

Observation of brain development in neonates/infants using Diffusional Kurtosis Imaging

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Introduction

For infants and low birth weight infants, MRI is performed to evaluate myelination with T1WI, T2WI and Diffusion Tensor Imaging (DTI). T1WI is the most sensitive biomarker for myelination in neonates/infants before the age of 1. And T2WI is the most sensitive between the age of 1 and 2 demonstrating gradual shift from hyper- to hypo-intense relative to gray matter. Furthermore, DTI is more sensitive compare to T1WI or T2WI. Diffusional Kurtosis Imaging (DKI) is an extension of DTI, and characterizes non-Gaussian water diffusion behavior¹. DKI is expected to be a more sensitive biomarker for representing microstructure of the tissue compare to conventional DTI. And Kurtosis represents the degree of deviation from Gaussian water molecule diffusion, and is thought to be an index of micro structural complexity. Our goal is to evaluate the neonatal/infants brain development with DKI, and to compare the quantitative values derived from DKI with the conventional diffusion value (apparent diffusion coefficient [ADC] and fractional anisotropy [FA]).

Materials and Methods

Acquisition: DWI were acquired from 9 children who were born as LBW and one child who was a term infant with suspicious delayed myelination (4 male and 6 female; age in days 82.7±67.4; range; 14-226 day; corrected age in days; 300.6±79.3), with a SIEMENS MAGNETOM Avanto 1.5T using a Twice Refocused Spin Echo EPI sequence with b-value=0, 1000, 2000 [s/mm²]; δ/Δ = 32.7/37.4 [ms]; TR/TE = 5000/88.0 [ms]; FOV 25.6 [cm]; acquisition matrix 86×86; slice thickness; 3.0 [mm]; 41 axial slices; Number of MPG; 30 axes; GRAPPA factor=2. These acquisition times were 320 [sec]. These acquisitions were performed in adding to routine examinations, and confirmation of the abnormal image was not in all subjects.

Diffusion Tensor and Diffusional Kurtosis analyses: These analyses were performed on console. The generated images were trace, ADC, FA, Mean Diffusional Kurtosis (MDK), Radial Diffusional Kurtosis (RDK), and Axial Diffusional Kurtosis (ADK).

Regions of Interest (ROIs) setting and evaluation: We performed the whole brain and local analyses by using MRICro (<http://www.mccauslandcenter.sc.edu/mricro/mricro/index.html>). Using trace image, cerebrospinal fluid was excluded, and ROIs were placed at the cerebrum and the cerebellum plus midbrain (the cerebellum). Quantitative values were evaluated using these ROIs, and paired t-test was performed between the average of cerebrum and cerebellum. We also calculated the correction coefficients between the corrected age and quantitative values.

Results and Discussion

ADC decreased and others increased in proportion to the corrected age (Fig.2, 3). ADC and FA showed the same trend as the previous study². MDK, RDK and ADK also changed in the brain other than ADC and FA. The paired t-test, there was a significant difference in MDK, RDK and ADK ($p<0.05$), but there was no significant in ADC and FA (Fig.4). Therefore, we assumed that these quantitative values are high sensitivity for evaluating the difference of the development of the cerebrum and the cerebellum. Additionally the kurtosis values in the cerebellum were significantly greater than those in the cerebrum. The diffusion dynamic state in the cerebellum is possibly more complex than in the cerebrum. DKI can demonstrate these differences. The correction coefficients showed the correction (0.540 - 0.964) (Table 1). The highest correlation coefficient was ADK of cerebellum. It is said that the inner granular layer and cortical volume becomes large³, our result may have reflected this microstructure change and become a powerful tool for observing the growth of neonatal/infant brain. And future works should include normal volunteers and images should be acquired with higher resolution to enable segmentation and measurements in white and gray matter.

References

- [1] Jensen JH. Magn Reson Med 2005; 53: 1432-1440.
- [2] Miller SP. J MRI 2002; 16: 621-632.
- [3] Sidman RL. Brain Research 1973; 62: 1-35.

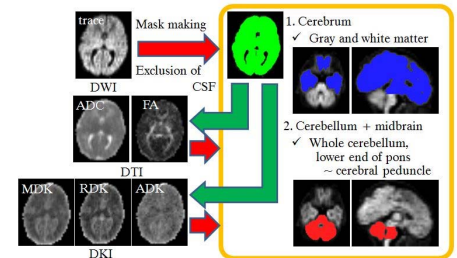


Fig.1. ROI setting

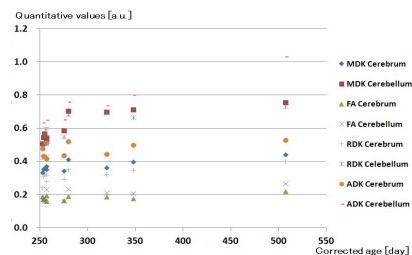


Fig.2. Corrected age and FA, MDK, RDK and ADK

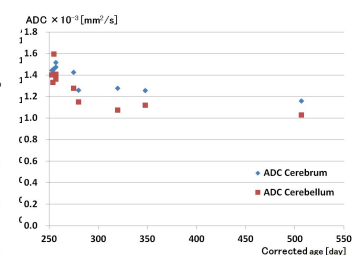


Fig.3. Corrected age and ADC

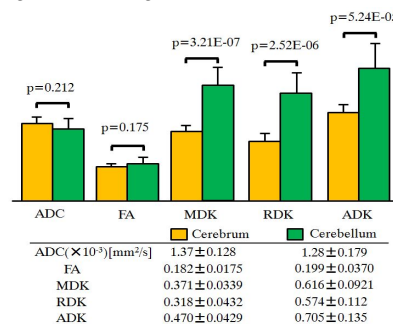


Fig.4. Result of paired t-test

Table1. The correction coefficients

	Cerebrum	Cerebellum
ADC	-0.828	-0.724
FA	0.716	0.728
MDK	0.807	0.787
RDK	0.775	0.727
ADK	0.540	0.964