Nerve atrophy and a small cerebellopontine angle cistern in patients with trigeminal neuralgia

Clinical article

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Object. The aim of this study was to provide information to help confirm the diagnosis of trigeminal neuralgia (TN) using MR imaging.

Methods. The authors evaluated atrophy of the trigeminal nerve, the cross-sectional area of the cerebellopontine angle (CPA) cistern, and the length of the cisternal segment of the trigeminal nerve on the affected side in 26 consecutive patients with TN who were treated using Gamma Knife surgery.

Results. The mean volume of the trigeminal nerve on the affected side was significantly smaller than the mean volume of the trigeminal nerve on the unaffected side (p < 0.001). Nerve atrophy was present in 25 patients (96.2%) on the affected side and in 1 patient on the unaffected side. The mean cross-sectional area of the CPA cistern on the affected side (188.5 mm²) was significantly smaller than the mean volume on the unaffected side (232.8 mm²) in 25 of the 26 patients (p = 0.001). The mean length of the cisternal segment of the trigeminal nerve on the affected side (7.9 mm) was significantly shorter than the mean length on the unaffected side (9.6 mm) in 25 of the 26 patients (p = 0.001).

Conclusions. Among the patients with TN, there was a statistically significant difference in the MR imaging findings of the affected side compared with the unaffected side of the trigeminal nerve. Atrophy of the trigeminal nerve and a small CPA cistern in patients with TN provides additional markers for the diagnosis of TN and helps confirm the diagnosis based on clinical examination. (DOI: 10.3171/2008.8.JNS08522)

Key Words • cerebellopontine angle cistern • Gamma Knife surgery • magnetic resonance imaging • nerve atrophy • trigeminal neuralgia

TRIGEMINAL neuralgia is believed to be caused by vascular compression and focal demyelination of the trigeminal nerve root, leading to the excitability of the involved nerve fibers. Eighty to 90% of all cases of TN are caused by neurovascular conflict between the trigeminal nerve and the surrounding blood vessels. Magnetic resonance imaging can assist in the visualization of the neurovascular conflict and thus help to confirm the diagnosis of TN. However, 25–49% of healthy control patients have the neurovascular conflict of a close proximity between the trigeminal nerve and blood vessel wall. Therefore, other factors present on MR imaging might aide in the diagnosis and improve our understanding of the pathophysiological causes of TN.

It has been suggested that morphological and volumetric changes occur in the affected trigeminal nerve and can also be visualized using MR imaging. Atrophy of the trigeminal nerve is found in most cases of TN and is likely secondary to structural abnormalities, such as axonal loss and demyelination. A significant volume difference between the affected and the unaffected side in patients with TN suggests nerve damage. Atrophy is one of the signs of nerve damage.

Rasche et al. reported that the volume of the CPA cistern on the affected side is smaller than the volume on the unaffected side. A smaller cistern with the descending tentorium cerebelli can cause a closer nerve-vessel relationship, and as a result, a higher incidence of neurovascular conflict is possible.

Magnetic resonance imaging has been used only for the evaluation of patients with symptomatic neuralgias. The diagnosis of TN is based on the clinical neurological examination, but the new high-resolution MR sequences and workstations for 3D reconstruction allow physicians to confirm the diagnosis of TN and modify treatment as needed. The purpose of the present study was to analyze the anatomical characteristics of the trigeminal nerve and the CPA cistern in association with TN using MR imaging.
Methods

Patient Population

Twenty-six patients with unilateral TN were treated using GKS at our center between January 2005 and December 2007. These patients were treated using GKS as the primary treatment modality. We excluded patients from the study who were treated previously using microvascular decompression or percutaneous ablation surgery. Two independent observers who were blinded to the symptomatic and nonsymptomatic sides retrospectively reviewed the MR imaging studies. Differences between the 2 observers were resolved by means of consensus. We separately performed bilateral measurement of the volume of the trigeminal nerves in the CPA cisterns, the cross-sectional area of the CPA cisterns, and the length of the cisternal segment of the trigeminal nerves in all patients.

Anatomical Measurements of the Trigeminal Nerve and CPA Cistern

Both T1- and T2-weighted MR images with a slice thickness of 1.5 mm and CISS images with 0.5 mm axial slices were used for the 3D reconstructions and treatment planning. The CISS imaging helped define the trigeminal nerve in the CPA cistern and provided a good contrast between the cerebrospinal fluid and the nerves because it was highly T2-weighted. The MR images were transferred to a workstation for postprocessing and analysis. Leksell GammaPlan software (Elekta Instruments AB) was used to reconstruct the sagittal and coronal images and to measure the volume of the trigeminal nerve.

The trigeminal nerve was outlined on the axial images for comparison with the 3D coronal and sagittal reconstructed images of the same section, and then their volumes were calculated (Fig. 1). The volume of the cisternal segment of the trigeminal nerve was measured to compare the affected side with the unaffected side. The cisternal segment of the trigeminal nerve emerges from the lateral pons at the REZ and passes through an opening in the dura mater (the porus trigeminus) to the Meckel cave. Nerve atrophy was defined when the size of the nerve was smaller than that of the contralateral nerve, which was determined by comparison of the nerve volume on the MR imaging studies.

The CPA cistern is a subarachnoid space filled with cerebrospinal fluid; it lies between the anterolateral surface of the pons and cerebellum, and the arachnoid membrane that rests on the posterior surface of the petrous bone. In the present study, the volume of the CPA cistern was calculated from the cross-sectional measurement of the same section of the REZ on the axial images (Fig. 2). Posteriorly, this area extends into the cerebellar floculus, and is separated on both sides by the basilar artery in the prepontine cistern. The picture archiving and communication system (INFINITT) was used to measure the cross-sectional area in the CPA cistern.

The length of the cisternal segment of the trigeminal nerve was also measured to evaluate the volume of the CPA cistern, even though on the axial scan the length is the anteroposterior width of the CPA cistern, on the same section from the REZ to the narrow aperture of the Meckel cave (Fig. 3).

Statistical Analysis

The volume of the trigeminal nerve, the cross-sectional area of the CPA cistern, and the length of the cisternal segment of the trigeminal nerve on both sides were compared using the t-test for dependent samples. All analyses were performed using SPSS Version 14.0 for Windows.
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**Results**

Twenty-six patients with unilateral TN (9 men and 17 women) with a mean age of 64.9 years (range 39–83 years) who were treated using GKS between January 2005 and December 2007 were included in this study. Twenty-one patients had right-sided TN and 5 had TN on the left side.

Twenty-four (92.3%) of the 26 patients had nerve atrophy, a small cross-sectional area in the CPA cistern, and a short cisternal segment of the trigeminal nerve on the affected side (Fig. 4). A significant difference was found between the affected side and the unaffected side with regard to nerve atrophy, the cross-sectional area of the CPA cistern, and the length of the cisternal segment of the trigeminal nerve (Table 1). One patient (3.8%) had nerve atrophy, but did not have a small CPA cistern on the affected side; another patient had a relatively small CPA cistern, but did not have nerve atrophy.

**Volume of the Trigeminal Nerve**

In patients with TN, the mean volume of the cisternal segment of the trigeminal nerve was 26.7 mm\(^3\) (range 8.5–58.5 mm\(^3\)) on the affected side and 44.2 mm\(^3\) (range 10.6–68.1 mm\(^3\)) on the unaffected side. The mean volume of the trigeminal nerve on the affected side was significantly smaller (39.6%) than the mean volume on the unaffected side (p < 0.001). Nerve atrophy was present in 25 patients (96.2%) on the affected side and in 1 patient on the unaffected side.

**Cross-Sectional Area of the CPA Cistern**

The mean cross-sectional area of the CPA cistern was 188.5 mm\(^2\) (range 104.1–284.7 mm\(^2\)) on the affected side and 232.8 mm\(^2\) (range 142.4–337.6 mm\(^2\)) on the unaffected side. The mean area of the CPA cistern on the affected side was significantly smaller (19.0%) than the mean area on the unaffected side (p = 0.001).

**Length of the Cisternal Segment of the Trigeminal Nerve**

The mean length of the cisternal segment of the trigeminal nerve on the affected side (7.9 mm) was significantly shorter (17.7%) than the mean length on the unaffected side (9.6 mm; p = 0.001). The mean length of the cisternal segment ranged from 4.9 to 14.2 mm on the affected side and from 6.7 to 12.8 mm on the unaffected side.

**Discussion**

Trigeminal neuralgia is a paroxysmal lancinating pain syndrome involving 1 or more branches of the trigeminal nerve. The presence of a vascular component has frequently been associated with TN, and neurovascular conflict has been proposed as the cause of this disorder.\(^1,16\) The constant pressure exerted by the pulsation of the blood vessel on the nerve leads to nerve demyelination. The neuralgic pain is believed to be the result of short circuits caused by demyelination.\(^10\) The use of high-resolution MR imaging with 3D reconstructions provides additional information to better understand the structure of the trigeminal nerve and associated vessels. Akimoto and colleagues\(^1\) reported that 3D images reconstructed from CISS imaging accurately depicted the compressing vessels, closely simulating intraoperative observations. Sindou and associates\(^16\) reported that in 96.7% patients, 1 or several offending vessels were identified under the operating microscope in a consecutive series of 579 patients with TN. However, despite the relatively large number of cases, there are some reports of patients with TN without evidence of neurovascular conflict; this percentage varies from 3.3 to 28.5%.\(^2,16,17\) Moreover, Magnaldi et al.\(^19\) reported that 25% of healthy control patients showed a close association between the trigeminal nerve and a

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**TABLE 1: Comparison of the anatomical measurements of the trigeminal nerve and CPA cistern on the affected and unaffected side in patients with TN**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Affected Side</th>
<th>Unaffected Side</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>vol of cisternal segment of trigeminal nerve (mm(^3))</td>
<td>26.7 (8.5–58.5)</td>
<td>44.2 (10.6–68.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>cross-sectional area of CPA cistern (mm(^2))</td>
<td>188.5 (104.1–284.7)</td>
<td>232.8 (142.4–337.6)</td>
<td>0.001</td>
</tr>
<tr>
<td>length of cisternal segment of trigeminal nerve (mm)</td>
<td>7.9 (4.9–14.2)</td>
<td>9.6 (6.7–12.8)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* Values are expressed as mean (range) unless otherwise indicated.

188.5 mm\(^2\) (range 104.1–284.7 mm\(^2\)) on the affected side and 232.8 mm\(^2\) (range 142.4–337.6 mm\(^2\)) on the unaffected side. The mean area of the CPA cistern on the affected side was significantly smaller (19.0%) than the mean area on the unaffected side (p = 0.001).
blood vessel. Kakizawa and colleagues\(^8\) reported that among 220 normal trigeminal nerves, 49% came in contact with blood vessels. Therefore, a diagnostic reference on MR imaging may aide in the diagnosis of TN.

The diagnosis of TN is limited by a poor understanding of its pathophysiology; currently, the diagnosis is based only on the clinical examination results. Magnetic resonance imaging is helpful in diagnosing TN by excluding mass lesions or multiple sclerosis and by providing useful information on neurovascular conflict at the REZ of the trigeminal nerve.\(^5^9\) With advanced MR imaging techniques using 3D reconstructed high-resolution CISS images, the pathological changes that occur in the affected trigeminal nerve can be visualized on a dedicated workstation.\(^11\) In addition, the quantitative analysis of the volume of the CPA cistern containing the trigeminal nerve and the blood vessels has been improved.\(^15\)

**Nerve Atrophy**

Demyelination of the trigeminal nerve at the REZ into the pons is the main pathological finding of TN due to nerve compression.\(^12\) The pathological findings of nerve samples from patients with TN show evidence of axonal loss, axonopathy, demyelination, dysmyelination, residual myelin debris, and collagen deposition.\(^16\) These findings suggest that nerve atrophy might be a late consequence of morphological tissue changes caused by chronic physical stress on the trigeminal nerve by vascular compression. Moreover, the findings related to the loss of nerve tissue can appear as nerve atrophy on MR images or gross findings. Up to 42% of symptomatic nerves have gross atrophy that can be directly visualized at surgery.\(^17\) Erbay et al.\(^4\) reported that trigeminal nerves on the symptomatic side were smaller than trigeminal nerves on the asymptomatic side in patients with severe TN. To demonstrate nerve atrophy on MR imaging, Herweh and associates\(^5\) used the diffusion tensor imaging–derived parameter FA in 7 healthy volunteers and 6 patients. It was suggested that an abnormally low FA might be a finding associated with nerve atrophy of the affected nerve, with neurovascular conflict within the REZ. The FA measures might be sensitive to tissue recovery with remyelination. Erbay et al.\(^4\) measured the cross-sectional area of the trigeminal nerve to evaluate nerve atrophy. However, a single cross-sectional area might not reflect the nerve atrophy, because the cross-sectional area is variable throughout the whole length of the nerve. In our study, we measured the volume of the cisternal segment of the trigeminal nerve and observed nerve atrophy on the symptomatic side in 25 of 26 patients by quantitative measurements obtained using 3D reconstructed CISS images. The volume of the trigeminal nerves on the affected side was 39.6% smaller than the volume of the trigeminal nerves on the unaffected side (p < 0.001). Therefore, nerve atrophy identified on MR imaging can be useful to confirm the diagnosis of TN.

**Small CPA Cistern**

The trigeminal nerve arises from the mid pons and courses through the superolateral portion of the CPA cistern. Rasche et al.\(^15\) suggested that a smaller CPA cistern might be associated with a higher incidence of neurovascular conflict between the trigeminal nerve and the surrounding vessels. The smaller volume of the cistern on the affected side in patients with TN is mainly due to a smaller Meckel cave and a descending tentorium cerebelli on that side. The CPA cistern is surrounded by an ambient cistern, preoptic cistern, and cerebellomedullary cistern. Measuring the real volume of the CPA cistern is not easy because the boundary of the CPA is not clear on MR images. Moreover, the neurovascular conflict usually occurs at the REZ in the CPA cistern, even though the main portion of the CPA cistern is the inferolateral portion of the cistern. We believed that it would not be accurate to measure the entire volume of the CPA cistern for the evaluation of a small CPA cistern in relationship to the symptomatic side of the affected nerve. The cross-sectional area at the same axial section of the REZ in the CPA cistern and the length of the cisternal segment of the trigeminal nerve were considered to be the volume of the CPA cistern associated with the nerve on the affected side. The results of this study showed that a significantly smaller volume of the CPA cistern was observed using high-resolution MR imaging on the affected side. The cross-sectional area of the CPA cistern on the affected side was 19.0% smaller than the area on the unaffected side (p = 0.001). In addition, the length of the cisternal segment of the trigeminal nerve on the affected side was 17.7% shorter than the length on the unaffected side (p = 0.001). Therefore, in the smaller CPA cistern, the opportunity for neurovascular conflict might be increased compared with the CPA cistern of normal size.

**Conclusions**

Atrophy of the trigeminal nerve and a small CPA cistern are relatively common MR imaging findings on the affected side of TN compared with the unaffected side. Their presence in patients with TN provides additional markers for the diagnosis of TN and helps confirm the diagnosis based on clinical examination.

**Disclaimer**

The authors do not report any conflict of interest concerning the materials or methods used in this study.

**References**

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