3-D MRSI of Patients with Gliomas using a 7T Whole Body MR Scanner

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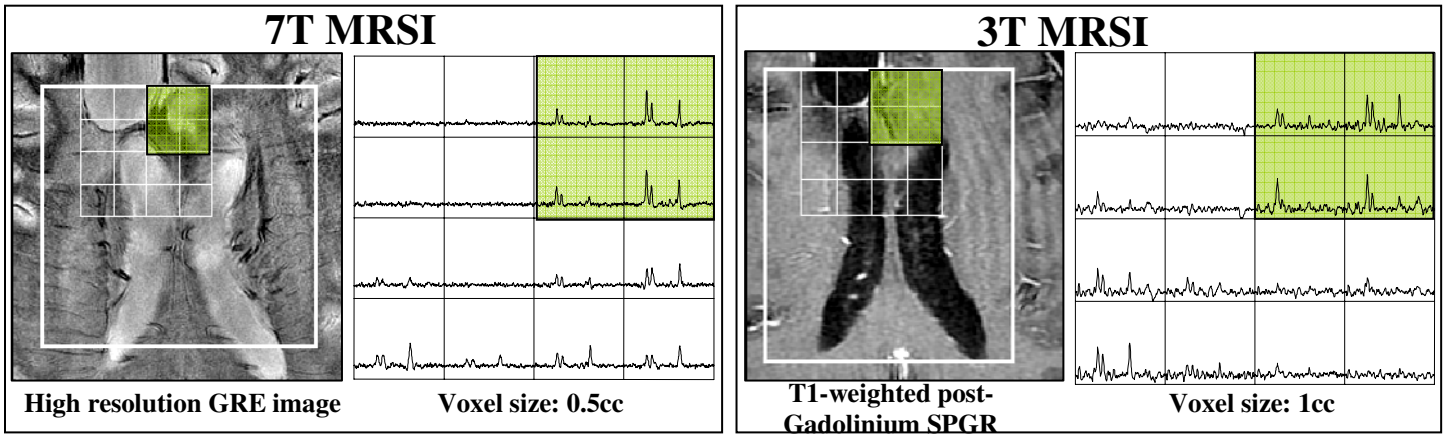
Introduction: Proton Magnetic Resonance Spectroscopic Imaging (MRSI) has been shown to provide valuable information for distinguishing regions of tumor from normal brain and treatment effects for patients with primary brain tumors. Applications that have been proposed are predicting outcome, planning focal therapy and evaluating response to therapy. While the MRSI data do provide information that is not offered by conventional MRI, they are currently limited in terms of the spatial resolution that they can provide within clinically feasible acquisition times. One approach to improving the signal to noise of this technique is to use MR scanners with higher field strength. Our previous studies have shown that by using an eight channel phased array coil in conjunction with a 3T whole body MR scanner it is possible to increased the signal to nose ratio of 3D MRSI data by a factor of 2 over data obtained with a volume head coil at 1.5T. In the current study we investigated the feasibility of further exploiting the increased sensitivity of high magnetic fields by obtaining 3D MRSI data from patients with gliomas using a 7T whole body scanner.

Methods: Ten patients with gliomas were scanned using a 7T whole body MR scanner (GE Healthcare Technologies, Waukesha, WI) with a commercial transmitter coil and 8-channel phased array receiver (Nova Medical, Wilmington, MA). Patients had previously been treated with a combination of surgery, radiation and chemotherapy. The MR examination consisted of acquiring scout images in all 3 planes, a parallel imaging calibration dataset that could be used for combining the signals from the different coil elements and high-resolution gradient echo images to provide an anatomic reference. Higher order shimming was performed using software developed in our group [1]. The 3D MRSI data was acquired in 17 minutes using a custom designed PRESS-MRSI sequence with TR=2s, TE=144ms or 90ms, 2048 pts, 5000Hz bandwidth, CHESS water suppression was used with 12x12x8 phase-encoding and elliptical k-space sampling with field of view chosen to provide a nominal isotropic voxel size of either 8 or 10mm. The pulses used to define the PRESS selected volume in the phase and frequency directions were custom designed, phase modulated, symmetric sweep, high bandwidth, spectral-spatial pulses [2] that yielded minimal in plane chemical shift artifact. The selected volume was over-prescribed to reduce chemical shift effects in the through plane direction and low power, high bandwidth, very selective saturation (VSS) pulses were employed to sharpen the volume selection profile and reduce residual chemical shift effects. The MRSI data from each receiver were apodized with a 4Hz Lorentzian function, Fourier transformed and phase corrected. Signals from the individual elements of the phased-array coil were combined using methods that were previously developed in our group [3].

Results: The 7T high-resolution anatomic images were able to visualize differences in image contrast corresponding to small vessels and regions of hyperintensity that reflected either tumor, edema or treatment effects. In regions of normal appearing brain the ratios (median +/-sd) of choline to N-acetylasparate (NAA) and choline to creatine were 0.46+/-0.09 and 0.95+/-0.11 respectively. There were voxels in all patients for which the estimated choline to NAA index (CNI) and choline to creatine index (CCrI) were greater than 2 standard deviations above the variations in normal tissue. The median of the maximum CNI value for each patient was 7.5 (range 2.9 to 18.3) and the median of the maximum CCrI was 5.0 (range 2.4 to 13.4). The figure below shows a lesion identified in the 3T and 7T MRSI in a region that is non-enhancing on the T1-weighted post-Gad 3T image. Note the increased signal to noise ratio at 7T despite the two-fold smaller voxel size.



Discussion: MRSI data were obtained using a 7T whole body MR scanner within a clinically acceptable examination time for patients with brain tumors at a 2-fold finer spatial resolution as compared to 3T. While signal losses were observed for regions close to the sinuses, our higher order shimming routine provided a significant improvement in spectral linewidth and data quality in other regions of the brain. For the cases where 3T spectra were obtained from patients on the same day there were similarities in the spatial distribution of abnormal voxels and it was possible to use the 7T data to calculate metabolic indices such as choline to NAA (CNI) and choline to creatine index (CCrI), as we have previously reported at 1.5T and 3T. While further work needs to be done to elucidate the relaxation times of the individual metabolites, it was clear that there were differences in the relative levels of choline, creatine and NAA in tumor compared with normal tissue from the contralateral hemisphere that could be used for diagnosis and directing patient care.

Acknowledgements and References: This work was supported by grants LSIT01-10107, and ITL-BIO04-10148 from the UC Discovery program in conjunction with GE Healthcare. *[1] Hammond K et al, ISMRM 2006. [2] Xu et al, ISMRM 2007, [3] Li et al, in press MRI, 2006.*