# Defining Normal and Abnormal DTI Parameters in Premature Newborns

S. C. Veeraraghavan[1], S. P. Miller[2], P. Mukherjee[1], N. N. Charlton[1], D. Xu[1], A. J. Barkovich[1], D. B. Vigneron[1]

[1]Department of Radiology, University of California, San Francisco, CA, United States, [2]Department of Neurology, University of California, San Francisco, CA, United States

## Introduction

MR diffusion tensor imaging (DTI) is a powerful technique for assessing tissue microstructure. Prior studies have demonstrated the ability of diffusion tensor imaging (DTI) to identify maturational trends in white and gray matter reflecting microstructural changes in the developing newborn brain [1-7]. In this study, DTI from premature newborns with normal 1-year neurodevelopmental outcome was used to establish normative DTI values and to investigate quantitative differences in DTI in those with poor outcome.

## Materials & Methods

A total of 79 exams were acquired from 51 premature newborns born at estimated gestational ages of 24-34 weeks and imaged between 27-43 weeks. All imaging was done using an MRI-compatible incubator with a specialized high-sensitivity neonate head coil [8]. Neurologic outcome was assessed at 1 year of age using a validated neuromoter score (NMS) of 0-5 and mental development index (MDI) of the Bayley's Scales of Infant Development II. To assess normal maturation, 44 exams from 31 newborns with normal neurodevelopmental outcome (NMS 0, MDI > 85) were used to form a normative database of mean values for Dav. A total of 35 exams from 20 premature newborns with abnormal neurologic outcome (9 w/NMS 1, 6 w/NMS 2, 1 w/NMS3, 2 w/NMS 4) were then compared with the normative values defined in this study. Whole-brain axial interleaved DTI images were acquired on a 1.5T Signa Echospeed scanner (GE Healthcare, Milwaukee, WI) in 4.8 minutes at a 1.4 x 1.4 x 3.0 mm spatial resolution using a single-shot EPI sequence with 6 gradient directions, b=0 and 600s/mm2, TE=99.5ms, TR=7s, and 3 repetitions. ROI analyses were performed for the directionally-averaged apparent diffusion coefficient (Dav), each eigenvalue ($\lambda 1$, $\lambda 2$, $\lambda 3$), fractional anisotropy (FA) and relative anisotropy (RA) localized to basal ganglia (BG), thalamus (Thal), corticospinal tracts (CST), optic radiations (OR), parietal white matter (PWM), frontal WM (FWM), and the posterior limb of the internal capsule (PLIC) (Figure 1). Those with abnormal outcome were analyzed as standard deviations from the normative mean values.

## Results

The subjects with normal 1-year outcome showed a significant ($p<0.05$) decrease in Dav between regions and with increasing age. No significant differences were found between right and left sides. The subjects with abnormal neurodevelopmental outcome demonstrated spatial heterogenitiy in abnormal DTI values and when grouped by NMS score did not show significant differences in Dav from normative values, in any specific anatomic region. However, in individual subjects with abnormal outcome, 19/20 (3/3 severely abnormal) showed differences of at least 2 standard deviations from normal values in at least 1 of the specific regions studied (median 2 regions, see Figure 2 for example).

## Discussion

This study demonstrated that premature brain injury as detected by DTI is heterogeneous with abnormal findings varying anatomically between individuals. Additionally, the time of injury relative to the time of scan is different for each subject and is often unkown. In cases where subjects with abnormal outcome were studied serially, Dav values that differed signficantly from normal values often were observed in a specific region at the earlier time point and not later and vice-versa This suggests that evolution of injury maybe able to be detected by DTI as previously noted [9]. Ultimately, this normative data may be clinically useful for identifying injury in preterm neonates by the deviation from normal diffusion values and also to monitor the evolution of abnormal diffusivity.

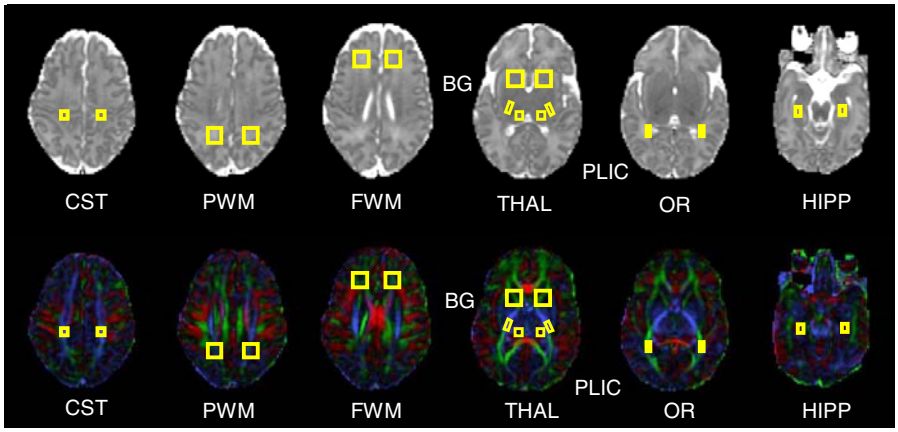


**Figure 1:** Representative regions of interest placed on Dav and FA images

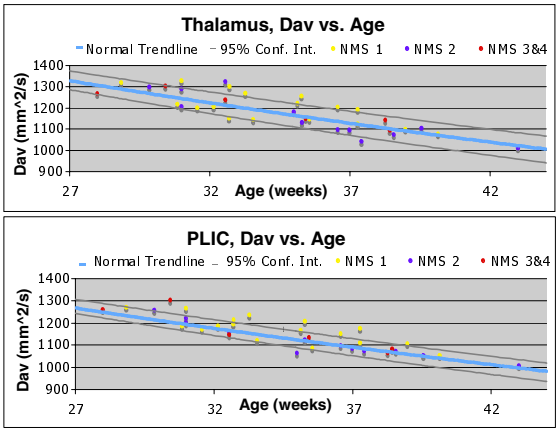


**Figure 2:** Graphs illustrating Dav vs. Age in Thal and. PLIC. The blue line represents the normal trends; gray lines indicate the 95% confidence intervals and points outside of the gray lines indicate abnormal Dav values.

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