Single breath hold multi-echo liver fat quantitation

M. K. Ivancevic[1,2], J. Smink[3], H. K. Hussain[2], and T. L. Chenevert[2]

[1]MRI, Philips Medical Systems, Cleveland, OH, United States, [2]Radiology, University of Michigan, Ann Arbor, MI, United States, [3]MRI, Philips Medical Systems, Best, Netherlands

Introduction

Magnetic resonance imaging and spectroscopy provide a tool for fat quantitation for a wide range of liver conditions such as steatosis, non alcoholic fatty liver disease (NAFL), or non alcoholic steatohepatitis (NASH). Various methods are being used for fat quantitation, such as MR spectroscopy or 3-point Dixon. A practical method based on dual flip angle and in-phase and out-of-phase (IP-OP) echoes has been developed on 1.5T [1] and validated at 3T [2]. The method consisted of 3 distinct scans: a high flip angle (70°) and low flip angle (20°) in- and out-of-phase gradient echo sequences, followed by another T2 weighted dual-echo gradient echo scan for T2* measurement. Here we present an improvement of the method, where we acquired 6 echoes (3 in-phase/out-of-phase pairs) with 2 flip angles providing fat quantitation and T2* correction in a single breath hold scan.

Methods

The pre-clinical evaluation of the technique was performed in 5 volunteers. Images were acquired on a 3T clinical MR system (Philips Achieva, R2.5) with a 6-channel phased-array surface coil. The exam consisted of a localizer, a multi-echo dual flip angle gradient-echo breath hold scan, and a single voxel spectroscopy scan. The sequence parameters for the multi-gradient-echo sequence were following: multi-slice 2D fast field multi-echo (mFFE), 6 echoes, TR/TE 184/1.15 ms, ΔTE 1.2 ms, dynamic flip angle: 70°/20°, voxel size 2.2x2.47mm, 17 slices of 7 mm, 1 mm gap, FOV 360x280 mm (106x164 matrix), SENSEx1.8, 1135 Hz/pix bandwidth, 24s breath hold duration. Proton MR spectroscopy was acquired with a single voxel PRESS sequence, TR 4000 ms, TE 45, 65 ms, 2 NSA, 2 phase cycles, 1.95 Hz spectral resolution, 30x30x30 mm^3 voxel size placed in a homogenous region of the liver, 16 sec scan duration. Fat content was calculated from the m-FFE images using the dual flip angle technique [1]. Integration of water and fat spectral peaks at TE=45 ms and 65 ms allowed for removal of T2 bias in MRS fat estimation [2].

Results

By implementing the dynamic flip angle into the multi-echo gradient echo sequence, we were able to obtain high and low T1 contrast, in and out of phase echoes in a singe breath hold scan, allowing for fat content measurement with T2* correction. Color –coded fat content maps and T2* maps were created from the dual flip angle multi-echo gradient-echo images (figure 1). Fat content values calculated by the dual flip angle multi-echo method and MR spectroscopy are plotted in figure 2. Good correlation was found between the two methods (R=0.947).

Conclusion

The dual flip angle method has been developed and validated as a reliable and accurate fat content measurement at 1.5T and 3T. While demonstrating good correlation with the standard MRS technique, this method provides better spatial coverage within comparable scan time. While MRS is considered a gold standard, like histopathology it measures only a small volume in the liver which does not yield a measurement of a heterogeneous disease. In this work we further improved its implementation, by providing fat content and T2* measurement of the whole liver in a single breath hold scan.

References: [1] Hussain HK, et al. Radiology 2005; 237:1048-1055. [2] Hussain HK, et al, Proc. Intl. Soc. Mag. Reson. Med. 16 (2008), #713.

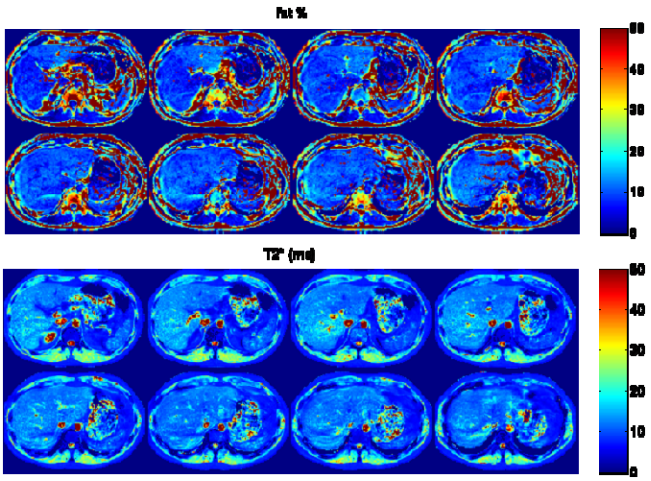

Figure 1. Fat content map (above) and T2* map (below) calculated from the multi-echo images using the dual flip angle method (8 of 17 slices shown).

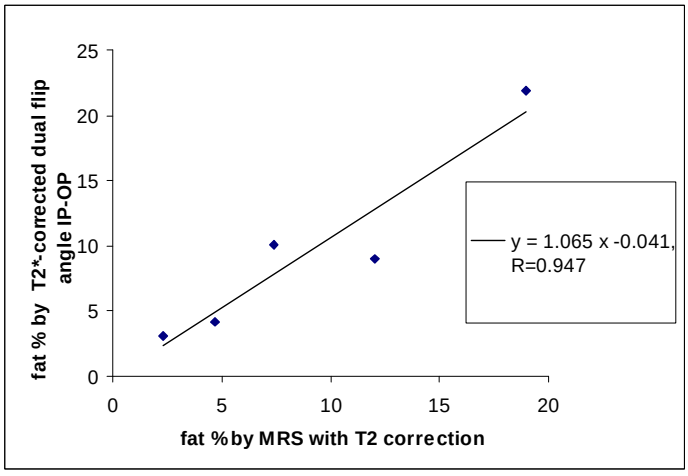

Figure 2. Comparison of fat content values calculated by dual flip angle method and spectroscopy.