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The Evaluation of the Cochlear Aqueduct and Internal Acoustic Canal in Patients with Unilateral Subjective Tinnitus and Normal Hearing

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ABSTRACT

Objective: We investigated the relationship between idiopathic subjective tinnitus and internal acoustic canal, cochlear aqueduct, vestibule, and lateral semicircular canal measurements by temporal magnetic resonance imaging.

Methods: In this retrospective study, temporal magnetic resonance imaging sections of 25 patients (8 males and 17 females) with unilateral tinnitus and normal hearing were included. The internal acoustic canal, cochlear aqueduct, vestibule, and lateral semicircular canal measurements and internal acoustic canal and cochlear aqueduct shape classification were determined in the ipsilateral tinnitus side and contralateral non-tinnitus side.

Results: The cochlear aqueduct length and width and internal acoustic canal opening width, length, width, and area of the ipsilateral tinnitus side were not different from the contralateral side. Similarly, the vestibule area and lateral semicircular canal height and width values were not different between the ipsilateral tinnitus side and the contralateral side. The main cochlear aqueduct type was type 2 in both ipsilateral and contralateral sides. For the internal acoustic canal types, cylindrical and funnel shapes were the most common types for the ipsilateral tinnitus side and contralateral side. There were positive correlations between the internal acoustic canal and vestibule areas; cochlear aqueduct length and internal acoustic canal areas; cochlear aqueduct width and width of the lateral semicircular canal; internal acoustic canal area and length and cochlear aqueduct length; internal acoustic canal opening width and height of the lateral semicircular canal; and width of the lateral semicircular canal dimensions. In older patients, the ipsilateral internal acoustic canal area was found to be smaller.

Conclusions: In idiopathic subjective tinnitus, there were no important pathologies detected in the internal acoustic canal, cochlear aqueduct, vestibule area, and lateral semicircular canal. We concluded that there are no statistically significant morphometric differences compared to the healthy side in the internal acoustic canal, cochlear aqueduct, vestibule, and lateral semicircular canal areas detected by temporal magnetic resonance imaging in patients with unilateral subjective tinnitus and normal hearing.

Keywords: Temporal MRI, idiopathic subjective tinnitus, internal acoustic canal, cochlear aqueduct, lateral semicircular canal

Introduction

Tinnitus is the formation of sound perception without a sound source. Tinnitus is one of the most common autological problems and significantly affects the quality of life by increasing psychological stress. Epidemiological linkage variable incidence studies affecting 5%-30% of the population, predominant in a man,[1] and about 15% of cases lead to negative interference in daily life.[2]

The prevalence of tinnitus increases with age.[1] Although progress has been made in the specific literature on tinnitus, its pathophysiology and consequently its etiology have not been fully elucidated. It is known that it may have a multi-factor etiology, and some of the reasons are middle ear diseases and neurological, neurodegenerative, cardiovascular, metabolic, and psychological disorders, or many of the cases are associated with sensorineural hearing loss.[3]

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Tinnitus is divided into 2 groups and examined: objective and subjective. Objective tinnitus describes the sound that not only the patient but also other people can hear. Subjective tinnitus describes only the sound that the patient can hear. In addition, in the literature for subjective tinnitus, cochlear pathologies are often blamed, and some histopathological studies have also supported this.[4]

The cochlear aqueduct (CA) is a bony canal that connects the subarachnoid space to the basal turn of the cochlea. The CA is the narrow bony canal that encircles the perilymphatic duct. The perilymphatic duct connects the scala tympani with the subarachnoid space. Its clinical importance has been investigated many times, but it has been overshadowed by vestibular aqueduct research. The most clinically suspected pathology about the way of otological infections spreading to the brain is the CA.[5]

Possible problems in this channel contribute to the pressure difference between the cerebrospinal fluid and the inner ear which may play a role in the etiology of tinnitus. The aim of this study was to examine the possible connection between tinnitus and CA, internal acoustic canal (ICA), vestibule, and lateral semicircular canal (LSC) morphological features in patients with normal symmetric hearing.

Methods

This study was designed according to the principles of the Declaration of Helsinki after ethical approval was obtained from the Kırıkkale University Non-invasive Research Ethics Committee (date: 07.08.2019, number: 2019.07.19). The magnetic resonance imaging (MRI) images were analyzed retrospectively obtained from the database of the Radiology Department. Because the data were evaluated retrospectively, informed consent was not needed.

Subjects

In this retrospective study, between 2016 and 2019 years, 635 patients who were diagnosed with idiopathic subjective tinnitus and their temporal MRI sections were examined. The images were taken from Kırıkkale University Faculty of Medicine Hospital's picture archiving and communication system. Patients with unilateral or bilateral hearing loss according to the audiometry results, or bilateral tinnitus, Meniere's disease, or mass lesions of the temporal or cranial regions were not included in the study. Finally, 25 patients (8 males and 17 females) with unilateral tinnitus (14 right-sided and 11 left-sided) and normal hearing were included in the study. The mean age of the patients was 48.0 ± 10.9 years (ranged from 23.0 to 64.0 years).

Main Points

- This radiological-based study conducted in tinnitus will contribute to the description of anatomical variants of inner ear structures.
- The study contributes to the anatomical relationship between the cochlear aqueduct, vestibule, lateral semicircular canal, and internal acoustic canal in patients with unilateral subjective tinnitus and normal hearing.
- This study also will shed light on the morphometric explanation of normal magnetic resonance imaging anatomy of inner ear structures.

Audiologic Examination

All patients were evaluated with 0.125 to 8 kHz audiologic examination using a clinical audrometer (MADSEN Astera Otometrics, Taastrup, Denmark).[2] American National Standards Institute 1969 standards were used to evaluate the audiological tests.[6]

The hearing levels were normal. Pure tone average ≤25 dB (average of 500, 1000, and 2000 Hz) is accepted as normal hearing levels for air and bone hearing thresholds.

Temporal Magnetic Resonance Imaging

Temporal high-resolution MR images were obtained using a 1.5 T scanner (Gyroscan ACS NT; Philips, Best, the Netherlands). All MRI scans were performed for all patients in the supine position. After taking localizer sequences, a T1-weighted image was obtained, which provides an anatomical overview of the temporal bone using the built-in body coil of the scanner. A T2-weighted sequence was obtained to visualize the labyrinth using surface coils. A heavily T2-weighted 3-dimensional axial turbo spin-echo sequence was obtained to define fluid-filled inner ear structures (Time to repeat [TR]: 2.00/Time to echo [TE]: 500/Field of view [FOV]: 95/slice thickness: 0.66/matrix: 256 × 256). After completing the sequences, 3 planar (axial, coronal, and sagittal) reconstructions were performed. Images were acquired from the scanner evaluated at the workstation which has multiplanar reconstruction technology.

Measurements

All measurements were performed bilaterally at the tinnitus side (ipsilateral) and non-tinnitus side (contralateral) by the same authors (Y.Y. and A.Ö.).

1. IAC measurements. The following features were measured (Figure 1):
   - Opening width (mm): The distance between the posterior lip of the ICA and an anterior wall which is more medially located was used to measure the opening width.[7]
   - Longitudinal length (length) (mm): The distance starting from the midpoint of the IAC opening to the most

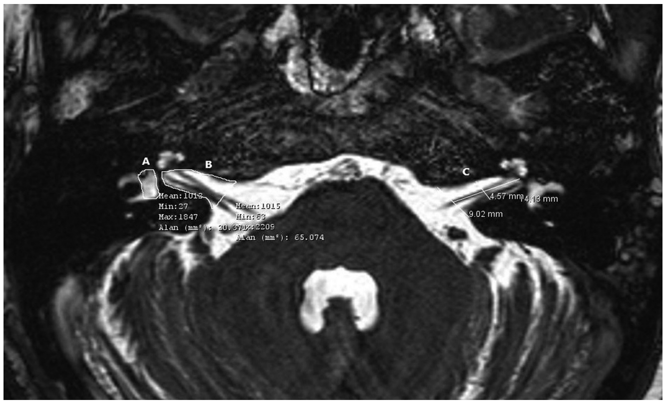

Figure 1. Internal acoustic canal (IAC) and vestibule measurements. (A) Vestibule area measurement, (B) IAC area measurement, and (C) IAC length, width, and opening width measurements are shown.

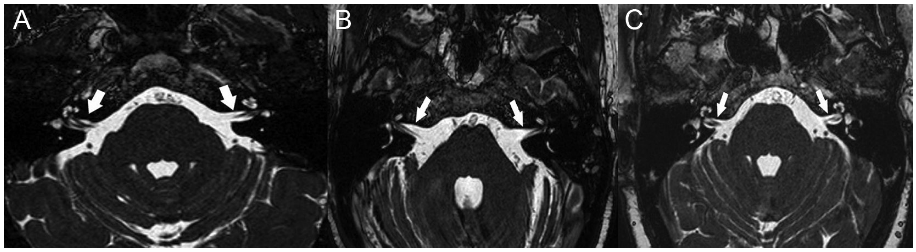

Figure 2. Types of internal acoustic canal (IAC). (A) Cylindrical, (B) funnel-shaped, and (C) bud-shaped IACs are shown (arrows).

concave portion which is the end of its long axis was used for measuring the length of the IAC.[7]

- Anteroposterior diameter (width) (mm): The inner anteroposterior diameter perpendicular to the IAC long axis at the midpoint of IAC length was used for measuring the anteroposterior diameter.[7]
- The selected area of the IAC (area) (mm^2): The triangular-shaped area in which its bottom formed by IAC opening and its top formed by the end of IAC long axis were used for calculating the area.
- The shape classification of IAC: cylindrical-, funnel-, or bud-shaped (Figure 2).

2. CA measurements (Figure 3)
   - Cochlear aqueduct length and CA width: The fluid length of CA was measured from the medial orifice to the most proximal point where the aqueduct is not visible. The fluid width of the medial orifice was measured on an axial plane.[8]
   - The classification of CA[8,9] is as follows:

Type 1 is defined when CA is fully visible starting from the basal turn of the cochlea to the subarachnoid space (Figure 4).

Type 2 is defined when the medial two-thirds of CA is visible.

Type 3 is defined when the medial one-third or only the medial orifice of CA is visible.

Type 4 is defined when CA is not visible.

1. Vestibule area: Naganawa et al[10] revealed a method depicting that the vestibule area can be measured by setting up a region of interest (ROI) on MRI with the following instructions: Set up a ROI for vestibule on MRI at the level of the lowest slice of LSC ring which visualized more than 240° and exclude the ampulla (Figure 1).
2. LSC measurements: LSC measurements were performed according to the method of Benoit et al.[11] The height of the lateral semicircular canal (hLSC) and the width of the lateral semicircular canal (wLSC) distances were measured (Figure 5).

Statistical Analysis

The statistical analyses were performed by using the Statistical Package for the Social Sciences (SPSS) version 16 software

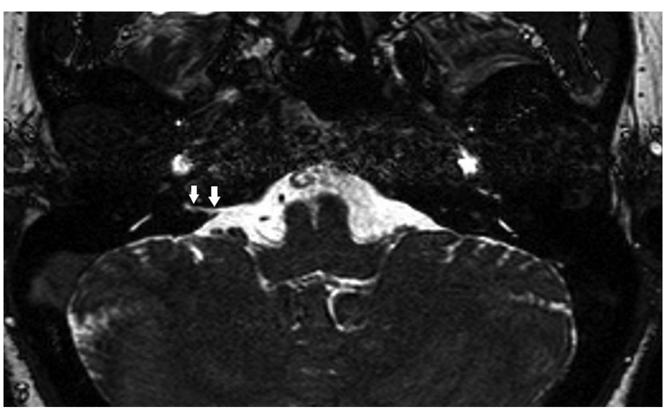

Figure 3. Cochlear aqueduct is shown (arrows).

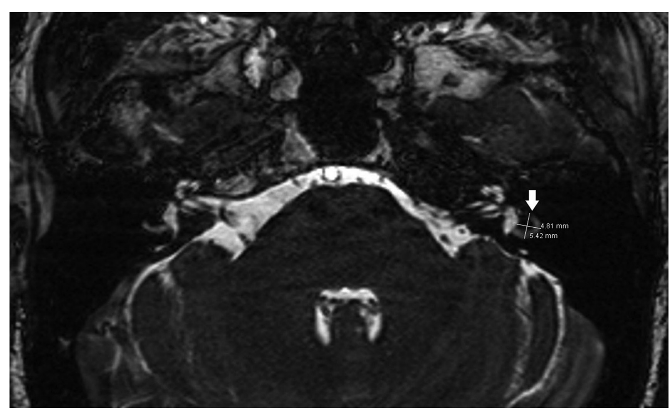

Figure 5. Lateral semicircular canal width and height measurements are shown (arrow).

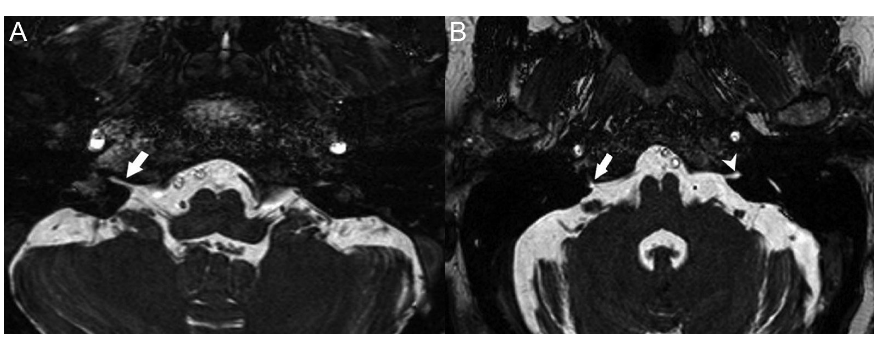

Figure 4. Types of cochlear aqueduct (CA). (A) Type 1 (white arrow), (B) type 2 left side (arrowhead), and type 3 (white arrow) CAs are shown.

Table 1. Measurement Results in Ipsilateral Tinnitus Side and Contralateral Side

		Tinnitus Side (Ipsilateral) (n = 25)			Non-tinnitus Side (Contralateral) (n = 25)			
		Mean	Median	SD	Mean	Median	SD	*P**
CA	Length	6.25	6.40	2.07	6.63	6.40	3.05	.775
	Width	1.22	1.18	0.54	1.40	1.18	0.61	.061
IAC	Length (mm)	10.42	10.60	1.58	10.65	10.59	1.73	.716
	Width (mm)	4.36	4.28	0.82	4.31	4.28	1.40	.681
	Opening width (mm)	6.39	6.06	1.58	6.67	6.66	2.08	.353
	Area (mm^2)	46.12	46.11	11.00	44.52	42.15	11.54	.270
Vestibule	Area (mm^2)	14.09	13.60	1.89	14.01	13.88	1.96	.530
LSC	hLSC	4.63	4.60	0.59	4.69	4.70	0.53	.438
	wLSC	4.97	5.04	0.75	5.20	5.31	0.65	.078

**P*-value shows the results of Wilcoxon-signed ranks test.
CA, cochlear aqueduct; hLSC, height of the LSC; IAC, internal acoustic canal; LSC, lateral semicircular canal; wLSC, width of the LSC.

(SPSS Inc.; Chicago, IL, USA). The Wilcoxon-signed ranks test, chi-square test, and Spearman's correlation rho efficient test were used.

A *P*-value <.05 was considered statistically significant.

Results

Cochlear Aqueduct

There were no significant differences between the CA length and width between ipsilateral tinnitus side and contralateral side (*P* > .05) (Table 1).

Types of Cochlear Aqueduct

Ipsilateral CA types were mainly type 2 (85.7%) in right-sided tinnitus patients and type 2 (63.6%) and type 3 (36.4%) in left-sided tinnitus patients (*P* > .05) (Table 2).

Contralateral CA types were type 2 (71.4%) and type 3 (21.4%) in right-sided tinnitus patients and type 2 (81.8%) and type 3 (18.2%) in left-sided tinnitus patients (*P* > .05) (Table 2).

Internal Acoustic Canal

There were no significant differences between IAC opening width, length, width, and area between the ipsilateral tinnitus side and the contralateral side (*P* > .05) (Table 1).

Types of Internal Acoustic Canal

Ipsilateral ICA types were funnel-shaped (50.0%) and cylindrical (42.9%) in right-sided tinnitus patients and cylindrical (45.5%) and funnel-shaped (45.5%) in left-sided tinnitus patients (*P* > .05) (Table 2).

Table 2. CA and IAC Types According to the Tinnitus Side

			Tinnitus Side				
			Right-Sided		Left-Sided		
			n	%	n	%	*P**
CA	Ipsilateral	Type 1	1	7.1	0	0.0	*P* = .056 χ^2 = 3.647
		Type 2	12	85.7	7	63.6	
		Type 3	1	7.1	4	36.4	
	Contralateral	Type 1	1	7.1	0	0.0	*P* = .838 χ^2 = 0.042
		Type 2	10	71.4	9	81.8	
		Type 3	3	21.4	2	18.2	
IAC	Ipsilateral	Cylindrical	6	42.9	5	45.5	*P* = .980 χ^2 = 0.001
		Funnel shaped	7	50.0	5	45.5	
		Bud shaped	1	7.1	1	9.1	
	Contralateral	Cylindrical	6	42.9	5	45.5	*P* = .965 χ^2 = 0.002
		Funnel shaped	6	42.9	4	36.4	
		Bud shaped	2	14.3	2	18.2	

**P*-value shows the results of the chi-square test.
CA, cochlear aqueduct; IAC, internal acoustic canal.

Table 3. **Correlations for Ipsilateral Tinnitus Side***

				Ipsilateral Tinnitus Side								
				CA		IAC				Vestibule	LSC	
				Length	Width	Length	Width	Opening Width	Area	Area	hLSC	wLSC
CA	Ipsilateral	Length	*r*		0.579	0.317	0.236	0.306	0.324	0.349	0.106	0.393
			P		.002	.122	.256	.137	.114	.087	.614	.052
		Width	*r*	0.579		−0.031	0.224	0.392	0.121	0.143	−0.105	0.475
			P	.002		.884	.283	.053	.563	.495	.617	.016
	Contralateral	Length	*r*	0.339	0.151	0.572	0.271	0.162	0.430	−0.026	0.015	0.147
			P	.097	.472	.003	.190	.438	.032	.901	.944	.482
		Width	*r*	0.171	0.333	0.260	0.268	0.040	0.134	0.000	−0.293	0.087
			P	.414	.104	.209	.195	.851	.523	1.000	.155	.679
IAC	Ipsilateral	Length	*r*	0.317	−0.031		0.338	0.208	0.660	0.375	−0.220	0.117
			P	.122	.884		.099	.318	.000	.064	.291	.579
		Width	*r*	0.236	0.224	0.338		0.486	0.697	0.230	−0.032	0.022
			P	.256	.283	.099		.014	.000	.268	.878	.916
		Opening width	*r*	0.306	0.392	0.208	0.486		0.575	0.194	0.246	0.576
			P	.137	.053	.318	.014		.003	.353	.236	.003
		Area	*r*	0.324	0.121	0.660	0.697	0.575		0.434	0.042	0.278
			P	.114	.563	.000	.000	.003		.030	.840	.179
	Contralateral	Length	*r*	0.312	0.123	0.449	0.296	0.182	0.488	0.523	−0.055	0.273
			P	.129	.560	.024	.150	.384	.013	.007	.795	.187
		Width	*r*	0.100	−0.027	0.343	0.678	0.476	0.651	0.483	0.133	0.035
			P	.634	.896	.093	.000	.016	.000	.014	.527	.867
		Opening width	*r*	0.448	0.355	0.354	0.323	0.595	0.485	0.335	0.257	0.655
			P	.025	.081	.083	.116	.002	.014	.102	.215	.000
		Area	*r*	0.462	0.211	0.492	0.624	0.591	0.797	0.444	0.044	0.293
			P	.020	.310	.012	.001	.002	.000	.026	.836	.155

(*Continued*)

Table 3. Correlations for Ipsilateral Tinnitus Side* (*Continued*)

				Ipsilateral Tinnitus Side								
				CA		IAC				Vestibule	LSC	
				Length	Width	Length	Width	Opening Width	Area	Area	hLSC	wLSC
Vestibule	Ipsilateral	Area	*r*	SLBL	0.143	0.375	0.230	0.194	0.434		–0.186	0.274
			P	.087	.495	.064	.268	.353	.030		.373	.185
	Contralateral		*r*	–0.026	–0.019	0.168	0.255	0.173	0.190	0.289	–0.251	0.074
			P	.902	.929	.423	.219	.407	.363	.161	.227	.725
LSC	Ipsilateral	hLSC	*r*	0.106	–0.105	–0.220	–0.032	0.246	0.042	–0.186		0.306
			P	.614	.617	.291	.878	.236	.840	.373		.137
		wLSC	*r*	0.393	0.475	0.117	0.022	0.576	0.278	0.274	0.306	
			P	.052	.016	.579	.916	.003	.179	.185	.137	
	Contralateral	hLSC	*r*	–0.126	–0.316	0.046	0.184	0.228	0.309	0.022	0.640	0.191
			P	.548	.124	.827	.378	.274	.133	.917	.001	.361
		wLSC	*r*	0.052	0.179	0.014	–0.251	0.196	0.056	0.063	0.171	0.574
			P	.804	.392	.948	.226	.349	.789	.766	.415	.003
Age			*r*	–0.127	0.275	–0.366	–0.304	–0.368	–0.473	0.157	–0.339	–0.287
			P	.546	.183	.072	.140	.070	.017	.453	.098	.164
Gender (code 1: male, code 2: female)			*r*	–0.065	0.093	–0.530	–0.101	0.274	–0.202	–0.173	0.453	0.333
			P	.756	.657	.006	.630	.185	.332	.409	.023	.104
Tinnitus side (code 1: right side, code 2: left side)			*r*	–0.084	–0.222	–0.117	–0.235	0.118	–0.296	–0.296	0.045	–0.190
			P	.690	.286	.576	.258	.575	.151	.150	.831	.363

**P*-value shows the results of the Spearman's correlation rho efficient test.
CA, cochlear aqueduct; hLSC, height of the LSC; IAC, internal acoustic canal; LSC, lateral semicircular canal; wLSC, width of the LSC.

Contralateral ICA types were cylindrical (42.9%) and funnel-shaped (42.9%) in right-sided tinnitus patients and cylindrical (45.5%) and funnel-shaped (36.4%) in left-sided tinnitus patients ($P > .05$) (Table 2).

Vestibule

There was no significant difference between the vestibule area and the ipsilateral tinnitus side and the contralateral side ($P > .05$) (Table 1).

Lateral Semicircular Canal

There were no significant differences between hLSC and wLSC dimensions between the ipsilateral tinnitus side and the contralateral side ($P > .05$) (Table 1).

Correlation Test Results

- Cochlear aqueduct: There were positive correlations between the ipsilateral tinnitus side's CA length and width; ipsilateral tinnitus side's CA width and wLSC dimensions; ipsilateral IAC area and length; and contralateral CA length ($P < .05$) (Table 3).
- Internal acoustic canal: There were positive correlations between IAC's ipsilateral measurement results (opening width, length, width, and area) and ipsilateral and contralateral measurement results ($P < .05$) (Table 3).

There were positive correlations between ipsilateral IAC and vestibule areas; contralateral IAC area and width; ipsilateral vestibule areas; and ipsilateral CA length and contralateral IAC areas ($P < .05$) (Table 3).

- Lateral semicircular canal: There were positive correlations between the ipsilateral tinnitus side's wLSC and ipsilateral CA width IAC opening width; ipsilateral and contralateral hLSC; and wLSC dimensions ($P < .05$) (Table 3).
- Age: In older patients, the ipsilateral IAC area got lower ($P < .05$) (Table 3).
- Gender: In females, the hLSC dimension was lower than those in the males ($P < .05$) (Table 3).
- Tinnitus side: There were no significant correlations between the tinnitus side and ipsilateral measurement results ($P > .05$) (Table 3).

Discussion

Inner ear or auditory pathway disorders generally cause subjective tinnitus, and muscular, vascular, and ossicle system disorders or tumors cause objective tinnitus. Subjective tinnitus complaints increase as sensorineural hearing loss increases. With age, the prevalence of tinnitus and hearing loss increases. Ten percent of the population over the age of 60 indicates severe ear tinnitus.[12-14]

Objective tinnitus describes the sound that not only the patient but also other people can hear. Subjective tinnitus describes only the sound that the patient can hear. Objective tinnitus usually has a vascular origin (dural arteriovenous malformation, carotid-cavernous fistula, and arteriovenous malformation of the vascular structures of the neck). Subjective tinnitus incidence is higher than objective tinnitus (IAC pathology, presbycusis, acoustic trauma, Meniere's disease, otosclerosis, labyrinthitis, effusion, ossicle system deformities, cholesteatoma, tumors, external auditory canal pathology, metabolic, neurologic, and psychological causes).[15] Non-pulsatile tinnitus is generally subjective tinnitus. In today's conditions, the etiology of tinnitus has not been revealed clearly. Therefore, it is an issue that needs more research.[16]

Generally, inner ear diseases occur with symptoms such as tinnitus, hearing loss, and vertigo. Disruption of endolymph and perilymph homeostasis in the inner ear and disorders in the hair cells and supporting cells are often the accused factors .[17]

In the present study, we investigated the relationship between idiopathic subjective tinnitus and CA, IAC, vestibule, and LSC measurements. Our results showed that CA length and width and IAC opening width, length, width, and area of the ipsilateral tinnitus side were not different from the contralateral side. Similarly, the vestibule area and hLSC wLSC values were not different between the ipsilateral tinnitus side and the contralateral side.

In Polat et al's[18] study, the diameters of the IAC in the tinnitus group were found to be statistically significantly smaller when compared to those in the control group ($P < .01$). The increased pressure on the cranial herves caused by the narrowed IAC was thought to result in tinnitus. Whereas different from Polat et al's[18] study, IAC measurements in the tinnitus side were not different from the contralateral side.

There are 3 channels between the intracranial structures and the inner ear: the vestibular aqueduct, the CA, and the internal auditory canal. Vestibular aqueduct contains an endolymphatic duct ending with a blunt sac, endolymphatic sac, which is embedded in 2 dural layers in the epidural space. The CA is a bony canal that connects the subarachnoid space to the basal turn of the cochlea with the perilymphatic duct. These channels have an important role in inner ear regulation, and homeostasis of fluid and disorders in these channels cause diseases of the inner ear.[19]

Cochlear aqueduct is a substantial structure that balances perilymphatic, endolymphatic, and cerebrospinal fluid pressures. The flow rate of liquids through tubes is a linear function of pressure, viscosity, and tube length, but the lumen radius is the fourth-degree power function.[20]

Yılmazer et al[21] studied the sizes of the CA in Ménière's disease. They formed a study group of 40 patients with bilateral Ménière's disease. There was no statistically considerable difference in the dimensions of the CA between patients with Ménière's disease and control group. As a result, it was concluded that the CA does not play an important role in perilymphatic pressure values between the 2 groups.

Thirty-one patients with otological symptoms (sudden sensorineural hearing loss, vertigo, or tinnitus) were evaluated with MRI for CA area and contrast development. Of the 62 ears, 48 (77.4%) showed the contrast increase of the CA, but there were no significant differences between the patients with and without otological symptoms. In addition, gender- or age-related differences were not detected.[22] In our study, similarly, CA measurements were not different between the tinnitus side and the contralateral side. Moreover, there were no significant correlations between CA measurement and gender and age similar to the results of Nakamura et al's study.[22]

In the present study, the main CA type was type 2 in both ipsilateral and contralateral sides. For the IAC types, cylindrical and funnel shapes were the most common types for the ipsilateral tinnitus side and contralateral side.

There were positive correlations between IAC and vestibule areas; CA length and IAC areas; CA width and wLSC; IAC area and length and CA length; IAC opening width and hLSC; and wLSC dimensions. In older patients, the ipsilateral IAC area got lower. In females, the hLSC dimension was lower than that in males.

Normal adult IAM volume, shape, and dimensions vary greatly, even between the right and left sides of the same subject.[23] The internal auditory canal might be affected from the eighth cranial nerve formation and development.[24] If a patient has a narrow ICA or meatus, congenital sensorineural hearing loss and cochlear nerve hypoplasia should be investigated.[25,26] Dilated internal acoustic meatus shows expansion secondary to an acoustic neuroma or other masses.[25]

Glastonbury et al[27] stated that if IAM's vertical or transverse diameter was less than 4 mm, IAM was regarded as abnormal. Valvassori et al[28] declared that there were differences in the internal auditory canal size. Its diameter might vary from 2-3 mm to 12 mm (mean 5 mm). In the present study, the IAC width was 4.36 mm on the tinnitus side and 4.31 mm on the contralateral side.

Papangelou[29] noticed that the size of the internal auditory canal was larger in males than females. Also, while there was a relation between canal length and gender, no relation was found between canal length and age. The length of the IAM was developed in the second decade (11-20 years).[29] However, in the present study, the ipsilateral IAC area got lower in older patients, and there were no significant correlations between sex and ICA measurement. We only found hLSC values were lower in females than males. In Erkoç et al's study,[26] the AP diameter of IAC was reported to be 5.93 and 5.83 mm in Turkish males and females with MRI. In addition, Erkoç et al[26] did not find a significant difference between genders in terms of IAM width, and while the same measurement reached the maximum value in the third decade (20-30 years), the minimum value was obtained in the fifth decade (41-50 years). In Polat et al's study,[30] there were no found significant differences in internal acoustic meatus width ($P = .352$) and height ($P = .953$) in the right and left sides.

The IAC measurement values are important because it contains important structures. In the IAC, "vestibulocochlear nerve" splits into 3 parts (cochlear, superior vestibular, and inferior vestibular).[31] Internal acoustic meatus length was reported to be 8.7 mm (minimum 4 mm and maximum 18 mm) by Kobayashi and Zusho.[32] Moreover, the inferior length of the IAM was found to be 8.39 mm, whereas the superior length of the IAM was 10.75 mm.[23] In the present study, the IAC length was 10.42 mm on the tinnitus side and 10.65 mm on the contralateral side.

According to the American Academy of Otolaryngology—Head and Neck Surgery Foundation guideline about tinnitus, additional imaging modalities are not recommended for the patients with tinnitus unless they have 1 or more of the following findings: pulsatility of tinnitus, tinnitus that affects 1 ear, focal neurological abnormalities, or asymmetric hearing loss.[33] Our study also supports that there would be additional symptoms other than only idiopathic subjective tinnitus to expect a pathologic measurement result in IAC, CA, vestibule, and LSC on MRI.

Our results showed that in idiopathic subjective tinnitus, there were no important pathologies detected in IAC, CA, vestibule, and LSC. We concluded that there are no statistically significant morphometric differences compared to the healthy side in the IAC, CA, vestibule, and LSC areas detected by temporal MRI in patients with unilateral subjective tinnitus and normal hearing. Due to a limited number of patients with unilateral subjective tinnitus included in this study, possible pathologies with low incidence may not have been demonstrated. Therefore, studies with larger populations are needed.

Ethics Committee Approval: This study is retrospective. Ethics committee approval was obtained from the Kırıkkale University Non-invasive Research Ethics Committee (date: 07.08.2019, number: 2019.07.19).

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