Preoperative Assessment of Trigeminal Neuralgia and Hemifacial Spasm Using Constructive Interference in Steady State-Three-dimensional Fourier Transformation Magnetic Resonance Imaging

Iwao YAMAKAMI, Eiichi KOBYASHI, Shinji HIRAI, and Akira YAMAURA
Department of Neurosurgery, Chiba University School of Medicine, Chiba

Abstract
Results of microvascular decompression (MVD) for trigeminal neuralgia (TN) and hemifacial spasm (HFS) may be improved by accurate preoperative assessment of neurovascular relationships at the root entry/exit zone (REZ). Constructive interference in steady state (CISS)-three-dimensional Fourier transformation (3DFT) magnetic resonance (MR) imaging was evaluated for visualizing the neurovascular relationships at the REZ. Fourteen patients with TN and eight patients with HFS underwent MR imaging using CISS-3DFT and 3D fast inflow with steady-state precession (FISP) sequences. Axial images of the cerebellopontine angle (CPA) obtained by the two sequences were reviewed to assess the neurovascular relationships at the REZ of the trigeminal and facial nerves. Eleven patients subsequently underwent MVD. Preoperative MR imaging findings were related to surgical observations and results. CISS MR imaging provided excellent contrast between the cranial nerves, small vessels, and cerebrospinal fluid (CSF) in the CPA. CISS was significantly better than FISP for delineating anatomic detail in the CPA (trigeminal and facial nerves, petrosal vein) and abnormal neurovascular relationships responsible for TN and HFS (vascular contact and deformity at the REZ). Preoperative CISS MR imaging demonstrated precisely the neurovascular relationships at the REZ and identified the offending artery in all seven patients with TN undergoing MVD. CISS MR imaging has high resolution and excellent contrast between cranial nerves, small vessels, and CSF, so can precisely and accurately delineate normal and abnormal neurovascular relationships at the REZ in the CPA, and is a valuable preoperative examination for MVD.

Key words: cerebellopontine angle, hemifacial spasm, microvascular decompression, magnetic resonance imaging, trigeminal neuralgia

Introduction
Trigeminal neuralgia (TN) and hemifacial spasm (HFS) can be caused by vascular compression at the root entry/exit zone (REZ) of the trigeminal nerve and the facial nerve. Microvascular decompression (MVD) surgery is widely performed for the treatment of TN and HFS. However, MVD is not always curative, as the long-term success rates are 84% for TN and 86% for HFS.27 The patterns of vascular compression are closely related to results of MVD.28 The postoperative recurrence rate is significantly high when either a small, unnamed artery or a vein is the only vessel responsible.9 MVD results are poor when surgery discloses no vascular compression or only venous contact with the nerve.29 More exact preoperative assessment of neurovascular relationships at the REZ may improve the results of MVD and prevent unnecessary surgery.

Computed tomography (CT) provides only limited visualization of the posterior fossa structures, so magnetic resonance (MR) imaging has recently been used for preoperative evaluation of patients with TN and HFS. However, conventional T1- and T2-weighted MR imaging sequences and even gradient-echo MR imaging cannot completely delineate neurovascular relationships at the REZ.11,24,27,28,30 The constructive interference in steady state (CISS)-three-dimensional Fourier transformation (3DFT) MR imaging technique provides excellent contrast between cerebrospinal fluid (CSF) and cranial nerves.4

Received May 2, 2000; Accepted July 26, 2000

545
This study assessed the value of CISS-3DFT MR imaging for visualizing the neurovascular relationships at the REZ in patients with TN and HFS, as a method for indicating MVD.

Materials and Methods

I. Clinical materials
The study included 14 patients with TN (3 males and 11 females, aged 42 to 73 years old) and eight patients with HFS (3 males and 5 females, aged 45 to 67 years old). The 14 patients with TN had typical clinical features and had been treated with carbamazepine. Eight patients with HFS underwent electrophysiological examination including spontaneous electromyography, assessment of the blink reflex, and electromyographic study of the facial muscle response (confirming the diagnosis of HFS. All 22 patients underwent conventional T1- and T2-weighted MR imaging to confirm that no tumor, arteriovenous malformation, demyelinating disease, or other pathology was responsible for TN or HFS. Seven patients with TN refractory to medical treatment and four patients with HFS underwent MVD after further MR imaging studies described below.

II. MR imaging techniques
All studies were performed on a 1.5-T MR imaging system (Magnetom Vision; Siemens, Erlangen, Germany). All 22 patients underwent MR imaging using CISS-3DFT and three-dimensional fast inflow with steady-state precession (3D-FISP) sequences. Parameters for 3D-FISP were repetition time (TR): 37 msec, echo time (TE): 6.5 msec, flip angle: 20 degree, field of view (FOV): 230 mm, matrix: 192 × 512, slab thickness: 61 mm, number of partitions: 68, and acquisitions: 1. Parameters for CISS-3DFT were TR: 12.25 msec, TE: 5.9 msec, flip angle: 70 degree, FOV: 200 mm, rectangular FOV: 7/8, matrix: 224 × 512, slab thickness: 36 mm, number of partitions: 40, and acquisitions: 1. The center of the slab was the same in the two sequences. Axial images (0.9 mm contiguous sections) of the cerebellopontine angle (CPA) obtained by the two sequences were reviewed to assess the neurovascular relationships at the REZ of the trigeminal and facial nerves. Reconstructed 3D CISS MR images in the coronal, sagittal, and oblique sagittal planes were also obtained.

III. Review of MR images by two observers
Two observers (I.Y. and E.K.), blinded to the patient’s clinical diagnosis, independently reviewed the axial CPA images obtained by FISP and CISS sequences. For each imaging modality, the two observers answered either “yes” or “no” to the following six items: a) trigeminal nerve delineated; b) facial and acoustic nerves delineated; c) facial nerve differentiated from acoustic nerve; d) petrosal vein delineated; e) vascular contact with nerve demonstrated at the REZ; and f) deformity of the REZ demonstrated. The REZ was defined as the segments of the nerves within 5 mm from their exits from the brainstem. Deformity of the REZ was noted when both vascular contact with the nerve at the REZ and deformity at the REZ were present. According to the answers of the two observers, each item was categorized as “yes,” “equivocal,” or “no.” The item was considered equivocal when the answers of the two observers differed. Results obtained were analyzed statistically using chi-squared tests with Yates’ correction.

Results

I. Delineation of nerves and petrosal veins
The trigeminal nerve was depicted more clearly by CISS than by FISP because of the excellent CSF-nerve contrast provided by CISS (Fig. 1). FISP delineated the trigeminal nerve in 38 of 44 CPAs in 22 patients; 38 trigeminal nerves were categorized as “yes” and six as “equivocal” (Table 1). CISS delineated both trigeminal nerves in all 22 patients (44 nerves), significantly higher compared to FISP (p < 0.05). FISP delineated the facial-acoustic nerve group in only eight of 44 CPAs, whereas CISS delineated these nerves in all 44 CPAs in 22 patients (p < 0.01). FISP failed to delineate the facial and acoustic nerves because of poor CSF-nerve contrast. CISS identified the facial nerve as clearly separate from the acoustic (vestibulocochlear) nerve in the CPA and in the internal auditory meatus (Fig. 2). FISP usually failed to delineate the petrosal vein near the trigeminal nerve, although a large petrosal vein sometimes showed an equivocal high signal. CISS demonstrated the petrosal vein as a low intensity signal contrasting with the hyperintense CSF (Fig. 3). Reconstructed 3D CISS images depicted the course of the petrosal vein. The petrosal vein was delineated in two of 44 CPAs by FISP and in 32 of 44 CPAs by CISS (p < 0.01).

II. Vascular contact with nerve at REZ
FISP delineated vascular contact at the REZ in six of 14 symptomatic trigeminal nerves (43%) in 14 TN patients, whereas CISS demonstrated the contact in all 14 (p < 0.01) (Table 2). FISP delineated vascular contact with the nerve at the REZ in one of eight symptomatic facial nerves (13%) in eight HFS patients, whereas CISS showed the contact in five
Fig. 1 A 49-year-old female with right trigeminal neuralgia. Axial magnetic resonance images of the cerebellopontine angle at the level of the trigeminal nerve obtained by fast inflow with steady-state precession (FISP) and constructive interference in steady state (CISS) sequences. FISP image (left) showing the superior cerebellar artery (arrow) clearly as a high intensity signal because of the good contrast of the artery, but the trigeminal nerve is not delineated. CISS image (right) delineating the trigeminal nerve (arrowhead) clearly because of the excellent cerebrospinal fluid-nerve contrast.

Table 1 Delineation of nerves and petrosal veins by fast inflow with steady-state precession (FISP) and constructive interference in steady state (CISS) sequences

<table>
<thead>
<tr>
<th></th>
<th>&quot;Yes&quot;</th>
<th>&quot;Equivocal&quot;</th>
<th>&quot;No&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigeminal nerve</td>
<td>38/44</td>
<td>6/44</td>
<td>0/44</td>
</tr>
<tr>
<td>CISS</td>
<td>44/44*</td>
<td>0/44</td>
<td>0/44</td>
</tr>
<tr>
<td>Facial and acoustic nerves</td>
<td>8/44</td>
<td>26/44</td>
<td>10/44</td>
</tr>
<tr>
<td>CISS</td>
<td>44/44**</td>
<td>0/44</td>
<td>0/44</td>
</tr>
<tr>
<td>Facial nerve differentiated from acoustic nerve</td>
<td>44/44</td>
<td>0/44</td>
<td>0/44</td>
</tr>
<tr>
<td>Petrosal vein</td>
<td>2/44</td>
<td>6/44</td>
<td>38/44</td>
</tr>
<tr>
<td>CISS</td>
<td>32/44**</td>
<td>8/44</td>
<td>6/44</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01 compared with FISP.

Fig. 2 Axial magnetic resonance images of the cerebellopontine angle at the level of internal auditory meatus obtained by fast inflow with steady-state precession (FISP) and constructive interference in steady state (CISS) sequences, and the schema (lower). FISP (upper) and CISS images (middle) delineating the facial and acoustic nerves. The CISS image identifies the facial nerve (arrow) as clearly separate from the acoustic nerve (double arrow). The abduces nerve (arrowheads) is visible only on the CISS image. BA: basilar artery, BS: brainstem, SCC: semicircular canal.
A 51-year-old female with left trigeminal neuralgia. Axial magnetic resonance images of the cerebellopontine angle obtained by fast inflow with steady-state precession (FISP) and constructive interference in steady state (CISS) sequences, and the schema (right). FISP image (left) delineates the superior cerebellar artery (SCA) (arrows) compressing the trigeminal nerve clearly as a high intensity signal. However, the petrosal vein (arrowhead) is not conspicuous because small veins do not appear as a high intensity signal on FISP. CISS image (center) clearly delineates both the SCA and the petrosal vein as a low intensity signal within the hyperintense cerebrospinal fluid. FISP and CISS images demonstrate the vascular contact with the left symptomatic trigeminal nerve at the root entry/exit zone. BA: basilar artery, P: pons, V: trigeminal nerve.

Table 2 Identification of vascular contact with nerve at the root entry/exit zone by fast inflow with steady-state precession (FISP) and constructive interference in steady state (CISS) sequences

<table>
<thead>
<tr>
<th></th>
<th>“Yes”</th>
<th>“Equivocal”</th>
<th>“No”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptomatic trigeminal nerve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FISP</td>
<td>6/14</td>
<td>4/14</td>
<td>4/14</td>
</tr>
<tr>
<td>CISS</td>
<td>14/14</td>
<td>0/14</td>
<td>0/14</td>
</tr>
<tr>
<td>Symptomatic facial nerve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FISP</td>
<td>1/8</td>
<td>4/8</td>
<td>3/8</td>
</tr>
<tr>
<td>CISS</td>
<td>5/8*</td>
<td>3/8</td>
<td>0/8</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01 compared with FISP. †p<0.05 compared with the result in symptomatic facial nerve.

Table 3 Identification of deformity of the root entry/exit zone by fast inflow with steady-state precession (FISP) and constructive interference in steady state (CISS) sequences

<table>
<thead>
<tr>
<th></th>
<th>“Yes”</th>
<th>“Equivocal”</th>
<th>“No”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptomatic trigeminal nerve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FISP</td>
<td>0/14</td>
<td>2/14</td>
<td>12/14</td>
</tr>
<tr>
<td>CISS</td>
<td>4/14</td>
<td>2/14</td>
<td>8/14</td>
</tr>
<tr>
<td>Symptomatic facial nerve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FISP</td>
<td>0/8</td>
<td>0/8</td>
<td>8/8</td>
</tr>
<tr>
<td>CISS</td>
<td>0/8</td>
<td>1/8</td>
<td>7/8</td>
</tr>
</tbody>
</table>
(p < 0.05). Vascular contact at the REZ representing so-called "false positives" was identified in three nerves (10%) by FISP and in seven (23%) by CISS (p > 0.05) among 30 nonsymptomatic trigeminal nerves in 22 patients (14 nerves on the uninvolved sides in 14 patients with TN, and 16 nerves in eight patients with HFS). "False positive" vascular contact was identified in no nerves by FISP and in two (6%) by CISS (p > 0.05) among 36 nonsymptomatic facial nerves.

### III. Deformity of the REZ

Deformity of the REZ was delineated in no case by FISP and in four of 14 symptomatic trigeminal nerves by CISS (p > 0.05) (Table 3, Figs. 4 and 5). Neither CISS nor FISP delineated any deformity of the REZ in eight symptomatic facial nerves.

### IV. Preoperative MR imaging, surgical observations, and results

Eleven patients (seven with TN and four with HFS) underwent MVD after MR imaging studies
<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Vascular contact at REZ</th>
<th>Deformity of REZ</th>
<th>Offending vessel</th>
<th>Surgical results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>FISP</td>
<td>CISS</td>
<td>Surgery</td>
<td>FISP</td>
</tr>
<tr>
<td>1</td>
<td>M</td>
<td>lt TN</td>
<td>&quot;yes&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;equivocal&quot;</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>lt TN</td>
<td>&quot;yes&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>rt TN</td>
<td>&quot;equivocal&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>rt TN</td>
<td>&quot;yes&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>rt TN</td>
<td>&quot;no&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>lt TN</td>
<td>&quot;equivocal&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>rt TN</td>
<td>&quot;no&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>rt HFS</td>
<td>&quot;equivocal&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>lt HFS</td>
<td>&quot;equivocal&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>lt HFS</td>
<td>&quot;equivocal&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>lt HFS</td>
<td>&quot;yes&quot;</td>
<td>&quot;yes&quot;</td>
<td>yes</td>
<td>&quot;no&quot;</td>
</tr>
</tbody>
</table>

Fig. 6 A 70-year-old female with left trigeminal neuralgia (Case 6). Two contiguous axial constructive interference in steady state magnetic resonance (MR) images at the level of the trigeminal nerve (left, center), and the schema (right). The caudal loop of superior cerebellar artery (arrowhead in MR images, arrowheads in schema) compresses the root entry/exit zone (REZ) of the symptomatic trigeminal nerve. A groove (arrow) in the middle of the trigeminal nerve made by arterial compression contains hyperintense cerebrospinal fluid, demonstrating the deformity of the REZ. P: pons, V: trigeminal nerve.

Fig. 7 Case 6. Reconstructed three-dimensional oblique sagittal constructive interference in steady state magnetic resonance image (upper) and the schema (lower). Compression of the root entry/exit zone of the symptomatic trigeminal nerve by the caudal loop (arrowheads) of superior cerebellar artery (SCA) causes deformity of the nerve (arrow). ant. anterior, C: cerebellum, P: pons, PB: petrous bone, post.: posterior, V: trigeminal nerve.

using FISP and CISS sequences. The offending artery compressing the REZ was identified during surgery and surgical results were excellent with TN or HFS resolved completely in all patients (Table 4, Figs. 6–8). Preoperative MR imaging revealed vascular contact at the REZ in 4/11 cases using FISP and in 11/11 using CISS (p < 0.05). Preoperatively, CISS delineated deformity of the REZ in three patients with TN, which was confirmed at surgery. FISP did not detect deformity of the REZ in any patient. The offending artery identified during surgery was the superior cerebellar artery (SCA) in all seven patients with TN, and all seven offending arteries were correctly identified preoperatively by CISS. FISP identified only two of the seven arteries (p < 0.05). The offending artery identified during surgery was the posterior inferior cerebellar artery (PICA) in two patients with HFS [Cases 8 and 9], the anterior inferior cerebellar artery (AICA) in one patient [Case 10], and an arterial complex including the vertebral artery, AICA, and PICa in one patient [Case 11]. CISS correctly identified the offending artery but FISP did not in three cases. Neither FISP nor CISS correctly identified the arterial complex in Case 11.
Fig. 8  Case 6. Intraoperative photographs during microvascular decompression (upper row) and the schemas (lower row). The medial segment (asterisk) of the symptomatic trigeminal nerve is severely thinned down and is almost transparent (left column). Turning over the nerve using a microsurgical hook discloses the caudal loop of superior cerebellar artery (SCA) compressing the transparent segment of the nerve (right column). Preoperative assessment of the neurovascular relationships by constructive interference in steady state magnetic resonance images (shown in Figs. 6 and 7) completely coincided with the surgical observations. Trigeminal neuralgia completely resolved after surgery. P: pons, PV: petrosal vein, V: trigeminal nerve, VII: facial nerve.

Discussion

I. MR imaging techniques for assessment of TN and HFS

MR imaging is the most reliable method for assessment of TN and HFS, so preoperative use of CT and angiography have greatly decreased. Various MR imaging techniques have been reported for assessment of patients with TN and HFS. Conventional $T_1$- and $T_2$-weighted imaging can exclude multiple sclerosis and mass lesions that sometimes manifest as TN or HFS. Therefore, these conventional sequences are indispensable for routine preoperative assessment of patients with TN and HFS. However, the main role of preoperative MR imaging has shifted to the identification of abnormal neurovascular relationships at the REZ. The most common offending vessels are the SCA, AICA, and PICA.\cite{6,8,13,14} The maximum diameters of these arteries are less than 2 mm,\cite{10} and the arterial segment compressing the REZ may be as small as 1 mm or less in diameter. A large artery like the vertebral artery can be identified as a signal void,\cite{20} but conventional sequences will not show an artery of 1 mm in diameter as a signal void. The slice thickness of 3 mm in conventional $T_1$- and $T_2$-weighted imaging may miss vascular compression at the REZ by a small offending artery because of the partial volume effect, since the offending artery is small relative to the slice thickness. Therefore, these conventional...
sequences are not sufficiently sensitive to depict such neurovascular relationships.\textsuperscript{11,27,28,30}

II. FISP and CISS sequences for assessment of TN and HFS

FISP and spoiled gradient recalled sequences, routinely employed for MR angiography, have recently been advocated for evaluation of the neurovascular relationships in TN and HFS.\textsuperscript{2,5,9,16} The sections can be very thin (<1 mm) without gaps between sections, so high spatial resolution is accomplished. Furthermore, these sequences provide excellent contrast between the high signal intensity of arteries and the low signal intensity of CSF.\textsuperscript{19}

The CISS sequence provides a finely detailed cisternographic image in which the brain, nerves, and vessels appear with low signal intensity and are well delineated within the high signal intensity CSF.\textsuperscript{4,7} The contrast between the hypointense brain, nerves, and vessels and hyperintense CSF is excellent. CISS also provides high spatial resolution based on very thin sections with no intervening gaps. The parameters of CISS sequence (FOV: 200 mm, matrix: 224 $\times$ 512) may contribute to the higher spatial resolution compared to the FISP sequence in the present study.

The present study showed that CISS is superior to FISP for assessing the neurovascular relationships at the REZ in patients with TN and HFS. CISS was significantly superior to FISP for delineating the normal fine structure in the CPA and the abnormal neurovascular anatomy responsible for TN and HFS. CISS more clearly delineated the trigeminal nerve, facial and acoustic nerves, the petrosal vein, and vascular contact at the REZ. CISS also permitted more accurate identification of the offending artery in TN than FISP.

III. Delineation of nerves and veins

FISP images often lack CSF-nerve contrast in spite of the excellent contrast between hyperintense arteries and hypointense CSF.\textsuperscript{2,3,6} The trigeminal nerve is large enough to be delineated by FISP in most cases, but the facial and acoustic nerves are smaller and have more complex anatomical structure, and are not demonstrated by FISP. CISS can delineate the facial nerve separately from the acoustic nerve because of the excellent CSF-nerve contrast and high spatial resolution. In fact, CISS can identify four nerves within the internal auditory meatus: superior and inferior vestibular nerves, cochlear nerve, and facial nerve.\textsuperscript{4} CSF-movement compensation in CISS can abolish signal loss due to CSF flow in the CPA, and contribute to delineation of the fine anatomical structures in the CPA.\textsuperscript{4}

CISS delineates the petrosal vein more reliably than FISP. FISP clearly depicts an artery with rapid blood flow as a zone of high signal intensity, but does not delineate small veins like the petrosal vein because of the slow venous flow. In contrast, CISS depicts small arteries and veins as hypointense structures, and the petrosal vein appears in clear relief as a low intensity signal within the hyperintense CSF. The petrosal vein is differentiated from arteries by the drainage pattern that can be delineated by reconstructed 3D CISS images. FISP with gadolinium enhancement has been recommended to visualize small arteries and veins,\textsuperscript{15,16} but is relatively costly and carries the risk of side effects due to gadolinium administration.\textsuperscript{22} Interruption of the petrosal vein sometimes results in venous complications after MVD, and unexpected tearing of the vein during surgery may cause uncontrollable and catastrophic bleeding.\textsuperscript{20} Preoperative assessment of the petrosal vein is important for avoiding such complications in MVD. The petrosal vein can be the offending vessel in TN and HFS.\textsuperscript{1,3,14} CISS can identify a vein in contact with the REZ, but FISP cannot.

IV. Vascular contact and neurovascular relationships at the REZ

CISS delineated vascular contact with the symptomatic trigeminal nerves at the REZ in significantly more cases than FISP, including contact in all 14 patients with TN. Preoperative assessment of the neurovascular relationships at the REZ by CISS completely coincided with surgical observations in the seven patients with TN who underwent MVD. The offending vessel was the SCA in all cases, and CISS invariably implicated the SCA. CISS precisely and accurately delineated normal and abnormal neurovascular relationships at the REZ in all patients with TN.

Vascular contact at the REZ was clearly delineated by CISS in five of eight patients with HFS, a significantly lower detection rate than 14 of 14 patients with TN (p < 0.05). The REZ of the facial nerve is anatomically more complicated than that of the trigeminal nerve, including the vertebral artery, AICA, PICA, the flocculus, and facial and acoustic nerves. The offending vessel is often complex, as in our Case 11 in which an aggregate consisting of the vertebral artery, PICA, and AICA compressed the REZ of the facial nerve. The complicated neurovascular relationship at the REZ in cases of HFS remains difficult to delineate clearly by MR imaging.

CISS disclosed “false positive” vascular contact at the REZ in 23% of the nonsymptomatic trigeminal

_Neurol Med Chir (Tokyo) 40, November, 2000_
nerves and in 6% of the nonsymptomatic facial nerves. FISP demonstrated “false positive” vascular contact less frequently. “False positive” vascular contact of the trigeminal nerve has been observed at 6% to 30% in previous MR imaging studies. Postmortem studies reported that 3% to 35% of adults without TN or HFS had “false positive” vascular contact. Distortion and grooving of the nerve observed during surgery support the notion of compression rather than simple contact, with such compression or deformity being necessary to cause TN and HFS.

Deformity of the REZ was observed in four of 14 symptomatic trigeminal nerves by CISS. Deformity of the REZ delineated by preoperative CISS in three patients with TN was confirmed at surgery in all cases. Deformity of the REZ may be a unique finding in TN and is considered particularly important. The present CISS study observed no deformity of the REZ involving the facial nerve in patients with HFS. Deformity of the REZ of the facial nerve may be too subtle to be delineated by MR imaging, although often observed during MVD performed for HFS.

References

Neurol Med Chir (Tokyo) 40, November, 2000
magnetic resonance imaging visualizing vascular compression of the trigeminal or facial nerve. J Neurosurg 77: 379–386, 1992

Address reprint requests to: I. Yamakami, M.D., Department of Neurosurgery, Chiba University School of Medicine, 1–8–1 Inohana, Chu–ku, Chiba 260–8670, Japan.

Commentary

There is a direct correlation between surgical results and correct indication for surgery in patients suffering from trigeminal neuralgia and hemifacial spasm. Therefore, the better we understand the neurovascular relationships in such cases, the better we can plan the surgical treatment and predict the outcome. As we all know from our own experiences, preoperative neuroradiological assessment with magnetic resonance imaging includes a variety of problems: clear visualization not only of larger structures such as the trigeminal root, but also of smaller nerves with a more complex anatomical structure such as the facial and acoustic nerves; clear depiction of different vascular structures such as arterial loops and the petrosal vein; the necessity of using gadolinium in certain imaging techniques, to demonstrate not only a vascular contact with certain nerves, but also to furnish evidence of compression (deformity of structures) with high spatial resolution; and finally to recognize a "false positive" vascular contact. The authors have addressed all these problems in a well-designed and accurate study and have achieved clear results. They demonstrated that constructive interference in steady state-three-dimensional Fourier transformation magnetic resonance imaging is the best neuroradiological technique for preoperative examination. This is a most valuable contribution to the efforts of improving the accuracy of magnetic resonance imaging for neurosurgical purposes.

Hermut BerTalanFFy, M.D.
Department of Neurosurgery
Philips University Hospital
Marburg, Germany

The authors are congratulated for their beautiful work utilizing MR imaging techniques of CISS and FISP for defining anatomical details of the trigeminal nerve at the root entry zone as a preoperative diagnostic tool for MVD for trigeminal neuralgia and hemifacial spasm. At international scientific conferences, the use of this imaging method has been a common practice, however, in Japan it belongs to a rather pioneer work. If they could provide further information regarding the visualization rate of the petrosal vein by gathering the data from their affiliated hospitals using the same imaging techniques and sequences with different brand 1.5-T MR imaging machines, it would be more beneficial and informative.

Hiromichi Hosoda, M.D.
Department of Neurosurgery
Chigasaki Tokushukai Medical Center
Chigasaki, Kanagawa, Japan

The causative relationship between neurovascular compression and the development of trigeminal neuralgia and hemifacial spasms is not always clear in many clinical situations. Nevertheless, decompression of the nerves is widely used in neurosurgical procedures with good outcome in a large number of cases. The failure of surgery or recurrence after a period of relief is always very disappointing to the patient, since these are major invasive procedures. Also, surgical complications in these cases are harder to tolerate than other pathological conditions. Since the outcome depends on whether there is or is not true neurovascular compression, the certainty of the preoperative etiological diagnosis is absolutely crucial. Taking into account such points, one may consider the study as of utmost importance for neurosurgeons dealing with these conditions. The results are very enthusiastic and clearly exposed. The reader can easily realize that CISS sequences are superior to FISP as well as standard MRI sequences. One remark, however, should be made. CISS presented a higher frequency of false positive results on non-symptomatic individuals than FISP. This relatively higher rate of false positives may be dangerous if it occurs in

Neurol Med Chir (Tokyo) 40, November, 2000
symptomatic individuals as well. This would result in operating upon patients without actual neurovascular compression, which is the first step towards therapeutic failure. Nevertheless, this sequence has indeed new advantages in comparison to other ones and should be considered in the evaluation of nerves and vessels in the posterior fossae.

André G. Machado, M.D.
and Evandro de Oliveira, M.D.
Instituto de Ciências Neurológicas
São Paulo, Brasil

Neurol Med Chir (Tokyo) 40, November, 2000