Fast Water and Fat Imaging Using a Radial GRASE Technique with the IDEAL Algorithm

Z. LI[1], S. W. Squire[1], A. F. Gmitro[1], M. I. Altbach[1]

[1]University of Arizona, Tucson, AZ, United States

Introduction: Three-point Dixon methods have been investigated as a means to generate water and fat images without the effects of field inhomogeneities [1]. However, the success of the 3-point Dixon method to correct for field inhomogeneties relies on a phase unwrapping algorithm that is sensitive to global tissue connectivity and noise. Recently an iterative water-fat separation method was proposed (IDEAL, Iterative Decomposition of water and fat with Echo Asymmetry and Least squares estimation). This algorithm is more robust for the separation of water and fat, especially if the data are acquired with asymmetric phase differences [2,3]. However, its application with Fast Spin Echo (IDEAL-FSE) imaging is not time efficient since only one echo shift is collected per TR [3]. To increase imaging speed we propose to use IDEAL in combination with a method derived from a gradient- and spin-echo (GRASE) technique. The method is presented here for radial data acquisition. Radial data sampling offers robustness to motion over Cartesian trajectories as well as the possibility of generating high resolution *T2*, $T2^{\dagger}$ maps in addition to the water and fat images [4]. This has advantages for certain clinical applications.

Methods: A diagram of the acquisition of data based on GRASE is shown in Fig. 1. In this figure we show two possible combinations of relative echo shifts for water/fat separation at 1.5 T. The echo shift combination shown in Fig. 1b is reported to be more robust to arbitrary water/fat ratios [3,5]. This combination can only be attained with a receiver bandwidth (BW) of ±125 kHz (assuming the acquisition of 256 readout points). The echo shift combination shown in Fig. 1a was chosen for the acquisition of data with a receiver bandwidth (BW) of ±62.5 kHz.

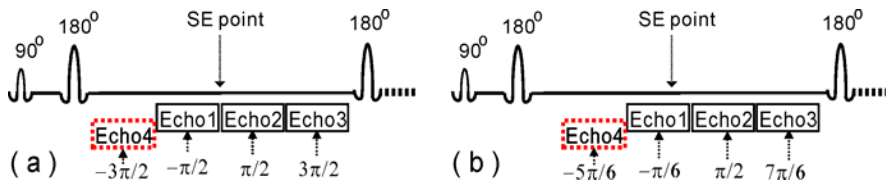

Fig. 1. Acquisition of echoes within a GRASE technique.

Although the minimum number of echoes required to reconstruct separate water and fat images with field inhomogeneity correction is 3, there is extra space forced by the asymmetric acquisition of echoes with respect to the SE point, thus a fourth echo (indicated by the dotted rectangle) can be acquired to improve the noise performance without increasing the total scan time.

A radial GRASE sequence with arbitrarily shifted data acquisition windows was implemented on a 1.5T GE Signa NV-CV/i MRI scanner. The scanning direction of radial k-space views for each echo was alternated to eliminate additional phase and position shifts due to eddy current caused from switching gradient polarities. A water and fat phantom (two vials of baby oil surrounded by water) was used to evaluate this technique. Phantom data were acquired with ETL=4, TR=800 ms, 256 radial views per echo, 256 readout points per view. Pelvic images were acquired with ETL=4, TE_{eff}=40 ms, TR=1000 ms, 192 radial views per echo, and 256 readout points. Abdominal images were acquired with ETL=8, TE_{eff}=98 ms, TR=1000 ms, 192 radial views per echo, and 256 readout points. The IDEAL algorithm was implemented using MATLAB and the data were processed to generate the water and fat images as well as the phase maps.

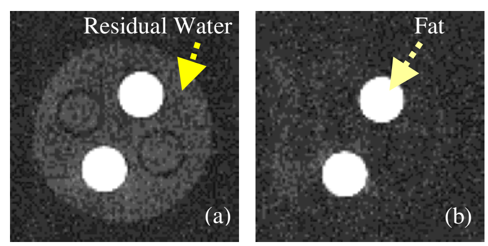

Fig. 2. Fat images from data acquired at 62.5 kHz with (a) (-π/2, π/2, 3π/2); (b) (-3π/2, -π/2, π/2, 3π/2).

Results: Fat images of the phantom acquired with (-π/2, π/2, 3π/2) and (-3π/2, -π/2, π/2, 3π/2) are shown in Fig. 2a and 2b, respectively. Note that although there is uniform water suppression in both cases, there is better water and fat separation in the image acquired with the 4-echo scheme. The SNR and water/fat ratio (W/F) in the water region is higher for the 4-echo scheme compared to the 3-echo scheme ($SNR_{4\text{-echo}}$ = 185, $W/F_{4\text{-echo}}$ = 47; $SNR_{3\text{-echo}}$ = 145, $W/F_{3\text{-echo}}$ = 32).

Shown in Fig. 3 are examples of (a) pelvic and (b) abdominal images acquired with (-3π/2, -π/2, π/2, 3π/2) and (-5π/6, -π/6, π/2, 7π/6), respectively. The latter were acquired in a breath hold. These results demonstrate that excellent water and fat separation can be achieved by combining the IDEAL algorithm and the asymmetrical GRASE technique.

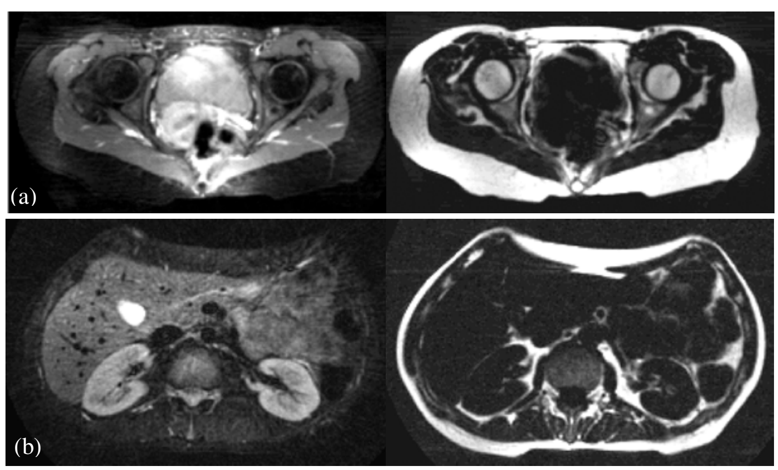

Fig. 3. (a) Pelvic and (b) abdominal water and fat images from data acquired with (-3π/2, -π/2, π/2, 3π/2) and (-5π/6, -π/6, π/2, 7π/6), respectively.

Conclusion: In this work we demonstrated that robust and time efficient water and fat separation can be achieved by combing the IDEAL algorithm and radial GRASE method. With the asymmetrical GRASE technique, four echoes can be acquired instead of three without increasing the scan time to achieve better noise performance and possibly better water/fat separation. With this technique, one complete data set can be acquired in 1/3 of the time compared to the IDEAL-FSE method.

Acknowledgement: This work is supported by NIH (CA099074), the American Heart Association (0355490Z), and the Arizona Hispanic Center of Excellence.

References: [1] Glover GH, MRM 18:371, 1991. [2] Reeder SB, MRM 51:35, 2004. [3] Reeder SB, MRM 54:636, 2005. [4] Gmitro AF, MRM 53:1363, 2005. [5] Pineda AR, MRM 54:625, 2005.