Multi-slice MRSI at 7T with Dualband Suppression and Hahn Echo Acquisition

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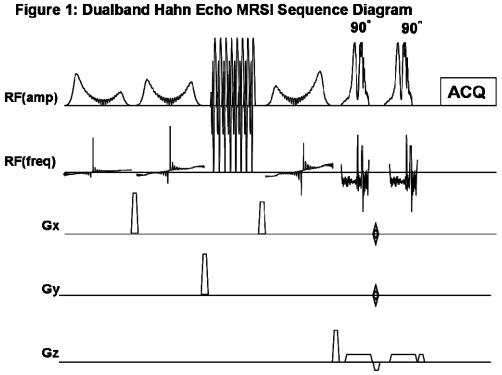
Introduction:

Multi-slice Magnetic Resonance Spectroscopic Imaging (MRSI) [1] was recently combined with a dualband[2,3] water and lipid suppression sequence with integrated Outer Volume Suppression (OVS) at 3T[4]. This sequence surpassed VAPOR[5] by a factor of two in terms of water suppression, and lipid suppression performance was 10 times better than using OVS alone. For this reason, the sequence is very robust against foldover lipid artifacts commonly seen in SENSE MRSI[6]. With a 32-channel phased array coil, an acceleration factor of 6=3x2 has been reliably implemented in research and clinical scans. Moving from 3T to 7T, as spectral resolution more than doubles so does chemical shift displacement, which excludes RF pulses with low bandwidths. In addition, both dualband suppression and multi-slice signal acquisition need to be modified to cope with more restrictive SAR limit and faster T2 relaxation. The T2 factor particularly favors localization methods permitting shorter echo times than PRESS (~70ms when used with frequency modulated refocusing). In this abstract, a 7T multi-slice MRSI sequence with dualband suppression and Hahn echo acquisition with high bandwidth slice selective pulses and short echo time is presented.

Figure 1: Dualband Hahn Echo MRSI Sequence Diagram



Materials and Methods

Three dualband, frequency modulated suppression pulses (40ms duration) were generated with the following peak B1's(in μT) for water and lipid respectively: (2.61, 1.1), (1.34,1.18), (1.39,2.44). Target B1's were numerically optimized using a cost function similar to the one published for 3T[4]. The 100ms delay between the 2nd and 3rd suppression pulses allows time for 8 OVS pulses of 95° flip angles (Fig.1). The total length of the dualband sequence was 186ms. A slice selective Hahn echo (90°-90°) MRSI sequence was implemented with an inverted rewinder gradient for the 2nd 90° refocusing pulse. TE/TR was 35ms/3s. With an excitation/refocusing bandwidths 3.8kHz, the chemical shift displacement between NAA (2.02ppm) and Glx (3.8ppm) was 14%. Two 15 mm thick axial slices were recorded. A FOV of 190x230mm was sampled with an MRSI resolution of 7mm ×7mm ×15mm. To investigate the effect of echo time on signal amplitude in vivo, the same sequence was repeated without phase encoding at multiple echo times from 27ms to 110ms. Experiments were performed on 3 normal volunteers on a 7T Achieva system (Philips Healthcare), equipped with a 32-channel phased array receiver coil (NOVA, inc). SENSE factor was 2x1.5, resulting in a scan time of 13 minutes. Prior to data acquisition, a rapid dual-field mapping technique was used to optimize B_0 homogeneity and determine optimum transmit B_1 level.

Figure 2: Hahn Echo Spectra at 5 TE's

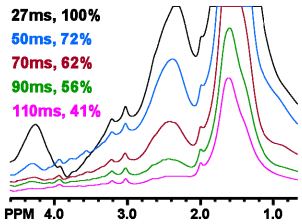


Figure 3: In Vivo Spectrum of 7T MRSI

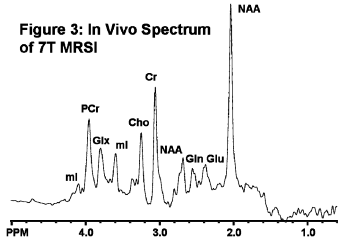
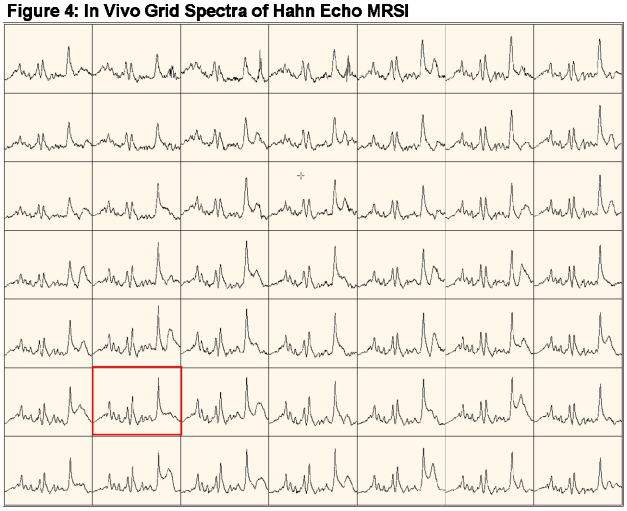


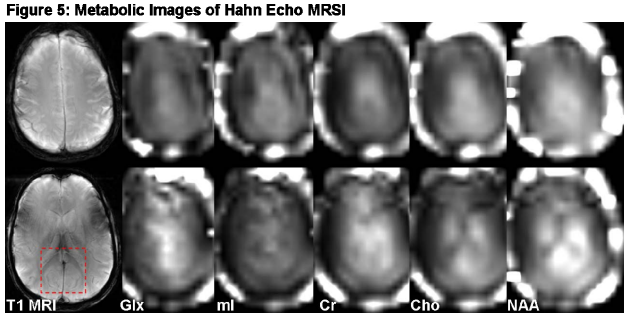
Figure 4: In Vivo Grid Spectra of Hahn Echo MRSI



Results

Figure 2 shows Hahn echo spectra at echo times of 27ms through 110ms. The amplitude of the Cr peak in each spectrum was baseline-corrected and normalized to the value at 27ms. At a TE of 70ms, the signal dropped to 62% of the maximum value. Figure 3 shows a selected spectrum from one voxel located at medial gray matter. Figure 4 shows a 7×7 grid of MRSI spectra from the lower slice, consisting high quality spectra comparable to that in Fig.3 (with voxel location marked in red). Residual water and lipid signals were well suppressed in all voxels, not interfering with the spectral peaks between 4.1ppm and 1.8ppm. Figure 5 shows metabolic images of Glx, mI, Cho, Cr and NAA along with T1-weighted MRI (with grid location marked in red). The quality of the Glx and mI maps was comparable to those of Cho, Cr and NAA, demonstrating the advantage of moving MRSI from 3T to 7T.

Figure 5: Metabolic Images of Hahn Echo MRSI



Discussion & Conclusion

Compared to the Hahn echo MRSI, a standard spin echo with half of Hahn echoes' refocusing bandwidth would result in a minimum TE of 70ms and 2.3 times the SAR, which would eventually result in about twice the scan time (~25min). The TE comparison in Fig.2 shows the shortened TE of a Hahn echo can compensate significantly versus a full amplitude spin echo with extended TE. The 7T dualband sequence shows excellent performance (Fig.4) in the presence of increased B1 inhomogeneity at ultra high field. In conclusion, a multi-slice Hahn echo MRSI with dualband suppression was demonstrated to be a successful solution to moving in vivo MRSI from 3T to 7T.

Reference: [1] Duyn et al. *Radiology* **188**, 277-282 (1993) [2] Smith et al. *MRM* **54**: 691-696 (2005) [3] Gu et al. *MRM* **61**: 462-466 (2009) [4] Zhu et al. *MRM* **63**: 1486-1492 (2010) [5] Tkac et al. *MRM* **41**: 649-656 (1999). [6] Dydak et al. *MRM* **46**: 713-722 (2001).Supported in part by P41RR15241.