Phased Array MR Spectroscopic Imaging of the Brain at 7T

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Introduction: With the non-significant risk classification of 7T, high field MR scanners are poised to advance neuroradiological research through improved anatomic MRI and metabolic MRSI. Quantitative comparisons have indicated an average 80% increase for 7T phased array brain MRI as compared to 3T [1]. However, major challenges facing 7T MRSI include increased chemical shift misregistration, B1 peak power limitations, Bo and B1 inhomogeneity, and increased spectral bandwidth. The goal of this project was to develop specialized rf pulses and acquisition methods for 3D MRSI at 7T to address these challenges. The new MRSI sequence and rf pulses were then applied in volunteer studies to evaluate these methods for 7T spectroscopic imaging.

Methods: All studies were performed on a 7T GE MR scanner (GE Healthcare Technologies, Waukesha, WI) equipped with a commercial quadrature excite and 8-channel phased array receive coil (Nova Medical, Wilmington, MA). High resolution MR images were first obtained with the phased-array coils and image-intensity corrected for the inhomogeneous reception profile of the coils[2]. Higher order shimming was performed using routine provided by the manufacturer. The 3D MRSI data in 5 volunteers with informed consent was acquired in 17 minutes using a custom PRESS-MRSI sequence with a TR=2s, TE=144ms, 2048 pts, 5000Hz bandwidth, CHESS water suppression, 12x12x8 phase-encoding matrix with elliptical k-space sampling at 1cc nominal resolution. Custom designed, phase modulated, symmetric sweep, high bandwidth, spectral-spatial pulses [3] were created to replace the conventional refocusing 180^{o} pulses, yielding virtual no chemical shift in plane. Specially designed, low peak power (0.12G), high bandwidth (~6kHz), very selective saturation (VSS) pulses were employed to sharpen the volume selection profile and combined with over prescribed volume to reduce chemical shift misregistration effects in the z-dimension, selected by the 90. The signals from the different phased-array coil elements were combined using previously described methods.[2] The data presented below was processed with a 4Hz Gaussian apodization and with first point phasing and baseline correction but without k-space filtering.

Results: Whole brain 3D MRSI data is demonstrated in Figure 1 with no detectable chemical shift misregistration in plane and minimal effects in z. The seemingly low metabolite levels near the edges and around the corners are due to the shim profile, which is an ellipse at time of acquisition. Figure 2 demonstrates the increased modulation effects at 7T, where Glx peak seem to be refocused and still visible at a long TE of 144 ms. Cho had a linewidth of 17.2 to 19.5 Hz, Cr of 17.5 to 21.7 Hz, and NAA of 21 to 25.5 Hz across the slices superiorly to inferiorly. SNR varied due to slice location. In the top slice where the best Bo homogeneity was achieved, the mean Cho SNR is 57, with Cr at 69, and NAA at 164.

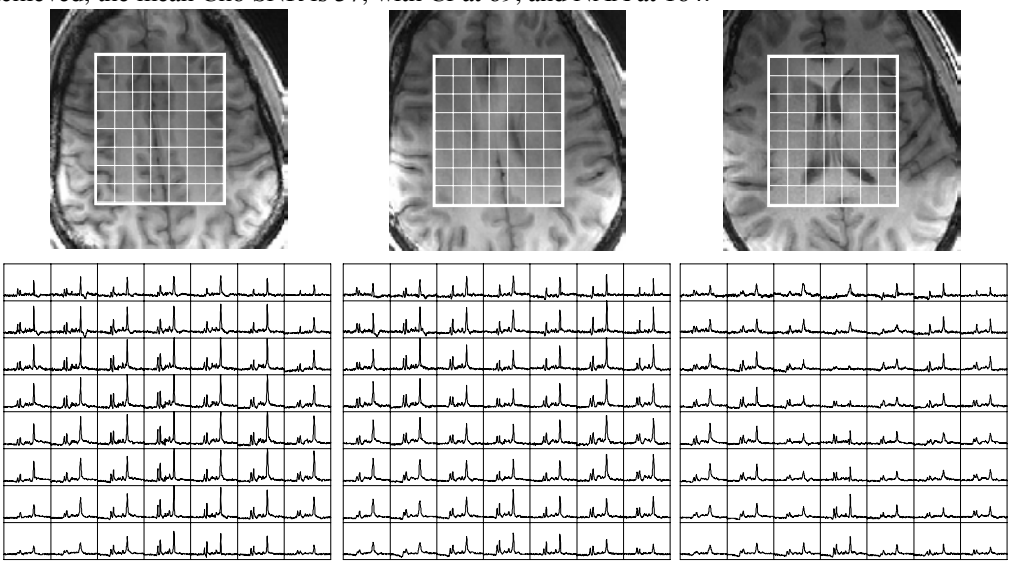

Figure 1 demonstrates 3 slices of the acquisition showing excellent metabolite profile in-plane and across the slices.

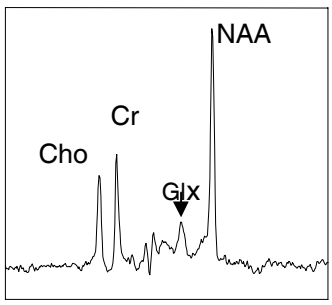

Figure 2 demonstrates Glx at 7T, visible and upright at 144ms.

Discussion: Although performing spectroscopy at high field proved to be challenging, carefully designed pulses and optimized parameters can yield high quality spectra with excellent spectral separation and metabolite profile. Using this set of SSRF and VSS rf pulses, high SNR 3D MRSI at 7T with excellent spatial coverage and high spectral resolution was demonstrated.

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References: [1] Xu D et al, Proc 44th ASNR 2006; P75. [2] Wald LL et al, Magn. Reson. in Med. 1995; 34:433-439. [3] Cunningham CH et al, Proc 14th Ann ISMRM. 2006; P72.