used (2, 6, 11, 12).

Due to the developments in radiological imaging techniques in recent years, imaging methods such as magnetic resonance imaging (MRI) and computed tomography (CT) are used extensively to elucidate the anatomy of IAC (7, 13 – 16). It was determined that the studies using CT or MRI in the literature are related to the distance of IAC to various parts of the temporal bone, length of canal, diameters of IAP and shapes of IAC (4, 6, 7, 15, 17). When the literature studies were examined, we believe that there is a great need a study with more comprehensive, more organized and including more parameters related to IAC. It is also an academic necessity knowing of the volume of IAC, which has not been studied much in the literature. In this context, we were aimed to determine the morphometry, lateral angle (LA) and volume of IAC in this study.

MATERIAL VE METHODS

The study was carried out on the CT images of 210 individuals randomly from the normal population between the ages of 10-90 between 2015 and 2021, in Selcuk University Department of Radiology. Scans were performed with a 256-slice MDCT scanner (Siemens Somatom Flash, Erlangen, Germany). Imaging parameters were as follows: kV=120; mA=160; rotation time=0.5 s; collimation=64×0.625; FOV=220 mm. Images that included the IAC were analy -zed retrospectively on a workstation (Snygo Via, Siemens, Germany). In this study, morphometric measurements of IAC (LA, canal length, anteroposterior (AP) diameter of IAP, distance from IAP to vestibular aqueduct (VA)) were performed **(Figure 1)**. In addition, the shape (funnel, cylindrical, bud) and volume of IAC was determined. Cases were divided into 7 different subgroups, 10-14, 15-20, 21-30, 31-40, 41-50, 51-60 and 61 years old, depending on their age (18, 19). Cases whose skull integrity was impaired or who had undergone surgical intervention were excluded from the study. Demographic information of each of individuals in study was noted.

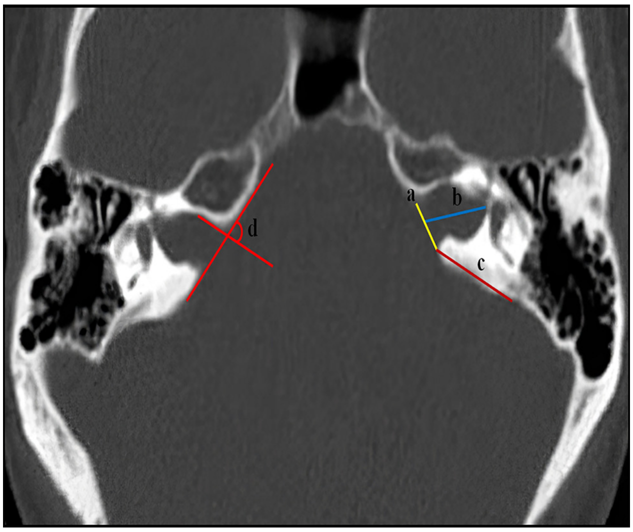

Figure 1: Morphometric measurements of internal auditory canal. (**a**; anteroposterior diameter of internal acoustic pore, **b**; canal length, **c**; distance from internal acoustic pore to vestibular aqueduct, **d**; lateral angle)

Ethical Committee

This study was approved by the local institutional review board Selcuk University (09.11.2021/489).

Statistical Analysis

Statistical analysis of the data was done with SPSS version 19.0 package program (SPSS Inc., Chicago, IL, USA). Statistical analysis included means, standard deviations and minimum (min) and maximum (max) values. Kolmogorov-Smirnov test was used for suitability of the data for normal distribution and it was determined that data was not homogeneous. Mann-Whitney U test was used in comparing the significance of the difference by gender and the sides measurements were evaluated, and the Kruskal Wallis test was used to compare among multiple age groups. The relationship between age groups and evaluation parameters were analyzed with Pearson's Correlation test. The results were evaluated in the 95% confidence interval and the data with p value less than 0.05 was considered statistically significant.

RESULTS

In our study, CT images of 210 cases were examined. 58% of these cases were male and 42% were female. The mean age was 37 ± 16 years. The mean values of diameter of IAP, canal length of IAC, distance of IAP to VA were determined as 6.3 ± 1.5 mm, 9.5 ± 1.6 mm, 17.6 ± 8.3 mm, respectively. The LA of IAC was detected as mean of 50º. The mean volume of IAC was calculated as 290 mm^3. In addition to that, the mean values, min and max of the parameter were given in **Table 1**.

Table 1: Mean, standard deviation, minimum and maximum values of the measurement parameters and volume of IAC

	Female (n:121)			Male (n:89)			Total (n:210)		
	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max
IAP diameter	6.3±0.15	2.4	10.7	6.3±1.5	0.8	10.3	6.3±1.4	0.8	10.7
Canal Length	9.4±0.15	3.8	14.2	9.7±1.7	4.6	15.5	9.5±1.6	3.8	15.5
VA-IAC	16.2±6.7	7.3	10.5	19.4±10.2	1.5	13.7	17.6±8.3	1.5	13.7
Lateral Angle	53±15	17	72	47±12.18	14	71	50±14	14	72
Volume	270±110	50	660	310±130	100	730	290±130	50	730

Internal auditory canal; IAC, internal acoustic pore; IAP, vestibular aqueduct; VA

When the IAC was examined according to the shapes, it was 25% bud shape, 29% funnel shape and 46% cylindrical shape in 420 IAC (210 left/right). When the IACs of each case were evaluated according to sides, it was seen as 77% symmetrical and 23% asymmetrical. It was statistically determined that the incidence of IAC shape patterns by gender and sides were not change (p=0.707; p=0.670 respectively).

In our study, age groups were adjusted as 10 to 14 (beginning of puberty period), 15-20 (end of puberty period), 21-60 (middle age) and above 61 years (geriatric population) according to the development of the temporal bone (18,19). In addition, the middle age group is divided into decades. All measurement data was recorded according to age groups and sides **(Table 2)**.

Table 2: Distribution of mean values of IAC volume and measurement parameters by age groups.

Age Groups		**10-14 (n:30)**	**14-20 (n:30)**	**21-30 (n:30)**	**31-40 (n:30)**	**41-50 (n:30)**	**51-60 (n:30)**	**61-90 (n:30)**	**Genel (n:210)**
IAP diameter	R	6.7±1.4	5.6 ±1.5	5.7±1.5	5.7±1.3	5.8±1.5	6±1.3	5.6±0.8	5.9±1.1
	L	7±1.6	6.8±1.3	6.9±1.4	6.8±1.2	6.3±1.3	6.4±1.3	7.2±1.4	6.7±1.4
Canal Length	R	9.6±1.6	9±1.8	9.6±1.5	9.7±1.4	9.2±1.6	9.4±2	9±1.2	9.3±1.6
	L	10±1.3	9.3±1.8	9.9±1.8	10±1.3	9.1±1.4	9.6±1.9	9.6±1.4	9.6±1.4
VA-IAC	R	12.2±2.1	11.1±2.1	12.5±2.7	12.3±2.5	11.9±2.2	12±2.9	11.7±1.9	11.8±9.3
	L	11.6±2.7	11.5±2.2	15.2±16.8	11.8±2.3	11.8±1.9	11.7±1.9	12.5±2.4	12.2±7.1
Lateral Angle	R	50±8	47±11	44±15	51±13	53±11	56±13	51±13	50±13
	L	48±12	48±12	48±15	46±13	55±19	55±13	47±11	50±15
Volume	R	200±100	320±120	300±130	280±100	290±110	360±140	280±90	310±130
	L	200±90	320±130	310±140	270±100	270±100	360±120	300±120	270±110

Internal auditory canal; IAC, internal acoustic pore; IAP, vestibular aqueduct; VA

When the study data was compared by gender, while the right IAP diameter and right IAC volume were statistically significantly higher in males, the right length of IAC canal and the LA of both sides were higher in females (p=0.007; p=0.043; p=0.038, p<0.001; p<0.001 respectively). When comparing the volumes of IAC by age groups, it was revealed that the right and left IAC volume in the 10-14 age group was statistically significantly smaller than other age groups (p<0.001; p<0.001). In addition, when the continuous relationship of morphometry, LA and IAC volume with age was examined, it was found that there were statistically weak positive correlations between age and LA (p<0.001, r=0.259), and between age and volume (p<0.001, r=0.193).

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DISCUSSION

Evaluation of preoperative anatomy before surgical applications is important in terms of predicting the complications that may occur during surgical application (20). In this context, it is of great clinical importance due to the neurovascular structures passing through the IAC. It can host several pathological processes that give clinical significance when these structures are involved. Certain pathologies might expand or narrow the IACs (21). In the radiological assessment of such processes, it would seem more desirable to have a reproducible quantifiable objective measure of the IAC rather than relying on the subjective impression of IAC asymmetry or unidimensional measurements of the acoustic pore. Such a quantitative measure could also serve as a baseline for subsequent comparisons when monitoring a disease process (15). For this reason, we evaluated morphometry, angles, and volume of IAC in our study.

The shapes of IAC in literature have been investigated, using different methods and classification types. In most of the literature studies, the types of IAC have been classified in three types as funnel, cylinder, bud. In Thomsen et al.'s study, the IAC of 115 patients were as follows: 70% cylindrical shape, 14% funnel shape and 14% bud shape (22). According to the same methodology used in Kobayashi and Zusho's study, IAC of 300 normal subjects were 72.7% cylindrical shape, 22.8% bud shape and 4.5% funnel shape (23). In Marques et al.'s study, the funnel shape IAC was the most common in both children and adults (74% and 58.3%, respectively), followed by the cylindrical shape (22% and 30.9%, respectively) and the bud shape (4% and 10.8%, respectively) (8). In Amjad et al.'s silicone casts study in 30 paired temporal bones showed that 16.7% of them were cylindrical shape, 43.3% of them funnel shape and 26.7% of them were bud shape (24). In our study, the shape of the IACs was found as 25% bud, 29% funnel and 46% cylindrical. The cylindrical shape was determined the most common shape of IAC in Thomsen et al.'s study, Kobayashi and Zusho's study (22, 23) and our study. However, in Marques et al.'s and Amjad et al.'s studies, it was found pyramid shape predominantly (8, 24) . Yet, the values found by our study are very different from those of the two studies mentioned. Considering that anatomical elements are determined during embryogenesis and that the related attribute is inherited as a polygenic trait, there is diversity among these patterns in different races and ethnic groups. Thus, such differences may be explained with racial heterogeneity.

Several studies examined the dimensions of the IAC using bony skulls and radiographs. One of these, in Marques et al.'s computed tomography study of 110 patients aged 1 to 92 years, the length of canal, IAP diameter, the distance between the canal and the vestibular aqueduct was 9.84±0.22 (9.43-10.2) mm, 4.47±0.10 (4.46-4.48) mm, 11.47±055 (10.7-11.6) in adults respectively and 11.17±0.22 (11.05-11.29) mm, 4.82±0.13 (4.64-5) mm,12.63±0.51 (12.31-12.96) in children respectively (8). Using caliper in 26 temporal bones (13 right and 13 left) from 13 cranium and 41 isolated temporal bones from different skulls, Ozocak et al. found a length of 7.6±1.3 mm (4.4-9.8), IAP diameter of 4.9±0.8 mm (3.5-7.1) and the distance between the canal and the VA 9.8±0.8 mm (8.5-11) (6). Although the values of our study are the same as the method used by Marques et al, it couldn't be compared clearly (8). Because the different age range of the cases causes inconsistency between the measurements. Since the use of temporal bone and caliper in the study of Ozocak et al. could reduce the sensitivity of the measurements, all measurement data is lower than our study (6).

Lateral angle of the IAC is one such measurement that was evaluated in prior studies on cadavers for sexing the temporal bone, with favorable results. Therefore, some of the studies in the literature are as follows. The mean values for the LA of the IAC in Akansel et al.'s CT study were 45.5º ±7.18 (30º-68º) for females and 41±6.78º (30º-60º) for males (25). In the Noren et al.'s cadaveric study, the mean values for the LA of the IAC were in female 45.5 ±7.1º (30º-68º) and in males 41.6 ± 6.7º (30º–60º) (26). In our study, the values were in female and male 53±15º (17º-72º), 47±12º (14º-71º) respectively. The mean values, ranges and standard deviations of mentioned above were lesser than in values of our study. However, in our study, as in other studies, the difference genders by gender was statistically significant and the mean LA values in females were higher than males.

Some pathologies might expand or narrow the IACs. In the radiological assessment of such procedures, IAC's reproducible quantifiable objective measurement seems more desirable than relying on unidimensional measurements. Assessment of the volume of the IAC could be considered as a more quantitative method when monitoring a disease process (21). There are very few studies on this subject in the literature. In another study, the volumes had been measured by submerging rubber casts of 242 cadaver IACs in water and Papangelou reported that volumes of IAC ranged from 60 to 388 mm^3 (27). Essbaiheen et al. determined that IAC volumes ranged from 74 to 502 mm^3 in males and 78 to 416 mm^3 in females. In addition, they showed that males' IAC volumes were larger than females (15). According to these values, it was determined that the volumes of IAC in Essbaiheen et al. and Papangelou's studies smaller than our study, and the volume of IAC was affected by gender and age in contrast with Essbaiheen et al. and Papangelou's studies. In addition, the volume of IAC in the 10-14 age group was reported to be statistically smaller than other age groups.

In conclusion, in the studies that conducted to determine the morphometry and morphology of IAC in the literature, age, sex, races and differences of methods have led to differences in numerical values. Knowing the clinical importance of the structures passing through the IAC, its proximity to the pontocerebellar angle, and the morphometric dimensions and morphological structure of the IAC in intervention to tumors in this region has great importance. For this reason, the following results were reached in this study where IAC morphometry, LA and volume were evaluated. In similar with the literature, the LA was found statistically significantly larger in females than in males. Thus, it has been reconfirmed that it is an effective measurement method for use in sex determination. Finally, it was determined that the IAC volumes of the 10-14 age group were statistically significantly smaller than other age groups but the IAC volume did not change with age in post pubertal (14-90) age groups. We hope that the results of this study will contribute to the disclosure of our community data and serve as a reference for surgical interventions.

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