Original Article

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Assessment of Trigeminal Neurovascular Conflicts Using 3D FIESTA-C Sequence on a 3T MRI

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Abstract

Background: Trigeminal neuralgia is an idiopathic chronic excruciating pain disorder along the distribution of trigeminal nerve. This condition is often sparked by facial movements or by speaking or sensory stimulation of one half of face. The cause of trigeminal neuralgia is primarily idiopathic and is implicated with vascular compression in most of the cases. Secondary trigeminal neuralgia occur due to underlying neurological disease. In this prospective study on patients with primary trigeminal neuralgia, we assessed the role of 3D FIESTA-C (Three-dimensional fast imaging employing steady state acquisition in cycled phases) sequence in detection, localisation and describing various patterns of neurovascular conflict (NVC). **Subjects & Methods -** This Hospital-based prospective study consists of 30 patients with clinically suspected trigeminal neuralgia, referred to the department of radiodiagnosis, Narayana medical college, Nellore, over a period of 2 years. All the 30 cases were imaged on a 3 tesla MRI scanner with a 3D FIESTA-C sequence. **Results -** In 30 cases, 18 were females, and 12 were males. The mean age at initial presentation is 53 years. The average duration of symptoms at initial presentation among study subjects in our study is 63 days. On MR imaging, in the 30 cases, Grade I conflict is seen in 17, Grade II conflict is seen in 7 and Grade III conflict is seen in 6 patients. The offending arteries include SCA in 24 cases, AICA in 7 cases, PCA in 1 case and VA in 1 case. **Conclusion -** The addition of the 3D FIESTA-C sequence in the MR imaging protocol helps in better identification of the cranial nerve anatomy and abnormalities. 3D FIESTA-C images help in depicting the neuroanatomy better before planning for microvascular decompression. Grading this neurovascular compression helps the surgeon in stratifying the patients and their treatment. Imaging evidence of neurovascular conflict must be correlated with clinical symptoms while making the diagnosis.

Keywords: Trigeminal Neuralgia, Neurovascular conflict, 3D FIESTA-C, 3D CISS, Trigger zone, Trigeminal Nerve.

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Introduction

The cranial nerves arise from the inferior surface of the brain and courses through the cisternal spaces of the subarachnoid space. Various arteries, veins located in these subarachnoid cisterns sometimes have close contact with the cranial nerves.

Neurovascular conflict is best explained as mechanical irritation of cranial nerves due to direct contact with adjacent blood vessels.[1] There can be either contact or compression or distortion of the nerve by an artery or vein.

The transition zone from central oligodendrocyte myelination to peripheral schwann cell myelination is located within this intra cisternal course of these cranial nerves.[2] This transition zone is highly susceptible to neurovascular conflict (NVC). NVC causes an alteration in the neuronal transmission of the involved cranial nerve and presents with abnormal neuronal discharges along with the distribution of cranial nerve course, termed clinically as cranial nerve neuralgia. It is characterised by paroxysmal attacks of pain or abnormal movements in the distribution of the affected nerve.[3]

The trigeminal nerve is composed of both sensory and motor roots. It is the largest cranial nerve,[4] The nerve arises from the lateral pons and lies in prepontine cistern. Then it passes into the Meckel's cave, forms the trigeminal ganglion otherwise known as Gasserian ganglion ; from here, the nerve divides into three subdivisions. The ophthalmic (V1), maxillary (V2) and mandibular (V3) divisions.[4,5]

The cisternal segment consists of the Dorsal root entry zone (REZ), Trigger zone (TZ) and Plexus triangularis or retrogasserian segment

TZ of trigeminal sensory fibres measures on an average 3.6 mm. TZ of motor fibres measures 0.3 mm and is located closer to the brainstem.[6]

Trigeminal neuralgia, or otherwise known as tic douloureux, is classically characterised by excruciating stabbing type of paroxysmal facial pain for a short duration, often triggered by harmless stimulation of the trigger zone (eating, cold weather, tactile stimulation), Characteristically involving along the V2 and/or V3 dermatomes.[7]

Commonly seen finding is a cisternal segment it is noted conflict in 80% to 90% of cases.[6,8]

Arteries are the most common offending vessels, with the superior cerebellar artery (SCA) in 75% to 88% cases and the anterior inferior cerebellar artery (AICA) in 9.6% to 25% cases.[9]

Computed tomography (CT) is advantageous in visualising the intraosseous segments of cranial nerves. Simultaneous visualisation of nerves and vessels is only possible on MRI. T2 weighted images, MR angiography and contrast-enhanced imaging are useful in the identification of vessels and cranial nerves.

Three-dimensional (3D) fast imaging employing steady state acquisition (FIESTA) is a fully refocused steady-state gradient-echo MRI sequence with high T2 weighting. The vessels and nerves are seen as dark structures in the background bright CSF. The compression and displacement of the nerve by the vascular loop are well assessed by the 3D FIESTA-C sequence.[10]

Three-dimensional fast imaging employing steady state acquisition, cycled phases (3D FIESTA-C) is a patented MR sequence on GE (General Electric) MRI systems. Equivalent sequence on other MRI scanners includes CISS 3D (Constructive interference into steady state) on SIEMENS MRI systems.

In this study, we are emphasising the role of Three-dimensional fast imaging employing steady state acquisition (3D FIESTA-C) sequence in detection, localising and grading of trigeminal neurovascular conflict in 30 patients.

Subjects and Methods

The main source of data was patients referred to the department of Radiodiagnosis, Narayana Medical College and Hospital, Nellore. This Hospital-based prospective study consists of 30 patients.

Methodology

Patients aged between 20-80 years irrespective of sex, with the following criteria in a period of 2 years, will be taken for the current study.

Inclusion Criteria

The current study includes

- Patients with symptoms of hemifacial spasm, trigeminal neuralgia, glossopharyngeal neuralgia, tinnitus, vertigo.
- Patients with headache, hypertension.

Exclusion Criteria

The current study will exclude:

- Patient having history of cardiac pacemakers and metallic foreign body insertion.
- Patient having history of claustrophobia.
- Patients < 12 years and pregnant women are excluded.

Technique

All patients are imaged on a 3.0 Tesla GE MRI scanner (DISCOVERY MR750w). Along with routine MR sequences, 3D FIESTA-C sequence was performed with the subsequent parameters: axial sections are obtained from the level of third ventricle to foramen magnum with the axis of baseline parallel to the direction of the corpus callosum. TE : 2.5 msec, TR : 6.2 msec, flip angle : 700, slice thickness : 0.6 mm, no interslice gap, bandwidth : 62.5 kHz, FOV : 210, matrix : 256 x 256, acquisition time : 2 minute 51 seconds. In the current study, the 3D FIESTA-C sequence is performed using these parameters.

Results

30 cases with complaints of single-sided trigeminal neuralgia with imaging evidence of trigeminal neurovascular conflict only were included in our study.

In 30 cases, Trigeminal NVC distribution was common in females (18, 60%) than males (12, 40%).

Cases were right-sided trigeminal NVC 10 cases were left-sided trigeminal NVC

The mean age at initial presentation is 53 years in our study.

The average duration of symptoms at initial presentation among study subjects in our study is 63 days.

On MR imaging, the 30 cases, Grade I conflict is seen in 17, Grade II conflict is seen in 7 and Grade III conflict is seen in 6 patients.

Types of trigeminal neurovascular conflict identified on MR imaging in our study include simple contact type in 17 cases, loop type in 8 cases, sandwich-type in 3 cases, tandem type in 2 cases.

The offending arteries in subjects with trigeminal neurovascular conflict include superior cerebellar artery (SCA) in 24 cases (73%), anterior inferior cerebellar artery (AICA) in 7 cases (21%), posterior cerebral artery (PCA) in 1 case (3%) and vertebral artery (VA) in 1 case (3%).

In 3 cases, SCA and AICA were seen, causing a sandwich neurovascular conflict of trigeminal nerve.

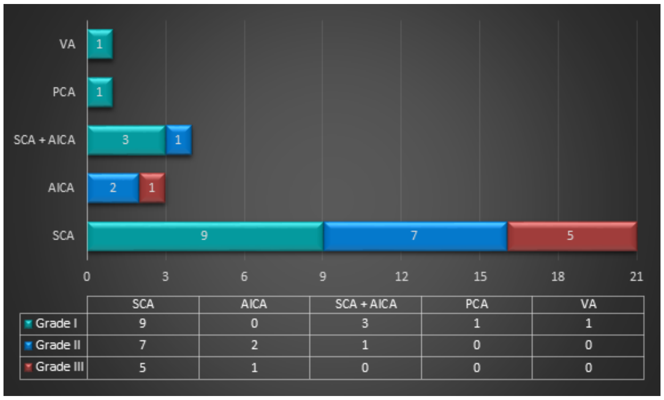

Figure 1: Bar chart showing number of cases, grade of conflict and offending arteries of trigeminal neurovascular conflict in 30 study subjects in this study.

The mean trigeminal-pontine angle were also measured bilaterally in our study. They are 39.2^0 on the affected side and 42.4^0 on unaffected side.

In our study, 10 patients were managed with anticonvulsants alone, 13 patients were managed with anticonvulsants and antispasmodics, 7 patients required microvascular decompression.

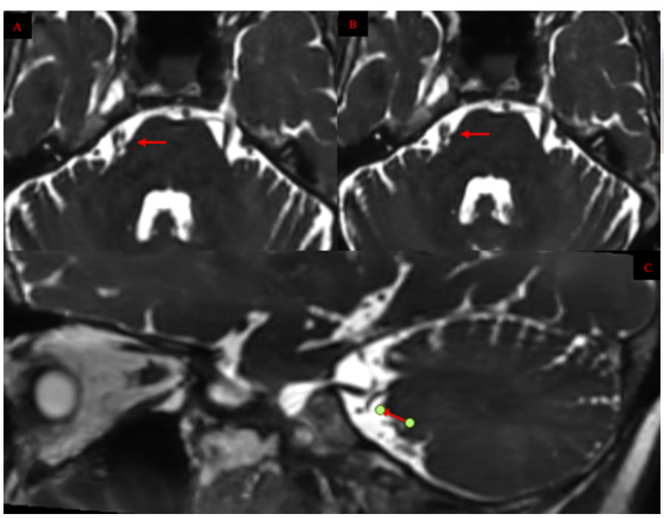

Figure 2: Axial (A, B) and Sagittal (C) reconstructed 3D FIESTA-C MR images of the brain demonstrating a grade I neurovascular conflict between the right posterior cerebral artery (PCA) and right trigeminal nerve.

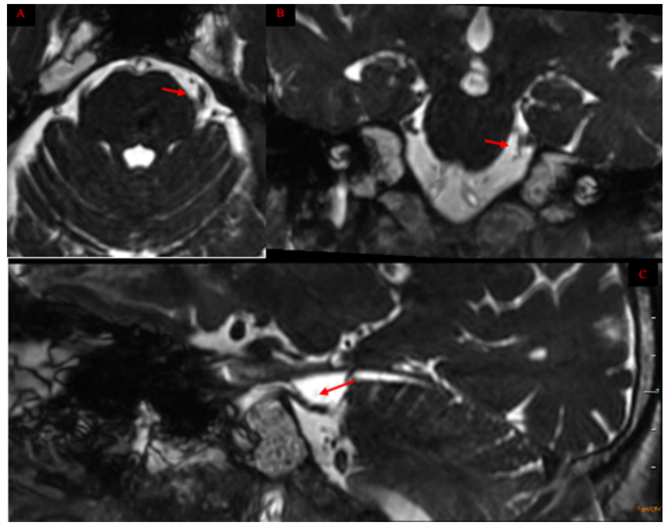

Figure 3: Axial (A), Coronal (B) and Sagittal (C) reconstructed 3D FIESTA-C MR images of the brain, demonstrating a grade II neurovascular conflict between left trigeminal nerve and left superior cerebellar artery (SCA).

Discussion

There are several imaging modalities to evaluate cranial nerve neuralgia. Computed tomography (CT) is useful to look at the intraosseous segments and provides an indirect view of cranial nerves. On contrast enhanced CT, vessels are better visualised but, the nerves are not visualised directly.

Simultaneous visualisation of nerves and vessels is only possible on MRI. T2 weighted images, MR angiography and contrast-enhanced imaging are useful in the identification of vessels and cranial nerves.

On 3D FIESTA-C sequence, both nerves and vessels appear as black structures enclosed by high-signal intensity CSF. Contact between the nerve and vessel, signal intensity changes in nerve are better appreciated on this 3D FIESTA-C sequence.

We evaluated thirty cases with trigeminal neuralgia in our study on a 3T MRI scanner. Images of all these patients showed high image quality, good signal characteristics and fewer signal artefacts.

Garcia et al.[11] assessed 47 patients with various cranial nerve neuralgias, comparing 3.0 and 1.5 Tesla scanners and using 3D CISS and 3D TOF sequences. They found that the image quality was significantly better with 3 T than with1.5 T for both sequences.

54 patients with TN were observed and compared between 3D CISS and 3D TOF sequences for detection of arterial NVC on a 1.5-T system by Yoshino et al.[12] and attained comparable

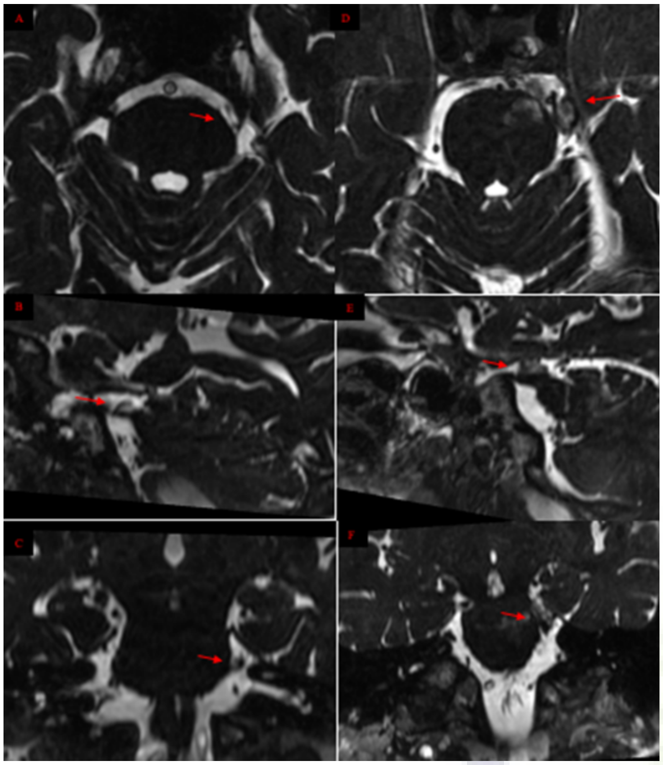

Figure 4: On the left side (A, B, C) - Axial, Coronal and Sagittal 3D FIESTA-C MR images of the brain demonstrating a grade III neurovascular conflict between the right superior cerebellar artery (SCA) and right trigeminal nerve. On right side (D, E, F) - Postoperative Axial, Coronal and Sagittal reconstructed 3D FIESTA-C MR images of same patient demonstrating Teflon placement after microvascular decompression.

results. Venous compressions were well appreciated on 3D CISS sequence, but 3D TOF sequence was unable to dertect venous compressions.

In our study, arterial compression is noted as the reason of trigeminal neuralgia in all 30 cases on 3D FIESTA-C sequence. No cases of venous compression were noted on imaging.[13–19]

In a study conducted on 100 patients with TN by Lacerda et al.[20] 96.7% sensitivity and 100% specificity was observed for diagnosis of NVC with MRI.

In a blinded study by S.Maarbjerg et al.[21] a total of 135 patients were assessed for the presence and graded according to the degree of neurovascular contact. They concluded that the symptomatic side has a high-grade neurovascular contact with displacement or atrophy of the trigeminal nerve.

In our study, we considered neurovascular conflict only on the symptomatic side. High-grade neurovascular conflicts were not found on the asymptomatic side of our study patients.

The average age of disease onset was 53 years, and the present age was 60.1 years in their study. In contrast, the mean age of onset in our study is 52 years in our study. Eighty-two (61%) patients were female.

Brînzeu et al.[13] performed a study on 100 patients with trigeminal neuralgia and studied the territory of pain in these patients. 54 were men, and 46 were women among the 100 patients. The majority of the patients (33.3%) had pain in V2 and V3 territories than in V1 territory (7.1%).

Our study shows similar observations with the majority of the patients (40%) had pain along V2, V3 territories and the least majority of patients (6.6%) had pain along V1 territory.

Anderson et al.[14] and Cheng et al.[15] described a variable degree of vessel and nerve contact in patients with neuralgia, ranging from no contact to severe deformation with or without nerve atrophy. In this grading system, veins are graded on a similar scale as arteries.

In our study, neurovascular conflicts were graded according to this classification by Anderson et al.[14] Among the 30 cases, 17 cases had Grade I conflict, 7 cases had Grade II conflict, and Grade III conflict was seen in 6 cases.

In a study, Leal et al.[20] has found that the common cause of trigeminal neuralgia is compression at REZ of trigeminal nerve by a vascular loop, frequently SCA in grade II and grade III NVC cases.[16]

Similar observations are noted in our study. In our study, there are 23 cases of trigeminal neurovascular conflict by SCA, in which 60 % of cases are of Grade II.

The relationship between the microstructural changes in the nerve and the trigeminal-pontine angle was well observed by Pang H et al.[22] Their case control study consisted of 25 patients who underwent microvascular decompression (MVD) for trigeminal neuralgia and 25 similar age and sex-matched controls. The mean trigeminal-pontine angle (38.60) and FA value (0.35) on the affected side were significantly lower when compared to the unaffected side and on both sides in control group ($p < 0.001$), while the mean ADC values were visibly higher (1.96 x 10-9, p< 0.01).

In our study, the mean trigeminal-pontine angle is 39.20 on the affected side and 42.40 on the unaffected side. SCA is noted as the most common artery involved in a conflict with the trigeminal nerve in our study and has sharper angles with the nerve, similar to the study by Pang H et al. ADC and FA values are not measured in our present study.

In a study published by Satoh et al.[17] assessing 66 patients with TN using T2-weighted 3D Fast spin-echo and 3D TOF sequences on a 1.5 T scanner, imaging finding of a neurovascular conflict was noted in the ipsilateral side with

Table 1: Comparing our study with various other studies and imaging techniques used in their study for the assessment of trigeminal neurovascular conflicts in patients with trigeminal neuralgia.

Study	No. of Nerves	No. of NVC	MR Imaging Technique used
Hutchins et al.	29	16	T1-weighted spin-echo, 3 mm sections
Tash et al.	6	6	T1-weighted spin-echo, 3 mm sections
Sens and Higen	5	5	3D fast low-angle shot; gadolinium-enhanced, 1 mm sections
Furuya et al.	4	3	3D fast low-angle shot, 0.8 mm sections
Nagaseki et al.	7	6	Gradient echo, 1 mm sections
Meaney et al.	55	42	3D FISP MR angio, 1 mm sections
Our study	30	30	3D FIESTA-C, 0.8 mm sections

Table 2: Imaging and surgical descriptions of the different grades of neurovascular conflict of cranial nerves.

Grade	Imaging Description	Surgical Description
0	Neurovascular relation without contact	Neurovascular relation without contact
I	Contact: the absence of interposed CSF layer	Simple contact without visible alteration of the root
II	Deviation of the root	Displacement/ distortion of the root
III	Indentation of the root	Indentation of the root/ engrooving/ focal demyelination

pain in 85% of cases. They also found neurovascular conflict in the TN contralateral to the pain in 35% of cases. They classified neurovascular conflict into simple, moderate and severe types. A severe neurovascular conflict was noted only on the ipsilateral side of the pain in their study.

30 patients with trigeminal neuralgia with ipsilateral imaging evidence of trigeminal NVC are included in our study. 20 cases were right-sided and 10 cases were left-sided trigeminal NVC, correlating with same side of their symptom.

Of the 30 cases in our study with trigeminal neurovascular conflict, surgery was done in 7 cases. All 6 patients with grade III neurovascular conflict underwent microvascular decompression surgery. A patient with grade II neurovascular conflict by right SCA underwent surgery as symptoms were not controlled by using medications. All these 7 patients are reported to be symptom-free post-surgery.

In all the 7 cases that underwent microvascular decompression, the imaging findings are similar to that of the surgical findings.

Q. Zhou et al.[6] studied 37 patients with typical unilateral TN who had 3D FIESTA imaging. Preoperative 3D FIESTA imaging recognized 35 out of 36 symptomatic conflicts, which were proved surgically. They stated that 3D FIESTA imaging is 97.2 % sensitive, 100% specific in identification of a trigeminal NVC and concluded that this MR sequence allows accurate preoperative visualisation of a neurovascular contact.

The location responsible for vascular contact in 35 patients with TN established by 3D FIESTA imaging includes medial in 17, lateral in 16, superior in 1, inferior in 1 in their study. In the 7 operated cases, location of vascular conflict are medial in 6 cases and inferior in 1 case.

These neuralgias can be symptomatically relieved by using anticonvulsants like carbamazepine. Carbamazepine inhibits the trigeminal nerve by acting centrally and is effective, indicating that it does not act at the site of vascular compression. Muscle-relaxing agents such as baclofen can be used alone or in combination with carbamazepine.[18]

Microvascular decompression (MVD), introduced by Janetta in 1967, remains the primary surgical procedure of choice. The surgery involves a 2-cm triangular retro sigmoid craniotomy. When the offending vessel is recognized, a Teflon sponge is commonly used to shield the nerve and relieve it from vascular compression. If the offending vessel is a vein, based on size, it can be decompressed or sacrificed.[19]

Other surgical procedures, like rhizotomy, are also performed, yielding better results. Gamma knife stereotactic radiosurgery is a recent non-invasive technique used to treat neurovascular conflict.

Lower-grade conflicts can be managed conservatively, but higher-grade conflicts can require surgical intervention.

Conclusion

The addition of the 3D FIESTA-C sequence in the MR imaging protocol helps in better identification of the cranial nerve anatomy and abnormalities. In all the 30 cases in our study, trigeminal neurovascular conflicts were better identified on 3D FIESTA-C images and graded accordingly.

The nerve and the vessel implicated in neurovascular conflict are identified better on 3D FIESTA-C images, which helps in depicting the neuroanatomy better before planning for microvascular decompression. Grading this neurovascular compression helps the surgeon in stratifying the patients and their treatment.

Imaging evidence of neurovascular conflict must be correlated with clinical symptoms while making proper diagnosis. Elimination of all other causes of cranial nerve neuralgia has an important role along with MR imaging.

References

1. Haller S, Etienne L, vari EK, Varoquaux AD, Urbach H, Becker M. Imaging of Neurovascular Compression Syndromes: Trigeminal Neuralgia, Hemifacial Spasm, Vestibular Paroxysmia, and Glossopharyngeal Neuralgia. Am J Neuroradiol. 2016;37(8):1384–1392. Available from: https://dx.doi.org/10.3174/ajnr.a4683.
2. Janetta PJ. Microsurgical approach to the trigeminal nerve for tic douloureux. Progr Neurol Surg;7:180–200. Available from: https://doi.org/10.1159/000428328.
3. Simone RD, Ranieri A, Bilo L, Fiorillo C, Bonavita V. Cranial neuralgias: from physiopathology to pharmacological treatment. Neurol Scienc. 2008;29(S1):69–78. Available from: https://dx.doi.org/10.1007/s10072-008-0892-7.
4. Sheth S, Branstetter BF, Escott EJ. Appearance of Normal Cranial Nerves on Steady-State Free Precession MR Images. Radio Graphics. 2009;29(4):1045–1055. Available from: https://dx.doi.org/10.1148/rg.294085743.
5. Naidich TP, Castillo M, Cha S, Smirniotopoulos J. Imaging of the brain. Philadelphia: Elsevier; 2013.
6. Zeng Q, Zhou Q, Liu Z, Li C, Ni S, Xue F. Preoperative detection of the neurovascular relationship in trigeminal neuralgia using three-dimensional fast imaging employing steady-state acquisition (3D-FIESTA) and magnetic resonance angiography (MRA). J Clin Neurosci. 2013;20(1):107–118. Available from: https://doi.org/10.1016/j.jocn.2012.01.046.
7. Donahue JH, Ornan DA, Mukherjee S. Imaging of Vascular Compression Syndromes. Radiol Clin North Am. 2017;55:123–138. Available from: https://dx.doi.org/10.1016/j.rcl.2016.08.001.
8. Leal PRL, Barbier C, Hermier M, Souza MA, Cristino-Filho G, Sindou M. Atrophic changes in the trigeminal nerves of patients with trigeminal neuralgia due to neurovascular compression and their association with the severity of compression and clinical outcomes. J Neurosurg. 2014;120(6):1484–1495. Available from: https://dx.doi.org/10.3171/2014.2.jns131288.
9. M??ller AR, Jannetta PJ. Microvascular decompression in hemifacial spasm. Neurosurgery. 1985;16:612–618. Available from: https://dx.doi.org/10.1097/00006123-198505000-00005.
10. Scheffler K, Lehnhardt S. Principles and applications of balanced SSFP techniques. Eur Radiol. 2003;13(11):2409–2418. Available from: https://dx.doi.org/10.1007/s00330-003-1957-x.
11. Garcia M, Naraghi R, Zumbrunn T, Rösch J, Hastreiter P, Dörfler A. High-Resolution 3D-Constructive Interference in Steady-State MR Imaging and 3D Time-of-Flight MR Angiography in Neurovascular Compression: A Comparison between 3T and 1.5T. Am J Neuroradiol. 2012;33:1251–1256. Available from: https://dx.doi.org/10.3174/ajnr.a2974.
12. Yoshino N, Akimoto H, Yamada I, Nagaoka T, Tetsumura A, Kurabayashi T, et al. Trigeminal Neuralgia: Evaluation of Neuralgic Manifestation and Site of Neurovascular Compression with 3D CISS MR Imaging and MR Angiography. Radiology. 2003;228(2):539–545. Available from: https://dx.doi.org/10.1148/radiol.2282020439.
13. Dumot C, Brinzeu A, Berthiller J, Sindou M. Trigeminal neuralgia due to venous neurovascular conflicts: outcome after microvascular decompression in a series of 55 consecutive patients. Acta Neurochir. 2017;159(2):237–249. Available from: https://dx.doi.org/10.1007/s00701-016-2994-y.
14. Anderson VC, Berryhill PC, Sandquist MA, Ciaverella DP, Nesbit GM, Burchiel KJ. High resolution three-dimensional magnetic resonance imaging in the evaluation of neurovascular compression in patients with trigeminal neuralgia. A double-blind pilot study. Neurosurgery. 2006;58:666–673. Available from: https://doi.org/10.1227/01.neu.0000197117.34888.de.
15. Cheng J, Meng J, Liu W, Zhang H, Hui X, Lei D. Nerve atrophy in trigeminal neuralgia due to neurovascular compression and its association with surgical outcomes after microvascular decompression. Acta Neurochir (Wien). 2017;159:1699–705. Available from: https://doi.org/10.1007/s00701-017-3250-9.
16. Rasminsky M. Ephaptic transmission between single nerve fibres in the spinal nerve roots of dystrophic mice. J Physiol. 1980;305(1):151–169. Available from: https://dx.doi.org/10.1113/jphysiol.1980.sp013356.
17. Satoh T, Yagi T, Onoda K, Kameda M, Sasaki T, Ichikawa T, et al. Hemodynamic features of offending vessels at neurovascular contact in patients with trigeminal neuralgia and hemifacial spasm. J Neurosurg. 2019;130(6):1870–1876. Available from: https://dx.doi.org/10.3171/2018.1.jns172544.

18. Simone RD, Ranieri A, Bilo L, Fiorillo C, Bonavita V. Cranial neuralgias: from physiopathology to pharmacological treatment. Neurol Sci. 2008;29(S1):69–78. Available from: https://dx.doi.org/10.1007/s10072-008-0892-7.
19. Sade B, Lee JH. Microvascular Decompression for Trigeminal Neuralgia. Neurosurg Clin N Am. 2014;25(4):743–749. Available from: https://dx.doi.org/10.1016/j.nec.2014.06.007.
20. Leal PRL, Hermier M, Froment JC, Souza MA, Cristino-Filho G, Sindou M. Preoperative demonstration of the neurovascular compression characteristics with special emphasis on the degree of compression, using high-resolution magnetic resonance imaging: a prospective study, with comparison to surgical findings, in 100 consecutive patients who underwent microvascular decompression for trigeminal neuralgia. Acta Neurochir. 2010;152(5):817–825. Available from: https://dx.doi.org/10.1007/s00701-009-0588-7.
21. Maarbjerg S, Wolfram F, Gozalov A, Olesen J, Bendtsen L. Association between neurovascular contact and clinical characteristics in classical trigeminal neuralgia: A prospective clinical study using 3.0 Tesla MRI. Cephalalgia. 2015;35(12):1077–1084. Available from: https://dx.doi.org/10.1177/0333102414566819.
22. Pang H, Sun H, Fan G. Correlations between the trigeminal nerve microstructural changes and the trigeminal-pontine angle features. Acta Neurochir. 2019;161:2505–2511. Available from: https://dx.doi.org/10.1007/s00701-019-04099-6.

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