Diffusion Tensor Parameters of the Optic Radiations are associated with Visual Acuity and Retinal Nerve Fiber Layer Loss following Optic Neuritis

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Introduction:

Functional recovery after optic neuritis (ON) is variable and the specific mechanisms underlying differential recovery are poorly understood. Transsynaptic degeneration may occur in the visual system, and may be measured as changes in the optic radiations (OR) on diffusion tensor imaging (DTI). We evaluated DTI parameters in OR remote from unilateral ON and evaluated their relationship to visual function and axonal loss in the anterior visual system.

Methods:

14 patients (age 18-60 yrs) with remote (>6 months) ON underwent visual acuity testing, measurement of retinal nerve fiber layer (RNFL) thickness (Stratus Optical Coherence Tomography), and whole-brain DTI at 3T. DTI measurements were performed on a Siemens TIM Trio (Erlangen, Germany) with a standard 12-channel head coil. HARDI data were acquired with a twice-refocused spin echo (1) (TE/TR=102/7700msec, 128x128x48 matrix, FOV=256x256x96mm), 71 b=1000 sec/mm2 acquisitions with gradient directions selected by a coulomb repulsion algorithm (2), and 8 b=0 acquisitions at equally spaced intervals. Motion correction was performed using an iterative method (3) based on FSL (4). Spherical deconvolution, with regularization optimized by generalized cross validation, was performed in each voxel to estimate fiber orientation (5). Regions of Interest (ROI) were manually drawn on the lateral geniculate nucleus and occipital cortex using AFNI (6), which served as seed points and targets for OR fiber tracking. Probabilistic tracking between seed and target regions was performed, with each step determined by rejection sampling (7). The number of tracks intersecting each voxel is used to generate a track density map between seed/target regions. The track density map was used to determine OR pathway-dependent diffusion measures for fractional anisotropy (FA), transverse diffusivity (TD), and longitudinal diffusivity (LD) (8). An anatomic white matter mask was applied for each individual patient. Burden of T2 lesions in the OR was quantified by expert rater using ordinal scale. Spearman's rho was used to evaluate the relationship between visual acuity, RNFL, and OR DTI measures.

Results and Discussion:

Visual acuity in the ON-affected eye correlated with ipsilateral OR FA (100% contrast: r=0.525, p=0.054; 2.5% contrast: r=0.580, p=0.030). Temporal RNFL of the ON-affected eye plus nasal RNFL of the unaffected eye correlated with synaptically-matched OR LD(r=-.538, p=0.047) but not TD(r=-0.393, p=0.164) or FA (r=0.226, p=0.436). FA and TD but not LD were associated with T2 lesion burden within the OR.

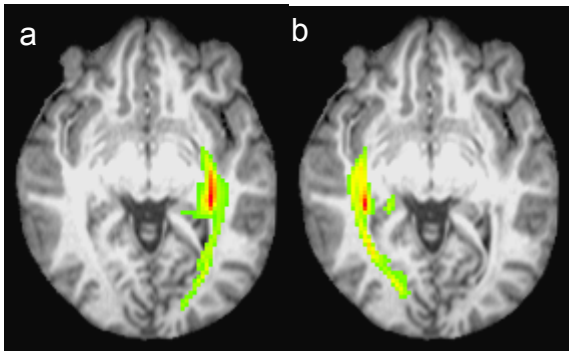

Figure 1. Examples of left (a) and right (b) track density maps of optic radiations from a single patient.

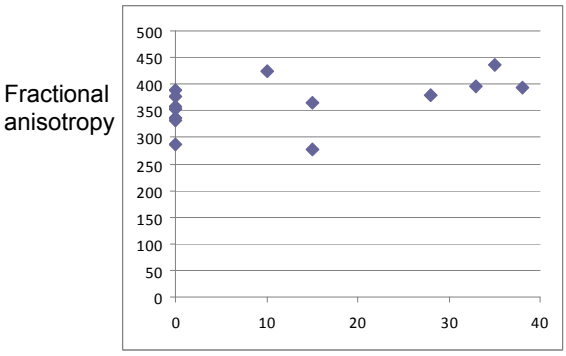

Figure 2: Plot of optic radiation fractional anisotropy vs. visual acuity (letters correct on 2.5% contrast eye chart) (r=0.580, p=0.030).

Conclusion:

DTI is a valuable tool to assess tissue injury in regions and ways that are inaccessible by retinal imaging and conventional MRI. FA appears to have the strongest functional correlations. LD may be the most sensitive measure of transsynaptic changes and may be the least impacted by focal demyelinating lesions.

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