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Microstructural assessment of multiple sclerosis lesions and peri-plaques using advanced multishell diffusion MRI

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Introduction:

Chronic active multiple sclerosis (MS) lesions, seen on susceptibility-based MRI as Paramagnetic Rim Lesions (PRL), are associated with increased clinical disability and axonal damage. Diffusion MRI (dMRI) can characterize *in vivo* tissue damage, however, the tissue microstructure specificity of established dMRI models is limited.

Objectives/Aims:

Here, we characterized PRL vs non-PRL microstructure and their surrounding peri-plaque white matter (PPWM) using Track Density Imaging (TDI) and 4 different dMRI models, including two novel ones; Microstructure Fingerprinting (MF) and DIstribution of Anisotropic MicrOstructural eNvironments in DWI (DIAMOND). To our knowledge, MF, DIAMOND, and TDI have never been used to depict the microstructure of MS lesions.

Methods:

In 75 MS patients (47 relapsing-remitting, 19 secondary progressive, 9 primary progressive) 582 lesions (330 PRL and 252 non-PRL) were detected on 3T high-resolution unwrapped-phase images. Their surrounding PPWM was automatically computed by extending their lesion mask by 4 mm in every direction. Each patient as well as 7 Healthy Controls (HC) underwent multishell diffusion-weighted imaging. For each lesion, we computed quantitative T1 values and extracted diffusion parameters using 4 dMRI models: Diffusion Tensor Imaging (DTI), Neurite Orientation Dispersion and Density Imaging (NODDI), DIAMOND and MF. TDI was derived from a probabilistically generated and filtered tractogram of 1 million tracts for a subset of 24 patients and 7 HC. Patient TDI images were spatially z-score normalized according to the average HC TDI.

Results:

PRL and PRL PPWM featured higher T1-values vs non-PRL and non-PRL PPWM, respectively ($p<0.001$). The DTI and DIAMOND models showed lower fractional anisotropy, higher mean diffusivity, and radial diffusivity in PRL and PRL PPWM vs non-PRL and non-PRL PPWM ($p<0.001$); NODDI and MF models showed respectively lower neurite density index and lower fibre volume fraction ($p<0.001$), suggesting impaired axonal integrity/density in PRL and PRL PPWM vs non-PRL and non-PRL PPWM. The TDI analysis showed reduced track density in PRL vs non-PRL lesions ($p<0.005$).

Conclusion:

Consistent with previous data, we show that PRL and their surrounding PPWM are characterized by higher axonal damage when compared to non-PRL. Results derived from the TDI, MF and DIAMOND models are in line with those obtained with DTI and NODDI, suggesting that these advanced diffusion imaging methods can be used to study MS lesion pathology.

Disclosures:

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