DTI tractography reveals changes in the optic radiation of patients with persistent visual failure following surgery for tumours causing optic chiasm compression

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Introduction

Tumours such as pituitary adenomas and meningiomas can cause compression of the optic chiasm and lead to visual failure or visual field (VF) deficits. These tumours account for up to 10% of all intracranial tumours. Previous studies have shown that RNFL thickness on optical coherence tomography (OCT) can predict visual recovery following surgery for optic chiasm compression[1], however no study has investigated the downstream changes in the visual pathway posterior to the optic chiasm from compressive pathology. The MRI technique of diffusion tensor imaging (DTI) tractography allows non-invasive investigation of the white matter pathways in the human brain in-vivo and DTI tractography can be used to visualise the structure of the white matter tracts of the visual pathway[2] such as the optic radiation (OR). This study aims to use DTI tractography biomarkers to investigate changes in the OR of patients with tumours causing optic chiasm compression.

Methods

Patients recruited to participate in the study were divided into two groups based on visual status. The normal vision group (n=10) had no VF deficit (Mean deviation >-10dB on SAP) and normal RNFL thickness (>75µm) on OCT. The abnormal vision group (n=4) had persistent VF deficit (Mean deviation <-10dB on SAP) and RNFL thinning (<75µm) on OCT. Patients from both groups underwent a single additional MRI on a clinical 3 Tesla MRI scanner at the Royal Melbourne Hospital at least one year post surgery which included T1 weighted 3DSPGR anatomical and 30-direction DTI (b=0.3000, 55 slices, 2.5x2.5x2.5mm voxel size, TR/TE=8000/80ms) protocols. DTI tractography of bilateral ORs for each patient was performed using a constrained spherical de-convolution[3] probabilistic algorithm using the MRtrix software package (http://www.brain.org.au/software). OR tractography was seeded from the anatomical location of the lateral geniculate nucleus and used a target located centrally on the ipsilateral primary visual cortex (calcarine sulcus) of each hemisphere (Figure a.). OR tractography images were analysed for anatomical measurements and a region of interest (ROI) located at the midpoint of the OR for each side (Figure b.) was used for analysis of DTI parameters including fractional anisotropy, longitudinal diffusivity, radial diffusivity and apparent diffusion coefficient.

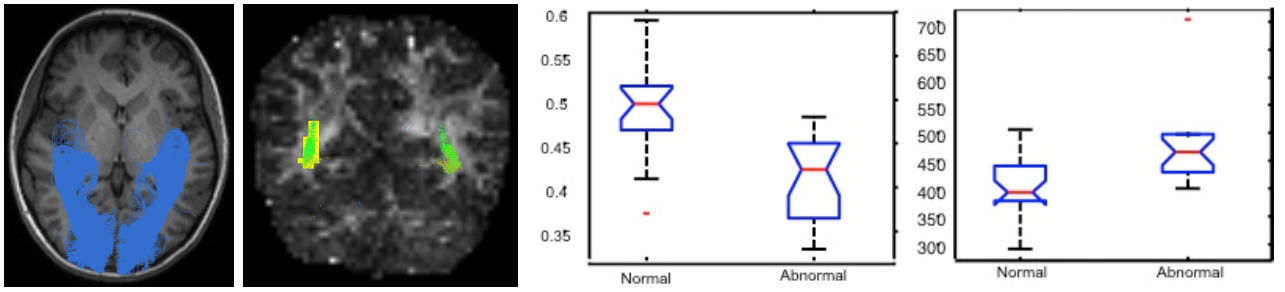
Results

The OR DTI tractography data from this study correlated well with previously published dissection and DTI tractography studies. Significant differences were observed in a number of anatomical measurements and DTI biomarkers between patients with normal and abnormal vision based on the results of our OR DTI tractography. Patients with abnormal vision had decreased area at the midpoint of the OR (p=0.02), decreased length of the OR (p=0.01), decreased fractional anisotropy (p=0.003) (Figure c.), increased radial diffusivity (p=0.008) (Figure d.) and increased apparent diffusion coefficient (p=0.04) compared to patients with normal vision.

Discussion

This is the first study to demonstrate downstream changes in the OR of patients with tumours causing optic chiasm compression. This study has shown differences in DTI biomarkers of the OR between patients with normal and abnormal vision following surgery for tumours causing optic chiasm compression. The findings in this study of compressive pathology are similar to the findings of other DTI studies of the OR involving other pathology affecting the visual pathway[4]. Additional studies of patients with tumours causing compressive pathology of the optic chiasm will continue to investigate how changes in DTI biomarkers of the OR correlate to visual deficits. Further studies of optic chiasm compression will also investigate DTI biomarker correlation with visual recovery and DTI biomarker changes in other parts of the visual pathway including the optic nerves and optic tracts. DTI biomarkers have the potential to be a clinically useful tool in the evaluation of patients with compressive pathology of the optic chiasm prior to surgical intervention.

Figures:



a. OR Tractography **b.** ROI for Analysis **c.** Fractional Anisotropy (p=0.003) **d.** Radial Diffusivity (p=0.008)

References: 1. Danesh-Meyer HV, et al. *Invest Ophthal Vis Sci* 2008;49:1879 **2.** Catani M, et al. *Brain* 2003;126:2093 **3.** Tournier J-D, et al. *Neuroimage* 2007;35:145 **4.** Kolbe S, et al. *Hum Brain Mapp* 2011