Assessment Of Slow Diffusion Component Changes In Relapsing Remitting MS By Q-Space Analysis

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Introduction: Diffusion weighted MRI (DWI) is sensitive to changes of structural and functional status of brain parenchyma. Imaging of the slow diffusion components is interesting for theoretical considerations and challenging for technical reasons. One way to visualise and analyse slow diffusion is q-space analysis, that extracts structural information without the use of a model. Q-space analysis has shown very promising results in demonstrating various pathologies including inflammatory-demyelinating tissue changes. It has been suggested, that the slow diffusion might predominantly represent intra-axonal/intra-cellular water diffusion. We developed and implemented sequences and analysis strategies along the lines suggested by Assaf, Cohen et al. and employed high b-value DWI and q-space analysis in MS patients to study the sensitivity and imaging information when compared to other contrasts, in particular to T_2-weighted MRI.

Materials and Methods: MRI was obtained in 18 patients with relapsing-remitting MS (13w, 5m, age 20-46 years) with EDSS scores from 0-4. Eight young normal controls (4f, 4m, age 24-42 years) were studied. As pathological controls resembling a focal pathology 2 young patients (1f, 1m). MRI was performed with a 1.5 T Siemens SONATA system. DWI with high b-value measurements for q-space analysis: SE prepared DW sequence, 6 directions, 14 b-values in each direction, b-value range: b = 0 - b=8182 s/mm^2 by linearly increasing the diffusion gradient amplitude TE/TR = 136/1500, 120x128 matrix Voxel size: 1.875x1.875x4.5 mm. MS patients also were investigated with a standardised protocol including T1w, FLAIR, T1w MRI after contrast injection. Postprocessing: 2D rigid body motion correction, eddy current correction. Q-space analysis for each direction provided 2 parameter maps: 1. A probability for zero displacement map (the peak intensity of the displacement distribution probability function). 2. the minimum displacement, extracted from the width at half-height given in arbitrary units and m respectively. The maps display the information using a color scaling scheme. The analysis focused on the probability for zero displacement maps. Images were compared for information content in regard to the delineation of anatomical structures and lesions. Lesions were identified on T_2w images and both lesions and normal appearing brain tissue were compared to the visualisation on zero probability displacement maps. Brain parenchyma of controls and patients was also compared using a histogram analysis.

***Results*:** Normal and pathological controls: Both Q-space derived maps provided strong contrast between grey and white matter emphasising the relatively low diffusion in normal white matter. This was also confirmed when comparing normal white matter (Fig.1A) with an acute stroke lesion (Fig.1B). Both tissues are characterised by prominent areas of low diffusion. All macroscopically visible lesions and areas of questionable hyperintensity on T2-weighted MRI were well displayed on zero probability displacement maps. (Fig. 2). These observations underlined the high sensitivity of q-space derived maps to structural integrity of white matter. Further histogramm analysis comparing controls and patients clearly demonstrated the loss of slow diffusion pixels in the white matter confirming earlier results (Fig.3) (2).

Discussion and Conclusion: DWI with high b-values and Q-space analysis provides images with a strong contrast indicating that tissue characteristics of grey and white matter differ in regard to the slow diffusion component. Q-space analysis is highly sensitive to tissue abnormalities in MS. The strong focus of Q-space analysis on the slow diffusion component may indeed be a new promising means to demonstrate white matter integrity more sensitively than diffusion imaging at lower b-values.

***References*:** [1] Cory DG, Garroway AN. Magn Reson Med 1990; 14: 435-444. [2] Assaf et al. Magn Reson Med 2002; 47:115-126

Figure 1

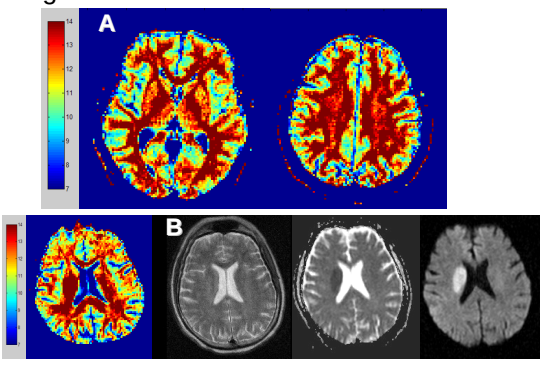

Figure 2

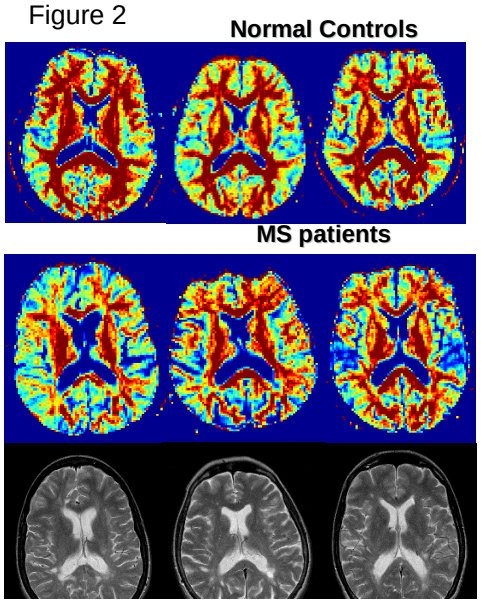

Figure 3