



Diffusion Tensor Imaging and Quantitative Magnetic Resonance Volumetric Assessment in the Diagnosis of Hemimegalencephaly: A Case Report

편측거대뇌증 환자에서의 확산 텐서 영상과 정량적 자기공명 체적 평가의 적용: 증례 보고

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A 27-year-old female presented with repeated seizures. As the left frontal lobe volume was enlarged in comparison with the right frontal lobe, hemimegalencephaly was suggested. Abnormal white matter fiber tracts running from the left frontal lobe to the fornix and hippocampus were found on diffusion tensor imaging (DTI). We performed quantitative measurements of brain volume and confirmed hemimegalencephaly. DTI and MRI-based volumetry techniques could be useful to objectively diagnose hemimegalencephaly.

Index terms Diffusion Tensor Imaging; Hemimegalencephaly; Magnetic Resonance Imaging; Seizure; Image Processing, Computer-Assisted

INTRODUCTION

Hemimegalencephaly or unilateral megalencephaly is defined by a rare hamartomatous congenital malformation of the brain, involving excessive growth of focal or hemispheric brain (1). The clinical triad consists of early-onset epilepsy, psychomotor retardation, and contralateral hemiparesis. However, mild cases may be asymptomatic and

Received February 20, 2018
 Revised June 19, 2018
 Accepted July 19, 2018

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are infrequently identified (1).

The conventional MRI features of hemimegalencephaly are characterized by an enlarged dysplastic-appearing hemisphere with abnormal gyration, thickened cortex, and white matter abnormalities. Additionally, an abnormal asymmetric midsagittal white matter bundle can be detected in hemimegalencephaly. Several studies have reported that diffusion tensor imaging (DTI) might be helpful to demonstrate this abnormal white matter bundle (2, 3).

Recently, MRI-based volumetric assessment of brain volume has been widely used in the study of neurodegeneration. Automated segmentation techniques can help obtain quantitative measurements of cortical thickness and gyral volume from brain regions of interest. A previous study (4) has applied MR volumetry to patients with temporal lobe epilepsy; however, to the best of our knowledge, there have not been many such studies on other types of epilepsy. We therefore applied DTI and MR volumetry techniques to demonstrate the abnormal white matter bundle and to perform quantitative analysis of gyral volume in a patient with hemimegalencephaly.

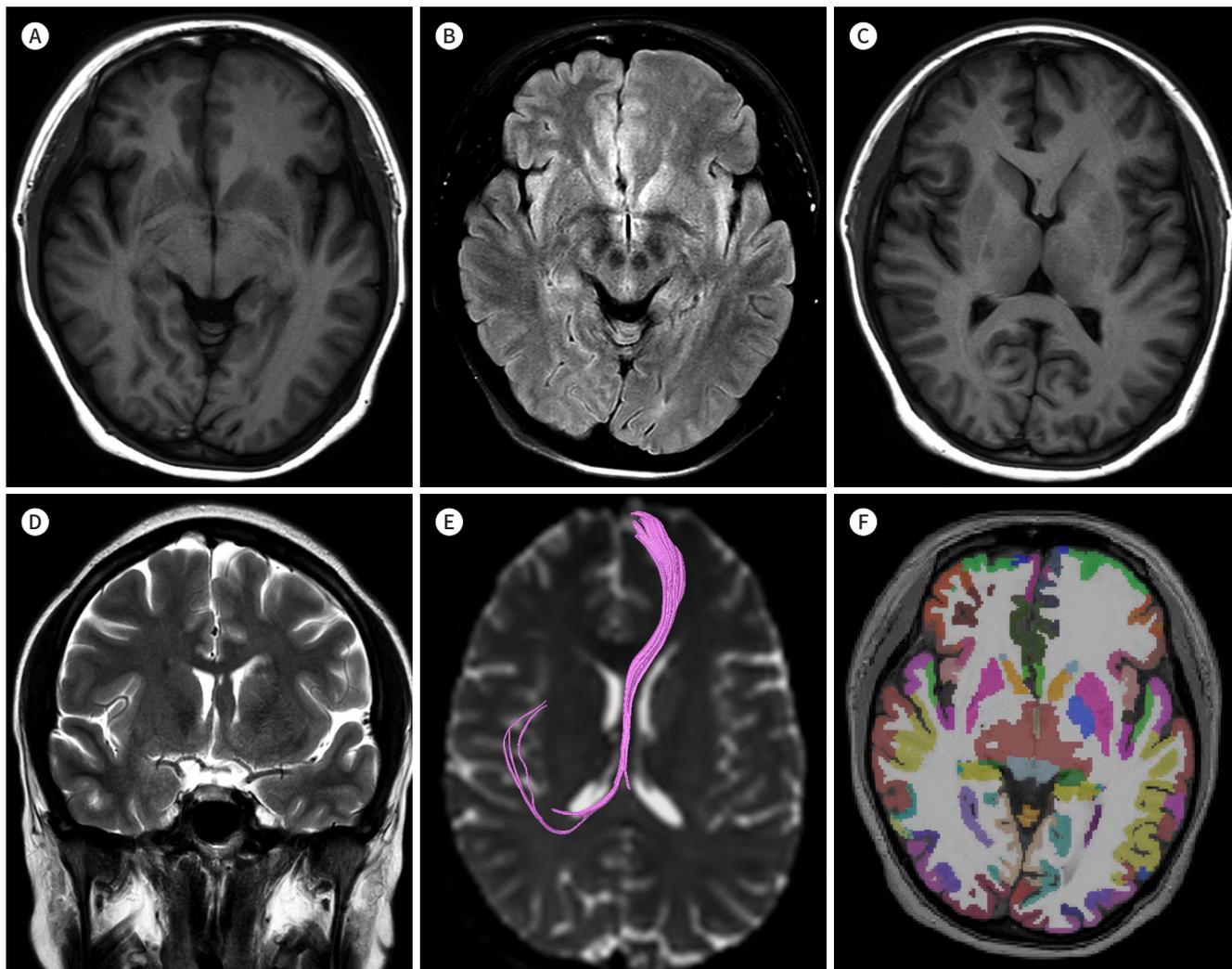
CASE REPORT

A 27-year-old female was investigated for repeated seizures. Recurrent seizures had occurred while having dinner and while sleeping in bed, on the same day. Another seizure occurred after visiting the emergency department. The seizures were consistent, and of a generalized tonic-clonic type, with eyeball deviation, salivation, and cyanosis. The woman had delivered a healthy baby 27 days previously. There was no familial history of epilepsy. There was no history of medication or trauma, other than a compressive fracture of T5 and T6 when the patient had fallen down because of a seizure attack two years previous, which was her first episode of seizure. No other seizure attack occurred during the two intervening years.

On conventional brain MRI, the gross volume of the left cerebral hemisphere white matter appeared slightly increased in comparison with the right hemisphere. Relatively decreased sulcation and indistinct gray-white matter differentiation were found in the left frontal lobe, and cortical dysplasia was suspected (Fig. 1A, B). The thick rostrum of the left corpus callosum was mildly compressing the frontal horn of the left lateral ventricle (Fig. 1C). Asymmetric enlargement of the left fornix opacified by white matter signal was accompanied (Fig. 1D). DTI fiber tractography (Fig. 1E) was performed with fractional anisotropy (4) threshold 0.2 and angle threshold 50° (5). Regions of interest were applied on the prominent white matter at the left frontal lobe and asymmetrically enlarged left fornix. Tractography demonstrated asymmetric white matter fiber tracts running from the left frontal lobe to the fornix and hippocampus. Finally, a mild form of left hemimegalencephaly was diagnosed. MR volumetry was applied to compare the cortex and subcortical white matter volumes in the each frontal lobes (Table 1). Automatic volumetric analysis was performed on three-dimensional T1-weighted images using FreeSurfer software version 6.0.0 (<https://surfer.nmr.mgh.harvard.edu>). An automated segmentation of the cerebral hemisphere was performed based on the Desikan and Destrieux atlas (Fig. 1F) (6, 7). When the total cortical volumes of the right and left frontal lobes were compared based on Desikan atlas, the cortical volume of the left lobe

Fig. 1. A 27-year-old female with feature of hemimegalencephaly on conventional MRI (A-D), DTI (E), and MR volumetry (F). Axial T1-weighted (A) and T2 fluid-attenuated inversion recovery (B) images show asymmetrically broadened gyri of the left frontal lobe with blurring of gray-white matter differentiation. Axial T1-weighted (C) and coronal T2-weighted (D) images demonstrate asymmetric thickened left fornix, which is iso-signal intensity to white matter and mildly compressing the frontal horn of the left lateral ventricle. Aberrant and asymmetric white matter fiber tracts running from the left frontal lobe to the fornix and hippocampus are observed on DTI (E). For MR volumetry, Destrieux atlas based automatic parcellation of cortical surface is overlaid on T1-weighted image (F).

DTI = diffusion tensor imaging



(99259 mm³) was revealed to be much higher than that of the right lobe (83198 mm³). Comparing the subcortical white matter volume and total volume of the left and right frontal lobe, left frontal lobe showed definitely larger volume compared to the right.

On electroencephalography, frequent spikes or sharp waves were detected at the left frontal region, and a partial seizure disorder was suggested. The patient took an antiepileptic drug for 6 months and was free of seizure for 8 months.

DISCUSSION

This report describes the finding of an asymmetric enlargement of the left frontal gyrus

Table 1. Summary of Cortical Volume and White Matter Volume in the Frontal Lobe of Both Hemisphere

Location	Cortical Volume (mm ³)		Subcortical White Matter Volume (mm ³)		Total Volume (mm ³)	
	Right	Left	Right	Left	Right	Left
Superior frontal gyrus	20079	26587	16397.6	22921.6	36476.6	49508.6
Rostral middle frontal gyrus	13123	18787	11221.4	19292.1	24344.4	38079.1
Caudal middle frontal gyrus	6028	6136	5756.3	6570.5	11784.3	12706.5
Pars opercularis	4599	6027	4201.9	4770.1	8800.9	10797.1
Pars triangularis	4888	4432	3722.7	4203.0	8610.7	8635.0
Pars orbitalis	2944	2848	1233.5	1741.2	4177.5	4589.2
Lateral orbitofrontal gyrus	6961	8813	6428.1	10455.4	13389.1	19268.4
Medial orbitofrontal gyrus	5139	6584	3894.4	6676.9	9033.4	13260.9
Frontal pole	1106	1049	313.4	509.5	1419.4	1558.5
Precentral gyrus	14471	13980	14290.3	13995.8	28761.3	27975.8
Paracentral lobule	3860	4016	3890.5	4495.8	7750.5	8511.8
Total volume	83198	99259	71350.1	95631.9	154548.1	194890.9

Location is based on the Desikan atlas.

and a midsagittal band-like structure in a patient presenting with seizure. We quantitatively measured the gyral and subcortical white matter volumes of both hemispheres and made comparisons between them. The gyral and subcortical white matter volume of the left frontal lobe was larger than that of the right lobe. We confirmed the suspicion of hemimegalencephaly by applying DTI and an MRI volumetry technique. The application of DTI and volumetry can provide objective and quantitative comparisons between hemispheres, enabling an objective and confirmative diagnosis of hemimegalencephaly.

Hemimegalencephaly is generally defined by excessive growth of all or part of a cerebral hemisphere (1). The pathogenesis of hemimegalencephaly is still unknown; however, it is thought to be a disease of increased cell proliferation and abnormal cell migration (8). There are three recognized hemimegalencephaly severity grades, which are divided according to anatomical involvement (1). The case described in this report was of the mild form (Grade I), which shows mild enlargement of the affected hemisphere with minimal ventricular asymmetry and minimal displacement of the midline (1). Grade II shows moderate enlargement of the hemisphere with midline displacement, different ventricle size, and focal cortical dysplasia, while Grade III shows marked enlargement of the hemisphere with a bulging occipital lobe, severe distortion of ventricles, and cortical dysplasia (1). In patients with hemimegalencephaly, the main feature on MRI is the combination of volume enlargement and high white matter signal intensity on T2-weighted sequences (8). Additionally, poor gray-white matter differentiation is also a common finding (1). Agyria, pachygyria, and polymicrogyria are frequently combined. In some cases, an enlarged ipsilateral corpus callosum, which is distorted or heavily myelinated, is apparent (1). In our case, mild asymmetric volumetric enlargement of the left cerebral hemisphere was detected on conventional MRI especially in the frontal lobe, and decreased sulcation with poor gray-white matter differentiation was also observed in the left frontal lobe. In a retrospective study of 26 patients with hemimegalencephaly, the distance between the anterior horns of the lateral ventricles was wid-

ened by more than 4 mm in most cases. The majority of cases also had an aberrant midsagittal band-like structure consisting of white matter signal beneath the corpus callosum, with asymmetric unilateral or bilateral fornix thickening (2). In our case, asymmetry of the fornix was also detected, and the distance between the anterior horns of the lateral ventricles was 13 mm.

Recently, several studies using DTI to evaluate hemimegalencephaly have been performed. By incorporating directionality into diffusion-weighted images, DTI allows the distribution and orientation of cerebral white matter fiber tracts to be visualized. Accordingly, fiber asymmetry in the cerebral hemispheres of patients with hemimegalencephaly can be detected with DTI (2). In another study using DTI to evaluate 6 regional subdivisions of the corpus callosum in 9 hemimegalencephaly patients, half of the regional subdivisions demonstrated asymmetric interhemispheric fiber tracts (3).

MR volumetry studies have been performed in patients with seizure. Atrophic change of the hippocampus on conventional MRI is well known in temporal lobe epilepsy, and Farid et al. (4) showed that MR volumetry can accurately enhance the depiction of hippocampal atrophy in patients with temporal lobe epilepsy. However, to our knowledge, there have been no studies applying MR volumetry to hemimegalencephaly. Hemimegalencephaly is a disease of increased cell proliferation and abnormal cell migration, which generally presents with a thickened cortex and increased white matter volume (8). In our case, the MRI volumetric analysis comparing the cortical and white matter volumes of the frontal lobes of each cerebral hemisphere showed increased volume in the affected left cerebral hemisphere, which was consistent with previous studies. And in our experience, MR volumetry was useful to evaluate the difference of cortex volume which could be overlooked in the conventional MRI, because the difference between thickened cortex and normal cortex was imperceptible for visual analysis.

Hemimegalencephaly has a high association with refractory seizures, which occur early in life, and cognitive impairment is a general rule (8). However, there are very few reported cases of incidental hemimegalencephaly patients either without seizure (9) or with a late-onset mild seizure attack, and with normal intellectual development (10). The reason for the mild clinical feature in this case is still unknown. The severity of clinical features may be related to the severity of radiologic features; however, according to a PET study, clinical manifestations could be more strongly related to cortical metabolism than to the severity of anatomical malformations (10).

In conclusion, the application of DTI and MR volumetry may be useful ways to demonstrate an asymmetric white matter fiber bundle and quantitatively evaluate asymmetric enlargement of cortical and white matter volume in a mild hemimegalencephaly case; features that could be overlooked on conventional MRI.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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27세 여성이 반복적인 경련을 주소로 내원하였다. 좌측 전두엽의 부피가 우측 전두엽과 비교하여 커져 있었기 때문에 편측거대뇌증이 의심되었다. 좌측 전두엽에서부터 뇌활과 해마에 이르는 비정상적인 백색질 섬유로가 확산 텐서 영상에서 발견되었다. 또한 뇌의 부피를 정량적으로 측정하고 편측거대뇌증을 확인하였다. 확산 텐서 영상과 자기공명영상 기반의 체적 측정 기법은 편측거대뇌증을 객관적으로 진단하는 데 유용할 수 있다.

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