Phase Navigators for Localized MR Spectroscopy using Water Suppression Cycling

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INTRODUCTION: Subject motion can cause scan-to-scan variations in phase and frequency of ^{1}H MRS signals, resulting in incoherent averaging and reduced signal-to-noise ratio (SNR) [1]. The under-suppressed water signal can be used to restore coherent averaging [2], by correcting phase and frequency errors from shot to shot. However, the large residual water peak due to incomplete water suppression can cause problems during spectral fitting. Therefore, a T_1 and B_1-insensitive water-suppression sequence was developed that alternates between water under-suppression (Fig. 1, left) and over-suppression (Fig. 1, center). The residual water can be used to perform shot-to-shot phase and frequency correction. When the individual FIDs are added, the opposing water signals are cancelled, yielding a spectrum with minimal residual water (Fig.1 right).

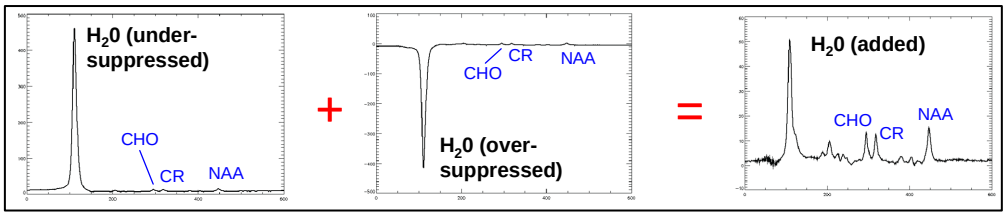

Figure 1

METHODS: Studies were performed on a Siemens Trio (3T), using a 12-channel head coil. The conventional water-suppression module of the PRESS sequence (TE/TR=30/3000ms) was replaced with the cycling scheme, using four chemically-shift selective RF pulses as follows (Figure 2):

90° - τ - 90° - τ - 180° - τ - 180° - τ for *positive* residual water

90° - τ - 90° - τ - 0° - τ - 180° - τ for *negative* residual water

The residual water is approximately ± 4% of M_0 (at brain T_1~1s; τ = 40ms), and can be shown to be insensitive to B_1 and T_1 variations.

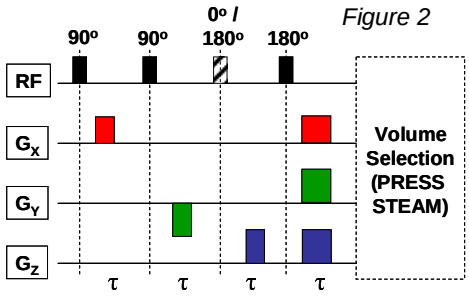

Figure 2

RESULTS: Figure 3 shows frontal gray matter spectra from a subject who held still (left) and intentionally oscillated his head by a small amount (simulated tremor). The phase fluctuation was ±5° without motion and ±102° with motion, resulting in almost complete signal loss with simple averaging (Fig. 3 center). Phase-correction of individual FIDs, using the residual (cycled) water signal, almost restored the original spectrum and resulted in a flat baseline (Fig. 3, right).

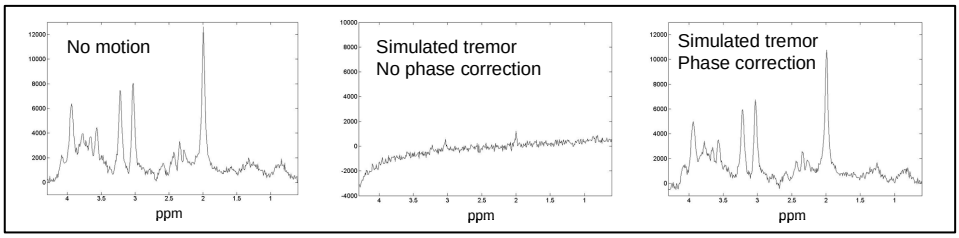

Figure 3

DISCUSSION: A novel water-suppression cycling scheme allows phase and frequency correction of individual FIDs using the residual water signal and restoration of signal losses due to incoherent averaging, but near-complete attenuation of residual water. A prior publication proposed cycling between inverted and non-inverted metabolites [3]; however, it is difficult to obtain consistent inversion across the entire spectrum. Conversely, our new method only manipulates the water resonance, leaving metabolite signals intact. Phase and frequency correction of individual FIDs will be particularly important for use with adaptive motion correction for localized MRS.

ACKNOWLEDGEMENTS: We would like to thank Dr. Steven Buchthal for technical support. This project was supported by U54 56883, 1R01 DA021146 (TE), K02-DA16991 (TE), and G12 RR003061-21 (RCMI).

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