Water Suppression in 1H MRSI by Reference Subtraction

C. Domenig[1], Y. Yu[1], A. Maudsley[1]

[1]Radiology, University of Miami, Miami, Florida, United States

INTRODUCTION: For ^{1}H MR Spectroscopic Imaging (MRSI) effective CHESS-based water suppression can be difficult to achieve over the whole imaged volume due to the presence of spatially-dependent field shifts, the magnitude of which can be larger than the water suppression bandwidth, particularly for whole-brain MRSI where a common finding is that the degree of water suppression varies considerably. The use of post-processing water suppression methods, for example by convolution-subtraction (1) or fitting of the water resonance and subtraction (2), is therefore considered essential to remove the residual water, however, robust implementation of these methods can again be difficult. Despite the use of both acquisition and post-processing water removal, one observation of volumetric MRSI is that the spectral baseline can vary rapidly in the neighborhood of the 3.2 'Choline' resonances, resulting in increased variability for automated spectral fitting (3) where a smoothly-varying baseline model is used. In this study we examine the use of water removal by subtraction of an interleaved water reference MRSI measurement. An additional benefit of this approach is a reduction of subcutaneous lipid signals.

METHODS: A volumetric echo-planar MRSI sequence has been implemented at 3 T (Siemens Trio) that includes an interleaved water reference measurement obtained using low flip-angle excitation (4). The metabolite MRSI is obtained with CHESS water suppression (bandwidth 80 Hz) and lipid inversion-recovery nulling. After resampling and FT of the metabolite and water reference data the residual metabolite water signal was removed by subtraction of a scaled and phase-corrected water reference, as: $SI'_{Met} = SI_{Met} - \alpha \cdot SI_{H2O} \cdot e^{-i\theta}$, where α and θ were determined by a simplex optimization procedure that minimized the difference signal over a user-defined spectral region of 3.8 to 4.1 ppm. In addition the water reference spectrum was smoothed in the region from 0 to 4.3 ppm to remove any metabolites from the water reference signal. For comparison residual water removal was also performed with the more common method of convolution subtraction. Results of spectral fitting of the choline peak were then evaluated for the standard post-processing water removal method and compared with the water-reference subtraction method.

RESULTS: In the following figure are shown example spectra from a brain region where the standard CHESS water suppression was not fully effective, and the result for the same voxel using the proposed reference-subtraction method.

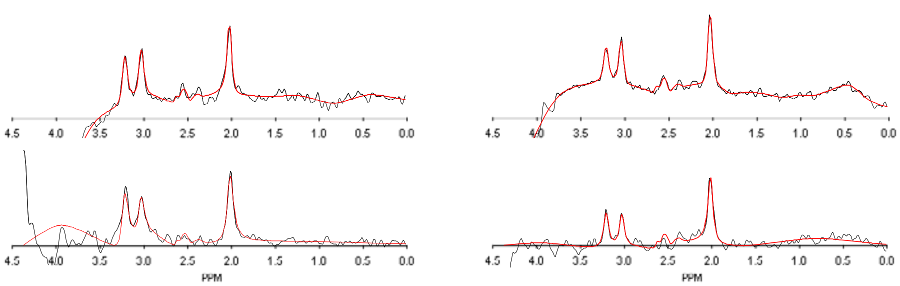

Figure 1: Top: Sample spectra from the frontal (left) and parietal lobe (right) acquired with standard water suppression and convolution subtraction. The fitted spectra are shown in red. Bottom: Corresponding spectra acquired with reduced water suppression and after water reference subtraction.

Table 1: Fitted Cho area (mean ± SD) for 4 ROI's in white matter.

	Convolution water removal	Reference subtraction
Cho (parietal lobe)	0.37 ± 0.06 0.32 ± 0.05	0.34 ± 0.05 0.25 ± 0.05
Cho (frontal lobe)	0.46 ± 0.07 0.39 ± 0.05	0.49 ± 0.08 0.38 ± 0.04

DISCUSSION: Over much of the SI data, where water suppression is relatively efficient, the proposed method provides comparable spectral quality, however, some improvement of spectral baselines can be obtained in some brain regions.

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