Assessment of White Matter Maturation in Preterm Infants by Using Diffusion Basis Spectrum Imaging

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Introduction

White matter (WM) maturation in preterm infants was associated with increasing fractional anisotropy (FA, directionality of water molecular displacement) and decreasing radial diffusivity (RD, related to myelination) derived from diffusion tensor imaging [4].

Diffusion Basis Spectrum Imaging (DBSI) is a new advanced diffusion MRI model. Besides FA and RD, it measures axonal density with fiber fraction. This could be an interesting way to assess white matter maturation of preterm infant brains.

Objectives & hypothesis

Objectives

- Characterize WM microarchitecture development in preterm using DBSI.

Hypothesis in WM maturation

- A reduction of fiber fraction happened in less maturate brains;
- less fiber fraction in younger preterm infants comparing to older ones;
- less fiber fraction in preterm infants comparing to term control infants.

Methods

Subjects

	Group 1 Preterm Scan 1	Group 2 Preterm Scan 2	Group3 Term control
Age at born (weeks)	32.36 ± 1.54	32.36 ± 1.54	
Ages at scan (weeks)	33.89 ± 1.03	40.45 ± 0.78	40.75 ± 1.32
Number	10	10	4

Region of interest

Corpus callosum(CC), optical radiation, PLIC, Frontal WM, Occipital WM.

Statistic analysis for each region of interest

- Preterm 1 vs Preterm 2 (Wilcoxon signed rank test, $p < 0.05$)
- Preterm 2 vs Term control (Wilcoxon rank sum test, $p < 0.05$)

MRI scan parameters

TR $[ms]$	TE $[ms]$	Resolution mm^3	b0	b values $[0 \sim 800s/mm^2]$
8000	87.6	$2 \times 2 \times 2$	2	25 b values, 25 directions[2]

* Metrics were extracted by using DBSI package [3]

Results

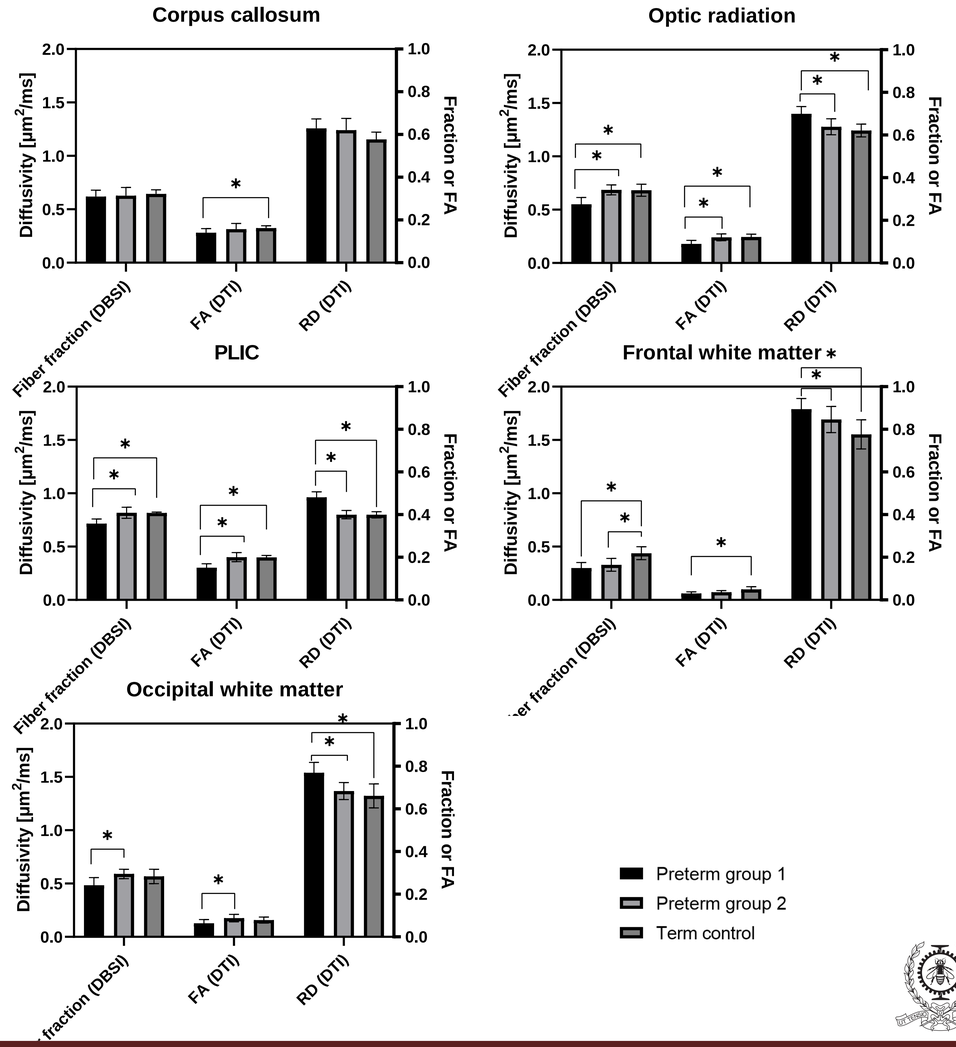

Figure 1. Fiber fraction, axial diffusivity, radial diffusivity in five white matter regions of preterm infant brain. Preterm group 1 and preterm group 2 were infant born at 32.36 ± 1.54 weeks, scanned at 33.89 ± 1.03 and 40.45 ± 0.78 weeks respectively; Term control group included 4 term infants scanned at 40.75 ± 1.32 weeks. Wilcoxon signed rank test and Wilcoxon rank sum test were used for statistics with $p < 0.05$.

Preterm scan 1 vs Preterm scan 2

- Increasing FA and decreasing RD from first to second scan were found as previously published;
- Fiber fraction (DBSI) increased in optic radiation, PLIC and occipital WM (24.31%, 14.15%, 22.01% respectively) (Fig. 1)
- Fiber fraction in CC and frontal WM showed a small increase that did not reach significance (1.2% and 10.36% respectively).

Preterm scan 2 comparing to term control

- Preterm born at 32 weeks scanned at "term" had 24.75% less fiber fractions in frontal WM comparing to control;
- Similar fiber fractions in two groups in the rest four regions.

Conclusion

- Preterm WM in optic radiation, PLIC and occipital regions undergo significant maturation between 33 and 40 weeks of gestation
- First time showed a striking impairment of frontal WM maturation in preterm born at 32 weeks with no significant brain injury.

References

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