A New Post-processing Method to Remove Ringing Artifacts in Clinical MR Spectra

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Introduction

Eddy current correction (ECC), based on a water-unsuppressed reference signal, is an effective deconvolution technique to remove time-dependent artifacts in *in vivo* Magnetic Resonance Spectroscopy (MRS). This traditional post-processing correction method will fail when the reference (water-unsuppressed) signal contains multiple-frequency components[1]. The envelope of the amplitude of a multiple-frequency signal will become discontinuous, thus, its phase function, calculated as arctangent of complex time-domain data, will also be discontinuous. When this impaired phase function is applied in ECC, unexpected ringing artifacts will appear in metabolite (water-suppressed) MR spectra. This work introduces an effective and fast method, referred to as "enhanced" ECC, to remove these unwanted ringing artifacts.

Methods & Materials

Discontinuities in reference phase function clearly demonstrate themselves as spikes in the first derivative of the phase function. To remove these spikes, the derivative data are first sorted, and the lower (25 percentile) and higher (75 percentile) thresholds are determined, any data points beyond these two limits will be considered as spikes and excluded from further analysis. Then, polynomial (degree of 3) curve fitting is used to smooth the intact data, and the new phase function free from any discontinuities will be synthesized from this curve-fitted derivative function. Two-dimensional chemical shift imaging (2D CSI) *in vivo* data were obtained on a 3T Achieva MR Scanner (Philips Medical Systems) with following acquisition parameters: PRESS sequence, TR/TE of 1500/144 ms, matrix of 24X24X1024 and spectral width of 2000 Hz. Simulated data were also generated to mimic the *in vivo* data, where the reference signal contained three components resonating at 8/14.9/24 Hz, with same amplitude and phase, and different relaxation damping (3.6/4.0/4.4 Hz). In vivo and simulated data were analyzed using home-written IDL (RSI Inc, Boulder, CO) routines.

Results & Discussion

Traditional and enhanced ECC have been applied to one simulated and one representative *in vivo* MR spectrum with results shown in Figure 1 and 2, respectively. Panel C clearly demonstrates ringing artifacts in simulation and in *in vivo* data after applying the traditional ECC, while Panel D shows the corrected spectrum free from any frequency modulation and with increased resolution after applying the enhanced ECC. Panel A and B show the original (red) and smoothed (blue) reference phase and its corresponding first derivative function; the spikes as can be seen in Panel B, corresponding to the discontinuities in Panel A, were completely removed using our proposed method. In comparison with an elegant algorithm designed by Simonetti, A. W., et al [2], our proposed method is more general, with no assumption on line shape of each spike in Panel B, and no limitation to linearity of the phase function in Panel A. Furthermore, our method is much more flexible and faster, with fewer parameters to be adjusted and no significant increase in post-processing time.

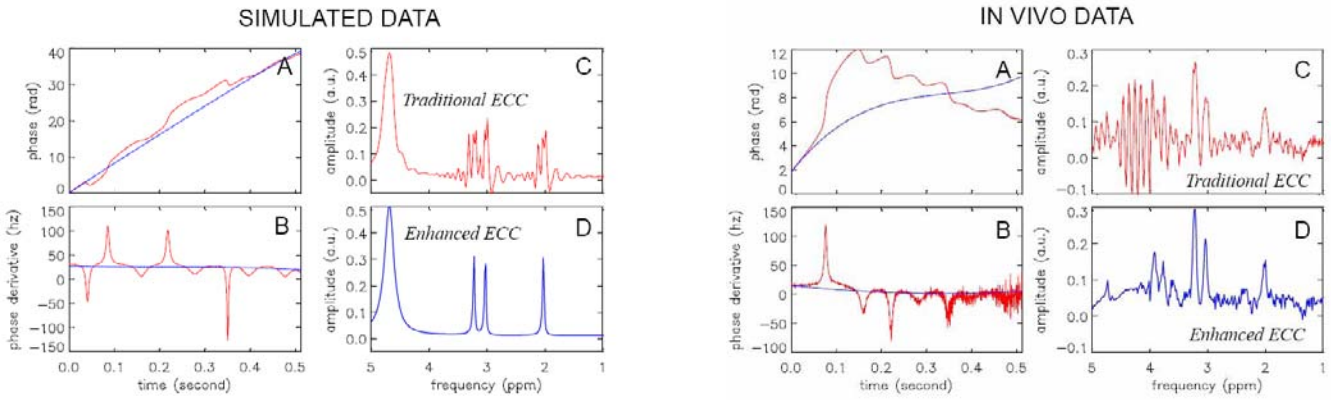

Figure 1 and 2, Simulated and *in vivo* data: (A) original (red) and smoothed (blue) reference phase function, (B) first derivative of phase functions in Panel A, (C) metabolite spectrum with traditional ECC, and (D) metabolite spectrum with enhanced ECC

References

(1). Wild, J.M., JMR, 1999. **137**(2): p. 430-436. (2). Simonetti, A.W., et al., JMR, 2002. **159**(2): p. 151-157.