Parallel Imaging in the Human Liver at 7 Tesla

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Introduction: Magnetic resonance imaging can be used to diagnose diseases of the liver including cirrhosis, hepatocellular carcinoma, and metastatic liver disease (1). One of the major challenges of liver imaging is dealing with motion from breathing. A common solution is to acquire images during a breathhold. However, patient health and compliance limits the feasible breathhold duration.

High magnetic fields have the potential to improve the quality of MRI by giving increased SNR, but with the challenge of increased B_1^+ and B_1^- inhomogeneity. While, for the challenge of generating a uniform B_1^+ field across the entire liver a multi-channel transmit systems is under development, the increased B_1^- field can be advantageous in parallel imaging, as the B_1^- inhomogeneity lowers the g-factor (2). The reduced g-factors at high field facilitate both high temporal and spatial resolution within a set amount of time, which is very useful in overcoming the challenges of liver imaging. Dynamic contrast enhancement (DCE) liver imaging is typically performed with a single baseline and two post-contrast time points. By shortening the time required to collect images, more post-contrast images can be acquired, increasing the amount of dynamic information and aiding in pharmacokinetic modeling. The goal of this work is to explore the potential of parallel imaging at 7 T for the liver.

Methods: All images of the liver were collected on a 7 T research magnet (Magnex Scientific, Oxfordshire, UK) with a Siemens Avanto gradient system and TIM console (vb 13, Siemens, Erlangen, Germany). A 16-channel flexible body surface array with TEM/stripline elements was used for transmit and receive (3). Each element was powered by a 1-kW RF amplifier with individual phase and gain control (CPC, Brentwood, NY). The transmit power envelope was monitored in real-time on all transmit channels using an in-house built 16-channel RF monitoring system. The transmit phase for each channel was optimized *in vivo* using a B_1^+ shimming algorithm described previously (4). Three healthy volunteers were studied under a protocol approved by our institution's IRB. Multislice gradient recalled echo (GRE) images were collected without acceleration and with 1-dimensional reduction factors of 2, 4, and 8 (data not shown), keeping all other parameters equal for the temporal resolution scans (Figure 1). For the spatial resolution scans (Figure 2), we increased the matrix size and decreased the field of view to achieve an effective acceleration factor of 6. We used the manufacturer's GRAPPA method for the improved temporal resolution and performed an offline reconstruction using opengrappa.m for the improved spatial resolution.

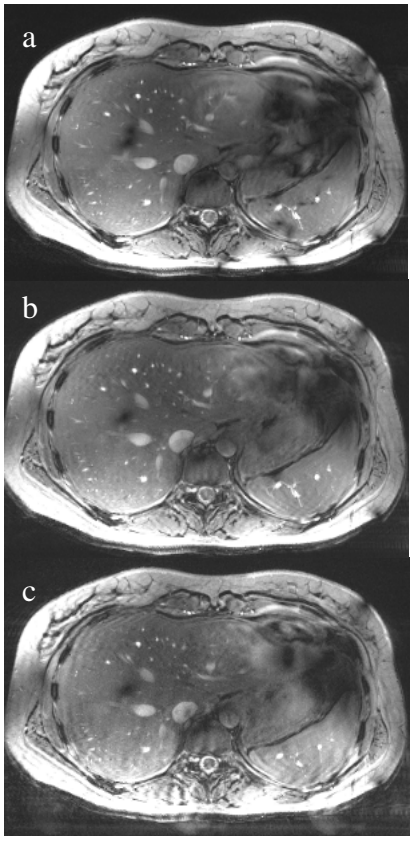

Figure 1 – Images from multislice acquisitions each collected during a single breathhold (TE/TR = 4.04/25), a) no acceleration, 19 sec; b) GRAPPA factor of 2, 11 sec; c) GRAPPA factor of 4, 7 sec

Results and Discussion: Using parallel imaging techniques we were able to improve the resolution obtainable within a single breathhold. We were able to increase the time resolution as shown in Figure 1 using GRAPPA with reduction factors of 2 and 4 before seeing significant artifacts. Additionally, we achieved an 18x smaller pixel size and thus were able to see two individual vessels that could not be resolved in the image without acceleration (Figure 2).

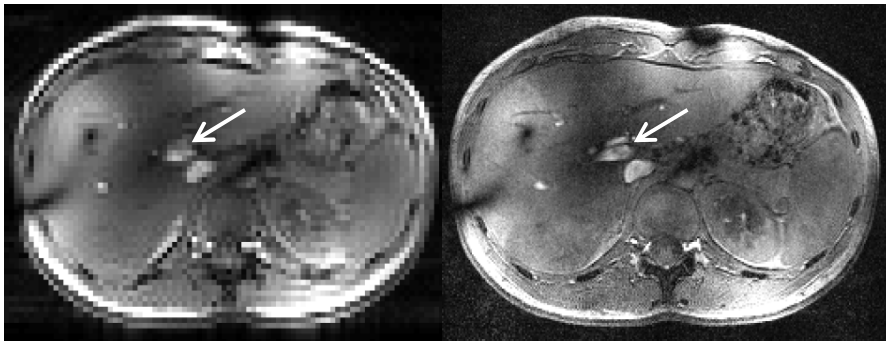

Figure 2- Each 3D GRE image was collected during one 20-second breathhold (TR/TE=6/3.1). The image on the right was collected with a reduced field of view and increased resolution and was reconstructed offline using GRAPPA to achieve a reduction factor of R=6x1, increasing the resolution from 3x3x5 mm (matrix=128x128x32) to 1x1x2.5 mm (matrix= 384x64x32).

The current phase-only B_1^+ shimming algorithm is designed to shim over small regions, but phase and magnitude algorithms for homogenous excitation over large regions are being developed, which should reduce the artifacts from inhomogenous excitation.

References: 1) Ramalho M, et al., MRIC 2007; 2) Wiesinger F, et al., NMR Biomed 2006; 3) Snyder CJ, et al., ISMRM 2007; 4) Van de Moortele P-F, et al., MRM 2005

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