High Resolution Three-dimensional MR Techniques for Topographic Analysis of Frontal Operculum

H. Miki[1], Y. Hiratsuka[1], K. Kikuchi[1], T. Mochizuki[1], S. Ohue[2]

[1]Radiology, Ehime University School of Medicine, Toon-city, Ehime, Japan, [2]Neurosurgery, Ehime University School of Medicine, Toon-city, Ehime, Japan

Introduction

It is well known that surface anatomy of the brain is strongly correlated to specific neurologic function, especially, sulci of frontal operculum are landmarks of Broca's area. Brain tumors nearby Broca's area, if possible, should be removed without disrupting these important function. MRI is a principal modality in the detection of brain tumors, however, it is difficult to understand that detail three-dimensional relation between Broca's area and tumors of frontal lobe in two-dimensional cross-sectional images. It is thought that three-dimensional (3D) images are necessary and essential to understand these normal structures for pre-operative evaluation.

Recently, parallel imaging methods make it possible to obtain high resolution 3D information of the whole brain in acceptable time. In this study, we evaluated the optimal way to make a high resolution 3D images of brain surface with parallel imaging. Furthermore, we validated the relationships of the frontal operculum to nearby sulci and gyri by high resolution 3D-MRI.

Materials and Methods

Twenty healthy volunteers were examined with a 1.5T MRI (Signa Excite, GE). At first, we evaluated 3D image quality with various scan parameters to decide optimal parameters in five healthy volunteers. MRI was performed by 3D-SPGR with matrices of 256x128-256(with/without 512ZIP), slice thickness of 0.7-1.5 mm (with ZIP), slice number of 60-256, TR 20-30ms, TE 2.5ms, a flip angle of 20 -30 degrees, and ASSET factor 2.0. These MRI data were transferred to post-processing workstation (Advantage Workstation 4.1), and volume rendering(VR) images of brain surface were generated from high resolution MR data. 3D computer graphic MR images were reconstructed from these cross-sectional images by a proprietary VR algorithm. To create VR images of brain surface, segmentation of a volume of interest (same intensity level as brain parenchyma) was performed semi-automatically by threshold technique. After the selection of optimal threshold, complete VR images ware generated by the erosion and dilation 3D processing tools. It took less than 3 minute to achieve segmentation and reconstruction. The generated VR images were displayed on a monitor by the black and white shading method.

VR images with various parameters were evaluated by the detection of anterior sulci of Sylvian fissure including anterior horizontal ramus (AHR) and anterior ascending ramus (AAR). Secondly, the identification of frontal sulci{central sulcus(CS), precentral sulcus(preCS), inferior frontal sulcus(IFS), and Sylvian fissure(Sy)} and the evaluation of the connection between these sulci were performed with VR images and MPR images in 20 healthy volunteers. Scan time of an optimal method was about 5 minutes which was acceptable time for clinical routine examination.

Results

High resolution 3D SPGR sequence with optimal parameters {a matrix of 256x192 (with 512ZIP), a slice thickness of 0.8 mm (with ZIP), slice numbers of 256, TR 25ms, TE 2.5ms, a flip angle of 20 degrees, and ASSET factor 2.0} was able to offer brain parenchyma in a good contrast for generating the VR images (Fig. 1). The resulting high resolution VR images depicted small sulci(AHR and AAR) and gyri of frontal operculum (Fig.2), as well as important landmarks of Broca's area. The frequency of sulcus connections was following, preCS-IFS(85%), preCS-Sy(52.5%), CS-Sy(17.5%). Our results were similar to those in past anatomic studies (1,2).

Discussions

We have shown that the VR images of frontal operculum from high resolution 3D MRI data set can be used for an evaluation of fine anatomical landmarks such as AHR and AAR. Requiring time for generating VR images by our procedure is acceptable for routine clinical use. The 3D image reconstruction is the only noninvasive way of obtaining this information since these structures cannot be identified with cross-sectional images.

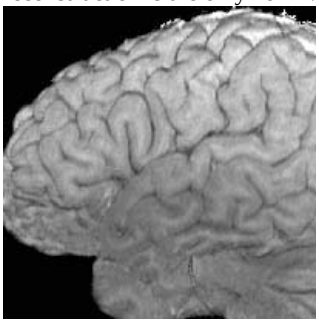

Fig. 1, left lateral view of VR image.

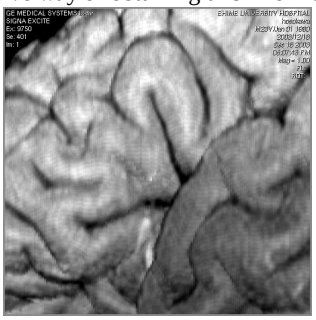

Fig. 2, left frontal operculum

Conclusion

We considered that high resolution 3D-MRI with parallel imaging well display the correct anatomy of frontal operculum, and it should be essential for the pre-operative evaluation of brain tumor nearby Broca's area.

References

1. Ebeling U. et al: AJNR 10:937-942, 1989

2. Naidich TP. Et al: Neurosurgery 36:517-532,1995