RELATIONSHIP BETWEEN MRS NAA CONCENTRATION AND DTI ADC VALUES

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Introduction

Diffusion tensor imaging (DTI) and proton magnetic resonance spectroscopy (MRS) yield different parameters for characterizing the evolution of a demyelinazation in white matter disease. NAA has been shown to be decreased in well-known demyelinating diseases such as multiple sclerosis (Mader et al, 2008). It is commonly believed to provide a marker of neuronal density, although this is not fully substantiated as NAA concentrations differ among neuron types. Diffusion tensor imaging may give information about the axonal impairment of the neurons by changes of the patterns of anisotropy, e.g. fractional anisotropy (FA) or apparent diffusion coefficient (ADC). Proton MR spectroscopy is thought to provide surrogate markers for the axonal integrity (Govindaraju et al., 2000). In this study FA and ADC within a spectroscopic single voxel region were compared to tNAA values.

Methods

In vivo single voxel proton spectroscopy and DTI has been performed in 19 healthy controls (HC) (mean age: 32.5 ± 8.8 years; 9 males). MR measurements were performed on a 3 T Siemens TRIO with a 12-channel head coil (Siemens Medical Solutions, Erlangen, Germany). A set of sagital, transverse and coronal MR images were first obtained to determine patient position. Based on the images a 10x40x10 mm³ single voxel was positioned in the frontal white matter. Five reduced water suppression localized spectra were performed with a PRESS sequence using following parameters: TE = 30 ms, 80, 200, 300 and 420 ms for T2 quantification. TR was set at TR = 6000 ms, and averages = 40 for each spectra. In addition fully relaxed unsuppressed water spectra were acquired with TR = 10 s and six different TEs for eddy current correction in LCModel and to estimate the absolute water signal at TE = 0. This was used for absolute quantification and to correct data for different coil loadings and possible coil inhomogeneities.

A diffusion weighted single shot EPI sequence with diffusion sensitised gradients in 20 directions (TR = 3000 ms, TE = 93 ms, b1 = 1000 s/mm2, slice thickness = 3 mm, number of slices = 20, FOV = 230 mm and 4 averages) was additionally acquired. Maps of FA and ADC were created by the Siemens Syngo Software (VB13). Spectral fitting was done with LCModel and GAMMA-simulated basis-sets. LCModel metabolite values for tNAA, tCr and tCho at the different TEs were fitted monoexponentially in Origin 7.0. The results were scaled with the interpolated water signal at TE = 0. CSF correction was done with a segmentation tool based on SPM2. Correlation was only done for those data with less than 1% CSF and more than 95 % white matter. The evaluation of mean FA and ADC within the spectroscopic voxel were accomplished with the same SPM2-based software tool which accounted for the different chemical shift displacement of each metabolite voxel (Fig. 1 a and b).

Results

	NAA con [mM]	Cr con [mM]	Cho con [mM]	FA NAA	FA Cre	FA Cho	ADC NAA	ADC Cre	ADC Cho
Mean	13.84	9.67	2.84	0.370	0.368	0.368	0.770	0.766	0.765
SD	0.90	0.91	0.40	0.027	0.027	0.027	0.036	0.034	0.033

We found a significant correlation between absolute tNAA concentration and the mean ADC value within the same voxel (Fig. 2). No correlation was found for the other metabolites or T2 relaxation times and FA or ADC.

Figure 1: left: FA map right: ADC map and spectroscopy voxel position

Discussion

Reduction of NAA may reflect structural abnormality such as reduced axonal density or reduced viability of neurons. The white matter tNAA concentration seems to be a marker of myelin lipid synthesis which is depended on NAA-derived acetate. DTI on the other hand is reflective for structural integrity of axonal tracts. These results show there is a direct relation between ADC values and absolute tNAA concentrations. Similar results have been found in a study of giant axonal neuropathy (Brenner et al. 2008), but had not yet been shown in healthy control subjects.

References

Mader et al., Eur J Radiol. 2008; Govindaraju et al, NMR in Biomed. 2000; Brenner et al J Magn Reson Imaging 2008
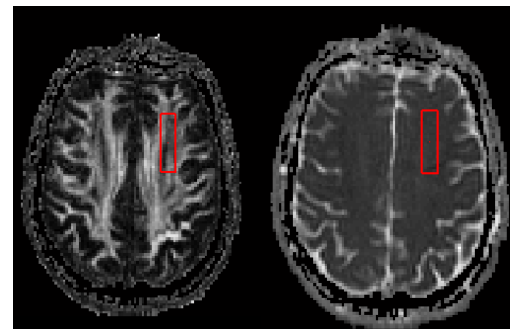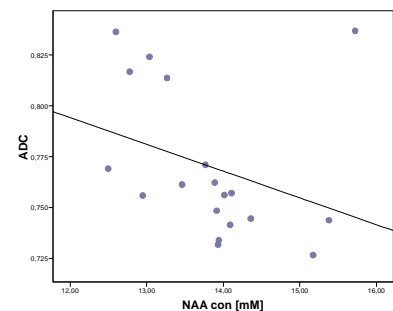
Figure 2: NAA concentration of frontal white matter and mean ADC of the measured voxel