PROTON MAGNETIC RESONANCE SPECTROSCOPY METHOD FOR THE DETECTION OF HUMAN BRAIN METABOLITES AT 7 TESLA

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Introduction

The increased magnetization and frequency separation at high magnetic field strength, such as 7 Tesla, can provide spectra of high signal-to-noise ratio and peak separation which allows the detection of various brain metabolites and macro-molecules. However, increased field inhomogeneity may compromise this advantage depending on the brain region. In addition, limited B1 field strength with volume transmission coils and inhomogeneous RF-fields can reduce the efficiency at high field strength. The in vivo spectra acquired from human brain at 7T were quantified using LC-Model [1]. Model metabolite solutions were used in a STEAM-VERSE sequence to create a basis set. In this study, the spectral quality in various brain regions was analyzed and the potential improvement over 3T evaluated.

Methods

All *in vitro* and *in vivo* measurements were performed on a whole body 7T system (Siemens, Erlangen, Germany). 8 healthy subjects (age 25- 44 years) were included. Stimulated-echo acquisition mode (STEAM) was modified by the introduction of the VERSE technique to reduce SAR at 7T [2]. Provencher [3] developed the LC-model method to analyze *in vivo* spectra as a Linear Combination of model spectra of *in vitro* metabolite solutions. Twenty model solutions were used. A 24 channel head coil (Nova Medical Inc.) was employed for human brain measurements, and a small quadrature coil (DSI–1148) has been used to acquire the model spectra. *In vivo* spectra of human volunteers at different anatomical positions have been quantified using LC-model. For reference, spectra were acquired at 3T with identical location using PRESS (TR/TE=2000/35 ms).

Results and Discussion

In vivo 1H-MR spectra were acquired from the human brain at 7T and at 3T. The increased spectral resolution at high magnetic field due to increased chemical shift yields an enlarged number of resolved spectral features as shown in figure 1. The SNR at 7T is higher than at 3T as indicated in figure 1(A) and (B) even though, the STEAM sequence has been used at 7T and more averages in a larger voxel were acquired at 3T. The signal-to-noise ratio was increased by a factor of 1.5 at 7T relative to 3T in this volume of interest selected in the ACC. Two aspects contribute to this gain: the small voxel size yields good homogeneity at 7T leading to narrow peaks. In addition, the 24-channel coil may offer superior sensitivity compared to the 8-channel coil used at 3T.

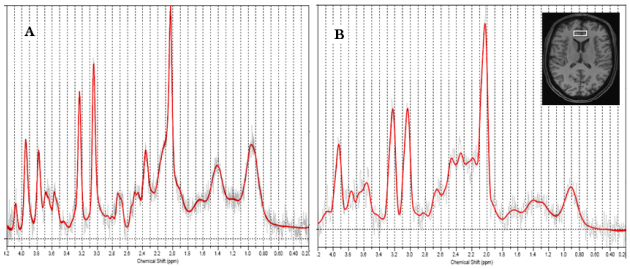

Fig.1 ACC spectra of the same volunteer. A) at 7T using STEAM with VERSE, 128 averages, TR/TE/TM=3000/20/15 ms, and voxel size=1.8 mL. The SNR=18 and FWHM=0.035 ppm. B) at 3T using PRESS 256 averages, TR/TE=2000/35 ms, voxel size=2.5 mL. The SNR=12.

Table 1 shows the comparison between the quantitative metabolite concentrations of glutamine, glutamate, N-acetylaspartate, gamma-aminobutyric at 3T [4] and the concentrations at 7T in the pgACC region. The metabolite concentrations are given relative to Creatine. The results of our measurements at 7T agree well with this study that used J-resolved PRESS spectroscopy with rather long scan times [4]. For example, Gln/Cr and Glu/Cr ratios are (0.30±0.09) and (1.52±0.33) relative to (0.34 ±0.15) and (1.35±0.13) at 3T, respectively.

Table 1. Comparison of metabolite concentrations.

	Mean(SD)	
measure	7T	3T
Cr, mM/kg	5.70(0.55)	6.30(0.96)
Gln/Cr	0.30(0.09)	0.34(0.15)
Glu/Cr	1.52(0.33)	1.35(0.13)
GABA/Cr	0.30(0.08)	0.21(0.07)
NAA/Cr	1.49(0.08)	1.50(0.15)

Figure 2 shows a spectrum from a parietal brain region. The small fit residual, the high SNR (43), and the narrow line width FWHM (0.027) ppm indicate better field homogeneity than in the frontal region leading to an even higher spectral quality. The small voxel size affordable by the high SNR possible at 7T results in improved shim. Therefore, more metabolites can be resolved.
Metabolites have been quantified using a basis set of twenty brain metabolites' spectra acquired at 7T. In this work, LC-Model allowed resolution of closely located metabolite peaks such as NAA and NAAG. In addition, the peaks of Glutamine (Gln), Glutamate (Glu) and myo-Inositol (Ins) were clearly resolved at 7T.

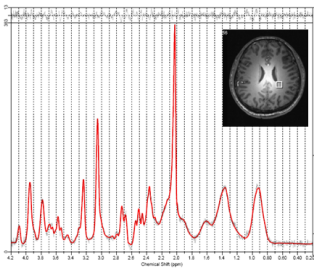

Fig.2 In vivo 1H NMR human brain spectrum acquired at 7T using STEAM (VERSE factor 1.4), 128 averages,3600 Hz spectral bandwidth, 2048 data points, TR/TE/TM=3000/20/15 ms, acquisition duration = 568 ms and voxel size= 1.7 mL.

Conclusion

The full improvement in line splitting and SNR can be achieved in "benign" (homogeneous) brain regions such as the parietal or occipital lobe only. In other regions (such as ACC), the benefits of high field are lower but spectral quality is still improved over 3T. Separation of J-coupled metabolites, such Glu/Gln with standard STEAM at 7T seems possible with similar sensitivity as J-resolved methods at 3T.

Acknowledgement

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References

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