Tractography-Based Quantitation of Diffusion Tensor Imaging Parameters in White Matter Tracts of Preterm Newborns

S. C. Partridge¹, P. Mukherjee¹, J. I. Berman¹, R. G. Henry¹, S. P. Miller²,³, Y. Lu¹, O. A. Glenn¹, D. M. Ferriero²,³, A. J. Barkovich¹, D. B. Vigneron¹
¹Radiology, Univ. of California, San Francisco, San Francisco, California, United States, ²Neurology, Univ. of California, San Francisco, San Francisco, California, United States, ³Pediatrics, Univ. of California, San Francisco, San Francisco, California, United States

**Purpose:** MR diffusion tensor imaging (DTI) of preterm newborns offers a unique opportunity to noninvasively study the formation and development of white matter pathways [1]. DTI fiber tractography (DTT) enables 3D segmentation of axonal bundles, allowing quantitation of DTI parameters within specific WM pathways [2,3]. DTT has potential advantages over standard region of interest (ROI) methods for quantitation within a tract, including the ability to select only those voxels dominated by a particular fiber pathway of interest, and quantification at multiple locations along the tract. The semi-automated DTT method may also improve reproducibility of tract localization in serial studies and between different subjects. The purpose of this investigation was to establish the feasibility and reliability of quantitative diffusion tensor tractography for assessing white matter maturation in the premature brain by comparing DTT-based quantitation with standard manually placed ROI measurements of diffusion tensor parameters in the pyramidal tracts of preterm infants.

**Materials & Methods:** Nine newborns born prematurely at 25 - 34 weeks (median, 29 weeks) gestational age (GA) with no evidence of white matter injury on conventional MRI were studied with DTI. The median age at scan was 35 weeks (range, 33 – 39 weeks) with five infants receiving a second MR exam at or near term age. DTI was acquired at 1.5T using an MR-compatible incubator with a high-sensitivity neonatal head coil, with a 4.8min single-shot, multi-repetition echoplanar sequence; TR/TE = 7s/100ms, 3 NEX, 256 x 128 matrix, 360x180mm FOV, 3mm slice thickness, no gap [4]. Diffusion gradients were applied in 6 directions with b= 0 and 600s/mm². DTT was performed to segment bilateral pyramidal tracts, using a fiber-tracking algorithm [2] originating in the cerebral peduncle (CP) and filtering through the posterior limb of the internal capsule (PLIC) and precentral gyrus (PCG) (Fig 1). Voxel values containing the resulting tracts were then used for quantitation of DTI parameters such as fractional anisotropy (FA) and directionally-averaged diffusion (Dₐv). DTT results were compared with standard manually placed ROI measurements at four corresponding locations along the tract. A single operator repeated all measurements for both the DTT and manual ROI measurement techniques to assess intra-observer repeatability of each method.

**Results:** The semi-automated DTT quantitation method demonstrated better reproducibility over manual ROI measurement for pyramidal tract quantitation and was less subject to intra-operator variability (p < 0.0001, Fisher test for equal variance). In general, the anatomic locations and measurements using the two techniques were in good agreement (Fig 3, 4). The pyramidal tracts had a median FA of 0.32 (range: 0.27 – 0.36) and median Dₐv of 1.12 mm²/s (0.98 – 1.26). Both methods of quantitation yielded the highest FA values in the PLIC and the highest Dₐv values in the high centrum semiovale, and Dₐv values were highest in the high centrum semiovale and lowest in the PLIC. In addition to improved reproducibility, the semi-automated DTT method provided more detailed quantitation of DTI parameters at multiple slice locations along the pyramidal tract.

**Discussion:** These preliminary data suggest that DTT is feasible in premature newborns, provides more reliable tract measurements than manual ROI methods, and enables quantitation along the entire 3D trajectory of the tract for more detailed DTI assessment of white matter maturation.

**References:**