The Effect of Vascular Loop in the Tinnitus Severity

Vasküler Loop'un Tinnitus Şiddetine Etkisi

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ABSTRACT

Objective: To evaluate the effect of vascular loop variations diagnosed by high resolution ear magnetic resonance imaging (MRI) on the etiology and clinic of tinnitus with both the features of tinnitus and the tinnitus handicap inventory (THI).

Material and Methods: The tinnitus handicap inventory was applied to the patients 18-55 years of age who presented to our clinic with the complaint of unilateral chronic tinnitus. Patients were grouped according to MRI findings and gender.

Results: There were 47 type I vascular loop patients (26 female: group I, 21 male: group II), 40 type II vascular loop patients (24 female: group III, 16 male: group IV) and 60 normal patients (34 female: group V, 26 male: group VI) with MRI findings. In each group, the number of female patients was higher and the THI averages of female patients were higher. Patients with type II vascular loop had higher THI averages. In addition, the age of onset of tinnitus was earlier in patients with type II vascular loop.

Conclusion: The type II vascular loop affects the tinnitus clinic by creating vascular compression. Our results suggest that it is possible to evaluate a type II vascular loop as a vascular compression syndrome due to its clinical effects.

Key Words: Vascular loop, Tinnitus, Tinnitus handicap inventory, Vascular compression syndrome

ÖZ

Amaç: Yüksek rezolüsyonlu kulak manyetik rezonans görüntüleme (MRG) ile tanı konulmuş vasküler loop varyasyonlarının tinnitus etiyolojisi ve kliniği üzerine etkisinin olup olmadığını hem tinnitusun özellikleri hem de tinnitus engellilik anketi (TEA) ile değerlendirmek.

Gereç ve Yöntemler: Kliniğimize tek taraflı kronik tinnitus yakınması ile başvuran, işitmesi normal 18-55 yaş arasındaki hastalara tinnitus engellilik anketi uygulandı. Hastalar MRG bulguları ve cinsiyete göre gruplara ayrıldı.

Bulgular: MRG bulgularına göre, 47 tip1 vasküler loop olan hasta (26 kadın: grup I, 21 erkek: grup II), 40 tip2 vasküler loop olan hasta (24 kadın: grup III, 16 erkek: grup IV) ve 60 normal hasta (34 kadın: grup V, 26 erkek: grup VI) vardı. Her grupta kadın hasta sayısı daha fazla ve kadın hastaların TEA ortalamaları daha yüksekti. Tip2 vasküler loopu olan hastaların da TEA ortalamaları daha yüksekti. Ayrıca tip2 vasküler loop olan hastalarda tinnitusun başlama yaşı daha erkendi.

Sonuç: Tip2 vasküler loop bir vasküler kompresyon oluşturarak tinnitus kliniğini etkilemektedir. Elde ettiğimiz sonuçlara göre tip2 vasküler loopu oluşturduğu klinik etkiler nedeniyle vasküler kompresyon sendromu olarak değerlendirebiliriz.

Anahtar Sözcükler: Vasküler loop, Tinnitus, Tinnitus engellilik anketi, Vasküler bası sendromu

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INTRODUCTION

Tinnitus is detection of a sound without any acoustic stimulus. If it is only heard by the patient, it is called subjective tinnitus, the most common form of tinnitus. Objective tinnitus if heard by both the patient and the external observer. It may be the pulsatile type, which is the most common type, or the non-pulsatile type. Acute tinnitus lasts shorter than 6 months while chronic tinnitus lasts longer than 6 months. The prevalence in the adult population is 10-15%. Despite being a common disorder in the community, its etiology, pathophysiology, clinical effect and treatment are still not fully understood and are controversial (1-3).

There are various etiological factors of tinnitus such as trauma, ototoxic medications, cold, and Meniere. However, etiological factors cannot be determined in most patients. A vascular loop is an anatomic variation in which there is vascular contact on the eighth nerve. A relationship has not yet been established between a vascular loop and the pathophysiology of tinnitus. However, it is thought that vascular loops result in tinnitus by causing abnormal stimulation with mechanical trauma and a pressure effect (4,5). Studies are needed to determine the relationship between a vascular loop and tinnitus.

The quality of life is significantly affected by tinnitus in approximately 1-2% of the population. Tinnitus is even associated with increased stress and depression levels (2). Tinnitus increases the level of stress and depression by causing sleep and concentration disorders. This situation also affects quality of life and general welfare level (6). The quality of life is reduced in 23% of patients with tinnitus (7). Therefore, various questionnaires have been developed to evaluate the effects of tinnitus on the quality of life. The tinnitus handicap inventory (THI) is one of the frequently used tests. Since objective measurement of tinnitus cannot be performed, these questionnaires are also used to monitor the clinical course of tinnitus and its response to treatment. In addition, these questionnaires have become more important in recent years in order to solve the clinical uncertainty of tinnitus. The results of quality of life questionnaires in patients with tinnitus have been compared according to age, gender, hearing loss and tinnitus noise levels and data about the tinnitus clinical picture obtained in this manner (2,7-9).

To our knowledge, despite the presence of studies on the factors affecting the tinnitus clinic and etiology, there is no study conducted in large patient series evaluating the relationship between tinnitus and vascular loop in the literature. The aim of our study was to evaluate the effect of a vascular loop diagnosed by ear magnetic resonance imaging (MRI) on the tinnitus clinic with the tinnitus handicap inventory (THI). Several factors such as the effect of the tinnitus on daily life and social activities, the capacity to deal with tinnitus, the degree of discomfort, and changes in the tinnitus when under stress were queried in patients with and without a vascular loop. Thus, whether the vascular loop has any affect on the tinnitus clinic was evaluated in a large patient series.

MATERIALS and METHODS

The authors assert that the study was conducted in accordance with the ethical standards stated in the 'Declaration of Helsinki'. Recep Tayyip Erdogan University Faculty of Medicine of Local Ethics Committee approval was obtained for the study (protocol number: 2018/151). All participants provided written informed consent.

Subjects

Patients who presented to our clinic with the complaint of unilateral chronic tinnitus between January 2014 and August 2018 were evaluated within the scope of the study. Patients aged 18-55 years with a history of unilateral subjective tinnitus complaints for more than 6 months who had no history of otological surgery and had normal bilateral tympanic membranes with otoendoscopic examination were included in the study. Those with psychiatric disorders, vestibular complaints, a history of ototoxic medication, chronic systemic and/or vascular diseases, a history of pregnancy or breastfeeding, and those who worked in noisy environments were excluded from the study. The audiological evaluations of the patients were performed with pure tone audiometry and the patients with hearing problems were not included in the study. The inner ear structures and retrocochlear region were evaluated by ear magnetic resonance imaging (MRI). Patients with any pathology (such as tumor, cyst) except a vascular loop were excluded from the study. Patients who allowed the administration of the tinnitus handicap inventory (THI) were included in the study.

The demographic data (age, gender) of the patients, the affected ear side (right or left), the age of onset of the tinnitus, the type of tinnitus (pulsatile or non-pulsatile), and the nature of tinnitus (continuous or intermittent) were recorded.

Pure Tone Audiometry

The pure tone audiometry test was performed in a sound-proof room with the AC40 device (Interacoustics; Assens, Denmark). Air conduction thresholds were measured using the Telephonics TDH39 headset (Interacoustics; Assens, Denmark) in the 0.25-8.0 kHz range. Bone conduction thresholds were measured using a B71 bone vibrator (Interacoustics; Assens, Denmark) at the 0.25-6.0 kHz range. The audiometric thresholds were determined by the mod-

ified Hughson-Westlake method (10). The normal hearing threshold was accepted as ≤25 dB HL at all frequencies (11).

Magnetic Resonance Imaging (MRI)

A 32-channel head coil was used for 1.5 T scanners (Somatom X; Siemens Magnetom Aera, Germany). The images were evaluated regarding the relationships of the vestibulocochlear nerve (VCN) with anterior inferior cerebellar artery (AICA) at the cerebellopontine angle (CPA) and internal acoustic canal (IAC). A high-resolution 3-dimensional (3D) T2-weighted (T2W) MRI sequence was used for the MRI scans, and the images were assessed by an experienced radiologist specialized in head and neck radiology. The vascular loops were classified according to the coursing patterns of the AICA and their relationships with the VCN as: 1) Type 1: vascular loop at the CPA level, 2) Type 2: vascular loop proximal to the IAC (Figure 1 A,B), and Type 3: vascular loop distal to the IAC (4).

Tinnitus Handicap Inventory (THI)

The Tinnitus Handicap Inventory (THI) with proven validity and reliability that is rated between 0 and 100 and consists of 25 items was used for our study (12). Patients were informed about the study and the questionnaire, and their approval was obtained before administering the questionnaire. THI was performed and recorded for each patient separately. The effect of tinnitus was evaluated using the scores obtained from the questionnaire (Table I).

Study Groups

Patients included in the study were divided into groups according to the MRI findings and gender (Table II). According to the data obtained from the MRI, those with and without a vascular loop were separated. The vascular loop patients were grouped by loop type. In addition, male and female participants were evaluated as different groups as the effect of tinnitus varies between genders (9).

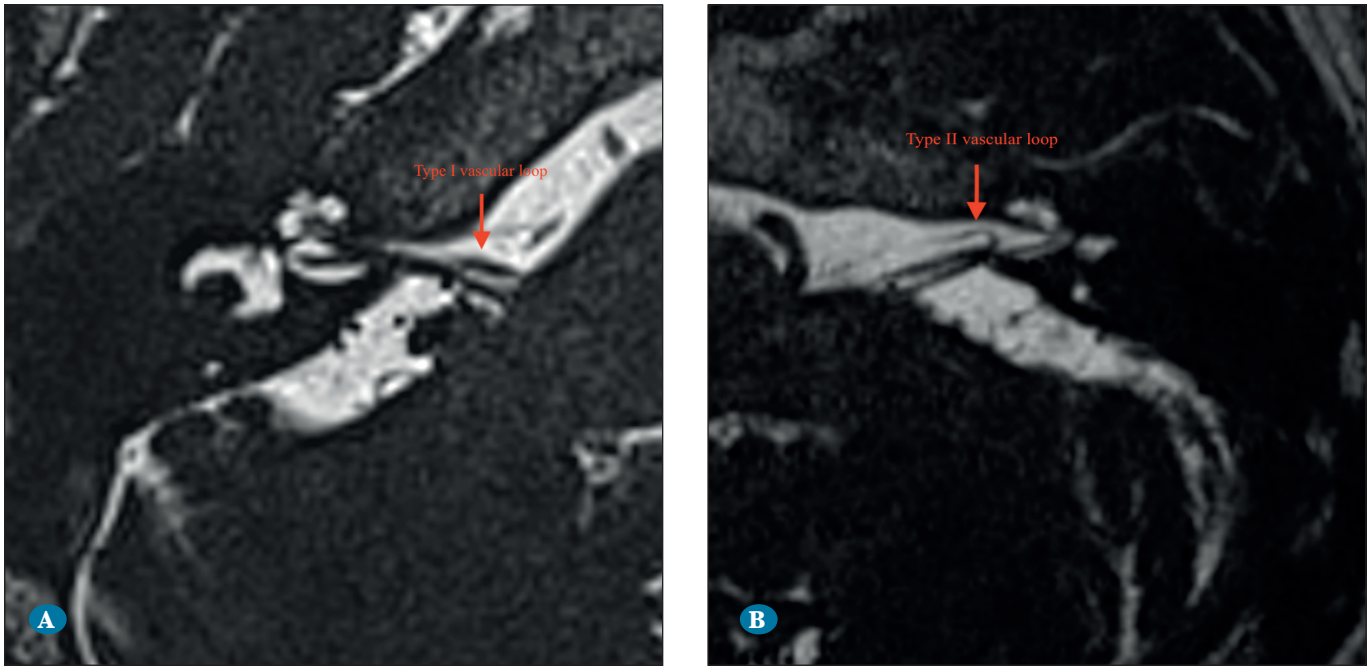

Figure 1: Axial thin-section 3D T2W MRI, **(A)** a type 1 vascular loop on the right side, and **(B)** a type 2 vascular loop on the left side. (MRI: magnetic resonance imaging, 3D: 3-dimensional, T2W: T2-weighted).

Table I: Grade and class according to tinnitus handicap inventory scores.

Grade	Total Score	Classification
1	0-16	Slight (heard only in silence)
2	18-36	Mild (can be masked easily with environmental noise)
3	38-56	Moderate (does not prevent daily activities although noticed in noise)
4	58-76	Severe (almost always heard, may cause disturbance in sleep patterns and may interfere with daily activities)
5	78-100	Catastrophic (always heard, interrupts sleep and prevents daily activities)

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, IL, USA). The ANOVA test was performed to determine whether there was a significant difference between the groups. The significance level was taken as $p<0.05$.

RESULTS

On the ear MRI evaluation, 26 female (group I) and 21 male (group II) patients had type 1 loop, and the mean age was 42.9 (20-55) and 41.6 (18-55) years, respectively. Twenty four female (group III) and 16 male (group IV) patients had type 2 loop and the mean age was 38.6 (21-55) and 37.2 (18-53) years, respectively. There were only 3 patients including 2 males and 1 female with type 3 loop. Because of the small number and taking into account that statistical comparison would not provide valid results, these 3 patients were not included in our study. On the MRI evaluation, there were 34 female (group V) and 26 male (group VI) patients without a vascular loop and the mean age was 41.6 (18-55) and 41.3 (18-55) years, respectively.

Table III presents the ear location, tinnitus starting age, type of tinnitus, the nature of tinnitus, and the scores obtained from THI in detail for each group.

There was a significant difference between THI values of the groups (p:0.036). The results obtained from the comparison of all groups in pairs are presented in Table IV.

Table II: Study groups.

Groups	
Group I	Type I vascular loop on MRI, female
Group II	Type I vascular loop on MRI, male
Group III	Type II vascular loop on MRI, female
Group IV	Type II vascular loop on MRI, male
Group V	Without vascular loop on MRI, female
Group VI	Without vascular loop on MRI, male

MRI: Magnetic Resonance Imaging

DISCUSSION

Tinnitus is one of the most common symptoms in daily practice in ear nose throat clinics. In the absence of any underlying disease, it may significantly affect the lives of individuals, even if it seems to be only a simple complaint. For this reason, the effects of tinnitus on the quality of life and the factors such as the age and sex that may affect tinnitus are still being evaluated. In our study, we investigated whether vascular loops in CPA have an effect on the etiology and clinic of tinnitus.

Schlee W et al. reported in their study that patients with an onset of tinnitus at a later age suffered more effects, especially with onset after the age of 53 (2). However, the average age of all groups in our study was below 50 and the age limit was 55 years. We therefore did not separate patients into age groups. However, the age of onset of tinnitus was queried in our study and we found a lower age of tinnitus onset in patients with a type 2 vascular loop.

Table III: Individual tinnitus characteristics and THI score data for each group.

Group	Tinnitus location n (%)		Starting age of tinnitus mean±SD (min-max)	Type of tinnitus n (%)		Nature of tinnitus n (%)		THI score mean±SD (min-max)
	Right	Left		Pulsatile	Non-pulsatile	Continuous	Intermittent	
I	14 (53.8)	12 (46.2)	41.23±10.8 (18-54)	15 (57.7)	11 (42.3)	17 (65.4)	9 (34.6)	43.85±24.7 (6-92)
II	13 (61.9)	8 (38.1)	39.86±11.2 (16-54)	13 (61.9)	8 (38.1)	14 (66.7)	7 (33.3)	39.43±22.3 (8-90)
III	10 (41.7)	14 (58.3)	35.04±10.2 (19-54)	16 (66.7)	8 (33.3)	9 (37.5)	15 (62.5)	54.92±21.0 (12-96)
IV	7 (43.7)	9 (56.3)	33.25±9.7 (16-46)	10 (62.5)	6 (37.5)	6 (37.5)	10 (62.5)	48.8±25.5 (8-90)
V	13 (38.2)	21 (61.8)	40.06±11.7 (16-54)	20 (58.8)	14 (41.2)	21 (61.8)	13 (38.2)	44±21.3 (8-90)
VI	11 (42.3)	15 (57.7)	40.23±12.5 (17-54)	14 (53.8)	12 (46.2)	15 (57.7)	11 (42.3)	41.6±19.7 (8-90)

mean: mean, **SD:** standard deviation, **n:** number, **min:** minimum, **max:** maximum, **THI:** Tinnitus Handicap Inventory

Table IV: P values obtained by comparing the THI of the groups in pairs.

Group	II	III	IV	V	VI
I	0.707	***0.017***	0.110	0.979	0.970
II		***0.009***	0.063	0.673	0.733
III			0.595	***0.012***	***0.015***
IV				0.098	0.103
V					0.947
VI					

THI: Tinnitus Handicap Inventory.

The effect of the tinnitus level on the quality of life was evaluated with THI. There is no correlation between the severity of tinnitus and THI scores, in other words the patients' discomfort levels (7). Therefore, tinnitus levels were not taken into consideration in our patients. In addition, the presence of hearing loss changes the effects of tinnitus. Patients with normal hearing are disturbed more from tinnitus (8). Thus, we included only patients with normal hearing. Tinnitus is mostly seen in the left ear. The presence of tinnitus in the right or left ear in individuals with normal hearing does not affect the quality of life (5,8). In our study, the tinnitus was mostly in the left ear in patients with a type 2 vascular loop and those without a vascular loop, while it was more common in the right ear in patients with a type 1 vascular loop.

Tinnitus is most commonly observed in men aged 40-70 years (13). However, there were more female patients than male patient in every group in our study. This may be related to the population we studied, or to the lower age range. Our result may indicate that the condition is more frequent in women at younger ages. Oiticica and Bittar evaluated the effect of tinnitus with a visual analogue scale (9). They stated that women with tinnitus were more uncomfortable than men. We also found similar findings in our study. We found women to have higher THI scores than men, with or without a vascular loop.

The cerebellopontine angle (CPA) is an anatomical area with complex interaction of vascular and neural structures. Sometimes vascular structures, as in loops, can show various anatomical variations and compress the neural structures. Various mechanisms such as neural demyelination and hyperactivity in the cranial nerve under compression can then cause symptoms such as tinnitus, vertigo and hearing loss. This condition is called vascular compression syndrome (14,15). However, there is no consensus in the literature on the clinical effects of the vascular loops observed in CPA (5,16-19).

Hoekstra et al reported in their studies that routine MRI had little or no value in patients with unilateral chronic tinnitus and that a vascular loop is rarely associated with tinnitus and should be considered as random when seen (16). Gultekin et al. (17) reported that a vascular loop could not be accepted as an etiological factor for tinnitus in their study where they evaluated ear MRI results of patients with and without tinnitus. However, Guevara et al performed microvascular decompression with a retro-sigmoid approach on patients with unilateral tinnitus in addition to a vascular loop on MRI (18). They stated that the complaints of the majority of the patients decreased and that the complaints of some of them were completely resolved during the long-term follow-up. Brookes likewise suggested that patients with severe tinnitus could be cured by vascular decompression (19). The relationship between a vascular loop and tinnitus is still controversial. However, when we look at the studies, a vascular loop can be detected incidentally on MRI and can be generally asymptomatic in some of the studies while it has been reported that serious symptomatic improvements were observed in patients with the elimination of the compression effect of the loop through vascular decompression surgeries in other studies. In other words, a vascular loop may be usually asymptomatic, but vascular loop detection in a patient with tinnitus may be associated with the patient's symptom. However, the effect of a vascular loop on the tinnitus clinical picture is not known. Ensari et al. evaluated the symptom severity of patients with unilateral tinnitus with and without a vascular loop with THI (5). They did not find a correlation between MRI findings and symptoms in a study of 14 patients with various types of vascular loop . In our study with a very large series, we evaluated not only THI but also other clinical features of tinnitus. Compering the THI results according to our study, tinnitus was found to affect the patient more in patients with a type 2 loop. This difference may be related to the higher number of patients in our study.

Vascular loops in the cerebellopontine angle (CPA) are seen in more than one third of the normal population. However, the probability of occurrence is twice as high in ears with unilateral hearing loss, and 80 times higher in ears with pulsatile tinnitus (20,21). Although most vascular loops

are asymptomatic, the incidence is therefore particularly high in ears with symptoms and individuals with pulsatile tinnitus. The accepted pathophysiological explanation of the vascular loop for pulsatile tinnitus is the rotation of the loop to the internal acoustic canal and the turbulence effect caused by this return of the blood being heard as a sound (21). The results in our study with more common pulsatile tinnitus in patients in all groups and the significantly higher prevalence of pulsatile tinnitus in patients with a type 2 vascular loop support this finding.

The results of our study indicate that women are affected more significantly by tinnitus. This may be related to the workload of the patients in daily life. Due to the intensity of the work life of men, they may have more to do during the day and may be less affected by tinnitus. Tinnitus is more frequently seen in patients with a type 2 vascular loop, while it is more continuous in the others. This may be related to the occurrence of tinnitus when blood volume and pressure increase in subjects with a type 2 vascular loop. Patients may experience tinnitus due to increased bloodstream in the veins when the blood pressure and volume increases while they may not be aware of it normally. The clinical features of the type 2 vascular loop and its effect on the quality of life are different from tinnitus with a type 1 vascular loop or cases without a vascular loop. In addition, the clinical features and effects of a type 1 vascular loop being similar to those without vascular loops suggests that type 1 vascular loops may have been identified by chance, as mentioned before. However, we think that a type 2 vascular loop can be associated with the etiology of tinnitus. Moreover, as the clinical behavior of a type 2 vascular loop is different, revealing its pathophysiology is important in the management of the symptom. The more significant effect of a type 2 vascular loop on the quality of life may be associated with the resultant tinnitus being intermittent, because the feeling that tinnitus can start at any moment can increase the level of anxiety in the patients.

An important limitation of our study could be the lack of a group with type 3 vascular loop due to the very low number of patients. Perhaps different data could be obtained in patients with type 3 vascular loops. In addition, studies with surgical data can be performed to elucidate the clinical picture of a type 2 vascular loop. Decompression surgery in suitable patients could eliminate the findings of compression and its long-term results could be evaluated.

CONCLUSION

In conclusion, the type 2 vascular loop can be an etiologic factor for tinnitus by creating a vascular compression. In addition, the clinical features of the resultant tinnitus can be different. It also affects the quality of life of the individuals. Although vascular loops are considered to be random in tinnitus, we do not think that this is valid for a type 2 vascular loop. In other words, we can evaluate a type 2 vascular loop as a vascular compression syndrome due to its clinical effects.

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