Three-Dimensional Short-Range MR Angiography and Multiplanar Reconstruction Images in the Evaluation of Neurovascular Compression in Hemifacial Spasm

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Purpose: To evaluate the diagnostic efficacy of three-dimensional (3D) short-range MR angiography (MRA) and multiplanar reconstruction (MPR) imaging in hemifacial spasm (HS).

Materials and Methods: Two hundreds patients with HS were studied using a 1.5T MRI system with a 3D time-of-flight (TOF) MRA sequence. To reconstruct short-range MRA, 6–10 source images near the 7–8th cranial nerve complex were processed using a maximum-intensity projection technique. In addition, an MPR technique was used to investigate neurovascular compression.

We observed the relationship between the root-exit zone (REZ) of the 7th cranial nerve and compressive vessel, and identified the compressive vessels on symptomatic sides. To investigate neurovascular contact, asymptomatic contralateral sides were also evaluated.

Results: MRI showed that in 197 of 200 patients there was vascular compression or contact with the facial nerve REZ on symptomatic sides. One of the three remaining patients was suffering from acoustic neurinoma on the symptomatic side, while in two patients there were no definite abnormal findings. Compressive vessels were demonstrated in all 197 patients; 80 cases involved the anterior inferior cerebellar artery (AICA), 74 the posterior cerebellar artery (PICA), 13 the vertebral artery (VA), 16 the VA and AICA, eight the VA and PICA, and six the AICA and PICA. In all 197 patients, compressive vessels were reconstructed on one 3D short-range MRA image without discontinuation from vertebral or basilar arteries. 3D MPR studies provided additional information such as the direction of compression and course of the compressive vessel.

In 31 patients there was neurovascular contact on the contralateral side at the 7-8th cranial nerve complex.

Conclusion: In patients with HS, 3D short-range MRA and MPR images are excellent and very helpful for the investigation of neurovascular compression and the identification of compressive vessels.

Index words: Magnetic resonance (MR), vascular studies Brain, MR Nerves, facial

Hemifacial spasm (HS) is a complex of symptoms of hyperactive dysfunction of a unilateral facial nerve and is characterized by involuntary, paroxysmal, painless contractions of the muscles innervated by the seventh cranial nerve. It typically begins in midlife as an intermittent twitching of facial muscles around one eye (orbicularis oculi). The patient may enjoy asymptomatic periods early in the course of hemifacial spasm, but eventually twitching recurs and gradually
progresses in severity and frequency and spreads downward to include all the muscles of facial expression, including the platysma and stapedius muscles\(^1,\ 2\). It is now widely accepted that compression of the facial nerve near its root exit zone (REZ) on the caudal brain stem by loops of otherwise normal-appearing vessels is the most frequent cause\(^3\). It has been claimed that the posterior inferior cerebellar (PICA), anterior inferior cerebellar (AICA) or vertebral arteries (VA) and less commonly the cochlear or basilar arteries (BA) or veins are responsible for HS\(^4-6\). It is, though, rarely caused by tumors, aneurysms or arteriovenous malformation in the cerebellopontine angle\(^2\).

Investigation of vascular compression by imaging has evolved from conventional arteriography, via CT, to MRI. Conventional arteriography and CT are inadequate to delineate the facial nerve in relation to smaller vessels, as are routine spin echo (SE) MRI techniques. To investigate neurovascular compression we used three-dimensional (3D) short-range MR angiography (MRA) including multiplanar reconstruction (MPR), thus demonstrating the MR findings of hemifacial spasm and efficacy of these MR sequences.

The purpose of this study was to evaluate the efficacy of 3D short-range MRA, including MPR, in the diagnosis of HS.

Materials and Methods

Two hundred patients with HS were studied using 3D time-of-flight (TOF) MRA. A hundred and twenty-four were women and 76 were men, and they were aged 23–75 (mean, 48) years. All examinations were performed using a superconductive system operating at 1.5T (Magnetom Vision; Siemens, Erlangen, Germany). To exclude the possibility of other organic lesions, routine T1-weighted SE (TR/TE = 600/12) and T2-weighted SE images (TR/TE = 3800/90) were first obtained. For MRA, 3D fast imaging with steady-state precession (FISP) sequencing and magnetization transfer saturation was then used, with the following parameters: TR/TE = 35/6, 25° flip angle, 113–132 × 256 matrix, 150 × 200 mm FOV, 1 mm thickness.

Initial axial source images were reviewed, and to reconstruct 3D short-range MRA, six to ten of these near the 7–8th cranial nerve complex were processed using a maximum-intensity projection (MIP) technique (Fig. 1). In addition, an MPR technique was used to investigate neurovascular compression. On symptomatic sides we observed the presence of neurovascular contact in the facial nerve root exit zone (REZ), the relationship between REZ of the facial nerve and com-

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**Fig. 1.** Patient with left sided HS.

A. Initially obtained axial source images.

B. After review of the axial source images, six to ten images near to facial nerve were used for reconstruction of 3D short-range MRA using maximum-intensity projection technique.

This patient with left sided hemifacial spasm (HS) showed compression at left facial nerve (FN) root exit zone (REZ) by anterior inferior cerebellar artery (AICA).
pressive vessel, the displacement of nerves, and brain stem indentation near the facial nerve REZ, and identified the compressive vessel by means of 3D short-range MRA and MPR images.

To investigate neurovascular contact, asymptomatic contralateral sides were also evaluated.

**Results**

In 197 of 200 patients (98.5%) with 3D short-range MRA there was vascular compression or contact at the facial nerve REZ on symptomatic sides, and in all cases this was caused by arteries (Fig. 2). In one of the remaining three patients acoustic neurinoma was identified on the symptomatic side, while in two there was no definite abnormal finding (Fig. 3) (Table 1). There was no aneurysm or arteriovenous malformation in the cerebellopontine angle. The left side was affected in 104 patients and the right in 96; compressive vessels were identified in all 197 patients, as follows: AICA, 80

<table>
<thead>
<tr>
<th>Table 1. Causes of HS for the Symptomatic Side (n=200)</th>
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<tbody>
<tr>
<td>Cause of HS</td>
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<tr>
<td>Arterial vascular compression</td>
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<tr>
<td>Acoustic neurinoma</td>
</tr>
<tr>
<td>No abnormal finding</td>
</tr>
<tr>
<td>Case No. (%)</td>
</tr>
<tr>
<td>197 (98.5%)</td>
</tr>
<tr>
<td>1 (0.5%)</td>
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<tr>
<td>2 (1%)</td>
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| HS : Hemifacial Spasm |

Fig. 2. Patient with typical finding of HS.
Three-dimensional short-range MRA of a patient with left sided HS showed vascular compression at left FN REZ by vertebral artery (VA).

**Fig. 3.** Patients without arterial vascular compression at FN REZ.
**A. B.** T1-weighted coronal image (A) and 3D short-range MRA (B) show compression of right FN REZ and brain stem indentation by mass adjacent cerebellopontine angle. The mass was confirmed to acoustic neurinoma after surgery.
**C.** This another patient had right sided HS. But 3D short-range MRA showed no high signal intensity vessel near the right FN REZ.
basilar arteries, as seen as one 3D short-range MRA image. Three-dimensional MPR studies provided additional information such as the direction of compression and the course of compressive vessels (Fig. 5). In most patients, the direction of compression was ventrocaudal and compressive vessels ran at right angles to the nerve. Brain stem indentation and displacement of the facial nerve REZ were found in 117 (58.5%) and 110 (55%) patients, respectively.

Thirty one cases of neurovascular contact occurred on the asymptomatic contralateral side; vascular diameter was smaller than on affected sides and there was no cranial nerve displacement or brain stem indentation (Fig. 6).

Microvascular decompression was performed in 120 of 200 patients; arterial vascular compression in the facial nerve REZ was observed in all these 120. During surgery, preoperatively evaluated compressing arteries were correctly identified in 107 patients (89%), partially correctly in eight (7%), and incorrectly in only five (4%).

**Discussion**

The central medullary cranial nerve sheath, composed of oligodendrocytes, merges into the strong peripheral medullary sheath of Schwann cells as it exits the brain stem; when the medullary sheath is deficient, this site—known as the “root entry zone” or “junctional area” (root exit zone)—sustains a great deal of stimulation. Neurovascular compression syndromes are thought to result from continuous compression of cranial nerves at the root exit zone by sclerotic arterial vessels (4, 7).

Two theories concerning the pathogenesis of spontaneous HS have received the strongest support. The first proposes that there is communication between adjacent axons of the facial nerve at the point of compression, perhaps secondary to demyelination; a false

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### Table 2. Arteries Compressing 7–8th Nerve REZ on the Symptomatic Side \( (n=197) \)

<table>
<thead>
<tr>
<th>Compressing Arteries</th>
<th>No. of Patients</th>
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<tbody>
<tr>
<td>AICA</td>
<td>80</td>
</tr>
<tr>
<td>PICA</td>
<td>74</td>
</tr>
<tr>
<td>VA</td>
<td>13</td>
</tr>
<tr>
<td>VA and AICA</td>
<td>16</td>
</tr>
<tr>
<td>VA and PICA</td>
<td>8</td>
</tr>
<tr>
<td>AICA and PICA</td>
<td>6</td>
</tr>
</tbody>
</table>

AICA: Anterior Inferior Cerebellar Artery  
PICA: Posterior Inferior Cerebellar Artery  
VA: Vertebral Artery

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**Fig. 4.** Patient with compression at FN REZ by two different vessels.  
Left FN REZ were compressed by two high signal intensity vessels on 3D short-range MRA. One is VA and the other is AICA.

**Fig. 5.** Patient with HS on 3D MPR images.  
Three-dimensional MPR oblique coronal images of two different patients with HS showed vascular contact at FN REZ with acute angle between compressive vessel and 7–8th cranial nerve complex, and ventrocaudal direction of compressive vessels. One is by left PICA (A) and the other is by right PICA and VA (B). These images, however, have limitation for identification of name of compressive vessels (asterisk: pons, short arrow: 7–8th cranial nerve complex).
Fig. 6. Arterial vascular contact on asymptomatic side. On 3D short-range MRA, bilateral arterial vascular contacts at both FN REZ were seen by both AICA. Right AICA was larger than left AICA in diameter. This patient had right sided HS.

Synapse (ephapse) is thus formed. Such ectopic excitation and ephaptic transmission result in an abnormal conduction of impulses through the peripheral portion of the facial nerve. The second theory proposes that the important pathophysiologic changes in HS occur within the facial motor nucleus, but also suggests that this can result from peripheral stimulation such as vascular compression (2).

In the past, assessment of patients with HS consisted of CT and/or conventional angiography. CT, however, is of limited utility in the evaluation of the posterior fossa and the first portion of the seventh nerve, while conventional angiography is invasive and fails to show the exact relationship between nerves and blood vessels. Because MRI clearly depicts the course of the 7th nerve from the REZ to the internal auditory canal and the relationship of this nerve to the vertebrobasilar system, it is now thought to be the best initial screening procedure in all patients with HS.

For the following reasons, the facial nerve and adjacent responsible vessels can be visualized more clearly on 3D FISP images than on SE images: (a) without an intersection gap, sections of 3D FISP images (source images) are very thin, and (b) the cranial nerves, CSF, and fast-flowing blood are shown as iso-, hypo-, and hyperintense to brain parenchyma, respectively (1). Our 3D short-range MRA gives more information, such as the identity of compressive vessels, without discontinuation from the parent vessel.

Some authors have emphasized that mere contact between a vessel and the REZ of the facial nerve is not sufficient to cause symptoms, but that the REZ must be compressed or deformed by the vessel (4, 8). The factors which produce arterial loops at the 7—8th cranial nerve REZ are not known, though anatomical studies (9) have shown correlation with old age and the possible influence of flow factors on displacement of the basilar artery. It has also been shown that the vessel which crosses the peripheral portion of the facial nerve or runs parallel to it dose not cause hemifacial spasm (4). Du et al (1) reported that the criteria that compressive vessels should run at right angles to the nerve before contacting and deforming the REZ were useful for differentiation between substantial and nonsubstantial compression. In most cases of HS, the direction of compression was ventrocaudal (1). Using 3D short-range MRA, our findings indicated that in more than 50% of 200 patients with HS the 7—8th cranial nerves were displaced and the brain stem indented near the REZ. These findings support those of earlier research, except in that vascular contact in the REZ, without cranial nerve displacement or brain stem indentation, may or may not induce HS.

Du et al (1) reported that the relationship between nerves and vessels is in some cases difficult to evaluate by means of transversely orientated 3D FISP imaging; the use of the MPR algorithm or oblique sagittal orientation might well improve the precision of evaluation (10, 11). Our 3D MPR studies provided additional information such as the direction of compression and the course of the compressive vessel.

In patients with HS, 3D short-range MRA and MPR images are excellent for the investigation of neurovascular compression and identification of compressive vessels and do not suppress tissue background. If, however, the compressing vessel was tortuous, cranio-caudal length was more than 1 cm and CSF space was shallow, the excessive condensation of 3D short-range MRA images resulted in mildly decreased spatial resolution between the 7—8th cranial nerves, cerebello-pontine angle system and pons. The use of more than two sessions of MIP processing with different axial source images compensated for this drawback, and so identification of the compressing vessel and demonstration of its relationship with the facial nerve were not impossible. Surgical correlation was not the purpose of our study, but surgical findings showed that the identification of compressing vessels was highly reliable (115/120, 96%). The compressing vessel was incorrectly identified in only five cases (4%), and these
occurred during the early stages of our study. In 114 (95%) of 120 patients who underwent microvascular decompression, symptoms improved significantly. Even when there was vascular contact at the REZ, cranial nerve displacement and brain stem deformity were not seen on the asymptomatic contralateral side. In addition, vascular diameter in these patients was less than on the affected side.

In conclusion, 3D short-range MRA, including MPR images, is excellent and very useful for the preoperative evaluation of patients with HS, not only for detection of the cause of HS but also for the identification of compressive vessels and the relationship between them and the 7–8th cranial nerve.

References


한국방사선의학회지 1998; 39:237-242

편측안면연축 환자에서 삼차원 소 영역 MR혈관조영상과 다 평면재구성(MPR) 영상을 통한 신경 압박의 평가

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최우석 · 김의종 · 이재규 · 이봉암

목 적: 편측안면연축 환자에서 삼차원 소 영역 MR혈관조영상(MRA)과 다 평면재구성(MPR) 영상의 진단적 효용성을 알아보고자 하였다.

대상 및 방법: 200명의 편측안면연축 환자를 대상으로 1.5T MRI기종을 이용하여 삼차원 time-of-flight (TOF) MR혈관조영상으로 분석하였다. 7~8번째 두개신경 복합체 근처에서 얻은 6~10개 척도의 근원영상은 최대강도 투사방법을 이용하여 삼차원 소 영역 MR혈관조영상으로 재구성하였으며, 신경 압박을 평가하기 위하여 다 평면재구성 방법이 추가되었다. 증상이 있는쪽의 7번째 두개신경의 root-exit zone(REZ)과 압박 혈관과의 관계를 관찰하였으며 그 혈관명을 확인하였다. 그리고, 무증상인 반대측도 동일한 방법으로 분석하였다.

결 과: 200명의 편측안면연축 환자중 197명이 증상이 있는쪽의 안면신경 REZ와 혈관 압박 또는 접촉을 보였 다. 나머지 3명 중 1명은 청신경초종이 원인되었으며 2명은 이상소견을 보이지 않았다. 압박혈관은 197명 모두에서 확인되었는데, 전하소뇌동맥은 80명, 후하소뇌동맥은 74명, 척추동맥은 13명, 척추동맥과 전하소뇌동맥은 16명, 척추동맥과 후하소뇌동맥은 8명, 전하소뇌동맥과 후하소뇌동맥은 6명이었다. 197명 모두에서 압박혈관은 삼 차원 소 영역 MR혈관조영상의 한 영상에서 척추동맥이나 기저동맥으로부터 끊어짐 없이 재구성되었으며, 삼 차원 다 평면재구성 기법은 압박의 방향이나 압박혈관의 주행등과 같은 추가정보를 제공하였다.

무증상의 반대측에서도 31명이 7~8번째 두개신경 복합체와 신경혈관 접촉을 보였다.

결 론: 삼차원 소 영역 MR혈관조영상과 다 평면재구성 영상은 편측안면연축 환자에서 신경혈관 압박을 평가하고 그 혈관명을 확인하는데 매우 유용한 것으로 사료된다.

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