Diffusion Tensor Imaging and Tractography of the Visual Pathways

AKADEMISK AVHANDLING

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet, kommer att offentligen försvaras i Hjärtats aula, Vita Stråket 12, Sahlgrenska sjukhuset, fredagen den 23 september 2016 kl. 13.00

av

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Professor John Duncan
University College London, United Kingdom

Avhandlingen baseras på följande delarbeten:

I. Lilja Y, Ljungberg M, Starck G, Malmgren K, Rydenhag B, Nilsson D
Visualizing Meyer's Loop: A Comparison of Deterministic and Probabilistic Tractography
Epilepsy Research: 2014, Mars;108(3): 481-90

II. Lilja Y, Ljungberg M, Starck G, Malmgren K, Rydenhag B, Nilsson D
Tractography of Meyer's loop for temporal lobe resection – validation by prediction of post-operative visual field outcome
Acta Neurochirurgica (Wien): 2015 Jun;157(6):947-56

III. Lilja Y, Gustafsson O, Ljungberg M, Nilsson D, Starck G
Impact of region-of-interest method on quantitative analysis of DTI data in the optic tracts
BMC Medical Imaging: 2016 Jul 11; 16(1): 42

IV. Lilja Y, Gustafsson O, Ljungberg M, Starck G, Lindblom B, Skoglund T, Bergquist H, Jakobsson K-E, Nilsson D
Visual-pathway impairment by pituitary adenomas – quantitative diagnostics by diffusion tensor imaging
In press: Journal of Neurosurgery, DOI: 10.3171/2016.8.JNS161290

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ABSTRACT

The visual pathways are essential for human vision. Injury to the structures will lead to visual impairment – from small deficits to blindness. Diffusion tensor imaging (DTI) can be used to assess nervous pathways in the brain, non-invasively and *in vivo*. Diffusion properties, measured by DTI, have been shown to correspond to pathology in nervous tissue and, furthermore, can be used for visualization of white matter tracts through *tractography*.

Temporal lobe resection (TLR) may be indicated for medically refractory temporal lobe epilepsy or tumors. At TLR the optic radiation (OR) may be surgically injured, which may lead to significant visual field defects (VFD). The aim of study I and II, was to assess the anatomical accuracy of tractography of the OR and, ultimately, the use of tractography for surgical guidance in order to reduce postoperative VFDs. Two different tractography algorithms were assessed: deterministic (DTG) and probabilistic tractography (PTG).

In Study I, PTG and DTG of the OR were performed in 23 DTI scans (46 ORs). The anterior extents of the OR tractographies were measured. Results by PTG placed the OR more anteriorly and were the closest match to dissection studies and to a histological atlas. The aim of Study II was to validate the individual anatomical accuracy of OR tractographies from eight patients who underwent TLR. The results showed that the postoperative degree of VFD could be predicted based on the preoperative OR tractography and the resection size.

In conclusion, PTG is a strong candidate for surgical guidance of TLR that aims to minimize injury to the OR.

Pituitary adenomas may cause visual impairment by compression of the anterior visual pathways. Early detection of injury is crucial in order to initiate treatment while it is reversible. DTI may be used as a diagnostic tool of early injury, however, the anterior visual pathways, including the optic tracts, represent challenging structures for DTI analysis.

The aim of Study III was to assess different DTI-data extraction methods of the optic tracts and to find a reliable method, defined as a method with low method-dependent variability and high anatomical accuracy. Four region-of-interest (ROI) methods were compared, out of which three could be found in previous literature and one was new, based on the FA-skeleton algorithm of tract-based spatial statistics (TBSS). DTI parameters by the four methods were significantly different and the semi-automatic method based on the FA-skeleton proved to perform best.

The aim of Study IV was to assess the value of DTI as an objective diagnostic tool for injury of the anterior visual pathways in patients with pituitary adenomas. The FA-skeleton ROI method was applied on DTI scans of 23 patients who underwent surgery for pituitary adenomas. DTI parameters proved to correlate with the degree of VFD and to differ significantly between patients and controls, which may correspond to levels of demyelination and axonal atrophy in the patient group.

In conclusion, DTI could detect pathology and degree of injury in the anterior visual pathways and may be useful as an objective diagnostic tool for patients with pituitary adenomas. Choice of ROI method was found to be highly influential on DTI parameters when the optic tracts were analyzed.