

Preferential Posterior Damage of Central Visual Pathways in Children with Periventricular Leukomalacia (PVL) : A TBSS and Probabilistic Tractography Study

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Purpose: To test the hypothesis that there is preferential damage to posterior extra-thalamic white matter tracts involved in central visual pathways in children with periventricular leukomalacia (PVL) using a combination of Tract-based spatial statistics (TBSS) and tractography techniques. We have previously demonstrated a selective microstructural injury to the pulvinar of the thalamus in this cohort.

Methods: DTI images were acquired on a 1.5T GE scanner in 25 directions on 16 children with PVL (mean age 5.6 ± 4) and 16 controls (mean age 5.7 ± 3.4). Tract-based spatial statistics (TBSS) was performed using Oxford's FMRIB FSL with an FA threshold of 0.18. Probabilistic tractography was performed using FSL to delineate the genu and splenium of the corpus callosum, bilateral corticospinal tracts, bilateral anterior thalamic radiations (ATR) and bilateral posterior thalamic radiations (PTR). Tract outputs were normalized to account for age range of the cohort. Deterministic tractography was performed using DTI studio (John Hopkins, MD, USA) delineating the same tracts of interest. Qualitative and quantitative tract integrity was compared between probabilistic and deterministic tractography. Statistical comparison was done using ANOVA with Bonferroni correction in SAS 9.2.

Results: TBSS showed decrease in white matter anisotropy in both anterior and posterior central tracts and also the parenchyma of the thalamus corrected for multiple comparisons ($p < 0.005$; **Figure 1**). Probabilistic tractography diffusivity metrics showed significantly decreased anisotropy in posterior white matter structures including the PTR compared to the ATR and the splenium compared to the genu (**Table 1**). Probabilistic tractography was able to more consistently delineate smaller contiguous tracts of interest as compared to deterministic tractography (**Figure 2**).

Discussion: TBSS showed widespread abnormalities in white matter tracts and thalamus in the children with PVL. In contrast, probabilistic tractography demonstrated preferential posterior white matter injury involved in central visual pathways including the splenium and the posterior thalamic radiation in a cohort of children with PVL with pulvinar abnormalities compared to anterior structural correlates. Further work is geared toward using probabilistic tractography to map other putative ventral visual pathways including the superior longitudinal fasciculus (SLF), inferior longitudinal fasciculus (ILF) and inferior fronto-occipital fasciculus (IFOF) in this cohort.

Conclusion: There is preferential posterior damage to central visual pathways including the splenium and posterior thalamic radiation in children with PVL and known pulvinar microstructural abnormalities.

References: 1. Nagasunder et al. AJNR, 2010. 2. Behrens et al. MRM, 2003. S. M. Smith, et al. Neuroimage, 2004.

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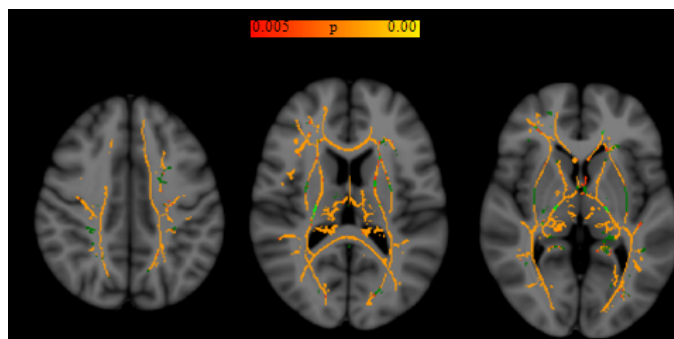


Figure 1. TBSS analysis shows significant diffuse anisotropy decrease in PVL cohort at $p < 0.005$. Results projected onto MNI152 standard space.

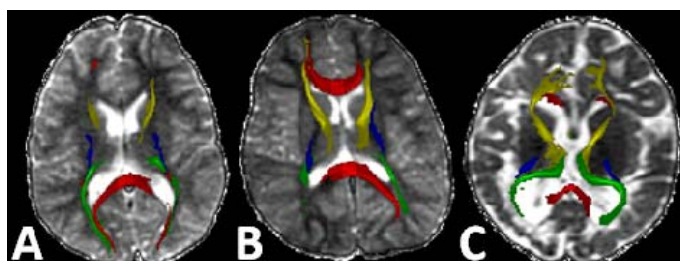


Figure 2. Probabilistic tractography of control (A) compared to structurally normal PVL (B) and abnormal PVL (C). Red- genu/splenium of corpus callosum, blue- corticospinal tract, yellow- anterior thalamic radiation, green-posterior thalamic radiation. Tracts are projected onto native T2 space.

Table 1. Probabilistic tractography diffusivity metrics

		CONTROL		PVL		p
		MEAN	SD	MEAN	SD	
CORTICO-SPINAL TRACT	FA	0.42	0.05	0.35	0.05	0.0075
	AD	1.19	0.09	1.35	0.12	0.0062
	RD	0.60	0.05	0.80	0.14	0.0002
	MD	0.80	0.05	0.99	0.13	0.0003
GENU	FA	0.48	0.06	0.36	0.08	0.0037
	AD	1.38	0.15	1.52	0.21	1
	RD	0.61	0.07	0.87	0.25	0.0122
	MD	0.87	0.08	1.09	0.23	0.0386
SPLENIUM	FA	0.51	0.05	0.34	0.11	0.0002
	AD	1.56	0.13	1.81	0.43	0.8281
	RD	0.66	0.05	1.10	0.48	0.0334
	MD	0.96	0.06	1.34	0.46	0.0865
POSTERIOR THALAMIC RADIATION	FA	0.33	0.04	0.27	0.05	0.0379
	AD	1.15	0.07	1.42	0.23	0.0054
	RD	0.69	0.05	0.96	0.23	0.003
	MD	0.85	0.05	1.11	0.23	0.0031
ANTERIOR THALAMIC RADIATION	FA	0.31	0.05	0.25	0.05	0.0534
	AD	1.08	0.07	1.15	0.15	1
	RD	0.67	0.06	0.78	0.12	0.0899
	MD	0.81	0.06	0.90	0.13	0.3453