fMRI and diffusion tensor imaging biomarkers for assessing optic pathway structure and function in patients with pituitary tumours

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Introduction

Pituitary adenomas represent 8-10% of all intracranial tumours. Growth of pituitary tumours superiorly may cause optic chiasm or optic nerve compression and lead to visual failure or visual field (VF) defects. Surgery to remove pituitary tumours and decompress the optic pathway may result in visual recovery in some patients. Previous studies have identified a structure-function correlation between retinal nerve fibre layer (RNFL) thinning on optic coherence tomography (OCT) and VF defects on standard automated perimetry (SAP) in patients with optic chiasm compression and that RNFL thickness on OCT predicts the likelihood of visual recovery following surgery for optic chiasm compression.

Functional magnetic resonance imaging (fMRI) using blood oxygenation level dependent (BOLD) contrast can measure visual cortex and lateral geniculate nucleus (LGN) activation in humans. Diffusion tensor imaging (DTI) tractography has been shown to be capable of imaging the structure and integrity of white matter tracts of the optic pathway including the optic nerve and optic radiation. These advanced MRI techniques may provide additional information to help us to understand how pituitary tumours affect the optic pathway is affected in patients with pituitary tumours and have the potential to influence management of these patients and the timing of surgical intervention.

We investigated whether fMRI and DTI can be performed routinely on patients with pituitary tumours in a clinical environment. We also investigated whether these non-invasive MRI biomarkers have a role to quantify alterations in brain function as measured by fMRI activation or brain structure as measured with DTI tractography.

Methods

We recruited 7 patients who had undergone surgery for pituitary tumours at The Royal Melbourne Hospital or Melbourne Private Hospital to undergo a single additional MRI scan with anatomical, fMRI and DTI protocols. All patients no visual field deficit (>-10dB from age-matched controls) using the Zeiss Inc. Humphrey Field Analyzer and normal average RNFL thickness (>75 microns) as measured by the Zeiss Inc. Stratus OCT.

MR imaging was performed at The Royal Melbourne Hospital Department of Radiology on a Siemens Trio 3 Tesla full body MRI scanner equipped with a clinical fMRI system manufactured by MRIχ Technologies (Chicago, IL) and a 12 channel head-only radio-frequency (RF) coil. Anatomical MRI protocol: Three-plane survey, T1-weighted isotropic voxel FSPGR, T2-weighted fluid attenuated inversion recovery (FLAIR), and field map. Diffusion MRI protocol: 64-direction (b=0,1000) DTI acquisition of 55 slices with 2.5x2.5.2.5mm isotropic voxels (TR/TE=8000/80ms). fMRI protocol: Matrix size 64x64, 3x3x3=9mm^3, 30-slice depth, MRIχ Technologies Synchronisation Control System (SCS) 3.1 block-designed paradigms.

Results

fMRI activation maps were obtained from all subjects. DTI tractography was obtained using a constrained spherical deconvolution (CSD) probabilistic tractography algorithm. Comparison of manually selected ROI seeded tractography and seeding based on fMRI activation of the LGN was performed. Theses results showed that fMRI and DTI tractography could be performed reliably in this patient population.

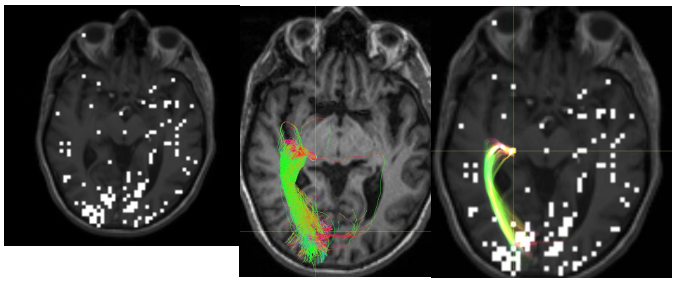

Fig 1. (A) fMRI activation map (B) Tractography seeded from ROI (C) Tractography seeded from fMRI

Discussion

We have shown that fMRI and DTI data can be reliably obtained to quantify optic pathway integrity and function in this patient population. The non-invasive nature of MRI offers an opportunity to investigate the structure and function of the optic pathway posterior to the retinal wall in humans that would not otherwise be possible. Further studies are warranted using fMRI and DTI tractography to investigate the structure and function of the human visual system and how the LGN, visual cortex and white matter tracts are affected by compression from pituitary tumours.

There is potential for these MRI biomarkers to improve and individualise the management of patients with pituitary tumours. fMRI and DTI data may be used to predict which patients are likely to suffer visual deterioration or which patients are likely to recover their visual function after surgery. This information would be valuable for clinicians to inform their patients about their condition and greatly influence patient selection for and timing of surgical intervention.