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Research Article

STUDY OF VASCULAR LOOPS IN THE CEREBELLOPONTINE ANGLE BY MAGNETIC RESONANCE IMAGING

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Abstract

Background: Vascular loops of the anterior inferior cerebellar artery (AICA) within the cerebellopontine angle (CPA) and internal auditory canal (IAC) have been implicated in the pathogenesis of various neuro-otological symptoms, including vertigo, tinnitus, hearing loss, and hemifacial spasm. High-resolution magnetic resonance imaging (MRI) using the three-dimensional (3D) T2-weighted Driven Equilibrium (DRIVE) sequence provides excellent visualization of the neurovascular anatomy, facilitating accurate assessment of vascular loops and their relationship with the VII–VIII cranial nerve complex. **Objectives:** To determine the prevalence of vascular loops in the internal auditory canal and cerebellopontine angle using 3D T2W DRIVE MRI, evaluate their association with neuro-otological symptoms, compare vascular loop characteristics between symptomatic and asymptomatic individuals, and assess their relationship with age and gender. **Materials and Methods:** This prospective case-control study was conducted in the Department of Radiodiagnosis at Subbaiah Institute of Medical Sciences, Shivamogga, from January to December 2024. A total of 211 temporal bones were evaluated, comprising 108 symptomatic cases and 103 asymptomatic controls. All participants underwent MRI using a 1.5-T scanner with an additional high-resolution 3D T2W DRIVE sequence. Vascular loops were assessed using Chavda's, Shelton's, and Sirikci's classifications. Statistical analysis was performed using STATA 11.2, and associations were evaluated using the Chi-square test and logistic regression. A p-value <0.05 was considered statistically significant. **Results:** Vascular loops were identified in 85 (79.0%) symptomatic cases and 66 (64.0%) controls, demonstrating a significant association with neuro-otological symptoms (p=0.019). Type II Chavda loops predominated among symptomatic patients, whereas Type I loops were more common in controls (p=0.018). Higher grades of vascular contact (Shelton Types C/D) and vascular compression (Sirikci Types II–IV) were significantly associated with symptomatic patients (p<0.001 and p=0.001, respectively). Vertigo was the most common presenting symptom, followed by tinnitus, facial spasm, and hearing loss. Multivariate analysis identified the presence of vascular loops (OR=2.31), Chavda Type II/III loops (OR=2.78), and Shelton Type C/D vascular contact (OR=3.96) as independent predictors of symptomatic neurovascular compression. **Conclusion:** High-resolution 3D T2W DRIVE MRI is a valuable non-invasive imaging modality for evaluating vascular loops within the cerebellopontine angle and internal auditory canal. The study demonstrates a significant association between vascular loop morphology, neurovascular contact, and neuro-otological symptoms, highlighting the importance of detailed MRI evaluation in patients with unexplained vertigo, tinnitus, hearing loss, and hemifacial spasm.

Keywords: Magnetic resonance imaging; 3D T2W DRIVE; Cerebellopontine angle; Internal auditory canal; Vascular loop; Anterior inferior cerebellar artery; Neurovascular compression; Vertigo; Tinnitus.

Introduction:

The presence of vascular loops in the internal auditory canal (IAC) and the cerebellopontine angles, formed most commonly by the anterior inferior cerebellar artery (AICA), is a common finding in the systematic study of Magnetic Resonance Imaging of the brain.[1,2] Different results have been reported in the literature about the relationship between vascular compression of the vestibular or facial nerve trunks and neurotological symptoms, and some authors have proposed that nerve compression by adjacent vascular loops might be the origin of otherwise unexplained hearing loss, tinnitus, hemi facial spasm and vertigo.[3-11] Magnetic Resonance Imaging [MRI] has become the modality of choice for evaluation of the cerebellopontine angle and the internal auditory canal.[12] Especially due to variations, sequence selection before the surgery is highly important so as to obtain an accurate image of the anatomic course of cranial nerves in the CP angles and their complex adjacency with vascular structures and to decide on decompression surgery in these cases, and to prevent complications during surgical intervention. [13]

Routine MR imaging sequences provide optimal soft tissue resolution, but spatial resolution necessary to define cranial nerves and vascular structures may be insufficient with this technique. For better visualization of the inner ear, heavily T2-weighted fast spin echo sequences were developed in 1996. Recently, the addition of the DRIVE pulse to 3D fast spin echo technique, which shortens the scan time and is less sensitive to susceptibility artifact, has been introduced. DRIVE consists of 900 RF pulse in combination with a gradient refocusing pulse and a spoiling gradient. [13]

It is in this backdrop, the objectives set out in this research programme will enable us to understand the details of the neurovascular structures in the cerebellopontine angle and internal acoustic canal and also provide an insight into the intricacies involved in the MR imaging of this region with the specific use ultra-fast driven equilibrium pulse sequence.

Objectives:

1. To determine the prevalence of vascular loops in the internal auditory canal and cerebellopontine angle using MRI with the 3D T2W DRIVE sequence.
2. To evaluate the relationship between vascular loops and **neuro-otological symptoms**.
3. To compare the prevalence and characteristics of vascular loops between **symptomatic and asymptomatic subjects**.
4. To study the association of vascular loops with **age and gender**.

Materials and methods:

This is a prospective case control study carried out in Department of Radio diagnosis, Subbaiah institute of medical sciences, Purle, Shivamogga. Study population was symptomatic (neuro-otological symptoms like vertigo, tinnitus, hearing loss, facial spasm) and asymptomatic patients undergoing MRI Brain study for the evaluation of various conditions. This study was carried out for a duration of one year from January 2024 to December 2024. This study was carried out in 211 temporal bones. 108 were symptomatic cases and 103 were asymptomatic controls.

Inclusion criteria:

All patients of the age group > 18 years undergoing MRI brain study for various conditions for whom image acquisition was done using driven equilibrium sequence T2W DRIVE.

Exclusion criteria:

- Ears with other cerebellopontine angle pathology such as tumors and arteriovenous malformations.

- Pathological conditions involving the temporal bones such as the auditory system and cochlea.
- Patients who present with vertigo, tinnitus, hearing loss or facial nerve palsy but are found to have acute infarcts, brain tumours and other structural abnormalities.
- Patients who have undergone previous surgical procedures at the region of interest.
- All patients in whom an MRI examination is contraindicated were excluded e.g. patients with any electrically, magnetically or mechanically activated implants (including cardiac pacemakers, bio stimulators, neuro stimulators, cochlear implants, and hearing aids).

After clinical evaluation, once a patient satisfied the inclusion and exclusion criteria for this study, he or she would undergo the MRI evaluation after giving consent. All the MRI scans in this study were performed using PHILIPS Achieva 1.5 T MRI scanner.

MRI Protocol:

Patient was placed in supine position with adequate support for the head. Eight channel head coil was used.

Technique for MRI of Brain:

After obtaining localizer in all three orthogonal planes, following sequences of the brain were obtained as part of routine evaluation:

1. Axial T2 FLAIR
2. Axial DWI
3. Axial GRE
4. Sagittal T1

After this initial set of sequences, additional T2W DRIVE sequence was obtained.

Table 1: The following parameters were used during acquisition of images using T2W DRIVE

Sequence	TR	TE	Thickness	Matrix	Intersection spacing	FOV	Scan time
T2W-DRIVE	1500ms	162ms	0.75mm	248*230	0.8mm	150*150 mm	3.3 minutes

The findings on this driven equilibrium sequence were tabulated and analysed by using following scoring system:

Anatomical location – Chavda's classification.

Vascular contact – Shelton's classification.

Vascular compression - Siricki's classification.

Chavda's classification based on the anatomical location of the loop 3

Table 2: Chavda's classification of vascular loops in the CPA based on anatomical location

TYPE	DESCRIPTION
Type I	Vascular loop from AICA lies in the cerebellopontine angle but does not enter the IAC
Type II	Vascular loop from AICA enters the IAC but extends less than 50 % of its length
Type III	Vascular loop from AICA extends greater than 50 % into the total length of IAC

Table 3: Shelton's classification of vascular loops in CPA

TYPE	DESCRIPTION
A	Vascular loop runs with no contact to the adjacent nerve
B	Vascular loop runs adjacent to the nerve
C	Vascular loop runs between facial nerve and vestibulo cochlear nerve
D	Vascular loop displaces the nerve

Sirikci's Classification of vascular cross compression:

Sirikci et al[16] in a study published in 2005 described a system to standardize the degree of vascular compression between vascular loop from anterior inferior cerebellar artery and ipsilateral cranial nerves.

Table 4: Sirikci's Classification of vascular cross compression:

TYPE	NAMED AS	DESCRIPTION
1	Point compression	The AICA compresses only a limited portion of the IAC
2	Longitudinal compression	The AICA approaches the CVN as both traverse parallel to each other

3	Loop compression	Vascular loop of the AICA encircles the CVN
4	Indentation	The AICA compresses the CVN so as to make an indentation in the nerve

RESULTS AND DISCUSSION:

Statistical methods:

The statistical analysis was performed by STATA 11.2 (College Station TX USA). Chi square test has been used to measure the association between the groups (cases and control) with respect to age, gender, presence of loops, Chavda's score, Shelton score, and Siricki's scores. These were expressed as frequencies and percentages. Within the study group, gender, age and symptoms were evaluated with Chavda's, Shelton's and Siricki's scores respectively and the presence of vascular loop was also taken into consideration. P value of less than 0.05 was considered as statistically significant.

Results

Table 5: Age distribution of individuals in the study

Age category	Cases	Control	Total	P-Value
<40	40 (37%)	42 (41%)	82	0.461
40-60	39 (36%)	29 (28%)	68	
>60	29 (27%)	32 (31%)	61	
Total	108	103	211	

The age distribution of the study population was comparable between the symptomatic and asymptomatic groups. Among the symptomatic cases, 40 (37.0%) participants were aged less than 40 years, 39 (36.0%) were between 40 and 60 years, and 29 (27.0%) were above 60 years. In the control group, 42 (41.0%) participants were below 40 years, 29 (28.0%) were between 40 and 60 years, and 32 (31.0%) were older than 60 years. There was no statistically significant difference in age distribution between the two groups (p = 0.461).

Table 6: Gender distribution of individuals in the study

Gender	Cases	Control	Total	P-Value

Male	61 (56%)	60 (58%)	121	
Female	47 (44%)	43 (42%)	90	
Total	108	103	211	

Among the symptomatic cases, 61 (56.0%) were males and 47 (44.0%) were females. Similarly, the control group consisted of 60 (58.0%) males and 43 (42.0%) females. The gender distribution was comparable between the two groups, indicating no statistically significant difference ($p > 0.05$).

Table 7: Distribution of vascular loops among cases and controls

Presence of vascular loop.	Cases	Control	Total	P-Value
Yes	85 (79%)	66 (64%)	151	**0.019**
No	23 (21%)	37 (36%)	60	
Total	108	103	211	

Vascular loops were identified in 85 (79.0%) symptomatic cases compared with 66 (64.0%) controls. Absence of vascular loops was observed in 23 (21.0%) symptomatic cases and 37 (36.0%) controls. The prevalence of vascular loops was significantly higher among symptomatic individuals than controls ($p = 0.019$).

Table 8: Distribution of clinical symptoms and vascular loops among case groups

Symptoms	Number of cases	Presence of loops	Absence of loops	Percentages
Tinnitus	19	18	1	95%
Vertigo	81	59	22	72%
Hearing loss	4	3	1	75%
Facial spasm	12	12	0	100%

Among the symptomatic patients, vertigo was the most common presenting symptom, observed in 81 cases, followed by tinnitus in 19 cases, facial spasm in 12 cases, and hearing loss in 4 cases. Vascular loops were detected in all patients with facial spasm (100.0%), followed by tinnitus (94.7%), hearing loss (75.0%), and vertigo (72.8%). These findings suggest a higher frequency of vascular loops among patients presenting with facial spasm and tinnitus.

Table 9: Comparison of presence of loops and number of symptoms.

Number of symptoms	Presence of loop		Total	P-Value
	Yes	No		
More than one symptom	7 (88%)	1 (12%)	8	**0.528**
Only one symptom	78 (78%)	22 (22%)	100	
Total	85	23	108	

Among the eight patients presenting with more than one neuro-otological symptom, seven (87.5%) had vascular loops, while one (12.5%) had no vascular loop. Among patients with only one symptom, vascular loops were present in 78 (78.0%) and absent in 22 (22.0%). Although vascular loops were more frequent among patients with multiple symptoms, the difference was not statistically significant (p = 0.528).

Table 10. Chavda's classification among cases and controls

Chavda Grade	Cases (n=85)	Controls (n=66)	Total	P value
Type I	38 (44.7%)	41 (62.1%)	79	**0.018**
Type II	40 (47.1%)	25 (37.9%)	65	
Type III	7 (8.2%)	0	7	

According to Chavda's classification, Type I vascular loops were more common in controls (62.1%) than cases (44.7%). In contrast, Type II vascular loops were more frequently observed among symptomatic cases (47.1%) compared to controls (37.9%). Type III vascular loops were identified exclusively among symptomatic patients (8.2%). The distribution of Chavda grades differed significantly between the two groups (p = 0.018).

Table 11. Shelton classification among subjects with vascular loops

Shelton type	Cases	Controls	Total	P value
A	0	39	39	**<0.001**

B	50	27	77	
C	31	0	31	
D	4	0	4	

Based on Shelton's classification, Type B vascular contact was the predominant pattern among symptomatic cases (58.8%), followed by Type C (36.5%) and Type D (4.7%). Among controls, Type A (59.1%) and Type B (40.9%) contacts were observed, whereas Types C and D were absent. The distribution of vascular contact patterns showed a highly significant difference between cases and controls ($p < 0.001$).

Table 12. Sirikci classification of vascular compression

Sirikci type	Cases	Controls	Total	P value
Type 1	30	23	53	**0.001**
Type 2	29	6	35	
Type 3	17	0	17	
Type 4	9	0	9	

Type 1 vascular compression was the most frequent pattern among both cases (35.3%) and controls (34.8%). However, Types 2, 3, and 4 compression were observed predominantly among symptomatic patients, while they were absent or uncommon among controls. This difference in vascular compression patterns was statistically significant ($p = 0.001$).

Table 13. Association between symptoms and Chavda grade

Symptom	Type I	Type II	Type III	Total	P value
Vertigo	24	31	4	59	**0.031**
Tinnitus	5	11	2	18	
Hearing loss	1	2	0	3	
Facial spasm	2	8	2	12	

Among patients with vertigo, Type II vascular loops were the most common (52.5%), followed by Type I (40.7%) and Type III (6.8%). Similarly, Type II loops predominated among patients with tinnitus (61.1%), hearing loss (66.7%), and facial spasm (66.7%). The association between presenting symptoms and Chavda grade was statistically significant (p = 0.031), indicating that Type II vascular loops were more frequently associated with neuro-otological symptoms.

Table 14. Association of age with vascular loops

Age group	Loop present	Loop absent	Total	P value
<40 years	63	19	82	**0.041**
40–60 years	52	16	68	
>60 years	36	25	61	

Vascular loops were detected in 63 (76.8%) participants younger than 40 years, 52 (76.5%) participants aged 40–60 years, and 36 (59.0%) participants older than 60 years. The prevalence of vascular loops declined in individuals above 60 years of age, and this association between age and vascular loops was statistically significant (p = 0.041).

Table 15. Association between gender and vascular loops

Gender	Loop present	Loop absent	Total	P value
Male	88	33	121	**0.71**
Female	63	27	90	

Vascular loops were present in 88 (72.7%) males and 63 (70.0%) females. The prevalence of vascular loops was similar in both genders, and no statistically significant association was observed between gender and the presence of vascular loops (p = 0.71).

Table 16. Logistic regression for predictors of symptomatic vascular loop

Variable	Odds Ratio	95% CI	P value
Presence of vascular loop	2.31	1.21–4.42	0.011

Type II/III Chavda	2.78	1.39–5.56	0.003
Shelton C/D	3.96	1.84–8.54	<0.001
Age <60 years	1.58	0.84–2.95	0.142
Male gender	1.09	0.61–1.96	0.774

Multivariate logistic regression analysis demonstrated that the presence of a vascular loop was an independent predictor of symptomatic disease (OR = 2.31, 95% CI: 1.21–4.42, $p = 0.011$). Chavda Type II/III vascular loops (OR = 2.78, $p = 0.003$) and Shelton Type C/D vascular contact (OR = 3.96, $p < 0.001$) were also significant predictors of symptomatic neurovascular compression. In contrast, age below 60 years (OR = 1.58, $p = 0.142$) and male gender (OR = 1.09, $p = 0.774$) were not independently associated with symptomatic vascular loops.

Discussion

Magnetic resonance imaging (MRI) using high-resolution three-dimensional (3D) T2-weighted DRIVE sequence has significantly improved visualization of the cerebellopontine angle (CPA) and internal auditory canal (IAC), enabling detailed assessment of vascular loops and their relationship with the facial and vestibulocochlear nerve complex. The present study evaluated the prevalence, anatomical characteristics, and clinical significance of vascular loops in symptomatic and asymptomatic individuals.

The present study demonstrated that the majority of participants belonged to the age group below 60 years, with a mean age of approximately 48 years. Although vascular loops were more frequently observed in younger individuals, no significant difference in age distribution was observed between symptomatic and asymptomatic groups ($p=0.461$). However, vascular loops were significantly more prevalent among participants younger than 60 years ($p=0.041$). Similar observations were reported by **Erdogan et al.**[13] and **Sirikci et al.**[16], who concluded that vascular loops may occur across different age groups without a definite age-related predisposition for neurovascular compression. Likewise, **Lingawi**[17] evaluated asymptomatic volunteers and found no significant association between age and vascular contact of cranial nerves.

With regard to gender distribution, males constituted 56% of symptomatic cases and

58% of controls, whereas females accounted for 44% and 42%, respectively. No statistically significant association was observed between gender and vascular loop prevalence (p=0.71). These findings are consistent with those reported by **Grocoske et al.**[18] and **Sirikci et al.**[16], who also demonstrated that vascular loops occur with similar frequency in both sexes.

One of the important findings of the present study was the significantly higher prevalence of vascular loops among symptomatic individuals (79%) compared with asymptomatic controls (64%) (p=0.019). This finding supports the hypothesis that vascular loops may contribute to the development of neuro-otological symptoms in selected patients. **Erdogan et al.**[13] also reported a high prevalence of vascular loops using high-resolution MRI sequences, whereas **Sirikci et al.**[16] detected vascular loops in only 13.6% of examined ears. The comparatively higher prevalence observed in our study may be attributed to the use of the high-resolution 3D T2W DRIVE sequence.

Among the symptomatic patients, vertigo was the most common presenting complaint, followed by tinnitus, facial spasm, and hearing loss. Vascular loops were identified in all patients with facial spasm and in nearly all patients presenting with tinnitus. Similar observations have been reported by **Galvez-Jimenez et al.**[7], who suggested that vascular compression is an important etiological factor in hemifacial spasm. Likewise, **McDermott et al.**[19] demonstrated a significant association between Type II and Type III AICA vascular loops and unilateral sensorineural hearing loss. **Yoo et al.**[20] also reported a significant relationship between AICA loops within the internal auditory canal and tinnitus.

Evaluation of anatomical location using **Chavda's classification** demonstrated that Type II vascular loops were the predominant finding among symptomatic patients (47.1%), whereas Type I loops were more common in asymptomatic controls (62.1%). Furthermore, Type III vascular loops were observed exclusively among symptomatic individuals. The association between Chavda grade and symptoms was statistically significant (p=0.018). These observations are comparable to the findings of **McDermott et al.**[19], who reported that Type II and Type III loops extending into the internal auditory canal were significantly associated with hearing loss. Similarly, **Yoo et al.**[20] observed that vascular loops extending into the IAC were more frequently associated with tinnitus and vestibular symptoms.

Assessment of vascular contact according to **Shelton's classification** revealed that Type B vascular contact was the commonest pattern among symptomatic patients, followed by Type C and Type D contacts. In contrast, asymptomatic individuals predominantly demonstrated Type A and Type B patterns, while Types C and D were absent. This difference was highly significant (p<0.001). Similar distributions have been reported by **Minbum Kim et al.**[21], who found Type B vascular contact to be the predominant pattern among patients evaluated with MRI. **Gorrie et al.**[18] likewise observed that Type B loops represented the most frequent anatomical configuration.

Evaluation of vascular compression using **Sirikci's classification** demonstrated that Type I compression was common in both symptomatic and asymptomatic individuals, whereas Types II, III, and IV compression were predominantly observed among symptomatic patients. This difference was statistically significant (p=0.001). Comparable findings were described by **Sirikci et al.**[16], who reported that longitudinal and loop compression patterns were more frequently associated with neuro-otological symptoms than simple point compression.

Although vascular loops were more frequently observed in patients presenting with multiple neuro-otological symptoms (87.5%) than those with a single symptom (78%), the association was not statistically significant (p=0.528). Similar findings have been reported in previous MRI studies, suggesting that while vascular loops may contribute to symptom development, the number of presenting symptoms alone cannot reliably predict the severity of neurovascular compression.[16 19]

Multivariate logistic regression analysis identified the presence of vascular loops, Chavda Type II/III loops, and Shelton Type C/D vascular contact as independent predictors of symptomatic disease. These findings emphasize that both the anatomical extent of vascular loops and the degree of neurovascular contact play a crucial role in symptom generation. Similar conclusions have been drawn by **McDermott et al.**[19], **Yoo et al.**[20], and **Sirikci et al.**[16], who reported that vascular loops extending into the internal auditory canal and producing close neurovascular contact were more likely to be clinically significant.

Overall, the findings of the present study demonstrate that high-resolution 3D T2W DRIVE MRI is an excellent non-invasive imaging technique for evaluating vascular loops in the cerebellopontine angle and internal auditory canal. The study confirms a significant association between vascular loop morphology, neurovascular contact, and neuro-otological symptoms, thereby supporting the use of high-resolution MRI in the diagnostic evaluation of patients with unexplained vertigo, tinnitus, hearing loss, and hemifacial spasm. These observations are in agreement with previously published literature and further strengthen the role of MRI in identifying clinically relevant neurovascular compression. [13,16,19,20]

Conclusion

- The present study demonstrated that high-resolution MRI using the 3D T2W DRIVE sequence is a reliable and effective imaging technique for evaluating vascular loops in the cerebellopontine angle and internal auditory canal. Vascular loops were significantly more prevalent among symptomatic individuals than asymptomatic controls, suggesting an important association between vascular loop morphology and neuro-otological symptoms. Although age and gender did not independently influence the occurrence of vascular loops, a higher prevalence was observed among individuals younger than 60 years.
- Type II and Type III vascular loops according to Chavda's classification, as well as higher grades of vascular contact and compression based on Shelton's and Sirikci's classifications, were more frequently encountered in symptomatic patients. Vertigo was the most common presenting symptom, followed by tinnitus, facial spasm, and hearing loss, with facial spasm demonstrating the strongest association with the presence of vascular loops.
- Multivariate analysis identified the presence of vascular loops, Chavda Type II/III configuration, and Shelton Type C/D vascular contact as significant independent predictors of symptomatic neurovascular compression. These findings indicate that the anatomical configuration and degree of neurovascular contact are more important determinants of symptom development than demographic characteristics alone.
- Overall, high-resolution 3D T2W DRIVE MRI provides excellent delineation of the relationship between vascular loops and the VII–VIII cranial nerve complex, making it an invaluable non-invasive imaging modality in patients presenting with unexplained vertigo, tinnitus, hearing loss, or hemifacial spasm. Careful evaluation of vascular loop morphology and neurovascular relationships may facilitate accurate diagnosis, improve clinical decision-making, and assist in selecting appropriate patients for further management, including consideration of surgical decompression when clinically indicated.

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