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Original Article

Radiology Section

Clinicoradiological Evaluation of Trigeminal Neurovascular Loops: A Retrospective Cohort Study from Eastern India

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ABSTRACT

Introduction: Several lesions may affect trigeminal nerve from the nucleus to peripheral branches causing facial pain, called Trigeminal Neuralgia (TN). Neurovascular Compression (NVC) of the trigeminal nerve is the primary cause of TN, usually occurring at the root entry zone but is known to occur in both symptomatic and asymptomatic nerves.

Aim: To evaluate Trigeminal Neurovascular Loops (NVLs) clinico-radiologically and to know the association between the shortest distance of loop as well as the severity of compression with clinical symptoms.

Materials and Methods: This was a retrospective cohort study conducted in March 2020 after collecting data from January 2017 to January 2020 in a tertiary care center of Eastern India. All the patients, detected with trigeminal NVLs by Magnetic Resonance Imaging (MRI) were evaluated clinically (from records) and radiologically and an association is drawn between the distance of the loop, the severity of compression with symptoms. Data were analyzed using Statistical Package for Social Sciences (SPSS) statistical software version 24.0.

Results: Among 103 cases studied, the symptomatic and asymptomatic loops were 76 and 27. In symptomatic group, males and females were 48 (63.2%) and 28 (36.8%) respectively with mean age of 56 years with male:female ratio in symptomatic group was 1.7:1. Left sided presentation and pain in the maxillary area were found in 39 (51.3%) and 33 (43.4%) cases. Sharp/electric current like lancinating pain was present in 72 (94.7%) case. Triggering factors and acute spontaneous pain were presentations in 70 (92%) and 66 (86.8%) cases. Magnetic Resonance Imaging (MRI) showed NVLs with a just contact to the nerve in all asymptomatic (27/27,100%) and most symptomatic cases (57/76, 75%). The superior cerebellar artery was found to be the most common vessel involved (59/76, 77.6%). Proximal and bilateral NVLs were found in 63 (82.89%) and 27 (35.5%) cases of symptomatic nerves. Severe NVC was only present in symptomatic nerves in 19 (25%) cases.

Conclusion: Typical clinical features of trigeminal neuralgia include male preponderance, lancinating pain on maxillary area of left face. Compression by NVLs are most common cause of TN, among which superior cerebellar artery is most common culprit vessel. Severe neurovascular compressions are more symptomatic. All neurovascular compressions are not always symptomatic.

Keywords: Facial pain, Superior cerebellar artery, Trigeminal neuralgia

INTRODUCTION

Trigeminal neuralgia (TN) is a debilitating pain syndrome characterized by recurrent lancinating facial pain with an annual incidence of 4 to 5 in 100,000 and higher female prevalence [1-4]. It occurs at any age and gender but most commonly in fifth to seventh decades of life [5].The most frequent cause of TN is mechanical irritation of the nerve at vulnerable sites only (root entry or exit zone) by abnormal loops [1]. The root entry zone is the transition zone of the central to peripheral myelin [1]. The sensitivity of MR imaging for the detection of vascular compression is high (94-97%) [6,7]. The superior cerebellar artery loop is responsible for most cases (60-90%) of neurovascular compression [8]. This study is undertaken because of the following lacunae in literature-: (1) clinical significance of neurovascular compression, a leading cause of trigeminal neuralgia remains vague in many prior studies (2) due to rareness, trigeminal neuralgia is many times misdiagnosed and under treated, which causes a marked reduction in quality of life. The objective of the study was to evaluate trigeminal neurovascular loops (NVLs) clinically (from records) and radiologically and to find an association between severity of compression, the distance of compression with clinical symptoms.

MATERIALS AND METHODS

This was a hospital based retrospective cohort study conducted from January 2017 to January 2020, at Radiology Department of PRM Medical College and Hospital, Baripada, Odisha, India, after getting approval from the Institutional Ethical Committee (Ref no-24/5th IEC meeting 21, Regd. No-EC/NEW/INST/2020/975-28th. Oct.2020, Odisha). The collected data was analysed in the month of March, 2020.

Inclusion criteria: All patients with NVL around trigeminal nerve on MR imaging of any age or sex with or without neuralgic pain and within study period were included in the study cohort.

Exclusion criteria: Patients with other imaging features (i.e. brainstem lesions, trigeminal nerve pathologies like neuromas), patients having symptoms of TN without neurovascular loops or ones having loops around other cranial nerves (12th, 9th) with trigeminal loops, pregnant ladies and patients with cardiac pacemakers were excluded from the study.

A total 103 patients who were satisfying inclusion criteria, out of all patients who underwent MR imaging within specified time frame were taken as study population.

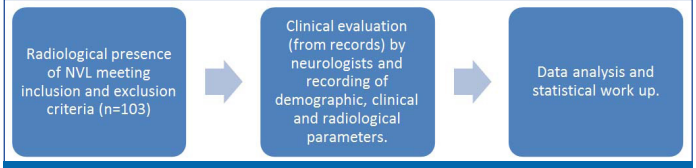
Procedure

Records were analysed which showed 76 cases (48 males, 28 females) were having TN. High resolution Magnetic Resonance Imaging (MRI) was performed to detect neurovascular contact and to exclude other causes of TN. Fast Imaging Employing Steady-state Acquisition (FIESTA) sequence was used along with other routine protocols.

MRI brain: has been done with 1.5T MRI GE SIGNA CREATOR with neurovascular head coil was analyzed. The protocols used were T1, T2, Fluid-Attenuated Inversion Recovery (FLAIR) Axial sequences, coronal T2, sagittal T1/FLAIR, 3D–FIESTA (Fast Imaging Employing Steady-state Acquisition) followed by 3D Time of Flight (TOF) MR angiography. 3D-FIESTA images can clearly depict both arteries and veins as low-signal-intensity structures, similar to the trigeminal nerve, whereas MR angiography images clearly depicts arteries only and combining these two sequences, the culprit vessel was determined.

Image analysis: Neurovascular Compression (NVC) was diagnosed in imaging when there was contact between the vascular loop and the trigeminal nerve, visualized along two different perpendicular planes with no Cerebrospinal fluid (CSF) visualized between nerve and vessel. The NVC's were graded as I, II, III as per imaging findings [9]. The gradations were, grade I - simple contact of vessel to nerve root without any visible indentation, grade II - root displacement and/or distortion and grade III - marked indentation of root. The absence of contact or compression in root can be graded as 0 [9].

Multiple vessel contact considered when two or more vessels in contact with the nerve [10]. The shortest distance between NVC and brain stem surface measured in each case and classified as proximal (<3 mm) or distal (≥3 mm) [10]. Again distance of site of NVC was compared between symptomatic and asymptomatic nerves. All MR Images were assessed carefully by two experienced consultant Radiologists of PRM Medical College (Professor and Assistant Professor) for any mass lesions or vascular loops. After radiological diagnosis of trigeminal NVLs, all the cases were clinically evaluated from records [Table/Fig-1]. All demographic and clinical data were analyzed by experienced Neurologist. Symptomatic and asymptomatic cases were grouped separately.



[Table/Fig-1]: Working methodology flowchart.
NVL: Neurovascular loops

STATISTICAL ANALYSIS

Data was entered in Microsoft excel and analyzed with software version 24.0 (Chicago IL, USA). Categorical variables were presented in number and percentage. Associations between shortest distance of compression and severity of compression by loop with clinical symptoms were compared using Student t-test and Chi-square test. A p-value≤0.05 was considered statistically significant.

RESULTS

The study population consists of 103 patients of trigeminal NVLs with 27 (26.2%) and 76 (73.8%) cases in asymptomatic and symptomatic groups respectively [Table/Fig-2]. In symptomatic group, males and females were 48 (63.2%) and 28 (36.8%) respectively with mean age of 56 years [Table/Fig-2]. Among symptomatic group M:F was 1.7:1 and Left (Lt.) side affection (51.3%) was common [Table/Fig-2]. Facial pain in maxillary distribution (V2) was present in 33 cases (43.4%) followed by mandibular (V3) (32.89%) and combined division (V2+V3) (23.68%). Electric current like lancinating pain and triggering factors were identified in 72 (94.7%) and 70 (92%) cases respectively. Absence of sensory deficit, left side distribution of facial pain and maxillary distribution of pain were significant in the present study (p<0.05) [Table/Fig-2].

In the present cohort Symptomatic: Asymptomatic loop ratio was 2.8:1. Culprit Loops were slightly more bilateral [Table/Fig-3,4(a) and (b)]. On Grading the NVCs, it is found that all asymptomatic cases (27/27,100%) and majority symptomatic patients (57/76,75%) were grade-I (just contact). Grade- II and III compressions (severe

Gender distribution	Male (n=48)	Female (n=28)	Total (n=76)	p-values
Side of face involved				
Left	28 (58.3%)	11 (39.3%)	39 (51.3%)	**0.045**
Right	20 (41.6%)	17 (60.7%)	37 (48.7%)	
Distribution of pain				
Maxillary division(v2)	21 (43.7%)	12 (42.8%)	33 (43.42%)	**0.036**
Mandibular division(v3)	16 (33.3%)	9 (32%)	25 (32.89%)	
Both (v2 + v3)	11 (22.9%)	7 (24.9%)	18 (23.68%)	
Pain characteristics				
Electric current like / shock like/sharp pain	45 (93.7%)	27 (96.42%)	72 (94.7%)	0.073
Throbbing	2 (4.1%)	1 (3.6%)	3 (3.9%)	
Dull / constant pain	1 (2%)	0	1 (1.3%)	
Others				
Triggering factors (Touch/ Breeze/ chewing/washing	45 (93.75%)	25 (92.6%)	70 (92%)	**0.0047**
Acute spontaneous pain	43 (89.5%)	23 (85%)	66 (86.8%)	
h/o previous dental treatment or procedure	13 (27%)	17 (60.7%)	30 (39.4%)	
No sensory deficit	48 (100%)	27 (96.4%)	75 (98.68%)	

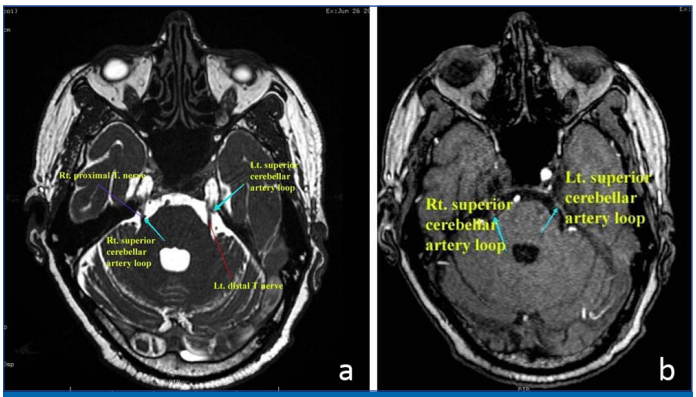
[Table/Fig-2]: Clinical presentation of symptomatic Trigeminal loops.

Trigeminal neurovascular loops n=103 (100%)	Symptomatic group 76 (73.8%)	Asymptomatic group 27 (26.2%)	
	Rt.- 25 (32.9%)		
	Lt.-24 (31.5%)		
	Bilateral -27 (35.5%)		
	Symptomatic n=76 (100%)	**Asymptomatic Group n=27 (100%)**	**p-value**
Culprit loops causing compression			
Superior Cerebellar Artery	59 (77.6%)	16 (59.2%)	**<0.001**
Venus loops	6 (7.89%)	9 (33.3%)	
Anterior Inferior cerebellar Artery	7 (9.2%)	2 (7.4%)	
Postero inferior Cerebellar Artery	1 (1.3%)	-	
Multiple vessels	3 (3.9%)	-	
Shortest distance of compression			
Proximal (≤ 3mm)	63 (82.89%)	5 (18.5%)	0.709
Distal (>3mm)	13 (17.1%)	22 (81.5%)	
Shortest distance of compression by loop			
<1 mm	23 (30.2%)	3 (11.1%)	**0.023**
1-1.99 mm	21 (27.6%)	1 (3.7%)	
2-2.99 mm	19 (25%)	1 (3.7%)	
3-3.99 mm	7 (9.21%)	2 (7.4%)	
4-4.99 mm	4 (5.26%)	3 (11.1%)	
≥5 m	2 (2.6%)	17 (62.96%)	
Gradation of Compression			
Grade I	57 (75%)	27 (100%)	**0.043**
Grade II	12 (15.8%)	-	
Grade III	7 (9.2%)	-	

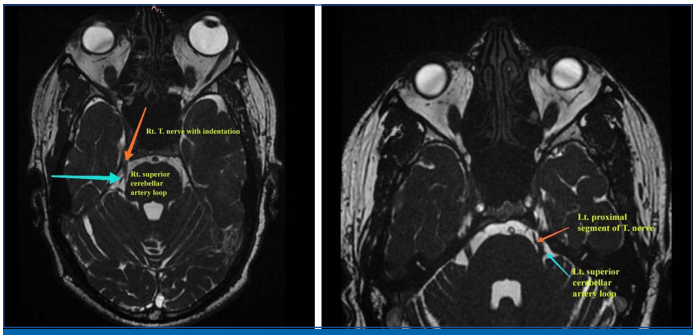
[Table/Fig-3]: Imaging evaluation of trigeminal neurovascular loops.
Grade I: Simple contact of vessel to nerve root without any visible indentation; Grade II: root displacement and / or distortion; Grade III: marked indentation of root

neurovascular conflict) were present in symptomatic cases only and p-value between gradation of compression was significant (p=0.043) [Table/Fig-3,5]. On calculating shortest distance of compression, proximal compressions (63/76,82.9%) were more in symptomatic group and distal compressions (22/27,81.5%) were more in the asymptomatic group [Table/Fig-3,4(a),6]. Here p-value

between proximal and distal compression was 0.709, which showed non significance of study. MR Imaging showed superior cerebellar arteries were most common culprit vessels (77.6%) [Table/Fig-3]. In present study, exact origin of vascular loop could not be made out and appeared to be venous origin in 7.89% case.



[Table/Fig-4]: a) Axial Fast Imaging Employing Steady-state Acquisition (FIESTA) Image showing bilateral superior cerebellar artery loops (blue) at Right proximal and Left distal cisternal segment of Trigeminal nerve; b) Magnetic Resonance (MR) Angiogram showing bilateral vascular loops.



[Table/Fig-5]: Axial FIESTA Image showing Right (Rt.) superior cerebellar artery loops (blue) at cisternal segment of Trigeminal nerve (orange) with indentation.
[Table/Fig-6]: Axial FIESTA Image showing Left (Lt) superior cerebellar artery loops (blue) at Proximal cisternal segment of Trigeminal nerve (orange).

DISCUSSION

Trigeminal neuralgia, though uncommon is a disturbing and disabling facial pain disorder characterized by unilateral electrical shock like pain that occurs along with one or more sensory divisions of the trigeminal nerve. Despite typical clinical presentation, it is missed sometimes in outpatient settings. In the present study, a total of 103 patients with trigeminal NVLs were included, out of which 76 (73.8%) cases present with TN. In 27 (26.2%) of cases loops were present without any symptoms and in 27 (35.5%) cases loops were bilateral even with unilateral clinical presentation of pain, which clearly indicates the presence of NVLs may be an anatomical variant in normal human beings.

The present study shown male dominance 48 (63.2%) with a mean age of presentation 56 years and the most common age group between 55-65 years. This is concordant with a study by Rai A et al., where 55% were males with an average of presentation 58.97 years for males and 59.96 years for females [11]. These results clearly state that TN is mainly a disease of adults and elders. The prevalence of women (60%) was significantly higher than males with an average age of onset 52.9 years in a prospective systematic study by Maarberj S et al., [12]. Katheriya G et al., shown in his study peak age of onset between fifth and sixth decades of life, with females (59.2%) more predicted for neuralgia than males [13]. Another Indian study by Rai A et al., showed equal affection of both sides [11]. These results were dissimilar to the present study where male dominance was found. This may be explained by the negligence of mild pain by females due to poverty and illiteracy. In the study by Maarbjerg S et al., chewing and touch were the most common triggering factors like the present study [12].

Regarding division of trigeminal nerve involved, it was found that maxillary (V2) and mandibular (V3) divisions were involved in 33 (43.42%) and 25 (32.89%) cases respectively while in remaining 18 (23.68%) cases both V2, V3 nerves were involved. This result was consistent with the study of Rai A et al., [11]. The study by Katheriya G et al showed the mandibular nerve as the most common nerve involved [13]. Hence all these studies had same observation that combination of V2+V3 division were less common as present study. The most common pain type in the present study was electric current like or sharp in nature, where as it is different in various studies, like shock type [11], stabbing [12], sharp type [13,14]. This shows a presentation with pain types can be varied.

Sometimes the pain of trigeminal neuralgia is mistaken as the pain of dental origin. In the present study, previous dental procedures/ treatments were found in 30 (39.4%) cases which are higher than the study by Rai A et al., where 13.33% cases underwent dental treatment [11]. Furthermore, Jainkittivong A et al., described that many patients with trigeminal neuralgia have lost teeth because of unnecessary extractions; odontogenic pain being a common misdiagnosis [14]. Thus, serious caution should be taken in cases of episodic toothache as TN is sometimes falsely attributed to dental origin.

Compression of the trigeminal nerve by anomalous vessels is a major cause of TN. Most of the time, the compression is caused by tortuous, elongated superior cerebellar artery loop (60-90%) although anterior inferior cerebellar artery loop or venous compression may be found in fewer cases [8]. Similar results have also been reported by other researchers [1,15]. Also in the present study, compression appears to be venous in 7.9% cases and by multiple vessels in 3.9% cases [Table/Fig-3] which is similar to study by Shameem Ahamed M et al., [15], where in 4 patients out of 34 NVLs, the exact origin of the loop could not be made out and appears to be venous. These are consistent with the present study, where Superior cerebellar artery was the culprit vessel in vast majority cases. Bilateral neurovascular loops with unilateral clinical presentation was a feature in the present study (35.5%), which implies the presence of loops does not always cause symptoms. Several autopsy studies shown 90% patients having TN, have some degree of contact between the trigeminal nerve and vessel loop [16]. To make it more clinically relevant, NVCs are graded as 1,2,3 [9]. Some studies have graded the relationship between severity of NVC and the presence or absence of symptoms.

In the present study, majority of symptomatic cases (57/76,75%) and all asymptomatic cases (27/27,100%) were having Grade-I compression (just contact). Severe NVCs (Grade-II and III) were only present in symptomatic group (19/76, 25%) [Table/Fig-3,5] and p-value between gradation of compression was significant (p-value=0.043). Lorenzoni J et al., reported that nerve dislocation or distortion by vessel was observed in 32% of cases on the symptomatic side, where as there was always simple contact on asymptomatic side [10]. In a study by Baldwin NG et al., 62% cases had vessels seen abutting or immediately adjacent to the trigeminal nerve on the side of their symptoms [17]. Maarberj S et al., in 2015, with 3 Tesla (T) MRI, evaluated 135 patients of classical trigeminal neuralgia. According to their study, neurovascular compressions were prevalent in both symptomatic and asymptomatic sides (89% versus 78%) with severe neurovascular contact highly prevalent in symptomatic sides compared to asymptomatic sides (53% versus 13%) [18]. One Indian study by Vedaraju KS et al., shown high grade neurovascular conflicts not found on asymptomatic sides as in the present study [19]. According to these studies, it seems that severe compression is highly associated with the symptomatic side as opposed to neurovascular contact in general, suggesting that degree of compression could be important in selecting patients for surgery.

Few studies, however, have evaluated the relationship between site of NVC and presence or absence of symptoms. Analysis by Antonini G et al., shown neurovascular contact at trigeminal root entry zone

was detected in 76% of symptomatic nerves [7]. Study by Miller JP et al., classified NVC as proximal, middle and distal-and shown NVC at proximal site was significantly more frequent in symptomatic nerves than asymptomatic nerves. However they did not clearly define proximal site [16]. A study by Suzuki M et al., showed TN occurrence in 83.1% cases at distance ≤3 mm (103/124) and 19.6% with distance >3 mm (9/46). According to them, NVC at a distance of 3 mm or less was associated with a high frequency of symptoms and the rate of symptomatic NVC significantly decreases with a distance greater than 3 mm [20]. Proximal compressions were more (82.9%) in the present study of symptomatic group and among them compressions at <1 mm, 1-1.99 mm distance from a nerve root in 23 (30%), 21 (27%) cases respectively whereas study by Shameem Ahamed M et al., shown compression at the proximity of nerve in 79% (27/34) patients [15]. So the proximal portion of the nerve mainly the root (at entry or exit zone) is vulnerable to compression and proximity of compression may correlate to neuralgia symptoms (p value=0.0709). The compression and displacement of the nerve by neurovascular loop is well evaluated by Constructive Interference in Steady State Sequence (CISS), which demonstrates the thinning of root entry zone and allows exact identification of NVL. It has been proposed as the initial screening procedure for all patients of refractory trigeminal neuralgia if surgical intervention is being needed [21].

Limitation(s)

The study was the retrospective cohort design instead of prospective study with small sample size and used the MRI machine of 1.5 Tesla instead of using the higher strength of 3 Tesla and drew conclusions based on observation from a single study center, hence was the main limitation.

CONCLUSION(S)

Trigeminal Neuralgia a treatable facial pain disorder, its common features which includes male preponderance, left side presentation, maxillary area distribution and sharp/lancinating pain with touch or breeze as common triggers. MRI with FIESTA Sequences and Angiography is considered as the main investigation in patients with trigeminal neuralgia. Neurovascular compression by vascular loop is the most common cause of TN and the superior cerebellar artery is the most common culprit vessel. Most of the loops causing TN are just in contact with the nerve and present in the proximal segment of nerve. The association between distance of compression and symptoms was found to be non significant. Imaging evidence of neurovascular conflicts must be correlated with clinical symptoms while making a proper diagnosis. Severe neurovascular contact is highly associated with symptomatic trigeminal neuralgia as opposed to neurovascular contact in general, suggesting neurovascular contact could be important for selecting patients for surgery. Unilateral neuralgic facial pain may be the only presentation with bilateral trigeminal loops. A future multicentre study is recommended with high strength (3T) MRI machine for better reliability of results.

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