An Efficient Chemical-shift Encoded Imaging for Liver Fat Quantification

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Target Audience: This work targets researchers in fat quantification with chemical-shift encoded imaging.

Introduction: Accurate fat quantification requires the acquisition of 6 or more gradient echoes to account for the confounding factors, such as T_2^* decay and accurate spectral modeling [1]. The 6 echoes are acquired using unipolar gradients separated by flyback gradients which prolong the echo-spacing and therefore cause SNR degradation [2]. Multi-shot acquisitions, where the echoes are acquired over multiple TR, are consequently employed to obtain optimal echo-spacing. On the other hand, bipolar acquisitions, where positive and negative readout gradients are employed, do not use flyback gradients. Hence the 6 echoes can be acquired in one TR, shortening the scan time compared to corresponding unipolar acquisitions. However, bipolar acquisitions suffer from phase and magnitude errors that can severely distort the water/fat separation process [3]. Recently, a new bipolar acquisition and reconstruction technique that overcomes these errors while providing accurate fat quantification has been proposed [4]. In this work we demonstrate the efficiency of this sequence for whole liver imaging, widely used for the diagnosis of non-alcoholic fatty liver diseases (NAFLD) [5].

Materials and Methods: This work was carried out under approval granted by our institution's Office of Research Ethics. Two healthy volunteers were scanned on a 3T MR (Discovery MR 750, GE Healthcare, Waukesha, WI) using a cardiac 8 coil-array. Unipolar and interleaved bipolar acquisitions were performed on both volunteers. Whole liver coverage was achieved in both acquisitions in ~25s breath-hold. The interleaved bipolar acquisition was performed as described in Soliman *et al.* [4]. The example shown was acquired at a bandwidth=$\pm$125 kHz, FOV=36 cm x 27 cm, matrix size=160x120x24, slice thickness=8 mm for both sequences; TR/TE1/ΔTE = 5.36/0.82/0.65 ms and 7.1/0.91/0.96 ms for unipolar and interleaved bipolar acquisitions, respectively. Parallel imaging with an outer acceleration of 1.3x1 for unipolar and 1x1 (no acceleration) for interleaved bipolar was used for a total scan time of 25s for each sequence. Conjugate-gradient SENSE [6] was used for parallel imaging reconstruction, Max-IDEAL [7] for water/fat separation and the generalized pseudo-replica method [8] for SNR calculations.

Results and Discussion: Water and fat images were successfully generated from both unipolar and interleaved bipolar acquisitions. Phase and magnitude errors were cancelled in the interleaved bipolar results without using further phase correction algorithms. As shown in the figure below accurate fat fraction maps with higher SNR maps of water and fat were obtained using the interleaved bipolar acquisition. The SNR in the liver was ~28% higher in the water image using the proposed sequence. It is worth noting that the echo-timing of the interleaved bipolar acquisition (TE1/ΔTE) is expected to achieve lower noise performance than its corresponding unipolar acquisition [2], particularly at low fat fractions; however the SNR gain from the efficiency of the interleaved bipolar is still remarkably higher than the unipolar acquisition.

Conclusion: We have demonstrated the efficiency of the interleaved bipolar acquisition in whole liver imaging compared to the conventional unipolar acquisition commonly used in NAFLD imaging.

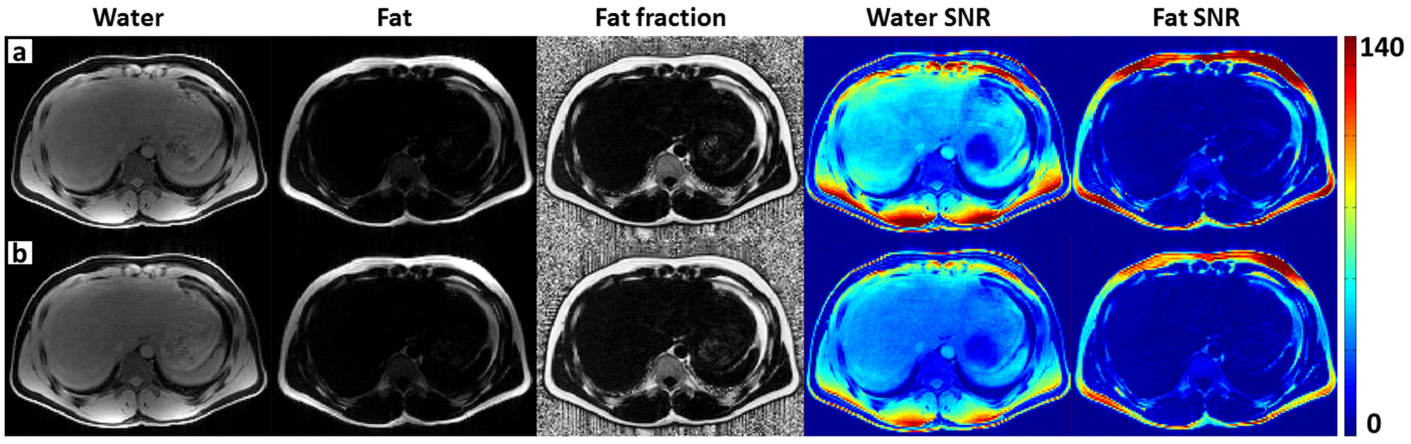

Figure 1: (a) Interleaved bipolar sequence, (b) unipolar sequence. The interleaved bipolar sequence demonstrated accurate fat fraction and higher SNR compared to the unipolar sequence.

References: [1] Yu, MRM 2008,60:1122; [2] Hernando, MRM 2012,67:638; [3] Lu, MRM 2008,60:198; [4] Soliman, ISMRM 2014:1673; [5] Hines, JMRI 2011,33:873; [6] Pruessmann, MRM 2001,46:638; [7] Soliman, MRM 2014,72:510; [8] Wiens, MRM 2011,66:1192.