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Patterns Of Neurovascular Conflict In Trigeminal Neuralgia Patients - A Retrospective Clinical Study

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Declarations:
Conflicts of interest: The authors declare that there are no conflicts of interest associated with this work.
Author contributions: Jebarani Jeevitha- conceptualization, data curation, formal analysis, investigation, methodology, and writing (original draft); Devika S Pillai - conceptualization, supervision, validation, visualization, and writing (review and editing).

Abstract
Introduction: *Trigeminal neuralgia (TN), a debilitating facial pain syndrome, is often linked to neurovascular conflicts (NVCs) involving the trigeminal nerve and blood vessels. This study aimed to assess the prevalence and patterns of NVCs in TN patients using magnetic resonance imaging (MRI) data.*
Objectives: *(1) Determine the prevalence of NVCs in TN patients. (2) Identify the precise anatomical locations and specific neurovascular structures involved in NVCs. (3) Enhance understanding of TN pathophysiology and guide treatment decisions.*
Methods: *A retrospective analysis of medical records and MRI scans of 25 TN patients, with 7 confirmed NVC cases, was conducted. Data on age, sex, side of involvement, and NVC severity was collected and analyzed using SPSS software.*
Results: *NVCs were present in 28% of TN patients. The superior cerebellar artery was the most commonly implicated vessel (85.7%). NVCs were predominantly found at the root entry zone (REZ) of the trigeminal nerve (71.4%). Grade 2 (simple contact) NVCs were the most frequent (42.9%).*
Conclusion: *NVCs are relatively common in TN, primarily involving the REZ and superior cerebellar artery. This study provides valuable insights into the anatomical distribution and severity of NVCs in TN, potentially aiding diagnosis, treatment planning, and future therapeutic advancements.*
Keywords: *Trigeminal neuralgia, neurovascular conflict, magnetic resonance imaging, facial pain, trigeminal nerve*

INTRODUCTION:

The Trigeminal Nerve is the fifth cranial nerve. It is the largest of all the cranial nerves. This nerve is a mixed nerve - having both sensory and motor fibres [1]. The origin of the trigeminal nerve is the annular protuberance at the limit of the cerebellar peduncles. It originates from three sensory nuclei (mesencephalic, principal sensory, spinal nuclei of trigeminal nerve) and one motor nucleus (motor nucleus of the trigeminal nerve) extending from the midbrain to the medulla. This intricate network, with three branches – the ophthalmic (V1), maxillary (V2), and mandibular (V3) nerves – controls sensation in the forehead, midface, and lower face, respectively [2]. Trigeminal neuralgia, a debilitating neurological disorder, manifests as excruciating, stabbing facial pain.

Neurovascular conflicts, where blood vessels intrude upon or compress nerves, are frequently implicated in the development of trigeminal neuralgia [3]. **The superior cerebellar artery (SCA), a blood vessel in close proximity to the nerve's root entry zone (REZ),** is known to play a crucial role in the development of trigeminal neuralgia. Neurovascular conflicts (NVCs) are situations where a blood vessel comes into close contact with or compresses a nerve. **Neurovascular conflicts exhibit diverse patterns, with varying**

locations, degrees of compression, and symptom expression. These conflicts can occur in various parts of the body, including the brain, neck, and spine. NVCs are often asymptomatic, meaning that they do not cause any noticeable symptoms. This is because the compression or contact of the nerve by the blood vessel is not severe enough to disrupt the normal functioning of the nerve. However, in some cases, NVCs can cause symptoms, such as pain, numbness, tingling, and weakness. These symptoms are typically caused by further irritation or damage to the nerve, which can be caused by factors such as aging, trauma, or other medical conditions [4].

Studies have consistently shown a high prevalence of neurovascular conflicts in trigeminal neuralgia patients. While the SCA is the most common offender, accounting for approximately 70% of cases, other vessels such as the anterior inferior cerebellar artery (AICA), vertebral artery, and basilar artery can also contribute to the disorder [5].

Diagnosing trigeminal neuralgia typically involves a comprehensive evaluation encompassing patient history, physical examination, and imaging studies. Magnetic resonance imaging (MRI) stands as the gold standard imaging modality, effectively identifying neurovascular conflicts and excluding other potential causes of facial pain [6]. Surgical interventions, such as microvascular decompression, aim to relieve nerve compression by repositioning the offending blood vessel. This meticulous procedure, performed under microsurgical visualization, involves identifying the site of conflict and carefully separating the blood vessel from the nerve.

Minimally invasive techniques, such as stereotactic radiosurgery, utilize precisely focused radiation to target the nerve root and provide pain relief. This non-invasive approach offers an alternative to traditional surgical interventions for patients who may not be candidates for surgery or who prefer a less invasive option [7]. By delving into the complex interplay between the trigeminal nerve and blood vessels, we can unravel the pathogenesis of this debilitating disorder and pave the way for more effective diagnostic and therapeutic strategies.

MATERIALS AND METHODS:

This descriptive study was carried out in the department of Oral Medicine and Radiology. Clinical data was retrieved retrospectively from the electronic clinical record database of patients diagnosed with TN from March 2023 to July 2023. A retrospective analysis of medical records and MRI scans of 25 TN patients, with 7 confirmed NVC cases, was conducted. All patients were examined using orthopantomography to rule out any pathology or other odontogenic causes. Clinical data regarding age, sex, side of involvement, and NVC severity was collected and analyzed using SPSS software (IBM Version 23).Two researchers were involved in the study: a primary researcher and a department faculty member. Data accuracy was ensured through cross-verification using patient records and clinical photographs. Additionally, sampling bias was minimized by avoiding any sorting process and including all relevant data.

Statistical Analysis:

Descriptive analysis was performed using Chi-square test (IBM SPSS 23) and the analysis used was correlation and association.

RESULTS AND DISCUSSION:

The present study evaluated the prevalence and characteristics of trigeminal neuralgia (TN) among 25 participants, including 7 males (28%) and 18 females (72%). The participants' ages ranged from 24 to 83 years, with a mean age of 55.52 ± 10.78 years. The majority of cases were observed in individuals aged 51 to 60 years, making up 64% of the study population. The findings showed a higher prevalence of TN among females, which is consistent with previous studies, such as the one conducted by Gianfranco De Stefano et al., confirming that TN is more common in females than in males. Furthermore, the study observed a higher incidence of TN on the right side of the face, affecting 5 patients (20%), whereas 4 patients (16%) had TN on the left side. This finding aligns with the broader literature, which suggests that TN more frequently affects the right side of the face.

Pain severity and neurovascular compression grades were also evaluated in this study. The assessment of neurovascular compression using MR imaging revealed that 18 participants (72%) had grade 0 neurovascular compression, indicating no significant vascular contact. Five patients (20%) were classified as grade 2, meaning there was mild indentation of the nerve by a vascular loop. One patient (4%) had grade 3, which involved significant displacement of the nerve without nerve atrophy, and another patient (4%) had grade 4 compression, which included nerve distortion with signs of atrophy. These findings are in agreement with the classification proposed by Soundarapandian A et al., who categorized neurovascular compression based on MR imaging for better prognostic and management considerations.

A statistically significant association was found between pain grade and gender ($p < 0.05$, Chi-square test), suggesting that females exhibited a higher grade of TN severity compared to males. Additionally, a significant relationship was noted between pain severity and the side of the face affected ($p < 0.001$), indicating that patients with right-sided TN were more likely to experience higher pain severity. This supports the hypothesis that neurovascular compression and pain severity may have an anatomical or physiological predisposition that favors one side of the face.

The distribution of the study population based on age further revealed that TN was most prevalent among individuals aged 51 to 60 years (64% of the cases), followed by those above 60 years (16%). Younger individuals under 45 years were less affected (12%), indicating that TN predominantly affects middle-aged and older individuals. This corresponds with previous studies by Katheriya G et al., which established that TN most commonly occurs between the ages of 50 and 70 years. The study findings align with the estimated annual incidence rates, where TN occurs in approximately 5.9 cases per 100,000 women and 3.4 cases per 100,000 men.

The neurovascular conflict grading further revealed that 75% of the patients had a vascular loop in the prepontine cistern that did not abut the nerve, while 20% of patients exhibited mild indentation of the nerve by a vascular loop. More severe cases, such as significant nerve displacement without atrophy, were observed in 4% of patients, and another 4% exhibited nerve distortion with atrophy. These findings indicate that while vascular compression is a common feature in TN, the degree of compression varies significantly among individuals, necessitating personalized treatment approaches.

The exploratory association analysis revealed that classical TN was significantly more common among males ($p = 0.033$), while the involvement of the first trigeminal division was also statistically significant ($p = 0.034$). Depression, as a comorbidity, was found to be more prevalent among female TN patients ($p = 0.029$). These findings emphasize the importance of sex-based differences in TN presentation and management. Given that TN has a significant impact on the quality of life, understanding the gender-related variations in its clinical characteristics and psychological effects is crucial for better patient outcomes.

The clinical implications of this study suggest that accurate assessment of neurovascular compression is essential for guiding treatment strategies. The findings also emphasize the need for a multidisciplinary approach, integrating radiological, neurological, and psychological evaluations, to optimize TN management [8]. Given that neurovascular compression was observed in various degrees, treatment decisions should be tailored according to the severity of compression and the patient's pain level [9]. Future research should focus on exploring newer imaging modalities and advanced machine-learning techniques to enhance the accuracy of TN diagnosis and classification.

Despite its valuable insights, this study has limitations, primarily the small sample size, which may limit the generalizability of the findings to a broader population. The use of a single imaging modality for neurovascular compression grading also presents potential biases, as variations in imaging techniques and interpretation may affect classification outcomes. Additionally, further research is warranted to explore the long-term outcomes of TN patients undergoing different treatment modalities based on neurovascular compression severity [10]. Expanding the sample size and including patients from diverse demographic backgrounds will be essential for validating these findings in future studies.

CONCLUSION:

This study sheds light on the prevalence, locations, and specific neurovascular structures involved in neurovascular conflicts (NVCs) in trigeminal neuralgia (TN) patients. Analyzing the clinical characteristics of 25 TN patients, with 7 confirmed NVC cases, revealed a higher prevalence in the right side and among female patients, particularly those aged 51-60 years. The major limitation of this study is the small sample size, which could have influenced discrepancies between these results and those of previous studies, preventing generalization to a larger population. Nonetheless, the findings contribute valuable insights into TN pathophysiology and offer valuable information for diagnosis, treatment planning, and potential therapeutic interventions. Further research in this field, incorporating the suggested future scopes, can advance personalized management strategies and improve the quality of life for TN patients.

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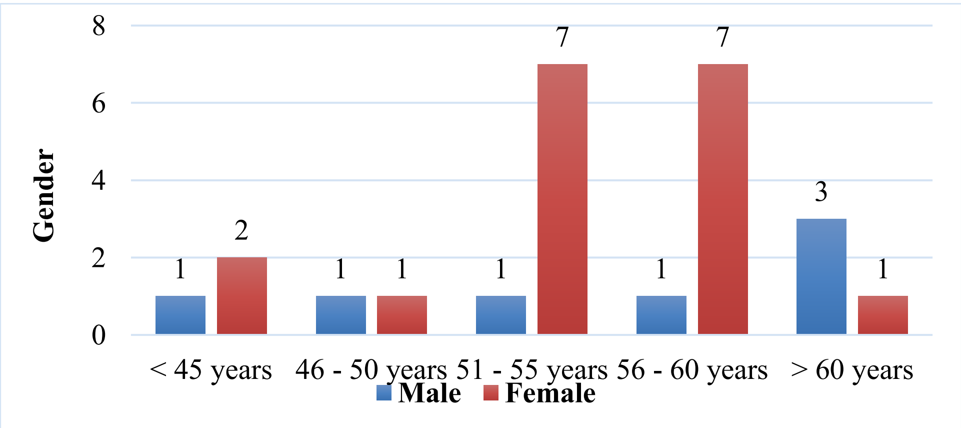
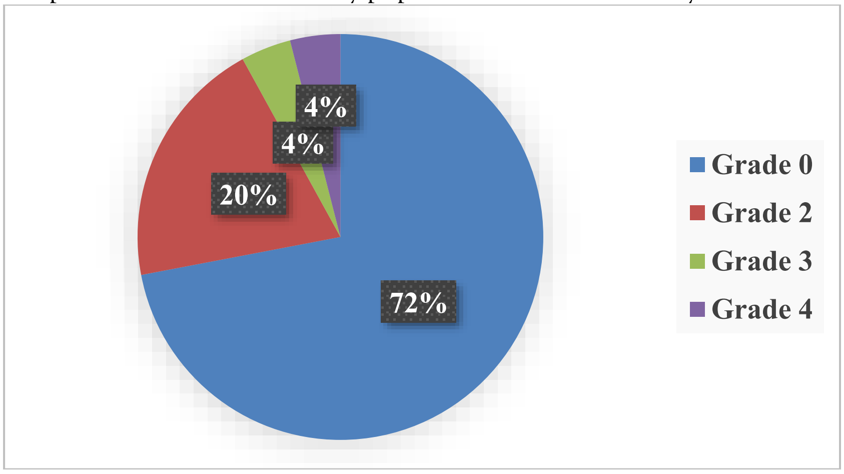
Graph 1: Distribution of study population based on age and gender



Graph 2: Distribution of study population based on severity of neurovascular conflict



Graph 3: depicts the side of the face affected with trigeminal neuralgia in the study population.

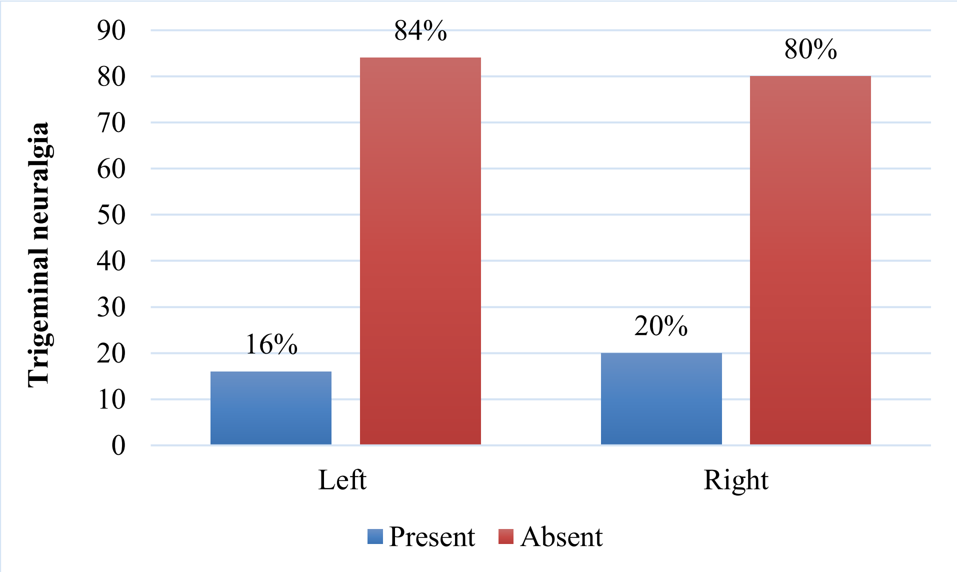


Table 1: Distribution of the study population based on grade of trigeminal neuralgia and age, gender, side of the face affected
*Significant at $p<0.05$, Chi-square test

		Grade 0 n(%)	Grade 2 n(%)	Grade 3 n(%)	Grade 4 n(%)	Total n(%)	p-value
Age	< 45 years	3(12)	0	0	0	3(12)	0.374
	46 – 50 years	0	1(4)	0	1(4)	2(8)	
	51 – 55 years	5(20)	3(12)	0	0	8(32)	
	56 – 60 years	7(28)	1(40	0	0	8(32)	
	> 60 years	3(12)	0	1(4)	0	4(16)	
Gender	Male	5(20)	1(4)	0	1(4)	7(28)	0.031*
	Female	13(52)	4(16)	1(4)	0	18(72)	
Side of face affected	Left	0	3(12)	0	1(4)	4(16)	0.001*
	Right	0	4(16)	1(4)	0	5(20)	<0.001*