Quantification of diffusional anisotropy in regions of complex tissue microstructure using non-conventional diffusion MRI

Markus Nilsson

Lund University Bioimaging Center (LBIC)

During the last two decades, diffusion tensor imaging (DTI) has become an indispensable tool in neuroscience. The technique enables the mapping of water diffusion anisotropy in nerves in terms of parameters such as the fractional anisotropy (FA). The FA has provided new insights into the organisation of the brain, for example, by detailing which brain regions that increase during maturation or learning, and decrease in case of neural degeneration. However, DTI is inaccurate and yields counterintuitive results in regions of complex tissue microstructure, for example, in regions of crossing nerve fibres where a high level of axonal orientation dispersion is present. To circumvent this problem, we have devised a non-conventional diffusion encoding scheme to enable diffusion encoding in multiple directions simultaneously. By comparing the signal attenuation between encoding in three orthogonal directions, so-called isotropic encoding, and conventional unidirectional encoding, we can estimate the microscopic FA. We present initial results from in vivo studies of healthy volunteers and of brain tumour patients. Parameter maps of the microscopic FA in brain tumours show a good agreement with histology, where meningioma cells, organised in elongated cell fascicles, yield a high value, while the spherical geometry of astocytoma cells yield low values. In the healthy brain tissue, the microscopic FA displays little variation within the white matter, which we expect will enable accurate and more sensitive detection of neurodegeneration compared to conventional methods. In future work, we will optimize the imaging protocol in order to accelerate the imaging.