[SY01] Neuro Symposium l

SY01-01

State-of-the-art brain tumor imaging

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Learning Objectives:

To discuss standard of care brain tumor surveillance imaging and its limitations and also how we have incorporated perfusion imaging and PET/MR as a standard of care for our entire brain tumor patients.
Discuss role of emerging techniques such as MR fingerprinting, CEST, and Sodium imaging for brain tumor patients.
Discuss future contributions and directions for artificial intelligence in brain tumor imaging.

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SY01-02

Quantitative MR Imaging for Research and Practice

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Diffusion-weighted imaging (DWI) and magnetic resonance (MR) relaxometry are MR imaging techniques used for tissue quantification. These techniques are widely used in research and have some practical applications.

1. In addition to conventional DWI techniques such as diffusion tensor imaging, new DWI techniques have been introduced and show some promising results. Oscillating gradient spin-echo (OGSE) sequence is a technique that can shorten diffusion time by changing the DWI frequency, and can be applied on clinical MR units. It enables estimation of the diffusion time-dependency of tissue in normal and diseased condition. The information provided by OGSE will facilitate more detailed DWI research into the brain and spinal cord, and enhance the accuracy of clinical diagnosis. In addition to the single, linear encoding of conventional motion probing gradients (MPGs) for DWI, advanced encoding techniques for MPGs have been introduced, including some gradient waveforms and trajectories. For example, the double diffusion encoding (DDE) technique, which can be applied to clinical MR scanners, provides microstructural information on both microscopic anisotropy and compartment shape anisotropy. In other words, intra-voxel microstructure can be estimated by DDE, and this provides valuable additional information for clinical use.

2. Recently, the 2D synthetic MR imaging technique has been introduced as a rapid MR relaxometry technique for clinical use. After a combination of 5-7 minutes of MR scanning for source imaging, quantitative T1, and T2, proton density maps can be produced and used in conventional ‘weighted’ images. These include T1-weighted, T2-weighted, fluid-attenuated inversion recovery (FLAIR), short-TI inversion recovery (STIR), and other images with arbitrary imaging parameters, such as echo time, repetition time and inversion time. This means it is not necessary to fix these parameters before actual patient study, and this technique has a potential for new contrast MR images, which highlight specific abnormal conditions for clinical use. Moreover, synthetic MRI enables not only rapid, clinical, routine MR scanning, but also quantitative investigation of normal brain tissue and lesions. The outputs may provide new, useful information for clinical diagnosis, because conventional MR images needed relatively long scanning times in the past. Moreover, this technique has the potential for rapid myelin estimation based on relaxometry values, which is useful for investigations of inflammatory degenerative disease in clinical settings. The most recent improvement of this technique is that 3D synthetic MRI data acquisition has become possible. This may lead to the rapid combination of routine clinical imaging, MR relaxometry, and MR volumetry at the same time, during less than 10 minutes of MR imaging.

In this lecture, a brief review of the basics of advanced DWI and rapid MR Relaxometry, and the clinical application of these techniques for CNS disorders, will be presented.

Keywords : OGSE, DDE, Synthetic MRI

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SY01-03

Update on Advanced Diffusion Magnetic Resonance Imaging in Parkinson's Disease

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Parkinson's disease (PD) is the most common neurodegenerative movement disorder. The degeneration of dopaminergic neurons projecting from the substantia nigra pars compacta to the corpus striatum, which is known as the nigrostriatal pathway (NSP), is presumed to be the cause of the motor symptoms observed in PD. Moreover, the aggregation of a-synuclein in the form of Lewy bodies and neurites in the gray and white matter have also demonstrated as the major pathologies in PD.

Diffusion tensor imaging (DTI) allows the *in vivo* assessment of the microstructure of brain tissues by measuring directional changes in water diffusivity. The changes of DTI indices [fractional anisotropy (FA), mean diffusivity (MD), radial diffusivity (RD) and axial diffusivity (AD)] were widely demonstrated in PD, however, with inconsistent results. This might be contributed by some limitations of DTI, which include 1) DTI indices are sensitive to a large number of possible pathologies; therefore, it is difficult to infer the underlying pathophysiology of cerebral microstructural abnormalities; and 2) DTI assumes a single tissue compartment per voxel. The effect of partial volume (PVE) averaging in a voxel from extracellular free-water (FW) can bias the interpretation of DTI indices.

The recent development of diffusion MRI (dMRI) methods might address the limitations of DTI. Free-water (FW) imaging was developed to quantify the contribution of extracellular FW and eliminates its bias on estimations of tissue microstructures, enabling the differentiation between alterations in the tissues themselves, as measured by the FW-corrected DTI indices (FA_T, MD_T, RD_T, and AD_T), and extracellular FW changes, as measured by the fractional volume of FW. Further, a more advanced diffusion model, such as Neurite Orientation Dispersion and Density Imaging (NODDI), was developed based on a multi-compartment (intracellular, extracellular, and cerebrospinal fluid) diffusion model using multishell dMRI data. NODDI indices, the intracellular volume fraction (ICVF) and the orientation dispersion index (ODI), are assumed to reflect the density and direction of neurites, two separate disentangled facets of FA.

We used FWI and NODDI to assessed the white and gray matter and NSP of PD patients. Our results provide novel evidence that the FWI can be used to detect the causes of microstructural changes in early PD, such as neurodegeneration and inflammation, more specifically. With NODDI, we were able to show retrograde degeneration of NSP in PD patients. Moreover, compared to DTI, NODDI provides more specific and sensitive indices of WM pathology in PD patients with neurocognitive-psychiatric symptoms (NPS). Our findings suggest that reduced axonal density (indexed by ICVF) is one of the major factors underlying WM pathology related to NPS in PD. The changes seem to be first occurred in the anterior part of the brain then progressing to the posterior part of the brain.

Keywords : Parkinson's disease; Diffusion tensor imaging; Free-water imaging; Neurite orientation dispersion and density imaging