Diffusion Tensor MRI and Fiber Tractography in Malformations of Cortical Development

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Synopsis

We examined the patients with malformations of cortical development (MCD) by diffusion tensor MRI (DTI) and fiber Tractography (FT). DTI showed different FA values of heterotopic gray matter and FT demonstrated aberrant fiber connections in MCD. DTI & FT is useful in the evaluation of white matter abnormality and understanding pathogenesis of MCD.

Introduction

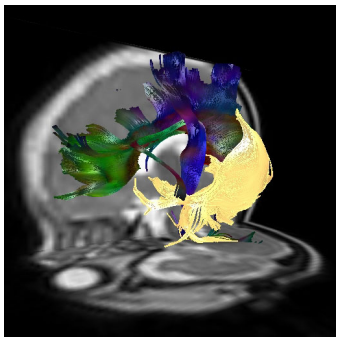
Malformation of cortical development (MCD) is a common cause of childhood epilepsy. Recently introduced diffusion tensor imaging (DTI) has a powerful ability to describing white matter integrity, and it can detect the abnormalities of brain tissue in earlier stage than conventional T2 or T1 weighted imaging. The purpose of this study was to evaluate the usefulness of diffusion tensor imaging in describing dysplastic gray matter as well as white matter changes and to investigate the potential use of fiber tractography based on DTI in the assessment of MCD.

Methods

Thirteen patients with malformation of cortical development {focal cortical dysplasia (n=3), diffuse cortical dyplasia (n=4), complex anomaly with CD and heterotopia (n=3), schizencephaly (n=2), band heterotopia (n=1)} were evaluated by DTI. All studies were performed using a 1.5T scanner (Intera, Philips Medical Systems, Best, Netherlands) using 6-channel SENSE head coil [SENSE factor 2, 96 matrix 128 recon, FOV 220mm, 2.3mm thk, TE = 70ms; TR = 6599-8280ms; NSA = 2, b = 600 s/mm^2, 32-diffusion directions. Fractional anisotropy (FA) of dysplastic gray matter was calculated using semi-quantitative ROI method according to the location of MCD, i.e. cortical dysplasia, band/nodular heterotopia and subependymal gray matter. T-test was performed for comparison with normal gray matter from control groups. White matter changes were assessed by neuroradiologists (S.K.L and D.I.K.) for their increase or decrease of signal intensity on T2 weighted images and fractional anisotropy maps. Fiber tractography was obtained in each patient around the areas of white matter abnormalities and their configurations were investigated visually.

Results

Gray matter in white matter, i.e. nodular or band heterotopic gray matter showed higher anisotropic value comparing to normal cortex with statistical significance (0.28±0.07 vs 0.18±0.02, p=0.0003). Subependymal gray matter and focal/diffuse cortical dysplasia showed slightly lower FA values without statistical significance (0.16±0.01, p=0.0859; 0.17±0.01, p=0.611). White matter signal change was variable. Five patients showed increased signal intensity of underlying white matter on T2WI, and 4 of them demonstrated decreased FA values comparing to the normal contralateral white matter. In a patient with band heterotopia, white matter fibers from deep portion failed to connect to cortex and sub-cortical U-fibers were absent (see right figure).



In focal cortical dysplasia, there were not any remarkable abnormal fiber connections in hemispheric fibers including longitudinal fibers and corticospinal tract (CST) except one patient in whom the precentral gyrus was affected. She showed more lateral and inferior bowing of CST around the dysplastic white matter and it was well correlated with the fMRI study, which showed motor activation signals at the inferolateral aspect of precentral gyrus.

Conclusion

DTI and fiber tractography are useful methods in describing aberrant white matter connections and understanding pathophysiology of brain development in MCD.