Phase distribution of white matter using phase difference enhanced MRI

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Introduction

Neonates, especially for preterm infants, are at a risk of the brain injury. Besides the detection of parenchymal damages such as hemorrhage and cystic changes, analysis of the white matter microscructure may provide deeper insight of the brain injury of neonates.

Phase different image has been introduced as a sensitive method for visualization of the white matter fiber bundle and nucleus [1] . The purpose of this study was to assess a distribution of intraparenchymal structures in comparison to diffusion tensor imaging (DTI) in neonates.

Subjects and Methods

Twenty neonates (gestational age, 25-40 weeks; gestational age at MRI, 37-42 weeks (median, 39 weeks)), who had screened at MRI resulting in no abnormal findings were enrolled. MRI was performed at MRI was performed at either a 1.5T MRI (Achieva, Philips) or a 3T MRI (Achiva or Ingenia, Philips). 3D gradient-echo imaging with multi-shot echo-planar imaging (EPI) (TR/TE, 109/40 (1.5T), 70/30 (3T) ms; flip angle, 20 degrees; multi-shot echo-planar imaging (factor, 7); matrix, 240; thickness, 2 mm; FOV 160 mm; fat-supression, SPIR) Phase images were transferred to a workstation, where phase wraps of the phase images were removed using the homodyne filer with a kernel size of 40, a mask was applied to select relatively small positive phase shift in the right handed system; final phase difference image was created by a convention of this masked phase image and magnitude image. ROIs were set at the bilateral posterior libs of the internal capsules, the genu and splenium of the corpus callosum, and the bilateral semiovale centers. The signal ratio of signals in these regions to that of the lentiform nucleus was calculated as follows: signal ratio = 1-(SO/SL), where SO means signal of the each object, SL means signal at the lentiform nucleus.

Diffusion tensor imaging (TR/TE, 6400/65 (1.5T), 6400/65 (3T) ms; matrix, 80; SENSE, 1.5; SPIR; b factor, 800 s/mm^2; six directions; fat-supression; SPIR) was also performed and fractional anisotrpy (FA) values of the same regions, measured at the phase sensitive images, were noted.

Distribution of phase ratio in each anatomical portion was compared in each infant using Friedrich test with the post-hoc test. Distribution of phase ratio was also compared to those of FA.

Results

The median value and range of the phase ratio of the internal capsule, the genu and splenuim of corpus callosum, and the semiovale center were 0.205 (range, 0.122-.0.368), 0.016 (range, -0.089-0.164), 0.020 (range, -0.139-0.174), and 0.205 (0.073-0.309), respectively. The signal ratio of each region in each infant was significantly different ($p<0.001$); the phase ratios at the internal capsule and the semiovale center were significantly higher than those at the corpus callosum (including both genu and splenium) ($p<0.05$). There was a different distribution between phase shift and FA.

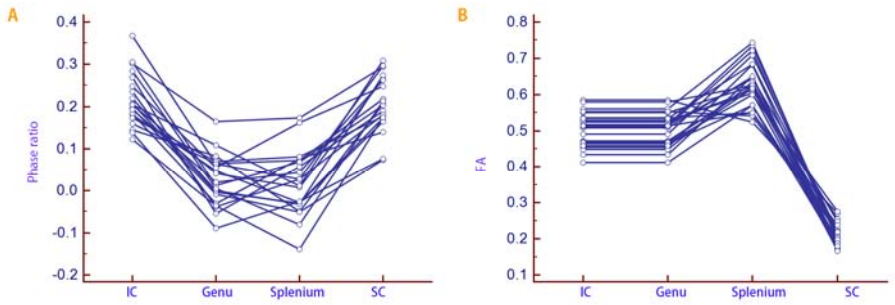

Figure 1. Distribution of phase ratio (Fig. A) and fractional anisotrophy (FA) (Fig. B) according to the anatomical portion (the posterior limbs of the internal capsule (IC); the genu of the corpus callosum (Genu); the splenium of the corpus callosum (Splenium); and the semiovale center (SC)).
Graph shows a certain pattern of the distribution of the phase (Fig. A) and FA (Fig. B) in neonates.

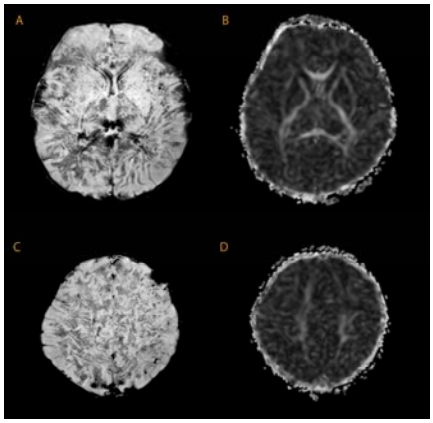

Figure 2. Images of an term infant.
A,C: Phase differerent image; B,D: Fractional anisotropy (FA) map.
Low signal at phase difference image means more phase shift. Note that distribution of greater phase shft is different from that of greater FA.

Discussion and Conclusions

We found a characteristic distribution of the phase ratio using a phase sensitive image, which reflect a phase shift in the brain parenchyma. In the previous reports, phase data were suggested to correspond to the brain fiber orientation, in which myelin may be a major factor of the contrast [2]. In our study, distribution of phase shift in phase different image generally corresponds to the known region of myelination, which was different from that in the FA on DTI. Therefore phase different image may reflect both fiber directions as well as the progression of myelination.

In conclusion, a characteristic distribution of phase shift was noted in neonates, which may reflect white matter micro structures.

References

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