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Preoperative demonstration of neurovascular relationship in trigeminal neuralgia by using 3D FIESTA sequence

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Abstract

Purpose: The purpose of the study was to evaluate the value of high-resolution three-dimensional fast imaging employing steady-state acquisition (3D FIESTA) imaging in the visualization of neurovascular relationship in patients with trigeminal neuralgia (TN).
Methods: Thirty-seven patients with unilateral typical TN underwent 3D FIESTA imaging. Neurovascular relationship at the trigeminal root entry zone was reviewed by an experienced neuroradiologist, who was blinded to the clinical details. The imaging results were compared with the operative findings in all patients.
Results: In 37 patients with TN, 3D FIESTA imaging identified surgically verified neurovascular contact in 35 of 36 symptomatic nerves. Based on surgical findings, the sensitivity and specificity of magnetic resonance (MR) imaging were 97.2% and 100%, respectively. Agreement between the position (medial, lateral, superior and inferior) of the compressing vessel relative to the trigeminal nerve identified by MR imaging and surgery was excellent (K=0.81; 95% confidence interval, 0.56–1.00). A statistically significant difference was found between the site of neurovascular contact and the clinical symptom related to the trigeminal branch (Fisher's Exact Test, P<.001).
Conclusions: Use of 3D FIESTA sequence enables accurate visualization of neurovascular contact in patients with TN. Anatomic relationships defined by this method can be useful in surgical planning and predicting surgical findings.

Keywords: Magnetic resonance imaging; Microvascular decompression; Neurovascular compression; Trigeminal neuralgia; Comparative studies

1. Introduction

Since Jannetta proposed the theory of microvascular compression, it has been established that neurovascular contact (NVC) is the main cause of trigeminal neuralgia (TN) [1–5]. Therefore, preoperative identification of NVC has an impact on the determination of appropriate treatment for TN. However, due to poor resolution, conventional imaging techniques are disappointing in preoperative evaluation of the vascular contact with the trigeminal nerve at the root entry zone (REZ) [6]. Three-dimensional fast imaging employing steady-state acquisition (3D FIESTA) sequence produces a very high-resolution T2-weighted image with an excellent contrast between structures, and this magnetic resonance (MR) imaging technique has been applied to visualize the complex posterior fossa anatomy [7–9].

In the present study, to preoperatively visualize neurovascular relationship, 3D FIESTA sequence was performed on 37 patients with TN. The aims of this study were (a) to assess the value of 3D FIESTA imaging in the visualization of NVC and (b) to evaluate the relationship between the site of NVC and clinical manifestation related to trigeminal branch in patients with TN.

2. Methods

2.1. Patients

The subjects were 37 patients with TN (16 women and 21 men; age range, 26–81 years; mean age, 55.3 years) who visited our hospital from January 2009 to November 2010. All of the patients have unilateral, medically intractable TN

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(left side involvement, n=14; right side involvement, n=23) with median duration of 5.5 years (range, 1.5–19 years). Table 1 shows the branches of the trigeminal nerve involved.

These patients underwent high-resolution 3D FIESTA and MR angiography examinations and were to be treated with microvascular decompression (MVD) of the trigeminal nerve. Written informed consent was obtained from all patients after the nature of the examination had been fully explained, and the study was approved by the institutional review board.

2.2. MR imaging

All MR imaging examinations were performed on a 3.0-T MR scanner (Signa; GE Medical Systems, Milwaukee, WI, USA) with a standard head coil. Each patient underwent MR imaging using 3D FIESTA and time-of-flight (TOF) MR angiography technique, centered on the pons in the region of the trigeminal nerve. The pulse sequences used were as follows: (a) 3D FIESTA sequence [6.1/1.5 (repetition time ms/echo time ms), 60° flip angle, 240 × 240-mm field of view, 512 × 512 matrix, two acquisitions, 31.25-kHz bandwidth, cartesian sampling) and (b) 3D TOF MR angiography (22/3.2, 15° flip angle, 240 × 240-mm field of view, 256 × 512 matrix, one acquisition, 44-mm slab thickness).

2.3. Image analysis

All 3D FIESTA images and 3D TOF MR angiography were independently analyzed by an experienced neuroradiologist, who was blinded to the clinical details. The relationship of the trigeminal nerve and adjacent blood vessel was evaluated.

(a) Assessing the severity of vascular contact with the trigeminal nerve by analyzing the 3D FIESTA and TOF images.

The assessment of the severity of the NVC was based on the morphologic contact between the outer walls of the offending vessel and the trigeminal nerve [10,11]. The degree of vascular contact with the trigeminal nerve was classified into the following categories: type I (compression type, distortion or deviation of the nerve resulted from vascular compression), type II (simple contact type, nerve and blood vessel only existed contact) and type III (noncontact and noncompression type).

Table 1
Clinically involved branches of the nerve in patients with TN

Branch	No. of patients (n=37)	Percentage of patients (%)
V1	0	0
V2	14	37.8
V3	17	45.9
V1+2	1	2.7
V2+3	4	10.8
V1+2+3	1	2.7

V1, V2 and V3=the first, second and third branch of the trigeminal nerve involved in patient with TN, respectively.

(b) Identifying the position of the blood vessel compressing the nerve on the 3D FIESTA image.

The position of the compressing vessels relative to the trigeminal nerve was classified into one of the following sites: medial, lateral, superior or inferior.

2.4. MVD analysis

MVD for the treatment of the symptomatic trigeminal nerve was performed by using standard microdissection techniques. In brief, this technique involves opening the skull using the suboccipital retromastoid approach, cutting the cerebral dura mater in the shape of "^," exploring the cerebellopontine angle, extensive cutting the arachnoid membrane around the trigeminal nerve, fully revealing the region where the trigeminal nerve entered pons, identifying and confirming the conflicting vessels, separating and subsequently padding them with Teflon cotton.

In each case, the degree of NVC and the position of responsible vessel relative to the trigeminal nerve were recorded by the surgeon.

2.5. Statistical analysis

Statistical analysis was performed by using the commercial software SPSS for Windows release 11.5 (SPSS Inc., Chicago, IL, USA). P values of less than .05 were considered statistically significant.

Associations between variables were assessed by using χ^2 test or Fisher's Exact Test. Based on the surgical findings, the resulting sensitivity, specificity, false-positive rate and false-negative rate of the 3D FIESTA imaging were calculated. Agreement between preoperative MR image visualization and surgical findings was assessed by using the Kappa (K) statistic. A K value of less than 0.40 was considered to reflect poor agreement, between 0.40 and 0.59 to reflect fair agreement, between 0.60 and 0.74 to reflect good agreement and 0.75 or more to reflect excellent agreement.

3. Results

The 3D TOF MR angiography and 3D FIESTA imaging demonstrated the trigeminal nerve and the surrounding vasculature in all patients (Figs. 1 and 2). On MR angiographic images, the artery was shown as a high-signal-intensity structure, the nerve as an intermediate-signal-intensity one and the cerebrospinal fluid (CSF) as a low-signal-intensity one. On 3D FIESTA images, the blood vessel and the nerve were shown as low-signal-intensity structures, and the CSF as a high-signal-intensity structure.

3.1. Comparison of 3D FISTA Imaging and MR angiography in the detection of the NVC

The severity of the NVC revealed by MR imaging on the symptomatic and asymptomatic side was summarized in Table 2. It was observed that the compression and contact