Eddy Current Compensated IDEAL

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Target Audience: This abstract is targeted towards researchers investigating quantitative fat-water imaging.

Introduction: Non-invasive quantification of fat has many applications, including evaluation of hepatic steatosis. In chemical shift imaging, eddy current induced phase inconsistencies between the first and subsequent echoes lead to biased estimates of proton density fat fractions (PDFF). In the past, this bias has been minimized by modifying the reconstruction (1-3); however, this results in significantly degraded noise performance. Instead, we propose modifications to the pulse sequence that minimize eddy current induced phase errors. We hypothesize this will allow us to use SNR optimal, complex image reconstruction techniques (4) without biased PDFF estimates.

Theory: Eddy currents result whenever gradients are switched on or off. In images that are acquired as part of an echo train, the gradient waveform that precedes the first echo is quite different from that which precedes the subsequent echoes This results in a significantly different phase error for the first echo as compared to subsequent echoes (Fig 1a). Additional gradients played out such that the gradient waveform immediately preceding each echo is the same should result in the same phase error for all echoes (Fig. 1b).

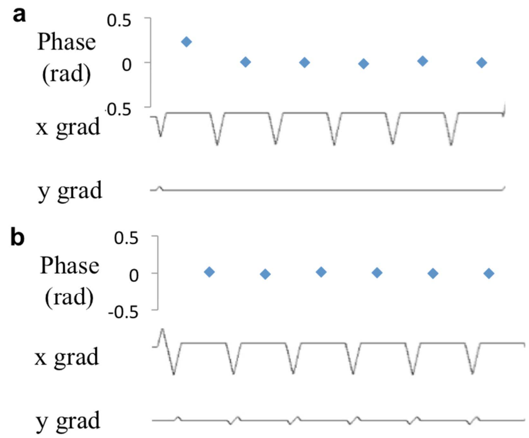

Fig 1: Demodulated phase and gradient readout for a conventional fly-back echo train (a) and eddy current corrected fly-back echo train (b).

Methods: After obtaining ethics approval and informed consent, abdominal datasets of a volunteer with no known liver steatosis were acquired using a conventional and eddy current corrected (ECC) IDEAL-SPGR sequence and an 8 channel cardiac coil at 3T (MR 750, GE Healthcare, Waukesha. WI). Imaging parameters for the conventional sequence were: TR=12.2ms, TE=[1.1, 2.8, 4.6, 6.3, 8.1, 9.9]ms, matrix size=192x72x30, echo train length=6, slice thickness=5mm, FoV=40x26cm, BW=90kHz, flip angle=3º. Imaging parameters for the ECC variant were: TR=11.8ms, TE=[1.6, 3.3, 5.1, 6.8, 8.5, 10.3]ms, matrix size=128x72x30, echo train length=6, slice thickness=5mm, FoV=48x26cm, BW=90kHz, flip angle=3º.

Results: The eddy current induced phase error is shown using a water-only phantom using similar imaging parameters to the *in vivo* data (Fig 1a). Here, the first echo is clearly affected by a different eddy current shift than the subsequent echoes, an effect that is removed by the use of eddy current compensating gradients (Fig 1c). The approach was also demonstrated *in vivo* to accurately measure fat fractions in the liver (Expected PDFF=0%). Regions of interest in the liver show PDFF estimates for the ECC Complex-IDEAL (0.7±1.7%), complex (2.2±1.3%) , and hybrid (1.1±1.3%) approaches.

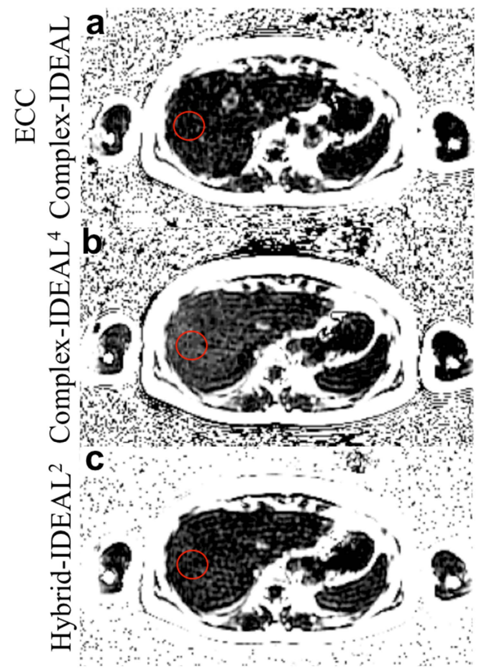

Fig 2: Fat fraction images using the ECC pulse sequence and eddy current sensitive complex fitting (a), and the conventional sequence with complex (b) and eddy current insensitive hybrid (c) fitting. reconstructions.

Discussion: The additional pulse in the frequency direction required for ECC-IDEAL will extend the initial TE, reducing the SNR of the reconstructed fat and water images(4). However, the improved SNR from the use of complex image reconstruction techniques will more than compensate for this loss of SNR (1).

Conclusion: Eddy current compensating gradients have been demonstrated to reduce bias in PDFF estimates.

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