Structure-Function Relationships in the Human Visual System Using DTI, fMRI and Visual Field Testing: Pre- and Post-Operative Assessments in Patients with Anterior Visual Pathway Compression

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Background

The recently developed magnetic resonance technique of diffusion tensor imaging (DTI), [1], is used clinically to trace the structure of white fiber tracts in the human brain. This novel imaging technique that derives microstructural and physiological features of tissues has many potential immediate practical applications. The focus of this paper is to improve our understanding of the relationships between brain structure and function, using pre- and post-operative assessment in patients with anterior visual pathway compression. The other objective is standardization of DTI acquisition protocol to reduce variation in acquired data sets; there is a lack of such a protocol. Pituitary tumors often compress the anterior visual pathways producing significant visual loss. Surgical resection of these lesions decompresses the optic chiasm and may lead to visual recovery. This improvement in visual function has been shown to occur in three stages: rapid recovery within minutes to days, delayed recovery over weeks to months, and late recovery in months to years. In this paper, we study conditions behind the rapid (days) and delayed (weeks to months) recovery. To test these theories, we investigate changes in the visual system of patients with large, compressive, pituitary tumors by applying DTI, functional MRI (fMRI), and automated visualfield (VF) testing before and after transsphenoidal tumor resection. We plan to include, in the future, benchmark studies with normal subjects, too.

Methods

We used Diffusion tensor imaging (DTI), an MRI technology to visualize white matter pathways in the brain by tracking the movement of water through various nerve fiber connections. In patients with acute optic chiasm compression, DTI imaging we demonstrate relatively normal connectivity between the optic chiasm and the visual cortex. Preoperative DTI disconnection or disorganization may predict the inability to recover visual function. The subject's functional visual cortex was also mapped using fMRI and a reversing checkerboard stimulus with a 30 sec duration. We used the UNC software for 3D presentation of the optic nerve pathways, [2]

Results

For our DTI study, we selected a patient that had been admitted by the Neurosurgical service of the Columbia Presbyterian Medical. This patient presented with slowly progressive visual loss and a compressive skull base tumor; her left optic nerve and optic chiasm crashed, and the right optic nerve partially functional. We were able to obtainpre-operative data including formal visual fields, a complete optical tensor MRI (DTI), a fine-cut contrastT1 MRI, as well as a complete MRI study. Furthermore, the functional MRI data are perfectly consistent with the patient's hemianopia as shown on the visual fields. The fiber tracks obtained from the DTI depicting the visual pathway originating from the visual cortex confirmed patient's diagnosis, Fig.1.

Conclusions

We have developed in-house software to process DTI images with formation of pseudo-colored images to visualize the nerve bundles, via extraction of Principle Component. This approach will provide us with a full understanding of the processed DTI data and allow better interpretation of white matter fiber images visualized in 3D.Performing fMRI and automated VF tests correlated with structural DTI abnormalities yield a potential powerful tool to understand pre- and post-operative functional deficits in patients with anterior visual pathway compression.

References

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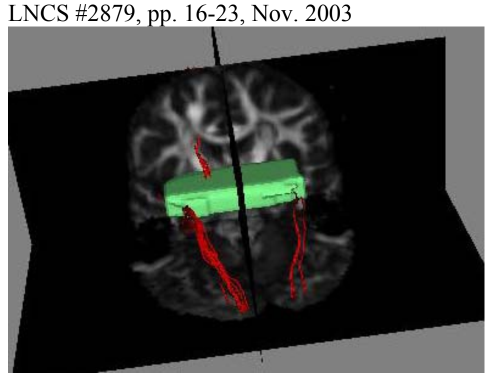

Fig.1. Visual pathways tracks originating from the visual cortex.