The Usefulness of the 3-D Overlapped Reconstruction MR Angiographic Technique in Patients with Hemifacial Spasm - A Preliminary Study

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Purpose : To investigate the applicability of the new three-dimensional overlapped reconstruction MR angiography (3-D ORMRA) technique in patients with hemifacial spasm and to compare the new 3-D reconstruction images with conventional MRA source images.

Materials and Methods : The study group comprised 27 patients with surgically proven hemifacial spasm. In all patients, conventional MRA source images and 3-D fast imaging employing steady-state acquisition (FIESTA) images were obtained prospectively. After 3-D MR angiographic images were obtained, the 3-D MRA and FIESTA images were overlapped at the workstation by using GE A/W 4.2 add/sub software. We analyzed the relationship between the offending vessels and root exit zone of the facial nerve using both 3-D ORMRA images and conventional MRA source images.

Results : In 25 of 27 patients, the offending vessel at the REZ of the facial nerve could be correctly identified on conventional MRA source images. In all patients, the presumed offending vessels depicted by the overlapped 3-D reconstruction MRA image corresponded well with the intraoperative findings. The 3-D reconstruction image showed more clear visualization of the spatial relationship between the offending vessels and the root exit zone of the facial nerve.

Conclusion : The overlapped 3-D reconstruction MR angiography technique is very useful and informative in patients with hemifacial spasm, as compared with conventional MRA angiography technique.

Index words :Magnetic resonance (MR), technology
Magnetic resonance (MR), angiography

Introduction

Vascular compression of the root exit zone of the facial nerve has been demonstrated as a major cause of hemifacial spasm (HFS). Therefore, microvascular decompression of the facial nerve has been established as one of the standard treatments for HFS (1 - 4). The

JKSMRM 11:33-38(2007)

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Received; April 10, 2007, acceepted; May 28, 2007

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precise preoperative assessment of the complex nerve-vessel relationship at the root exit zone of the facial nerve is important when planning microvascular decompression in patients with HFS. Recent advances in high-resolution MR imaging have made it possible to evaluate neurovascular compression using source images from three-dimensional 3-D time-of-flight MR angiography (5 - 7). Moreover, 3-D fast imaging employing steady-state acquisition (FIESTA) sequences have high contrast resolution and can provide excellent visualization of the root exit zone of the cranial nerve (8 - 11). Due to the 2-D nature of these source images, however, it may be difficult to identify the facial nerve and conflicting vessels, even the root exit zone.

A new 3-D reconstruction MR imaging technique has recently been developed and involves overlapping the 3-D MR angiography image and the FIESTA image. The purpose of this study was to evaluate whether this new 3-D reconstruction method could be applicable to patients with HFS and to compare the new 3-D MR reconstruction image with conventional MRA source images.

Materials and Methods

Patients

A total of 27 patients with HFS (16 women and 11 men; age range, 22 - 70 years; mean age, 49 years) were included in our study. All patients underwent preoperative and postoperative MR imaging. Patients with symptomatic HFS caused by tumor, multiple sclerosis or other vascular lesions were excluded from this study. All patients were treated by microvascular decompression surgery.

The study protocol was approved by the institutional review board, and informed consent was obtained from each patient.

MR Imaging Sequence

Conventional MR angiography source image

MR angiography imaging was performed using a GE Signa Excite, 1.5-T MRI System (General Electric Medical Systems, Milwaukee, WI. USA). Baseline data (axial source images) were obtained using 3-D time-of-flight MRA with spoiled gradient recalled acquisition in the steady state sequence (SPGR) (TR, 33 msec; TE, 6.9 msec; number of excitations, 1; flip angle, 25 degrees; matrix, 192x192; field of view, 21 cm; slice thickness, 0.8 mm; slice spacing, 0.4 mm overlap). A total of 120 continuous source images were obtained. The acquisition time was 5 minutes 33 seconds.

Fast imaging employing steady-state acquisition (FIESTA) image

A 3-D FIESTA sequence for visualization of cranial nerves in the cranial base was added to the routine MRI scan to improve the treatment planning for hemifacial spasm. This was performed with the same GE machine. The sequences included the following parameters: TR, 4.1 msec; TE, 1.4 msec; number of excitations, 4; flip angle, 45 degrees; bandwidth, 62.5; field of view, 21 cm; matrix 256×256; slice thickness, 0.8 mm; slice spacing, 0.4 mm overlap. The acquisition time was 4 minutes 29 seconds.

The 3-D MRA images using maximum intensity projection algorithms

MRA axial source image data were transferred to a workstation running the Advantage Windows software (version 4.2; General Electric Medical Systems, Milwaukee, WI, USA). The 3-D MRA imaging was performed using maximum intensity projection algorithms and was centered on the REZ of the facial nerve.

Overlapped 3-D reconstruction MR angiography techniques

The reconstruction image formed by overlapping the FIESTA MRI and 3-D MRA images was constructed at the same workstation. The most valuable 3-D FIESTA image was selected to in order to evaluate the facial nerve root exit zone (REZ). The selected FIESTA and 3-D MRA images were then combined using the add/sub software GE A/W version 4.2. Before the images were combined, the DFOV of the two images was decreased to 13 cm. Thus, a more focused image at the nerve REZ was acquired. It usually took about one minute for each image to process.

Image Analysis

In all patients with HFS, conventional 2-D MRA source images and overlapped 3-D reconstruction MR angiography images were constructed prospectively, and the images were compared by two experienced

neuroradiologists. The conspicuity of the vascular course and morphology of the offending vessels in HFS were compared with two different images and confirmed by post-operative records.

Results

The pathologically offending vessels at the REZ of the facial nerve were as follows: the anterior inferior cerebellar artery (AICA) in 16 cases, posterior inferior cerebellar artery (PICA) in 9 cases, and the vertebral artery (VA) in 2 cases. These lesions were confirmed intraoperatively (Table 1). The results of the microvascular decompression were reported as good in all patients.

On conventional 2-D fashioned axial source images, the offending vessel at the REZ of the facial nerve could be correctly identified in 25 cases (92.6%). The overlapped 3-D reconstruction MR angiographic images, however, were of acceptable quality for the correct identification of the offending vessels in all of the cases. The offending vessels at the REZ of the facial nerve identified in preoperative imaging with overlapped 3-D reconstruction MR angiographic images were in good agreement with those observed in the post-operative records. In addition, the overlapped 3-D reconstruction MR angiographic images demonstrated the spatial relationship between the offending vessels and the REZ of the facial nerve more clearly and with greater ease than the conventional MRA source image (Fig. 1).

Discussion

In this study, we demonstrated that the overlapped 3-D reconstruction MR angiography image showed the spatial relationship between the offending vessels and the REZ of the facial nerve more clearly than those of the 2-D MRA source image in patients with HFS.

Vascular compression at the REZ of the facial nerve is generally accepted as the primary cause of most cases of HFS. The AICA, PICA, VA and, less commonly, the basilar artery or veins have been described as the vessels responsible for the compression of the facial nerve (1-4). It is important for the detection of the presence of the causative vessels in patients with HFS not only for the differential diagnosis of this disease from other

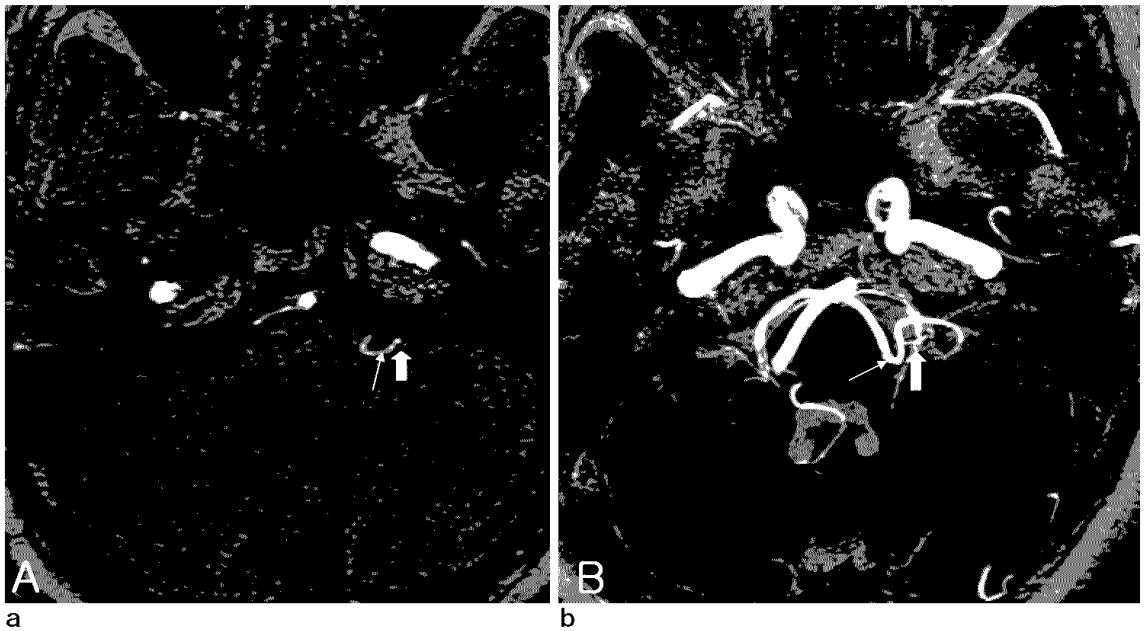

Fig. 1. Conventional MRA axial source image (**a**) and 3-D overlapped reconstruction image (**b**) in a 47-year-old woman with left hemifacial spasm. (**a**) The 2-D axial MRA source image shows a high intensity dot area (left PICA-arrow) that appear to be in contact with the REZ of the left facial nerve (thick arrow). (**b**) The overlapped 3D reconstruction image demonstrates that the REZ of the left facial nerve was compressed by the second and third loops of the left PICA (arrow), which are attached to the REZ of the left facial nerve (thick arrow).

diseases, but also to enhance the efficacy of decompression surgery. For this purpose, there have been a number of advances in MR imaging techniques.

Previous studies using 3-D constructive interference in steady state (CISS) or 3-D FIESTA were reported to provide good contrast between cerebrospinal fluid and nerves because these techniques are highly T2-weighted (8-12). It has been suggested that preoperative CISS MR imaging precisely demonstrated the neurovascular relationships at the REZ and correctly identified the offending artery in all seven patients with trigeminal neuralgia undergoing MVD (9). Another report also showed that the 3-D FIESTA sequence successfully demonstrated the trigeminal complex in 14 (93.33%) out of a total of 15 consecutive patients (11) and the facial nerve in 100% of patients in another report (12). Our study also showed that the facial nerve and the nerve-vessel complex at the REZ of the facial nerve in the cerebellopontine angle were depicted simultaneously on 3-D FIESTA images in all patients. The facial and vestibulocochlear nerves were identified separately based on their origin in the internal auditory canal and their course toward the nerve rootlets at the brain stem. The vessels were identified by tracing the vessels to their origin. However, because the vessels and the nerves showed similar low signal intensities on 3-D FIESTA images they were not easily distinguishable.

The 3-D TOF MRA from the SPGR or fast inflow with steady state precession (FISP) sequences image has been reported to be useful in evaluating patients with HFS (5-8). In a previous report, the diagnostic accuracy of MRA was a sensitivity of 95% and specificity of 77% (6). In another report, that was 92% and 86%, respectively (7). It has also been reported that, in 197 of 200 patients (98.5%) with hemifacial spasm, the preoperative 3-D short range MRA demonstrated the causative vessels of HFS, and additional multiplanar reconstruction studies provided supplementary information such as the direction of compression and course of the offending vessel (8). In our study, the sensitivity of MRA was 92.6% and this result was similar to that of the previous study. The conventional MRA source image, however, did not display the facial nerve as clearly as the 3-D FIESTA images. Therefore, we could not accurately understand the spatial relationships between the facial nerve and offending vessels using 2-D fashioned MRA source images.

Both 3-D FIESTA and 3-D MRA are useful sequences for the evaluation of neurovascular compression in HFS. However, they are complementary. The 3-D FIESTA images in the present study could not clearly distinguish between nerves and vessels. These results are consistent with those of the previous study, which reported that 3-D CISS images could not differentiate nerves from vessels by signal intensity in the cerebellopontine angle cistern (13). MRA images only show the vessels at high signal intensity, and the contrast resolution between the cerebrospinal fluid and the nerve is somewhat unclear (14). Although MRA source images show high diagnostic accuracy of causative arteries, the images are not suitable for the visualization of nerves.

Three-dimensional reconstruction images that demonstrate a clear spatial relationship between the vessels and the REZ of the nerve can provide useful information for the planning of MVD surgeries. Several studies have recently reported the usefulness of 3-D images reconstructed with the use of a surface rendering method involving spoiled gradient recalled acquisition in steady state MRI scans in patients with trigeminal neuralgia or HFS (5). Recent reports have also demonstrated the usefulness of 3-D reconstruction using two types of MRI scans (3-D FISP and 3-D CISS images) in patients with trigeminal neuralgia (13). They used a volume rendering method that is superior to a surface rendering method for the visualization of the spatial relationship. In addition, virtual endoscopic images by 3-D fast asymmetric spin echo cisternography for neurovascular compression could allow for surgical simulation (15). However, a relatively long period of one to two hours was acquired to generate the virtual endoscopic images in each case. We acquired 3-D FIESTA images and 3-D MRA from conventional MRA axial source images in patients with HFS. The 3-D reconstruction image was constructed by combining the two images.

As in the precedent study, our new technique can provide a higher degree of spatial resolution than two-dimensional images. It usually took about one minute for each image to process, which is a relatively short period of time in comparison to that associated with virtual endoscopic images. A previous study pointed out that axial MRI scans could not reveal the

pontomedullary junction or an offending vessel located caudally at the pontomedullary junction (16). Therefore, they suggested that oblique sagittal images showed the degree of vascular compression more exactly when the offending vessels had an upward compressing vector to the brain stem or REZ, as compared to a simple axial 3-D image. By developing a 3-D reconstruction technique involving the overlapping of 3-D FIESTA and 3-D MRA images, we could overcome the limitations associated with axial source images of conventional MRA.

We did not use contrast medium in MRA. Other reports, however, showed that contrast-enhanced MRA can enhance the depiction of vessels with relatively slow-flow velocities, due to the T1 signal shortening effect of the intravascular paramagnetic agents, and that this method can distinguish arteries from veins (17). Contrast-enhanced MRA is effective for the visualization of distal arterial branches and small veins. In our study, possible offending veins were not evaluated, which is a limitation of our study. Although most causative vessels of HFS are arteries, contrast enhancement may be necessary for evaluating patients with suspected venous compression.

In conclusion, the images obtained using the 3-D overlapped reconstruction MR angiography technique have higher spatial resolution than those of conventional MRA source images in patients with HFS and are very informative in the preoperative evaluation of HFS.

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대한자기공명의과학회지 11:33-38(2007)

반얼굴 연축 환자에서 삼차원 중첩 자기공명 혈관 조영술 기법의 유용성-초기 보고

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목적: 반얼굴 연축 환자에서 새로운 삼차원 중첩 자기공명 혈관조영술 기법(3-D overlapped reconstruction MR angiographic technique, 3-D ORMRA)을 기존의 MRA 원천영상과 비교하여 그 유용성을 알아보고자 하였다.
대상 및 방법: 수술로 반얼굴 연축이 증명된 총 27명을 대상으로 하였다. 모든 환자에서 전향적으로 기존의 MRA 원천영상과 3-D fast imaging employing steady state acquisition (FIESTA) 영상을 얻었다. 이 후 작업대 (work-station)에서 3-D MRA 영상을 만들고 GE A/W 4.2 add/sub software를 이용하여 이를 FIESTA영상과 겹쳐 3-D ORMRA영상을 얻었다. 그리고 나서 기존의 MRA 원천영상과 3-D ORMRA영상에서 각각 얼굴신경의 신경근출구부와 병적 압박혈관 사이의 관계를 분석하였다.
결과: 기존의 MRA원천영상에서는 27명중 25명의 환자에서 얼굴 신경근출구부에서의 병적 압박혈관을 구별 할 수 있었고, 3-D ORMRA영상에서는 모든 환자에서 병적 압박혈관을 구별 할 수 있었으며, 이는 수술소견과 일치하였다. 무엇보다 3-D ORMRA영상에서 얼굴 신경근출구부와 병적 압박혈관사이의 공간적인 관계를 좀 더 분명하게 볼 수 있었다.
결론: 3-D ORMRA 기법은 기존의 MRA 영상기법과 비교하여, 반얼굴 연축 환자에서 매우 유용하고 더 정확한 정보를 주는 방법이다.

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