Neurochemical Profiles of Several Brain Regions Determined By Short-Echo, ^{1}H MRS at 7T

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Introduction

Proton Magnetic Resonance Spectroscopy (^{1}H MRS) can benefit substantially from the signal-to-noise-ratio (SNR) and resolution advantages at ultra-high fields (UHF), particularly for quantifying neurochemical profiles that consist of up to 18 metabolites (1). However, T_2 relaxation times of metabolites in the human brain are relatively short at UHF and the SNR advantages quickly disappear with increasing echo times. Therefore, short-echo times are critical for quantifying neurochemical profiles. All studies that obtained a neurochemical profile from single voxel, short-echo ^{1}H MR spectra of the human brain at 7T so far utilized data from the occipital lobe acquired with half volume coils. Challenges of doing the same in other brain regions include limitations in maximum achievable B_1 field strength with volume coils. The goals of this study were 1) to demonstrate the feasibility of acquiring and quantifying short-echo, single voxel ^{1}H MR spectra by utilizing 16 channel transmit/receive transmission line coils and B_1 shimming and 2) to acquire neurochemical profiles of brain regions that are of interest for various neurological disorders; frontal white matter (demyelinating white matter diseases), posterior cingulate (Alzheimer's disease), putamen (Huntington's and Parkinson's diseases), and the substantia nigra (Parkinson's disease).

Methods

MR experiments were performed using a 7T, 90-cm horizontal bore magnet (Magnex) equipped with a Siemens console. A 16-channel transmit/receive transmission line array head coil was used. Destructive B_1^+ interferences in the volume of interest (VOI) were reduced by a fast, localized B_1^+ shimming protocol (2). Spectra were measured by a short-echo STEAM sequence (TE = 8 ms, TR = 5s) with VAPOR water suppression and outer volume saturation (3). The water spectrum acquired from the same VOI was used to remove residual eddy currents and reconstruct the phased array spectra (4). Spectra were acquired from the occipital cortex (OCC) (20 x 20 x 20 mm^3, nt = 128), posterior cingulate (PC) (20 x 20 x 20 mm^3, nt = 128), frontal white matter (FWM) (20 x 20 x 20 mm^3, nt = 128), putamen (PUT) (13 x 13 x 15 mm^3, nt = 256), and substantia nigra (SN) (6 x 13 x 13 mm^3, nt = 512), each from 5 healthy volunteers. Metabolites were quantified with LCModel (5) using the unsuppressed water signal as reference.

Results and Discussion

Figure 1 shows representative spectra obtained from different brain regions at 7T. We were able to acquire artifact-free spectra with an excellent data quality and a small chemical shift displacement error (maximum 7.5% at the edges of the spectra in each dimension). The high SNR of spectra enabled the quantification of a neurochemical profile consisting of at least 11 metabolites in all brain regions (Figure 2). Unique profiles for each VOI were observed. For instance, a high GABA concentration in SN and high glutamine levels in putamen were in excellent agreement with established neurochemistry (6). These findings demonstrate that single voxel ^{1}H MRS at UHF has the potential of becoming an objective tool to monitor disease-specific neurochemical changes in different brain regions.

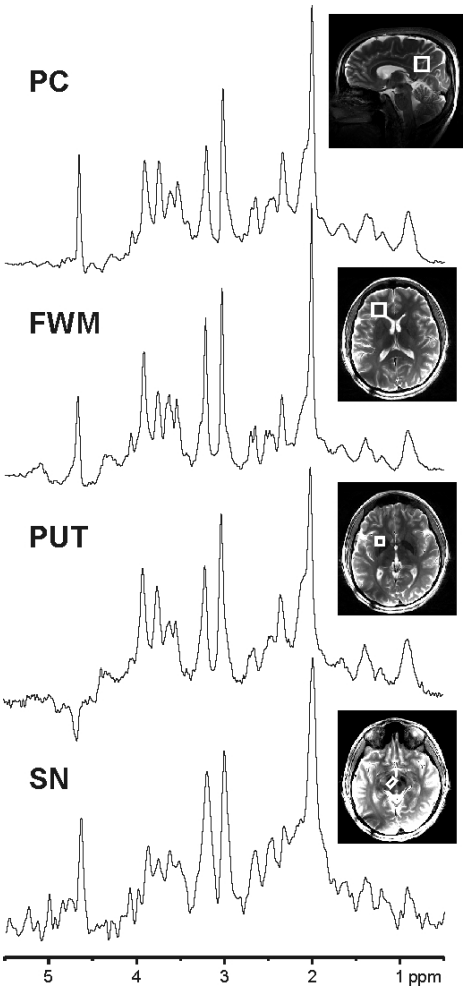

Figure 1. ^{1}H MR spectra obtained with STEAM (TR = 5 s, TE = 8 ms, TM = 32 ms) from four VOIs.

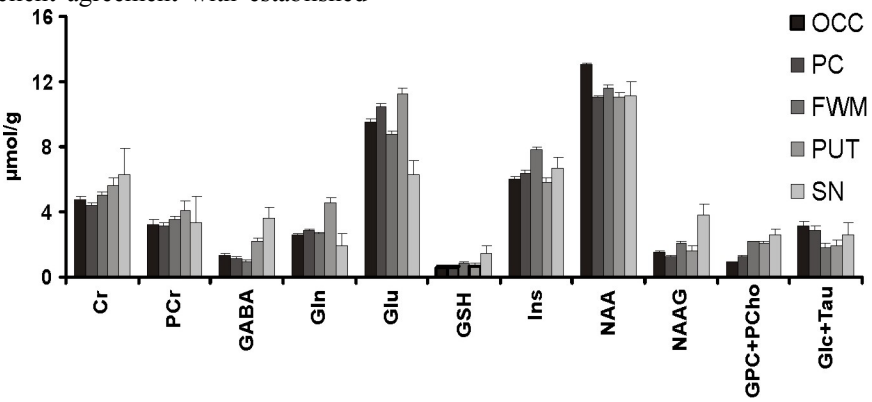

Figure 2. Metabolite concentrations determined by LCModel fitting. The errors shown are SDs.

References:

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