The Role of Imaging for Trigeminal Neuralgia

A Segmental Approach to High-Resolution MRI

Daniel P. Seeburg, MD, PhD, Benjamin Northcutt, MD, Nafi Aygun, MD, Ari M. Blitz, MD*

KEYWORDS

• Trigeminal neuralgia • Neurovascular contact • MRI

KEY POINTS

- High-resolution isotropic imaging allows detailed evaluation of nearly the entire course of the trigeminal nerve (cranial nerve [CN] V), from its brainstem nuclei to the distal branches of its 3 main divisions.
- Imaging in patients with trigeminal neuralgia (TGN) allows assessment for the presence, type, and degree of neurovascular contact in the cerebellopontine cistern.
- Imaging also allows evaluation for secondary causes of TGN, including multiple sclerosis (MS) as well as benign and malignant neoplasms.
- State-of-the-art MRI techniques, including diffusion tensor imaging (DTI) and functional MRI (fMRI), are providing insight into the pathogenesis of TGN.

INTRODUCTION

TGN is a rare unilateral episodic facial pain syndrome affecting the CN V and is characterized by paroxysmal lancinating shocklike pain attacks typically evoked by touch. With improvements in technology, the role of imaging in TGN has continued to evolve. High-resolution MRI now affords exquisite anatomic detail and allows radiologists to scrutinize nearly the entire course of CN V, from its nuclei in the brainstem to the distal branches of its 3 main divisions, the ophthalmic, maxillary, and mandibular nerves. This article focuses first on the normal MRI appearance of the course of CN V and how best to image each segment. Special attention is then devoted to the role of MRI in presurgical evaluation of patients with neurovascular conflict and in identifying the causes of TGN, including MS. Fundamental concepts in postsurgical imaging after neurovascular decompression are also addressed. Finally, how imaging has been used to better understand the etiology of TGN is discussed.

NORMAL MRI APPEARANCE OF THE TRIGEMINAL NERVE BY SEGMENT

CN V separates into 3 main divisions anteriorly as it exits the head: CN V.1—the ophthalmic division, CN V.2—the maxillary division, and CN V.3—the mandibular division. Each division subserves sensation to the face, with CN V.1, CN V.2, and CN V.3 responsible for sensation to the upper, middle, and lower thirds of the face, respectively.

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Division of Neuroradiology, The Russel H. Morgan Department of Radiology and Radiologic Science, The Johns Hopkins Hospital, Phipps B-100, 600 North Wolfe Street, Baltimore, MD 21287, USA
* Corresponding author.
E-mail address: Ablitz1@jhmi.edu

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In addition, CN V.3 has a motor function, innervating the majority of the muscles of mastication. Imaging of CN V is now commonly performed using high-resolution isotropic 3-D MRI, replacing the standard 2-D techniques, and allowing for exquisite anatomic evaluation of CN V.

At the authors' institution, a dedicated protocol for assessment of TGN has been used for several years and in several hundred patients afflicted by TGN. The protocol includes isotropic sequences used for evaluation of the CNs, including precontrast and postcontrast constructive interference in the steady state (CISS) images, which use fast imaging in steady state free precession to render an image with mixed T1 and T2 weighting as well as precontrast and postcontrast volumetric interpolated breath-hold examination (VIBE), which is a type of T1-weighted gradient-recalled echo sequence. The authors' experience with CISS imaging, which affords the highest spatial resolution and the greatest anatomic detail, forms the basis for much of the following information.

Previous reviews by Blitz and colleagues[1,2] have defined a standardized nomenclature of the segments of the CNs, which is expanded for CN V in this article (Box 1, Table 1). The nuclei of the CN V (CN V.a) extend from the midbrain to the upper cervical spinal cord with the parenchymal fascicular segments (CN V.b) extending anteriorly toward the surface of the pons. A full review of the CN V.a and CN V.b segments is beyond the scope of this review, which focuses primarily on the components of CN V more readily accessible to the surgeon.

Box 1
Nomenclature of the anatomic segments of the cranial nerves used in this review, as detailed in the articles by Blitz and colleagues

a. Nuclear
b. Parenchymal fascicular
c. Cisternal
d. Dural cave
e. Interdural
f. Foraminal
g. Extraforaminal

Adapted from Blitz A, Choudhri A, Chonka Z, et al. Anatomic considerations, nomenclature, and advanced cross-sectional imaging techniques for visualization of the cranial nerve segments by MR imaging. Neuroimaging Clin N Am 2014;24(1):1–15; and Blitz A, Macedo L, Chonka Z, et al. High-resolution CISS MR imaging with and without contrast for evaluation of the upper cranial nerves. Neuroimaging Clin N Am 2014;24(1):17–34.

The apparent origin of the cisternal segment of CN V (CN V.c) is identified arising from the lateral aspect of the midpons (Fig. 1A). Anatomic studies have shown that there is a somatotopic organization to the trigeminal sensory root, with nerve fibers of the CN V.1 primarily rostral within the root, CN V.2 fibers comprising a greater medial portion of the root, and nerve fibers from the CN V.3 caudolateral within the root.[3] The apparent origin of the motor root(s) of CN V is/are often identified arising separately from the remainder of the CN V rootlets, located superior and medial to the apparent origin of the much larger sensory component of the nerve.[2]

CN V.c enters the dural cave of CN V (CN V.d) (Meckel's cave) through the porus trigeminus (see Fig. 1). Meckel's cave contains the gasserian (also known as the trigeminal or semilunar) ganglion, which is positioned along the anterior and inferior margin of Meckel's cave and can be identified on axial and sagittal precontrast CISS images (see Fig. 1A, B). The ganglion normally demonstrates enhancement on postcontrast imaging (see Fig. 1B, C). The remainder of CN V, however, should not show enhancement on postcontrast imaging. CN V divides distal to the gasserian ganglion into the CN V.1, CN V.2, and CN V.3 divisions (Fig. 2). (Note: the authors prefer the term, *CN V.1*, to reduce ambiguity with the abducens nerve, CN VI.)

The interdural segment of the V.1 nerve (V.1.e) extends along the lateral wall of the cavernous sinus superiorly and anteriorly toward the superior orbital fissure. The foraminal segment of the V.1 nerve (V.1.f) begins at the superior orbital fissure. It divides in the superior orbital fissure into the lacrimal and frontal branches superiorly and into the nasociliary branch inferiorly, which continue into the orbit as extraforaminal branches of CN V (V.1.g). The frontal nerve extends through supraorbital foramen, the lacrimal branch extends to the lacrimal gland, and nasociliary branches extend to the globe and nasal cavity.

The interdural segment of the V.2 nerve (V.2.e) travels below V.1.e along the lateral wall of the cavernous sinus (Fig. 3) and extends anteriorly as the foraminal segment (V.2.f) through the foramen rotundum. The extraforaminal segment (V.2.g) extends to the pterygopalatine ganglion, where it divides into the infraorbital nerve, which travels through the infraorbital foramen; the zygomatic nerve, which enters the orbit via the inferior orbital fissure and divides into the zygomaticofacial and zygomaticotemporal branches, the latter of which sends a small twig to the lacrimal nerve; and the