Robust water and lipid suppression using multiple dualband frequency-selective RF pulses for 1H spectroscopic imaging at 3T

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Introduction

^{1}H magnetic resonance spectroscopic imaging has been increasingly used in diagnosis and treatment assessment in recent years. For in-vivo studies, water and lipid signals are large and, if not suppressed, greatly contaminate the desired metabolic information. Water suppression is typically achieved with a series of chemical shift selective (CHESS) pulses and dephasing gradient. Ogg et al, have previously demonstrated that optimizing the flip angles of the CHESS pulse train yields T1-and-B1 insensitive water suppression. [1] Taking advantage of increased chemical shift dispersion at 3T, we extend this approach by using dualband frequency-selective preparatory RF pulses to suppress both water and lipid resonances. This approach yields robust water and lipid suppression with no loss of metabolic signals.

Methods

To rotate water and lipid magnetization at the same time while not disturbing the singlet resonances of, Choline Creatine and NAA, under study, RF pulses with a dual-band rotation profile were designed using the Shinnar-Le Roux algorithm [2]. At 3T, NAA and the major lipid peaks are separated by 89 Hz. To rotate all lipid magnetization without disturbing NAA, 20 ms long minimum phase RF pulses were used to ensure sharp transition bands of 50 Hz. To count for B1 inhomogeneity and different T1s of water and lipid spins, four such pulses, 10ms apart, with different flip angles were used. The optimized flip angles were found by minimizing the maximum absolute value of residue longitudinal magnetization for 4 representative water and lipid T1s, 1.5s and 170/260/280 ms, at the time of excitation under the condition of 20 percent B1 inhomogeneity. To test the effectiveness of the water and lipid suppression, in-vivo brain MRSI data were acquired with standard CHESS water suppression and no lipid suppression and compared to data using the proposed multi-pulse dualband method with the following characteristics: TR/TE=2000/144 ms, single slice, 4.5 cc voxels and 6 minute acquisition time.

Results

The new minimum phase preparatory RF pulse and its dual band rotation profile are shown in Figure 1. The simulated absolute values of residual lipid magnetization at different T1s under the condition of 20% B1 inhomogeneity are plotted in figure 2. It is clearly shown that multiple rotation pulses achieved effective lipid suppression at the targeted T1s and were robust under 20% B1 inhomogeniety. The suppression is also effective for a large range of T1s especially for T1 longer than 1.5s. The four flip angles found using the optimization algorithm are 110/74/67/162 degrees (figure 3). Figure 4 shows spectra from two regions with CHESS water suppression/no lipid suppression and multiple rotation water/lipid suppression obtained from in vivo studies. The two representative regions are chosen such that one is in the subcutaneous fat on the back of the head and the other is within the brain. Excellent water suppression is clearly demonstrated with a flat baseline. The spectra from the voxel in the subcutaneous fat clearly show that the lipid signal is suppressed with multiple dualband pulses. The measured suppression is on the order of 20. The spectra from voxels within the brain show significantly reduced lipid artifacts and undisturbed metabolite peaks.

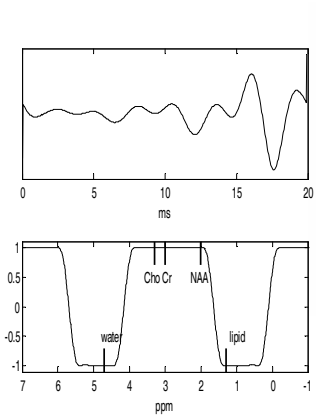

Fig. 1 Dualband minimum phase RF pulse and its spectral profile for a flip angle of 180^0.

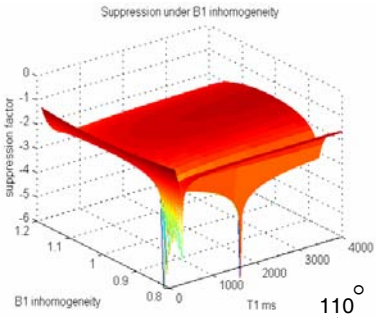

Fig 2. Simulated plots of absolute value of residue Mz at T1s from 100-4000ms under condition of 20% B1 inhomogeneity. Suppression factor is in log scale.

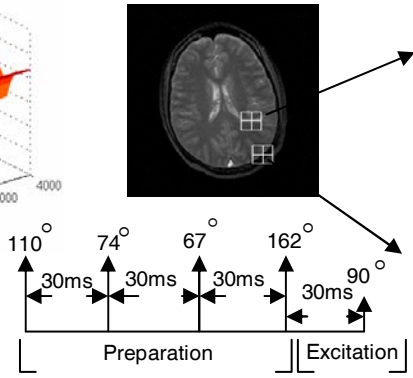

Fig 3. Scheme of multiple flip angle frequency selective pulses for both water and lipid suppression, dephasing gradients were applied after each preparatory RF pulses.

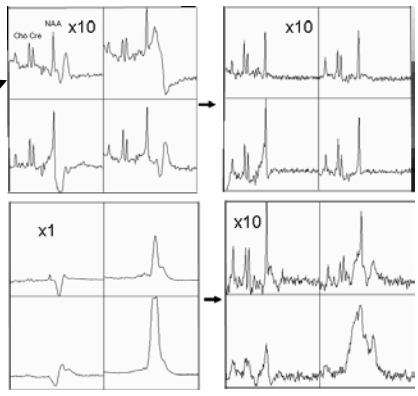

Fig .4 Spectra from representative regions, with CHESS water suppression/no lipid suppression and multi-pulse dualband water/lipid suppression, 4.5 cc, 6 minute scan.

Conclusion

We have designed and implemented a robust method to suppress both water and lipids using multiple dualband frequency-selective pulses for ^{1}H MRSI imaging at 3T. The effectiveness of the method is demonstrated in-vivo.

Acknowledgements

Lucas foundation, NIH RR09784, CA098523

Reference

[1] R. Ogg, et al, JMR, Series B 104, 1-10, 1994

[2] J. Pauly, et al., IEEE Trans. Med. Imaging 10, 53-65, 1991