White Matter Maturation from Birth to Adulthood: Evaluation with Fractional Anisotropy, Color Map and Diffusion Tensor Tractography

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Introduction: White matter maturation was formerly assessed with myelination observed in conventional T1-weighted and T2-weighted images [1]. On the other hand, diffusion anisotropy was reported to be observed even when axonal structures were unmyelinated [2,3]. The purpose of this study was to evaluate white matter maturation of the human brain from birth (infancy) to adulthood by using fractional anisotropy (FA), directionally-encoded color FA map (color map), and diffusion tensor tractography (DTT).

Methods: 42 patients from 35 weeks postconceptional age (PCA) neonate up to 44 years old adult were studied with a 1.5T MR imager (Excelart; Toshiba) using diffusion tensor imaging (DTI). DTI was performed using a single-shot SE-EPI sequence which acquires 7 images (b=0 and b=500 sec/mm2 in 6 directions) to calculate whole brain FA maps. Color maps and DTT were generated by using PC-based software (Volume-One™ and VizDT II+™, available at http://www.volume-one.org/ and http://www.ut-radiology.umin.jp/people/masutani/dTV.htm/ , respectively).

Results: High FA values were observed in the corpus callosum and the pyramidal tract even in 35 weeks PCA neonate, although most of these axonal tracts were unmyelinated. In term neonates, high FA values were also seen in the external capsule, the centrum semiovale and the optic radiation. Increase in anisotropy in the subcortical white matter was observed during infancy. These FA values tended to increase with age, suggesting further maturation of white matter structures. Color map was very useful in differentiating individual axonal tracts of the whole brain. DTT delineated development of individual axonal tracts when compared in the same FA thresholds and the same seeding ROI settings,.

Discussion: As DTI delineates maturation of axonal tracts even when these tracts are unmyelinated, DTI can be a new landmark of white matter maturation. FA yielded useful scalar information in the white matter maturation. Color map can provide additional directionally-encoded information of developing axonal tracts. DTT can further help recognition of individual axonal tracts maturation when compared in the same FA thresholds and the same seeding ROI settings.

References:[1]Barkovich AJ, et al, Radiology 1998;166:173 [2]Wimberger DM, et al, JCAT 1995;19:28 [3]Neil JJ, et al, Radiology 1998;209:57

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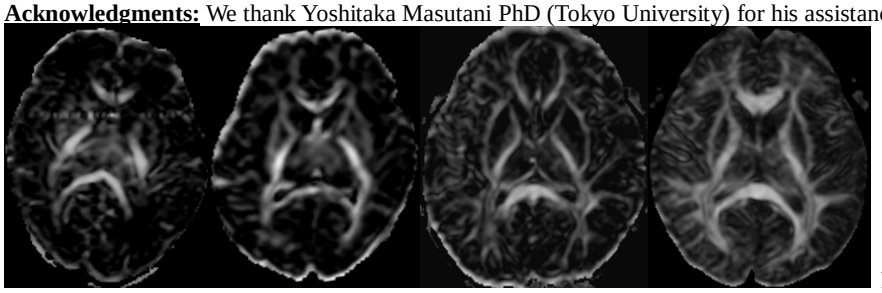

35 w PCA 40 w PCA 2 yrs 44 yrs

Fig.1 FA (upper) and color map (lower) in various ages.

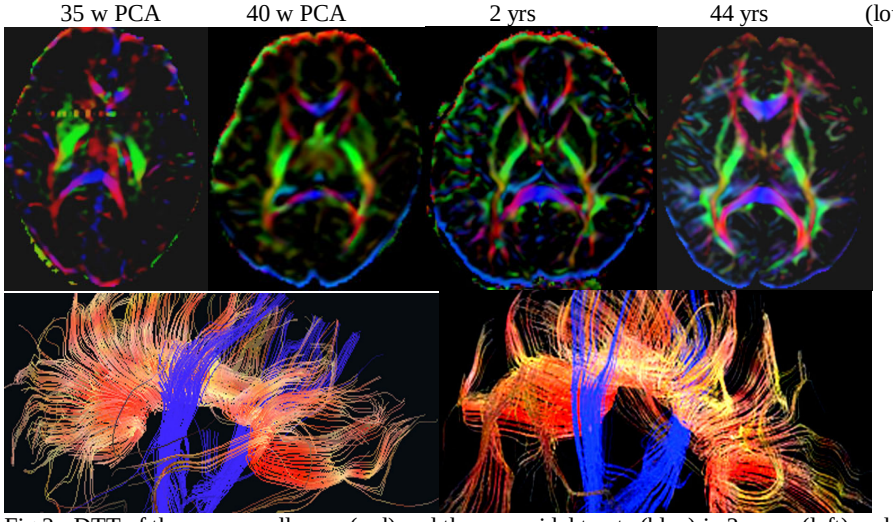

Fig.2 DTT of the corpus callosum (red) and the pyramidal tracts (blue) in 2 years (left) and 44 years (right) males.