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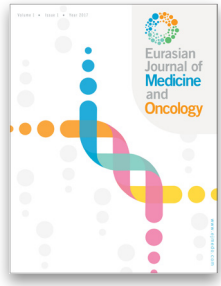

Research Article

The Analysis of the Relationship Between Subjective Tinnitus and Vascular Loop, and Age and Gender Distribution: An MRI Study

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Abstract

Objectives: The aim of the present study was to investigate the age and gender distribution of tinnitus and vascular loop adjacent to the eighth nerve and the relationship between tinnitus symptom and vascular loop in a large patient group.
Methods: The study was conducted on 606 measurements, including the right and left sides, of a total of 303 cases. Noninvasive evaluation of the microvascular structures at the cerebellopontine angle or in the internal auditory canal was performed using magnetic resonance imaging.
Results: There was no statistically significant difference in the incidence of tinnitus and vascular loop among the age groups and gender (p>0.05). Tinnitus and vascular loop were observed in 225 (37.1%) and 111 (18.32%) cases (n=606), respectively. The presence of a vascular loop was not found to be correlated with tinnitus (p>0.05). Vascular loop also demonstrated a high incidence in cases without tinnitus (20.2%).
Conclusion: The simple neurovascular contact is not a rare finding, and it does not appear to cause tinnitus. Therefore, further investigations that will be conducted on cases with vascular loop leading to neural angulation or displacement may contribute to case selection for microvascular decompression operations.
Keywords: Tinnitus, vascular loop, 3D FIESTA
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Tinnitus is perception of a sound in the ear of the subject without an external acoustic stimulant.[1] Even though, the earliest data on tinnitus traced back to the historical records of ancient Egypt, there is no consensus on its pathophysiology, classification and treatment today.[1]

Tinnitus is one of the most common otologic complaints. It may be accompanied by the complaints of hearing loss, vertigo or headache. The prevalence of tinnitus ranges between 7–32% in the literature;[2] and approximately 1–2% of the population suffer severely from tinnitus leading to impaired body function, concentration problems, labour loss, disruption of everyday activities and lack of sleep. Hence, decompensated tinnitus is most commonly accompanied by anxiety and depression.[3]

Some researchers suggest that vascular compression of the vestibulocochlear nerve (8th cranial nerve- 8th CN) at the cerebellopontine angle (CPA) or in the internal auditory canal (IAC) may be an etiological factor for pulsatile tinnitus. It is considered that anterior inferior cerebellar artery (AICA) and the neighboring veins at this location are responsible for microvascular compression and that improved findings obtained after microvascular decompression and further ligation of the 8th CN indicate this hypothesis.[4, 5] On the other hand, some researchers have also

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suggested that the vascular structures in contact with the 8th CN are not responsible for the pathological findings in all cases.[6, 7]

Magnetic resonance imaging (MRI) is the most appropriate method for noninvasive evaluation of the microvascular structures in this region. Vascular structures can be encountered around the cerebellopontine angle cistern (CPAC) by the spin-echo sequences. However, Three-dimensional (3D) gradient echo (GRE) sequences with high resolution such as fast imaging employing steady-state acquisition (FIESTA) and constructive interference in steady state (CISS) sequences can be used more effectively than other sequences for imaging neurovascular compression by the vascular structures.[8, 9]

The purpose of this study, is to investigate the gender and age distribution of tinnitus and vascular loop and the relationship between tinnitus and the vascular loop adjacent to the 8th CN detected in MRI.

Methods

This study was based on the electronic medical records of the patients between January 2016 and January 2017. Totally, our study included 350 patients who have applied to our Clinics of ENT or Neurology due to several complaints such as tinnitus, vertigo, hearing loss, trigeminal neuralgia and facial paralysis and have undergone MRI of the temporal bone. The study protocol was approved by Fatih Sultan Mehmet Training and Research Hospital Scientific Committee. The study was performed retrospectively, therefore informed consent was waived. Forty-seven of the 350 reviewed cases were excluded from the study because of suboptimal performance of MRI based on study protocol, presence of different pathologies related with 8th CN such as high jugular bulb and cerebellopontin angle tumors. Cases, which could be defined as idiopathic tinnitus due to the fact that etiological factors could not be detected in the hospital automation system scan, were included in the study. As a consequence, 303 cases were included in this study.

In this study, the frequency of tinnitus and vascular loop cases according to age and gender, the locations where the vascular loop compresses the nerve, and the ratios of unilaterality and bilaterality were evaluated. Additionally, the cases with tinnitus and without tinnitus in terms of presence of vascular loop were compared; thereby, the relationship between tinnitus symptom and vascular loop was investigated.

The presence of vascular loop was evaluated in the slices of temporal bone MRI. The vascular loop is divided into three anatomical groups based on location:

Type I: CPA (cisternal segment)

Type II: Proximal half of the IAC

Type III: Distal half of the IAC

The MRI studies were performed using 450w Gem Suite MR scanner (GE Healthcare, USA). 3D FIESTA and 3D T1 FSPGR (fast spoiled gradient-echo) sequences on the axial plane were obtained in accordance with routine MR imaging protocol. T2 weighted slices on the coronal plane were also obtained to diagnose edema and inflammation in the mastoid cells. The protocol routinely performed in our clinic for temporal bone MRI is as follows:

- Coronal T2 (TR:4582, TE:101, FOV:22, Bandwidth:62.5, Slice Thickness:3, Slice spacing:0.5, ETL:32, NEX:2)
- Axial 3D T1 FSPGR (TR:8.3, TE:4.2-14, Flip Angle:15, FOV:20, Bandwidth: 41.67, slice thickness:1, NEX:1.5)
- Axial 3D FIESTA (TR:5, TE:1.8-11, Flip Angle:55, FOV:20, SliceThickness:1, Bandwidth:41.67, NEX:2)

In some cases, contrast-enhanced 3D T1 FSPGR sequences on the axial plane were added.

3D FIESTA, being the most useful sequence in imaging microvascular anatomy, was especially determinant in detection of vascular loop. Contrast-enhanced sequences were also used in detection of vascular loop in a few cases.

Statistical Analysis

Statistical analyses were performed using NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) software. In evaluation of the study data, Student's t-test was used to compare the quantitative data and also to compare two groups in terms of normally distributed variables, together with the descriptive statistical methods. The comparison of qualitative data was performed using Pearson's Chi-Square test and Fisher's Exact test. Statistical significance level was accepted as $p<0.05$.

Results

The study was conducted on 606 images obtained from bilateral sides of totally 303 cases composed of 155 female (51.2%) and 148 male (48.82%) subjects. Ages of the cases ranged between 14 and 87.

Mean age of the cases with tinnitus was 55.26±13.31 years whereas the cases without tinnitus was 52.88±15.48 years. No statistically significant difference was found between the cases with or without tinnitus, according to the average of age ($p>0.05$).

Twenty-two point nine percent (n=30), 52.7% (n=69) and 24.4% (n=32) of the cases with tinnitus aged under 45, between 45–65 years, at 65 and over, respectively. There was no statistically significant difference in the incidence of tin-

Table 1. The distribution of tinnitus and vascular loop (n=606)

	n	%
Tinnitus		
Absent	381	62.9
Present	225	37.1
Vascular loop		
Absent	495	81.7
Present	111	18.3
Type I		
Absent	534	88.1
Present	72	11.9
Type II		
Absent	569	93.9
Present	37	6.1
Type III		
Absent	601	99.2
Present	5	0.8

Table 2. The relationship between tinnitus and vascular loop (n=606)

	Tinnitus (-) (n=281)		Tinnitus (+) (n=225)		
	n	%	n	%	p
Vascular loop					
Absent (n=495)	304	79.8	191	84.9	[a]0.117
Present (n=111)	77	20.2	34	15.1	
Type I					
Absent (n=534)	330	86.6	204	90.7	[a]0.136
Present (n=72)	51	13.4	21	9.3	
Type II					
Absent (n=569)	355	93.2	214	95.1	[a]0.336
Present (n=37)	26	6.8	11	4.9	
Type III					
Absent (n=601)	378	99.2	223	99.1	[c]1.000
Present (n=5)	3	0.8	2	0.9	

[a]Pearson's Chi-Square Test; [c]Fisher's Exact Test; **p<0.01.

nitus among the age groups (p>0.05).

Forty-five point eight percent (n=60) of the cases with tinnitus were female and 54.2% (n=71) of the cases with tinnitus were male. No statistically significant difference was found among the cases with tinnitus in terms of gender (p>0.05).

Tinnitus was found bilateral in 64.9% (n=85) and unilateral in 35.1% (n=46) of the cases. High incidence of bilateral tinnitus was statistically significant (p=0.001; p<0.01).

Mean age of the cases with vascular loop was 52.96±16.16 years whereas that of the cases without vascular loop was 54.24±14.04 years. Of the cases with vascular loop, 31.6% (n=25), 39.2% (n=69) and 29.14% (n=23) aged below 45, between 45–65 years, aged 65 and over, respectively. No statistically significant difference was found between the age groups according to incidence of vascular loop (p>0.05).

Of the cases with vascular loop; 54.4% (n=43) and 45.6% (n=36) were female and male, respectively. No statistically significant difference was found between the cases with vascular loop in terms of gender (p>0.05).

Tinnitus and vascular loop were detected in 37.1% (n=225) and 18.32% (n=111) of totally 606 sides on the right and left, respectively (Table 1).

Vascular loop was observed in totally 26.1% (n=79) of 303 cases, consisting of Type I, Type II and Type III vascular loops, in 17.5% (n=53), 7.6% (n=23) and 1.0% (n=3) cases, respectively.

No statistically significant relationship was found between cases of tinnitus and vascular loop (p>0.05). Moreover, no statistically significant relationship was detected between cases of tinnitus and Type I, Type II, Type III subtypes of vascular loop (p>0.05) (Table 2).

Discussion

Tinnitus was the most commonly reported complaint in the study group. Type I vascular loop was most commonly revealed in MR findings where Type II was less frequent and Type III was rare (Fig. 1a, b, and Fig. 2, and Fig. 3). Some cases had unilateral vascular loop, some had bilateral vascular loops in various types (same or different types on the right and left side).

It has been reported that prevalence of tinnitus increases by age. The prevalence of tinnitus was found to be 4.7% between the ages 20–29 years in a study whereas incidence of tinnitus in the cases aged between 60–69 years and over 70 were encountered 12.1% and 25–30%, respectively.[10] Brown et al. have reported in another study that the prevalence of tinnitus was found 1.6%, 4.9% and 7.9% between the age groups of 18–44, 45–64 and 65–74 years, respectively.[11] In this study, where the cases were grouped similar to Brown et al. in terms of age, no statistically significant difference was found between the cases aged below 45, between 45–65 and over 65 years old.

According to Kara E et al. vascular loop may be congenital, as well as, may be resulting from the thickening and hardening of the arterial walls due to the atherosclerotic changes with advanced age. In addition, advanced age-related reductions in cerebrospinal fluid and stretching of cranial nerves due to cerebral atrophy may lead to a contact between vessels and the 8th CN.[12] However, no finding which supports the increased prevalence of vascular loop

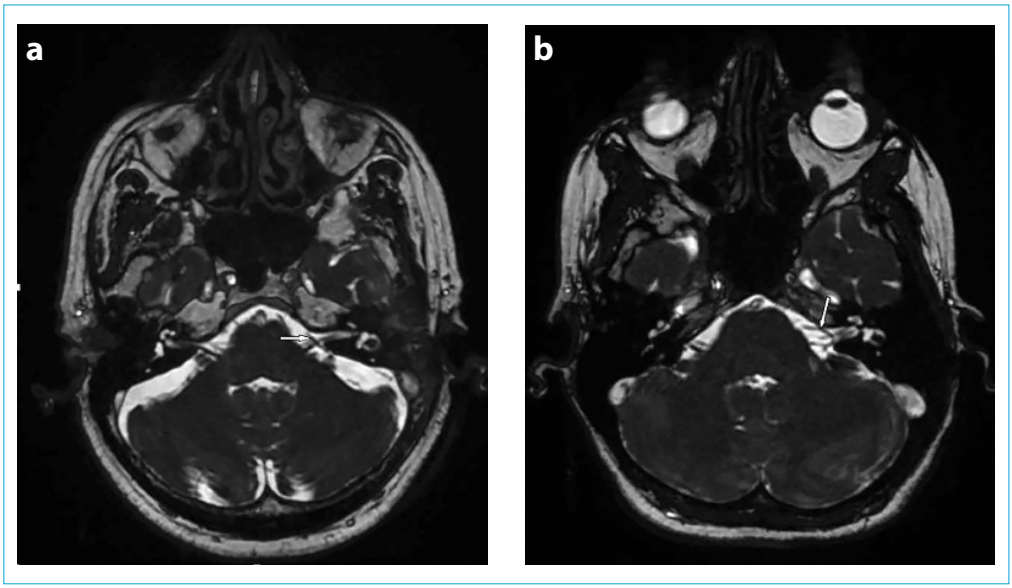

Figure 1 (a, b). 3D FIESTA axial images show cross-compression between neural cisternal segments and Type I vascular loop **(a)**, cross-compression between neural structures and Type II vascular loop at the entrance of IAC **(b)** on the left sides.

Figure 2. Contrast-enhanced 3D T1 FSPGR image shows cross-compression of the nerves by Type III vascular loop (thick arrow) at the right distal portion of IAC. Vascular loop is seen passing the cistern (thin arrow).

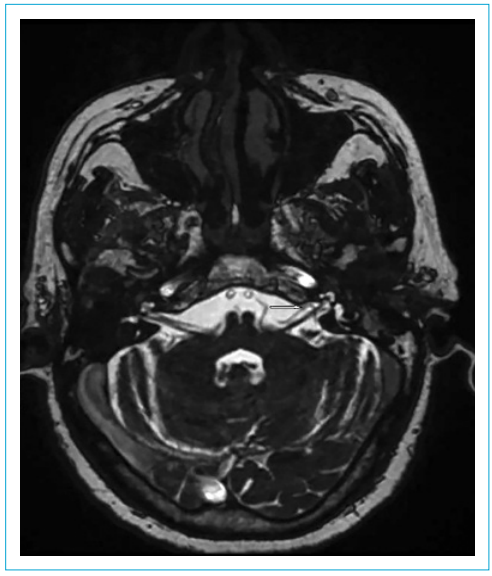

Figure 3. 3D FIESTA sequence. On the left side, cross-compression of the nerves by Type II vascular loop.

related with advanced age was found in this study.Frequency of vascular loop should increase with age, should it be the case that it was related to atherosclerotic changes.

Tinnitus may be unilateral or bilateral. Bilateral tinnitus was reported to demonstrate a higher probability. Sennaroglu et al. have found the cases of bilateral and unilateral tinnitus to be 52% and 37% in their study, respectively.[13] The prevalence of bilateral tinnitus was found higher also in this study. Some studies have suggested that incidence of tinnitus may differ according to gender. In contrast, other authors have demonstrated that there is no significant difference between females and males with respect to incidence of tinnitus.[10, 14, 15] Similarly, in this study, there was no difference between male and female in terms of tinnitus incidence.

Although, it is accepted that vascular compression of the 8th CN at the CPA may lead to vertigo, tinnitus and sensorineu-

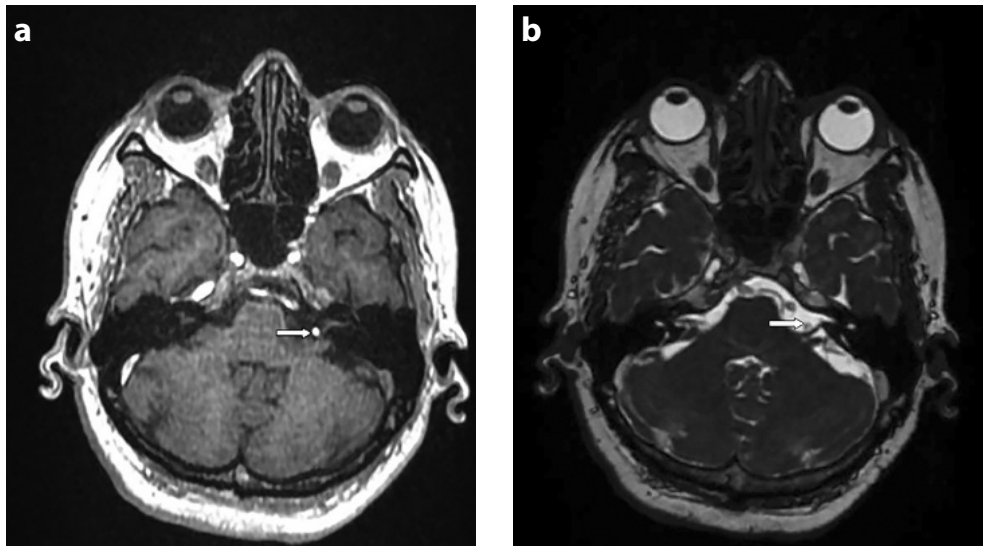

Figure 4 (a, b). Contrast-enhanced 3D T1 FSPGR **(a)** and 3D FIESTA **(b)** sequences show vascular loop which minimally displaced the 7th-8th cranial nerves at the left CPAC.

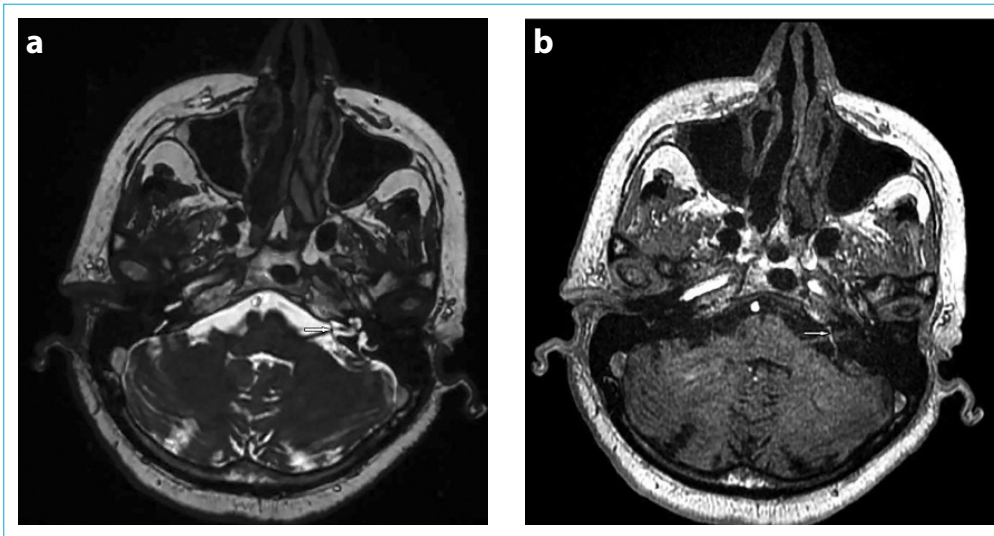

Figure 5 (a, b). 3D FIESTA **(a)** and contrast-enhanced 3D T1 FSPGR **(b)** sequences show cross-compression of 7th-8th cranial nerves by the vascular loop at the entrance of left side.

ral hearing loss, microvascular decompression of the 8th CN in treatment of tinnitus is still controversial.

Tinnitus caused by vascular compression is usually nonspecific; it has been reported that clinical features of non-pulsatile tinnitus is correlated with presence of neurovascular contact in the cisternal portion of the 8th CN while pulsatile tinnitus is correlated with vascular loops in the IAC.[16] However, in this study, no statistically significant increase was found in prevalence of tinnitus symptoms in presence of vascular loop either regardless of anatomic types orregarding with its anatomic types such as Type I, Type II and Type III.

The diagnostic importance of imaging vascular compression of 8th CN in radiological evaluation is still controversial because vascular contact with 8th CN without a tinnitus symptom was demonstrated in many postmortem evaluations and imaging studies. Therefore, some authors propose that the contact between blood vessels and 8th CN observed by MRI may not be an accurate indicator of vascular compression of 8th CN. Parnes et al. have shown that such a vascular contact presents a higher rate of 60% in the asymptomatic subjects.[17] In another study, which investigated the contact between the anterior inferior cerebellar artery (AICA) loop and 8th CN based on MRI slices, such a vascular contact was encountered in 25% and 21.4% of the patients with 8th CN symptoms and the asymptomatic subjects, respectively.[18]

In this study, no statistically significant correlation was found between presence of vascular loop in contact with 8th CN and tinnitus. Vascular loop was present in 20.2% of the subjects without tinnitus. Vascular loop was also found in 111 (18.32%) of all cases (n=606) in MRI. Vascular loop was observed in high prevalence in cases without tinnitus. Thus, vascular loop was a frequent finding in the temporal bone MRI performed due to different complaints by the use of three dimensional thin sliced MR sequences. MRI is one of the most important techniques which demonstrates the vascular compression of the 8th CN.[19] Furuya et al. have investigated 12 patients with clinical features of intracranial neurovascular compression using MRI and encountered presence of compression caused by one or two arteries in 9 of these 12 patients and thus MRI findings were confirmed intraoperatively.[20]

In this study group, only 5 of 111 vascular loop compressions caused minimal displacement of the 8th CN (Fig. 4a, b). In the remaining 106 cases, there was simple contact such as close neighbourhood and cross-compression between the 8th CN and vascular loop (Fig. 5a, b); Close neighborhood and cross-compression were found in 7 and 99 cases, respectively. In the study group, there were only five cases with minimal displacement, however neural angulation or remarkable displacement caused by vascular loop, wasn't detected.

One of the limitations of this study was inability to classify the cases in detail according to angulation and displacement. In addition, the calibration of the vascular loop was not taken into account. Since this study was retrospective, detailed data regarding the types and grading of tinnitus, was not presented.

The further investigations which will be conducted on the cases with vascular loop compression leading to displacement or angulation on the 8th CN will clarify the etiology of tinnitus and provide helpful outcomes for controversial necessity of microvascular decompression operations.

In conclusion, no increase in connection with advanced age was found in the incidence of vascular loop and tinnitus. No difference between genders was observed. The contact between the 8th CN nerve and vascular loop most frequently occurs at the CPAC. All types of neurovascular neighbourhood at the CPAC or in the IAC may not cause tinnitus. Therefore, further investigations on the cases with vascular loop leading to neural angulation on displacement becomes increasingly important. A relationship that can be defined as a simple contact between vascular loop and the 8th CN, is observed as close neighbourhood and most commonly cross-compression, and this simple relationship is not an etiological factor for subjective tinnitus according to the results of the study. Consideration of these issues at selection of the cases for microvascular decompression operations, is crucial to prevent unnecessary operations.

Disclosures

Ethics Committee Approval: The study was approved by the Local Scientific Committee.

Peer-review: Externally peer-reviewed.

Conflict of Interest: No conflicts of interest including funding, other financial support, and material support for this work.

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