HAYDARPAŞA NUMUNE MEDICAL JOURNAL

DOI: 10.14744/hnhj.2022.60963
Haydarpasa Numune Med J 2022;62(3):253–256

ORIGINAL ARTICLE

hnhtipdergisi.com

Using Osirix for Pre-Surgical Planning in Microvascular Decompression Surgeries

Ali Fatih Ramazanoğlu

Department of Neurosurgery, Umraniye Training and Research Hospital, İstanbul, Türkiye

Abstract

Introduction: Both trigeminal neuralgia (TN) and hemifacial spasms (HFS) cause vascular compression of the fifth and seventh cranial nerves, respectively, at the root entry zone. This study proposes a new technique for using both three-dimensional (3D) constructive interface in steady state (CISS) magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), and computerized tomography angiography (CTA) to show vascular compression on the trigeminal and facial nerves.

Methods: The study included 10 patients presenting with TN and HFS. The post-processing software Osirix was used to combine pre-operative 3D CISS MRI, MRA, and CTA to render a manipulative 3D image. This 3D image can be printed and used to show the vascular compression before the surgery.

Results: Of the 10 patients, four were male and six were female. All radiological imaging was imported to the Osirix DICOM Viewer. The vascular compression was shown in nine of the patients. In nine patients displaying vascular compression were found to have anatomic consistency (determined during surgery) to that of the 3D model. One patient did not display vascular compression in either the 3D models or images.

Discussion and Conclusion: The use of 3D CISS MRI, MRA, and CTA to create manipulative 3D images and models was shown to be useful in pre-operative surgical planning for patients with symptoms of vascular compression, for whom previous medical interventions had failed. If venous compression is not observed, it is important to be aware of the potential to compression of a vein and various other non-vascular lesions.

Keywords: Decompression; microvascular; osirix; planning; pre-surgical.

Trigeminal neuralgia (TN) consists of paroxysmal bouts of pain in trigeminal nerve innervation. TN typically does not manifest until after age 40 and becomes increasingly prevalent as age increases[1]. Hemifacial spasms (HFS) are a movement disorder of the seventh cranial nerve that is characterized by either brief or persistent and intermittent twitching of the muscles innervated by the facial nerve[2]. Diagnosis of TN and HFS is usually clinical. Magnetic resonance imaging (MRI) and computerized tomography angiography (CTA) are usually performed to understand the pathophysiology of the disease[3,4]. The cause of disease is typically vascular compression of the fifth and seventh cranial nerves at the root entry zone. There are other diseases and conditions, which may resemble and should be differentiated from TN and HFS. Due to the location of symptoms at face, TN may be initially mistaken for dental pain. Conditions such as vestibular schwannomas, meningiomas, epidermoid cysts, sac-

Correspondence (İletişim): Ali Fatih Ramazanoğlu, M.D. Umraniye Egitim ve Arastirma Hastanesi, Beyin ve Sinir Cerrahisi Klinigi, Istanbul, Türkiye
Phone (Telefon): +90 505 824 81 95 **E-mail (E-posta):** ali_fatihramazanoglu@hotmail.com
Submitted Date (Başvuru Tarihi): 05.04.2022 **Accepted Date (Kabul Tarihi):** 06.04.2022

cular aneurysms, or arteriovenous malformations can also cause TN. Multiple sclerosis and compressive lesions rarely cause TN. Additional rare causes that have been reported in recent literature include pontine infarction, brachium pontis, cavernous angioma, cysticercosis, amyloidoma of Meckel's cave, sarcoid granuloma, and Chiari I malformation[1,5]. Vein compression is also considered in TN's pathogenesis, either alone or in combination with arterial compression[6]. Blepharospasm, tardive dyskinesias, motor tics, psychogenic HFS, focal cortical seizures involving the facial muscles, and aberrant regeneration after facial nerve injury can mimic HFS[2]. Due to this, pre-operative radiological imaging with MRI and CTA should be performed to understand the exact pathophysiology[4,7]. These patients should be assessed thoroughly through detailed neurological examinations to decide the best option for treatment. Treatment options include non-surgical interventions, radiofrequency gangliolysis, balloon compression, stereotactic surgery, or microvascular decompression, especially for TN. Microvascular decompression is the first invasive treatment option for vascular compression. Different types of MRI sequences can be used to show vascular compression. For both TN and HFS, 3D constructive interface in steady state (CISS) MRI has proven to be a good method of diagnosing vascular compression[8]. It is also important to review and understand the bony and vascular anatomy by means of CT and CTA before surgery. The purpose of this study was to assess the usefulness of creating manipulative 3D models and images using 3D CISS MRI combined with CTA and magnetic resonance angiography (MRA) imaging to show the vascular compression on cranial nerves in the skull base.

Materials and Methods

The subjects of the study included 10 patients, eight of which had TN and two of which had HFS. After performing a neurological examination and an MRI, patients with tumors, multiple sclerosis, and infarctions were excluded from the study. Only vascular compressions were included in the study. After brain MRI, MRA, and/or CTA, all of the DICOM images were imported to the Osirix MD DICOM software. (Pixmeo, FDA cleared 510 k Class II medical device for MacOsX). A CTA of the head was performed, first without contrast and then with 100 mL of Omnipaque 350 intravenous contrast according to a stereotactic thin cut slice protocol. An MRI of the brain was performed before and following the administration of 7 mL Gadavist intravenous gadolinium contrast, according to a dedicated internal auditory canal protocol. An MRA of the circle of Willis was obtained without contrast utilizing a time-of-flight (TOF) technique. After point-based recognition of all images, a model was produced for TN of the fifth nerve and brain stem using the DICOM Viewer. After choosing the region of interest,[3] pixel value inside the ROI was set to 1000. Outside of the ROI, pixel value was changed to −1000. Using this method, a 3D volumetric image of the fifth nerve and brain stem is displayed as white. Using the same DICOM viewer, the produced 3D image is combined with CTA and MRA to very easily see the relationships between bone, vascular anatomy, the brain stem, and cranial nerves. A retrosigmoid approach can be simulated in this software, which helps to understand the anatomy from a surgical perspective (Fig. 1). The same process is done for the seventh nerve, as seen in the HFS case. All of the produced imaging and models were representative of the anatomy observed during surgical exposure.

Results

Four patients were male and six were female. Each patient was carefully assessed by neurological examination and all radiological imaging was imported to the Osirix DICOM Viewer. Two independent neurosurgeons prepared the data in the Osirix DICOM Viewer. The vascular compression was shown in nine of the patients. Both patients displaying vascular compression were found to have anatomic consistency (determined during surgery) to that of the 3D model. One patient did not display vascular compression in both the 3D models and images. In this patient, we saw venous compression during the surgery. We compared our results with two different neurosurgeons. There were no noticeable differences among the investigators. All of the patients were operated under general anesthesia. There was neither mortality nor morbidity noted in any case after a 3-month follow-up. All of the patients were discharged from the hospital on the 2nd post-operative day.

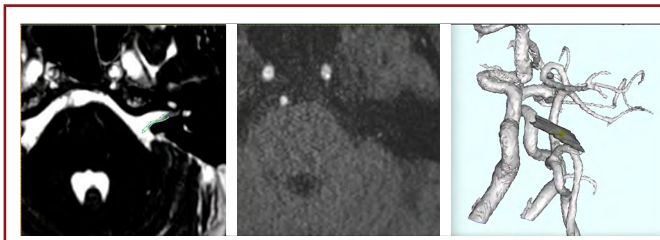

Figure 1. Pre-operative 3-dimensional construction through Osirix.

Discussion

For patients presenting with TN or FHS symptoms, the goals of treatment should include pain relief, tissue diagnosis, and tumor resection/decompression without producing new neurological deficits. In the absence of a mass lesion, decompression of the trigeminal nerve, such as in the case of microvascular decompression, has been demonstrated to be safe and effective,[9] even in elderly subjects.

In our study, we demonstrate the importance of creating manipulative 3D imaging and models using 3D CISS MRI and CTA, to achieve a better understanding of the surgical anatomy before performing microvascular decompressions for patients with TN and HFS. 3D CISS is a gradient-echo MRI sequence that is used to investigate a wide range of pathologies when routine MRI sequences do not provide the sufficient anatomic information. The increased sensitivity of the 3D CISS sequencing is a result of the accentuation of the T2 values between cerebrospinal fluid (CSF) and pathological structures. Apart from its well-recognized applications in the evaluation of the cranial nerves, CSF rhinorrhea, and aqueduct stenosis, we have found the CISS sequencing to be useful for the cisternal spaces, cavernous sinuses, and the ventricular system, where it is useful for detecting subtle CSF-intensity lesions that may be overlooked or missed on routine spin-echo sequences. Kumon et al. [10] used spoiled gradient recalled MRI and MRA in 3D reconstruction to show the compression for TN and HFS. Majole et al.[11] showed effectiveness of fast inflow with steady-state precession and contrast material-enhanced magnetization-prepared rapid acquisition gradient-echo sequences to show the vascular compression. Shigematsu et al. [12] used Virtual MRI endoscopy to show compression on the fifth and seventh nerve in six cases. Later, Ishimori et al. [13] used the same techniques effectively. Tsuchiya et al.[8] showed the effectiveness of 3D CISS MRI for treating TN and HFS as well. Anderson et al. [14] showed that 3D TOF MRA when used in combination with Gad-enhanced 3D spoiled gradient-recalled sequences could visualize neurovascular compression accurately in patients with TN. Cha et al. [15] reported the combined imaging of T2/FLAIR (Fluid-attenuated inversion recovery) enable us to evaluate neurovascular indentation more accurately. Moreover, multiplanar reconstructions of 3D FLAIR VISTA and 3D T2 VISTA fusion imaging yield excellent differentiations between vessel structures and CSF and enables confident and simple spatial evaluation of the vessel and nerve. Zhou et al. [16] reported that contrast-enhanced 3D TOF MRA is useful in the detection of vascular contact with the trigeminal nerve in patients with TN. They showed that 3D fast imaging employing steady-state acquisition images can show the vascular compression as well[17]. Chen et al.[18] demonstrated use of MRI and CT imaging combination in rhizotomy cases. Adamczyk et al.[19] reported that contact between a trigeminal nerve root and an artery in the pre-pontine cistern can be a frequently seen anatomical variant, which should be considered. Hitchon et al.[20] reported that the resolution of MRI was congruent with operative findings in 84% in TIC and 75% in HS. This review emphasizes that the decision to undertake MVD in TIC or HS should be based on clinical diagnosis and not visualization of a compressing vessel by MRI. Conversely, the presence of a compressing vessel by MRI demands perseverance by the surgeon until the nerve is decompressed.

In our study, we used combined imaging of CISS MRI, MRA, and CTA. Fusion of 3D CISS MRI and CTA proved to be much better for understanding the surgical anatomy, showing the vascular compression, and ultimately, if the patients have symptoms and the effectiveness of performing microvascular decompression to treat TN and HFS. If vascular compression is present and the patient is not symptomatic, it is not necessary to treat them. Neurological examination is essential for decision-making regarding cases of TN and HFS, but if there is no vascular compression, it is imperative to be mindful of venous compression or other non-vascular complications. Non-surgical treatments should always be considered as the first treatment option for these patients. Prospective and randomized trials are required in larger patient, population is needed to show effectiveness of this method.

Conclusion

Fusion of 3D CISS MRI, MRA, and CTA to create manipulative 3D images and models was shown to be useful in preoperative surgical planning for patients with symptoms (and ultimately the presence) of vascular compression, for whom previous medical interventions had failed.

Ethics Committee Approval: Umraniye Training and Research Hospital (No: B.10.1.TKH.4.34.H.GP.0.01/221/Date:23.06.2021).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Cheshire WP Jr. Trigeminal neuralgia. Curr Pain Headache Rep 2007;11:69–74. [CrossRef]
2. Chaudhry N, Srivastava A, Joshi L. Hemifacial spasm: The past, present and future. J Neurol Sci 2015;356:27–31. [CrossRef]
3. Kuroiwa T, Matsumoto S, Kato A, Harano K, Totoki T, Tabuchi K, et al. MR imaging of idiopathic trigeminal neuralgia: Correlation with non-surgical therapy. Radiat Med 1996;14:235–9.
4. Borges A, Casselman J. Imaging the trigeminal nerve. Eur J Radiol 2010;74:323–40. [CrossRef]
5. Swinnen C, Lunskens S, Deryck O, Casselman J, Vanopdenbosch L. MRI characteristics of trigeminal nerve involvement in patients with multiple sclerosis. Mult Scler Relat Disord 2013;2:200–3. [CrossRef]
6. Acioly MA, Simões EL, Parise M, Telles C, Nigri F. Developmental venous anomaly causing trigeminal neuralgia. Arq Neuropsiquiatr 2010;68:822–5. [CrossRef]
7. Borges A. Trigeminal neuralgia and facial nerve paralysis. Eur Radiol 2005;15:511–33. [CrossRef]
8. Tsuchiya K, Yamakami N, Hachiya J, Kassai Y. MR cisternography using a three-dimensional half-fourier single-shot fast spin-echo sequence. Eur Radiol 1998;8:424–6. [CrossRef]
9. McLaughlin MR, Jannetta PJ, Clyde BL, Subach BR, Comey CH, Resnick DK. Microvascular decompression of cranial nerves: Lessons learned after 4400 operations. J Neurosurg 1999;90:1–8. [CrossRef]
10. Kumon Y, Sakaki S, Kohno K, Ohta S, Ohue S, Miki H. Three-dimensional imaging for presentation of the causative vessels in patients with hemifacial spasm and trigeminal neuralgia. Surg Neurol 1997;47:178–84. [CrossRef]
11. Majoie CB, Hulsmans FJ, Verbeeten B Jr, Castelijns JA, van Beek EJ, Valk J, et al. Trigeminal neuralgia: Comparison of two MR imaging techniques in the demonstration of neurovascular contact. Radiology 1997;204:455–60. [CrossRef]
12. Shigematsu Y, Korogi Y, Hirai T, Okuda T, Ikushima I, Sugahara T, et al. Virtual MRI endoscopy of the intracranial cerebrospinal fluid spaces. Neuroradiology 1998;40:644–50. [CrossRef]
13. Ishimori T, Nakano S, Kagawa M, Yokoe K, Togami T, Asakura H, et al. Virtual endoscopic images by 3D FASE cisternography for neurovascular compression. Magn Reson Med Sci 2003;2:145–9. [CrossRef]
14. Anderson VC, Berryhill PC, Sandquist MA, Ciaverella DP, Nesbit GM, Burchiel KJ. High-resolution three-dimensional magnetic resonance angiography and three-dimensional spoiled gradient-recalled imaging in the evaluation of neurovascular compression in patients with trigeminal neuralgia: A double-blind pilot study. Neurosurgery 2006;58:666–73. [CrossRef]
15. Cha J, Kim ST, Kim HJ, Choi JW, Kim HJ, Jeon P, et al. Trigeminal neuralgia: Assessment with T2 VISTA and FLAIR VISTA fusion imaging. Eur Radiol 2011;21:2633–9. [CrossRef]
16. Zhou Q, Liu Z, Li C, Qu C, Ni S, Zeng Q. Preoperative evaluation of neurovascular relationship by using contrast-enhanced and unenhanced 3D time-of-flight MR angiography in patients with trigeminal neuralgia. Acta Radiol 2011;52:894–8.
17. Zhou Q, Liu ZL, Qu CC, Ni SL, Xue F, Zeng QS. Preoperative demonstration of neurovascular relationship in trigeminal neuralgia by using 3D FIESTA sequence. Magn Reson Imaging 2012;30:666–71. [CrossRef]
18. Chen KT, Lin MH, Tsai YH, Lee MH, Yang JT. Application of MRI and intraoperative CT fusion images with integrated neuronavigation in percutaneous radiofrequency trigeminal rhizotomy. Acta Neurochir (Wien) 2015;157:1443–8. [CrossRef]
19. Adamczyk M, Bulski T, Sowińska J, Furmanek A, Bekiesińska-Figatowska M. Trigeminal nerve - artery contact in people without trigeminal neuralgia - MR study. Med Sci Monit 2007;13(Suppl 1):38–43.
20. Hitchon PW, Zanaty M, Moritani T, Uc E, Pieper CL, He W, et al. Microvascular decompression and MRI findings in trigeminal neuralgia and hemifacial spasm. A single center experience. Clin Neurol Neurosurg 2015;139:216–20. [CrossRef]