Simultaneous Water and Lipid Suppression in Multi-slice Brain MR Spectroscopic Imaging

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Introduction

Water and lipid suppression are key factors in obtaining high quality localized proton spectra in vivo. This abstract reports the application of the BOOZE[1] suppression technique (Band Selective Offset-Optimized Z-Magnetization Elimination) to multi-slice proton MR spectroscopic imaging (MRSI) of the human brain.

Theory

To modulate the waveform a phase ramp is first incorporated into the sech phase profile, $\phi(t)$, as $\phi'(t) = \phi(t) \pm 2\pi ft$ where f is the desired frequency shift in units of Hertz. The modulated phase and amplitude are described as:

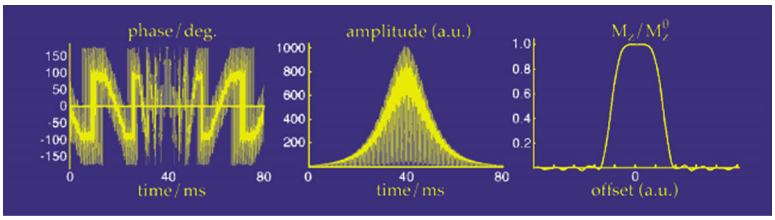
$\phi'(t) = \tan^{-1}\left(\omega'_{1y} / \omega'_{1x}\right)$, and $\omega'_1(t) = \sqrt{(\omega'_{1x})^2 + (\omega'_{1y})^2}$ respectively, with $\omega'_{1x} = \omega_1 \cos(\phi'(t))$ and $\omega'_{1y} = \omega_1 \sin(\phi'(t))$.

Materials and Methods

Scans were performed on a 1.5 T clinical system (Philips) using a transmit-receive head coil. The sequence, 3/4 FOV 2DMRSI with BOOZE water and lipid suppression, was tested on a 4 liter phantom (containing physiological concentrations of neurochemicals) and on the brains of normal human volunteers. The protocol had the following parameters: TR/TE 2650/280, SW 1000, 256 points, BOOZE water/lipid suppression and octagonal outer-volume lipid suppression, 3 slices, 15 mm thick, 3.0 mm gap, 24x18 cm FOV, 24x18 phase-encoding steps, 1 signal average, nominal voxel size 1.7 cm^3, scan time 14'27''. Water and lipid suppression consisted of an 80 ms BOOZE waveform used in a CHESS[2] prepulse scheme (10 ms spoiler gradient at 10 μT/m).

Results and Discussion

The phase and amplitude profile for the modulated waveform are shown in Figure 1. The calculated excitation profile of the waveform displays a pass-band of 200 Hz (approximately 3.1 ppm, centered between water and lipid) in which the magnetization remains 99% on the Z-axis and thus is untouched, while outside of this bandwidth spins are saturated (stop-band). The stop-band width is tunable and can be increased or decreased by varying proportionally the maximum frequency sweep, while the pulse width (inversely) controls the sharpness of the transition band. Spectra from representative regions of each slice are shown in Figure 2. Excellent water and lipid suppression was achieved using this scheme for all brain regions covered by MRSI.



Simultaneous water and lipid suppression saves time compared to sequential suppression schemes, allowing a slightly shorter TR to be used for multi-slice MRSI. It also helps to reduce the effects of T1 relaxation on suppression factors prior to the read pulse. It should be recognized that this approach cannot be used for the detection of lactate (which is saturated by the frequency selective lipid suppression pulse), or when field inhomogeneity is insufficient. Nevertheless, combined BOOZE water and lipid suppression may be helpful in proton MRSI of other lipid-rich organ systems such as the breast or prostate.

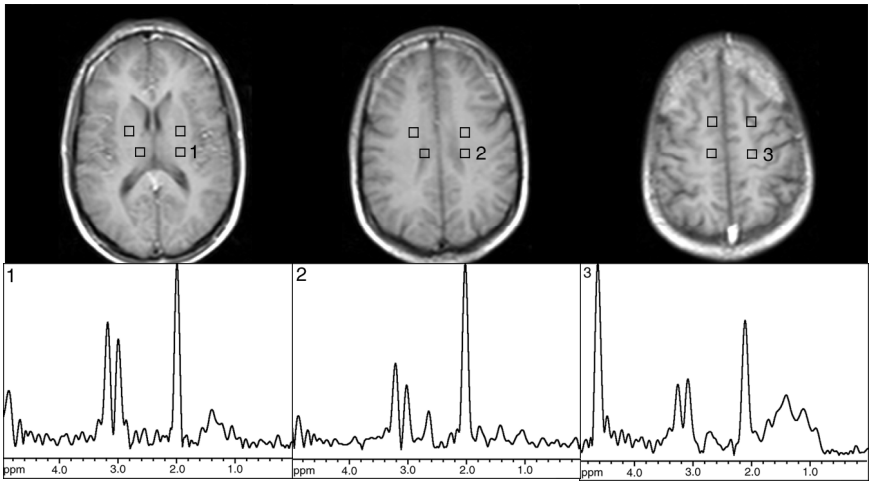


Figure 1. Theoretical phase, amplitude and inversion profile of the modulated 80 ms sech 90º pulse used for suppression. The inversion profile displays that 99% of the target spins will remain on +z over a bandwidth of +/- 100 Hz.

Figure 2. Top: T_1 MR images showing the slice locations used for the MRSI scan. Representative regions of interest are indicated by the black boxes. Bottom: Localized proton spectra from the regions of interest illustrated in the T_1 images.

References 1) Smith M et al., ISMRM 2003, 2) Haase A et al, D. *Phys. Med. Biol.* 1985, *30*, 341-344,
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