Evaluation of Vascular Variations at Cerebellopontine Angle By 3-Dimensional T2-Weighted Magnetic Resonance Imaging in Patients With Tinnitus

Tinnituslu Hastalarda 3 Boyutlu T2 Ağırlıklı Manyetik Rezonans Görüntüleme ile Serebelopontin Kenardaki Vasküler Değişikliklerin Değerlendirilmesi

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Abstract

Objective: Anatomical interactions of vascular and neural structures at cerebellopontine angle (CPA) are considered related to auditory-vestibular symptoms. Magnetic resonance imaging (MRI) has become the preferred method to visualize this complex anatomical region. This study aimed to assess the relation of vascular loops at CPA with clinical symptoms in patients with tinnitus using 3-dimensional (3D) T2-weighted (T2W) MRI.

Material-Method: The study included 476 patients, grouped as those with and without tinnitus, undergoing MRI for various clinical auditory symptoms. MRI scans were assessed regarding the presence of vascular abnormalities at CPA.

Results: For the patients with tinnitus on the left side, the frequencies of Type 1 vascular loop (at the CPA level) ($p=0.001$) and Type A vascular loop (contact with the vestibulocochlear and facial nerves) ($p<0.001$) vascular loops were significantly higher. For the patients with tinnitus on the right side, only the frequency of Type A vascular loop was significantly higher ($p=0.005$). For the patients with bilateral tinnitus, Type 2 vascular loop (proximal to the internal auditory canal [IAC]) on the right side ($p=0.035$) and Type A vascular loop on the left side ($p<0.001$) were significantly higher.

Conclusions: This study is the largest scale study evaluating vascular variations of cerebellopontine angle in patients with tinnitus using 3D T2W MR. The frequency of vascular loops at the CPA and IAC primarily depends on the diagnostic technique. Our results indicated that vascular causes could be shown more clearly with the use of high-resolution imaging methods. Accordingly, treatment options can be better determined by the clarification of etiology.

Keywords: Vascular loop, cerebellopontine angle, internal acoustic canal, tinnitus, magnetic resonance imaging.

Özet

Amaç: Serebelopontin köşe (PSK) vasküler ve nöral yapıların anatomik etkileşimleri işitsel-vestibüler semptomlarla ilişkili olduğu düşünülmektedir. Manyetik rezonans görüntüleme (MRG), bu karmaşık anatomik bölgeyi değerlendirmek için tercih edilen bir yöntem haline gelmiştir. Bu çalışmada, 3-boyutlu T2 ağırlıklı MRG ile tinnitus hastalarda (PSK)'da vasküler loop varyasyon ilişkisini değerlendirmeyi amaçladık.

Materyal-Metot: Bu çalışmada, açıklanamayan tinnitus olan ve kulak MRG tetkiki yapılan 149 hasta yer almıştır. Hastaların tinnitusu olan kulakları çalışma grubunu, şikâyet olmayan kulakları kontrol grubunu oluşturdu. Çift taraflı tinnitusu olanlar iki taraf ayrı ayrı olarak çalışma grubuna dâhil edildi. MRG taramaları, PSK'da vasküler varyasyon varlığına ilişkin olarak değerlendirildi.

Bulgular: Sol tarafta tinnitusu olan hastalarda Tip 1 (PSK düzeyinde) ($p=0.001$) ve Tip A (vestibüloklear ve/veya fasial ile temas) ($p<0.001$) vasküler loop anlamlı derecede yüksekti. Sağ tarafta tinnitusu olan hastalarda, sadece Tip A vasküler loop anlamlı derecede yüksekti ($p=0.005$). Çift taraflı tinnituslu hastalar için sağ kulakta Tip 2 vasküler loop internal akustik kanalı proksimal (İAK) ($p=0.035$) ve sol kulakta Tip A vasküler loop ($p<0.001$) anlamlı derecede yüksekti.

Sonuç: Bu çalışma, tinnituslu hastalarda 3D T2W MRG kullanılarak pontoserebellar köşe vasküler varyasyonları araştıran en büyük ölçekli çalışmadır. PSK ve İAK'daki vasküler loop sıklığı öncelikle tanı tekniğine bağlıdır. Bulgularımız, vasküler varyasyon nedenlerin yüksek çözünürlüklü görüntüleme yöntemleri kullanılarak daha net gösterilebileceğini gösterdi. Buna göre, tedavi seçenekleri etiyolojinin aydınlatılmasıyla daha iyi belirlenebilir.

Anahtar kelimeler: Vasküler loop, serebelopontin köşe, internal akustik kanal, tinnitus, manyetik rezonans görüntüleme.

Introduction

Patients commonly admit to otolaryngology clinics due to complaints such as sudden and/or progressive hearing loss, vertigo or tinnitus. In case of such a complaint, retrotrochlear pathologies should be elucidated at initial diagnostic evaluations. Tinnitus is typically described as a ringing or buzzing without a sound source (1,2). The two main types of tinnitus are pulsatile and non-pulsatile tinnitus (3). Although tinnitus is a highly prevalent complaint in clinical practice, the exact pathophysiology of this disorder has not been fully understood.

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Currently available evidence suggests that functional and anatomical changes at one or more regions of central or peripheral auditory pathways are involved in the mechanism (4,5).

Cerebellopontine angle (CPA) is an anatomical structure at which vascular and neural structures highly interact with each other. The neurovascular structures in this anatomical region are the cranial nerves (V, VII, VIII), anterior inferior cerebellar artery (AICA), auditory artery, branches of the petrosal vein, vein of the middle cerebellar peduncle, vein of the lateral recess of the 4th ventricle, and transverse pontine vein. This region covers three fissures, namely cerebellomesencephalic, cerebellopontine, and cerebellomedullary fissures, which are located at the superior, medial, and inferior positions, respectively (6,7,8). Anatomical interactions between these neural and vascular structures sometimes present as clinical symptoms that are called vascular compression syndrome (9). This syndrome generally includes vertigo, tinnitus, and hearing loss (10,11) and may be screened by abnormal results in neuro-otologic tests (12).

There are several methods used by clinicians in those cases, some of which are auditory brainstem response evaluations and computerized tomography (CT) scanning. However, it has been previously reported that intracanalicular lesions can be overlooked by auditory brainstem response evaluations and that CT evaluations are not sensitive to detect vestibular schwannomas irrespective of the use of contrast medium (13).

Contrast-enhanced magnetic resonance imaging (MRI) has emerged as the most appropriate method to evaluate the lesions of the CPA. With the advances in MRI technique, fast spin-echo sequences have allowed increased resolution for the assessment of internal auditory canal (IAC) and CPA, even without using contrast medium (14,15).

Since the assessment of CPA is crucial in patients with auditory symptoms, the aim of the present study was to evaluate the variations of CPA in patients with tinnitus using 3-dimensional (3D) T2-weighted (T2W) MRI.

Material-Method

Patients

This study has been approved by the Ethics Committee of Recep Tayyip Erdoğan Üniversity, Faculty of Medicine with the reference number 2015/17 and dated 22.05.2015.

The present study included 476 patients who underwent MRI for various clinical auditory symptoms. The images were evaluated regarding the relationships of VCN with AICA and posterior inferior cerebellar artery (PICA) at the CPA and IAC. A high-resolution 3D T2W MRI device was used for the MRI scans and the images were assessed by an experienced radiologist dealing primarily with head and neck radiology. The vascular loops were classified according to the coursing patterns of the AICA and PICA and their relationships with the vestibulocochlear nerve (VCN) and facial nerve as: 1) Type 1: vascular loop at the CPA level, 2) Type 2: vascular loop proximal to the IAC, 3) Type 3: vascular loop distal to the IAC, 4) Type A: contact with the VCN and facial nerve, 5) Type B: indentation to the VCN and facial nerve.

The patients were grouped according to the presence or absence of tinnitus and the groups were compared regarding the variations of CPA.

Magnetic Resonance Imaging Scans

A 32-channel head coil was used for 1.5 T scanner (Siemens Magnetom Aera, Germany). Pre-contrast technical parameters were as follows: a repetition time (TR) of 400 ms, an echo time (TE) of 8.6 ms, a field of view (FOV) of 256x320 mm, a FOV phase of 100, a slice thickness of 3 mm, a NEX of 1 for T1 images; a TR of 3820 ms, a TE of 96 ms, a FOV of 256x320 mm, a FOV phase of 100, a slice thickness of 3 mm, a NEX of 2 for T2 images; and a TR of 1000 ms, a TE of 266 ms, a FOV of 180x230 mm, a FOV phase of 80, a slice thickness of 0.7 mm, and a NEX of 1.4 for 3D Turbo spin echo T2 images (t2 spc-tra-p2 iso-0.6).

After an intravenous dose of 0.1mmol/kg body weight of gadolinium contrast agent (Gadoteric acid (Dotarem, Guerbet, Istanbul-Turkey), the technical parameters were as follows: a TR of 400 ms, a TE of 8.6 ms, a FOV of 240x320 mm, a FOV phase of 100, a slice thickness of 3 mm, and a NEX of 3 for T1 axial images and a TR of 471ms, a TE of 12 ms, a FOV of 224x320 mm, a FOV phase of 100, a slice thickness of 3 mm, and a NEX of 3 for T1 coronal images.

Statistical Analysis

Descriptive statistics were presented as mean and standard deviations for numerical variables and as frequency for categorical variables. Student's t-test and chi-square test were used for comparisons between independent groups of numerical variables and categorical variables, respectively. A statistical significance level of 5% was determined as a Type-I error limit in the study. All statistical analyses were performed two-sided by using the Predictive Analytics Software (PASW) Statistics version 18.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

The distributions of mean age, frequencies of Type 1, Type 2, Type 3, Type A, and Type B vascular loops, and vertebral artery tortuosity in the study patients (n=476) grouped based on the presence or absence of tinnitus according to the affected side are presented in Table 1. Accordingly, for the patients with tinnitus on the left side, the frequencies of Type 1 ($p=0.001$) and Type A ($p<0.001$) vascular loops were significantly higher and the frequency of vertebral artery tortuosity was lower ($p=0.034$). For the patients with tinnitus on the right side, only the frequency of Type A ($p=0.005$) vascular loop was significantly higher. For the patients with bilateral tinnitus, the frequency of Type 2 vascular loop on the right side ($p=0.035$) and the frequency of Type A vascular loop on the left side ($p<0.001$) were significantly higher.

Table 2 represents the distribution of Type A and Type B variations in each vascular loop variation. Accordingly, none of the Type 1, Type 2, and Type 3 variations had significantly different distributions of Type A and Type B variations.

The MRI images for the patients with tinnitus according to the vascular loop classification are demonstrated in Figures 1, 2, 3, and 4.

Table 1. Distribution of anatomical variations in the patients with and without tinnitus.

Left side	Patients: Without tinnitus (n=422)	With tinnitus (n=54)	p
Age, mean±SD	46.7±18.8	44.2±14.4	0.307
Type 1, n (%)	162 (38.5)	34 (63.0)	**0.001**
Type 2, n (%)	109 (25.9)	17 (31.5)	0.381
Type 3, n (%)	15 (3.6)	3 (5.6)	0.445
Type A, n (%)	254 (60.3)	50 (92.6)	**<0.001**
Type B, n (%)	11 (2.6)	4 (7.5)	0.075
Vertebral artery tortuosity, n (%)	82 (19.5)	4 (7.5)	**0.034**
Right side	**Without tinnitus (n=408)**	**With tinnitus (n=68)**	
Age, mean±SD	46.4±18.9	46.2±14.8	0.769
Type 1, n (%)	168 (41.2)	32 (47.1)	0.363
Type 2, n (%)	94 (23.0)	20 (29.4)	0.254
Type 3, n (%)	12 (2.9)	3 (4.4)	0.460
Type A, n (%)	259 (63.5)	55 (80.9)	**0.005**
Type B, n (%)	4 (1.0)	-	-
Vertebral artery tortuosity, n (%)	22 (5.4)	3 (4.4)	1.000
Bilateral	**Without tinnitus (n=449)**	**With tinnitus (n=27)**	
Age, mean±SD	46.6±18.6	42.7±14	0.216
Right side			
Type 1, n (%)	189 (42.1)	11 (40.7)	0.890
Type 2, n (%)	103 (22.9)	11 (40.7)	**0.035**
Type 3, n (%)	15 (3.3)	-	1.000
Type A, n (%)	292 (65.0)	22 (81.5)	0.080
Type B, n (%)	4 (0.9)	-	1.000
Vertebral artery tortuosity, n (%)	24 (5.3)	1 (3.7)	1.000
Left side			
Type 1, n (%)	181 (40.3)	16 (59.3)	0.052
Type 2, n (%)	117 (26.1)	9 (33.3)	0.405
Type 3, n (%)	16 (3.6)	2 (7.4)	0.272
Type A, n (%)	279 (62.1)	26 (96.3)	**<0.001**
Type B, n (%)	13 (2.9)	2 (7.7)	0.196
Vertebral artery tortuosity, n (%)	86 (19.2)	1 (3.8)	0.064

SD, Standard deviation.

Table 2. Distribution of Type A and Type B variations in each vascular loop variation. (Data are presented as number (%).)

Left side	Patients: Without tinnitus (n=422)	With tinnitus (n=54)	p
Type 1			
A+ or B+	144 (88.9)	33 (97.1)	0.206
A- and B-	18 (11.1)	1 (2.9)	
Type 2			
A+ or B+	105 (96.3)	17 (100.0)	-
A- and B-	4 (3.7)	-	
Type 3			
A+ or B+	12 (80.0)	3 (100.0)	-
A- and B-	3 (20.0)	-	
Right side	**Without tinnitus (n=408)**	**With tinnitus (n=68)**	
Type 1			
A+ or B+	151 (89.9)	32 (100.0)	0.080
A- and B-	17 (10.1)	-	
Type 2			
A+ or B+	90 (95.7)	19 (95.0)	-
A- and B-	4 (4.3)	1 (5.0)	
Type 3			
A+ or B+	12 (100.0)	3 (100.0)	-
A- and B-	-	-	
Bilateral	**Without tinnitus (n=449)**	**With tinnitus (n=27)**	
Right side			
Type 1			
A+ or B+	172 (91.0)	11 (100.0)	0.604
A- and B-	17 (9.0)	-	
Type 2			
A+ or B+	98 (95.1)	11 (100.0)	-
A- and B-	5 (4.9)	-	
Type 3			
A+ or B+	15 (100.0)	-	-
A- and B-	-	-	
Left side			
Type 1			
A+ or B+	162 (89.5)	16 (100.0)	0.374
A- and B-	19 (10.5)	-	
Type 2			
A+ or B+	113 (96.6)	9 (100.0)	-
A- and B-	4 (3.4)	-	
Type 3			
A+ or B+	13 (81.3)	2 (100.0)	-
A- and B-	3 (18.8)	-	

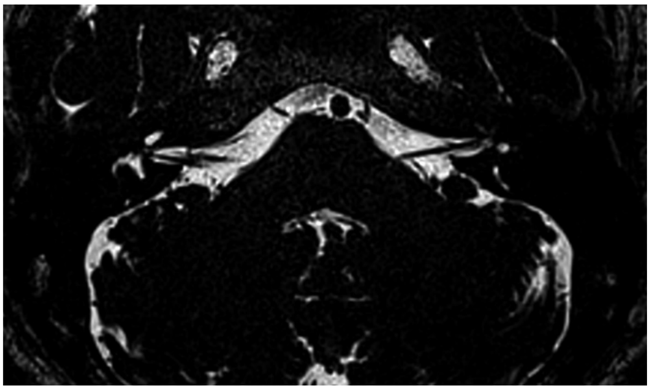

Figure 1. Magnetic resonance image of a right-sided Type 2A vascular loop in a 55-year-old male patient with right-sided tinnitus.

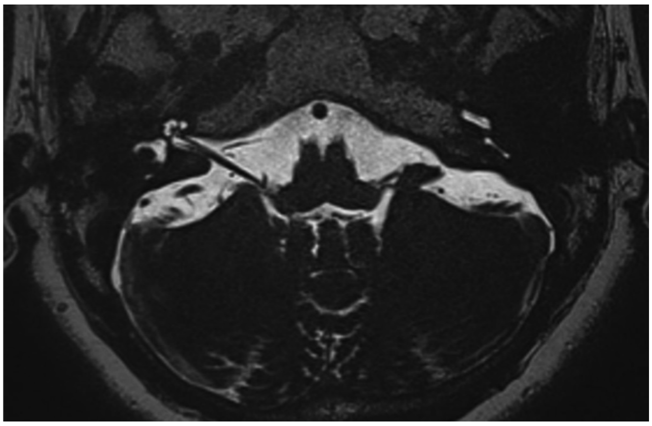

Figure 2. Magnetic resonance image of a right-sided Type 1A vascular loop in a 58-year-old female patient with right-sided tinnitus.

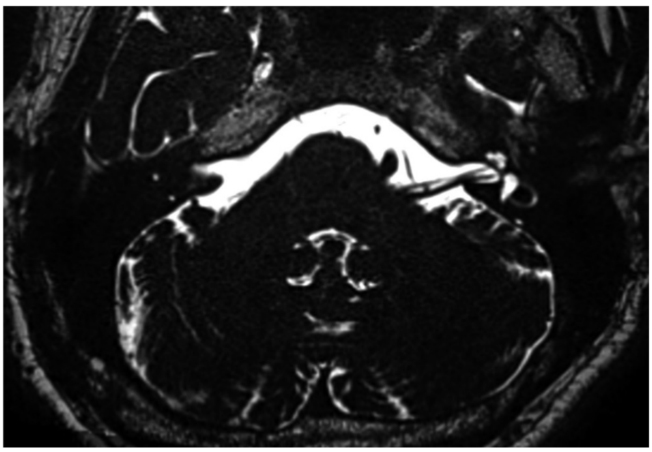

Figure 3. Magnetic resonance image of a left-sided Type 1B vascular loop in a 38-year-old male patient with left-sided tinnitus.

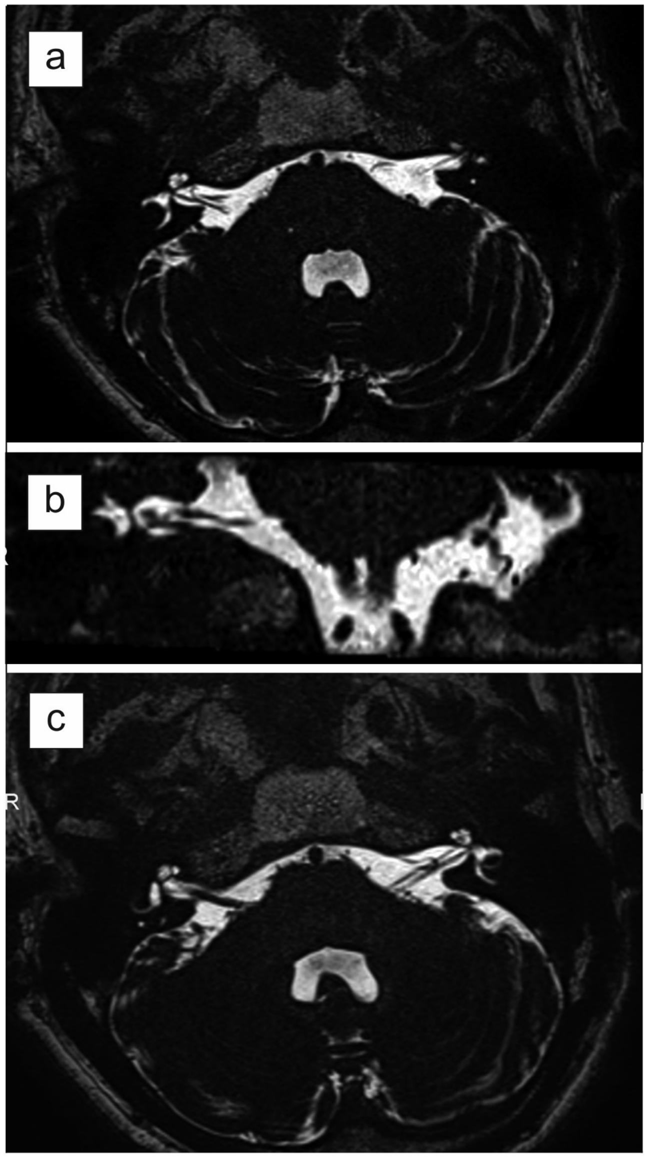

Figure 4. **(a)** Magnetic resonance image of a right-sided type 3A vascular loop **(b)** coronal plane image, and **(c)** magnetic resonance image of a left-sided type 2A vascular loop in a 64-year-old male patient with bilateral tinnitus.

Discussion

The CPA is the intersection area of several neural and vascular structures, which can be the address for clinical auditory and vestibular symptoms. One mechanism for these symptoms has been explained as that the anatomical contact of a vessel with the VCN could cause local demyelination, reorganization of the nerve, and axonal hyperactivity, which all results in tinnitus, hearing loss, or vertigo (16). Most common anatomical structures causing compression of the VCN are AICA, PICA, and/or their branches (6,17). In addition to these anatomical interactions, CPA is also the place at which many variations of vascular structures can be seen. The most common vascular variations, namely the vascular loops in the CPA, have been suggested to be the most common causes of pulsatile tinnitus (16,18). On the other hand, some studies have reported that vascular loops may be congenital (19), which may lead to the question that whether vascular compression is only an incidental finding instead of an etiological mechanism in these cases (20).

The results of the present study demonstrated that the frequency of contact of vessels with the VCN or facial nerve (Type A vascular loop) was significantly higher in the patients with tinnitus. Moreover, the frequency of vascular loop at the CPA level (Type 1) and the frequency of vascular loop proximal to the IAC (Type 2) were significantly higher in the patients with left-sided and bilateral tinnitus, respectively. This high frequency of vascular loops at the IAC localization might support the hypothesis that vascular contact of VCN causes tinnitus (16).

Another mechanism suggested to cause auditory-vestibular symptoms is aging. Since stiffness of arterial walls increase over time, aging should contribute to increased contact pressure on neural structures wherever they interact with vessels (8). Moreover, aging causes decreased cerebrospinal fluid and cerebral atrophy, which also causes stretching of nerves that result in symptoms. In the present study, evaluation of the patients in terms of age revealed no significant differences between the patients with and without tinnitus. This similarity between the groups regarding age might suggest that mechanical contact is an independent mechanism from aging to cause tinnitus.

The frequency of vascular loops at the IAC localization has been reported as between 21% and 50% in the radiological studies (20,21) and as 12.3% in the anatomical studies on cadavers (22). In the present study, we determined Type 1 vascular loops in 63%, Type 2 vascular loops in 40.7%, and Type A vascular loops in 80.9%-96.3% of our patients with tinnitus. These rates were higher than those reported in the literature, which might be related to the performance of high-resolution 3D T2W MRI device.

The advances in MRI technique have made this technique the method of choice for the diagnosis of vascular compression syndrome in patients with auditory-vestibular symptoms (20,23). In a previous study in which MRI evaluation of IAC for determining AICA loops was performed in patients with tinnitus, it was reported that all patients with tinnitus and only 5% of asymptomatic controls had an AICA loops (24). Nevertheless, the high anatomical variability of CPA should be kept in mind during both clinical and radiological evaluation of the patients.

In conclusion, the present study is the largest scale study evaluating vascular variations of cerebellopontine angle in patients with tinnitus using 3D T2W MR. According to the results of this study, higher frequency of vascular variation than those in the literature suggests that vascular causes can be shown more clearly by using high-resolution imaging methods in the investigation of the etiology of the tinnitus. Moreover, we are in the opinion that treatment options can be better determined depending on the clarification of etiology and thus saving time and money can be achieved for the diagnosis and treatment of these patients.

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