Whole Organ Coverage Volumetric T1-weighted In-phase/Out-of-phase Imaging For Body MRI at 3T

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Introduction

In-phase/out-of-phase (or "dual echo") gradient echo imaging is routinely used in body MRI to identify regions of fatty infiltration and adenomas[1]. Conventional 2D dual echo sequences rely on a large flip angle to achieve T1 weighting and the desired contrast [e.g. liver to spleen]. However at 3T, application of a large flip angle is limited due to the higher SAR requirement. In addition, standard 2D techniques typically limit the acquisition to that of relatively thick section (6-8mm) for adequate coverage of the liver. Volumetric T1-weighted techniques have been used routinely for body MRI to acquire thinner sections; however, with limited coverage due to breath-hold acquisition requirement. Moreover, the current 3D implementation can only achieve single echo acquisition, necessitating two acquisitions for in-phase/out-of-phase imaging. We have developed a volumetric dual gradient echo imaging sequence that allow for acquisition of both in-phase and out-of-phases images in the same acquisition within a breath-hold.

Materials and Methods

All studies were performed on a GE Healthcare SIGNA EXCITE 3.0T Whole Body Imager (Milwaukee, WI) using 8 channels torso phase array coil. The 3D dual gradient echo pulse sequence was developed to acquire two echoes in the same TR in sequential mode. The echo time is designed to be closed to the 3T fat/water out-of-phase (3.3/5.5ms) and in-phase (2.2ms) value as possible. Studies were performed on six healthy volunteers using the following imaging parameters: FOV=36-45cm, matrix size=256x160-416x384, flip angle=12-15^0, TR=7-8.2ms, TE=2.2/3.3/5.5ms, receiver bandwidth =+/- 62.5-125 kHz, 40-80 slices, 2-4mm slice thickness. Partial parallel imaging (ASSET) and/or partial Fourier acquisition were also employed to increase volume coverage while maintaining breath-hold acquisition (18-25 seconds). The standard dual echo multi-slice interleaved acquisition was also utilized for comparison using similar imaging parameters but with TR=200ms, flip angle= 80^0, 20 slices, 6mm thick, 2mm slice gap.

Results and Discussion

Figure 1 shows the abdominal images of an axial cross section (1.5mm interpolated / 3mm acquired) of a healthy volunteer using the proposed 3D in-phase/out-of-phase imaging pulse sequence. The image on the right is the out-of-phase image acquired with echo time of 5.5ms. The image on the left is the in-phase image at echo time of 2.2ms. The other imaging parameters are as follow: TR=8.1ms, FOV=38cm, phase FOV=0.7, flip angle=12^0, receiver bandwidth=+/-91kHz, matrix size =384x192, 54 slices, 3mm thick, 2X acceleration, 72% partial Fourier acquisition along slice encoding direction, total scan time=21 seconds. There is good liver and spleen contrast. The out-of-phase image shows excellent delineation of water-fat boundary. Figure 2 shows the abdominal images of an axial cross section (6mm) of the same volunteer using the standard 2D dual echo imaging pulse sequence at similar location to images in Figure 1. The image on the right is the out-of-phase image acquired at echo time of 5.8ms. The image in the left is the in-phase image at echo time of 2.4ms. The other imaging parameters are: TR=200ms, FOV=38cm, phase FOV=0.7, flip angle=80^0, receiver bandwidth=+/-142kHz, matrix size =384x192, 20 slices, 6mm thick, 2mm slice gap, 2X acceleration, total scan time=24 seconds. Figure 3 shows the in-phase/out-of-phase coronal reformat of the volumetric data obtained from the same volunteer in figure 1 demonstrating the whole liver coverage in 21 seconds acquisition. The 3D dual echo technique SNR is 25% higher on a 1.5m reconstructed slice than that of the standard dual echo 6mm slice with better CNR (>11%) between liver and spleen even though much lower flip angle was employed in the 3D case (12^0 vs. 80^0). The use of volumetric dual echo technique offer several well-known advantages over the conventional 2D acquisition[2] such as contiguous slice with no inter-slice gap and high SNR enabling the possibility of obtaining near isotropic resolution data in a breath-hold. The proposed 3D dual echo pulse sequence appears to be a useful alternative for T1-weighted in-phase/out-of-phase gradient echo imaging at 3T. Large whole organ/abdominal coverage can easily be achieved via the deployment of partial parallel imaging and/or partial Fourier acquisition. Furthermore, the proposed technique also features lower SAR requirement due to the smaller employed flip angle while maintaining adequate T1 weighted contrast.

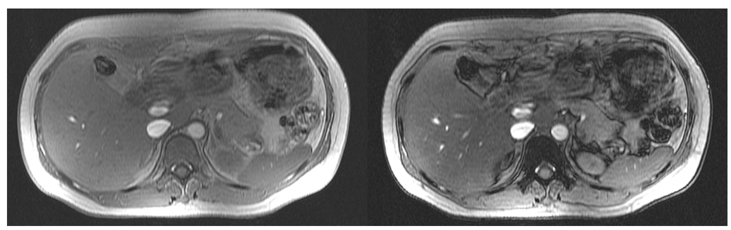

Figure 1. Images obtained with 3D dual-echo imaging pulse sequence

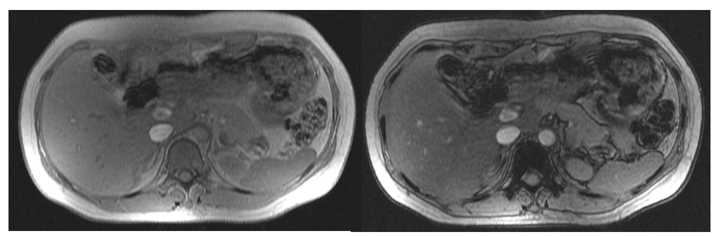

Figure 2. Images obtained with 2D dual echo imaging pulse sequence

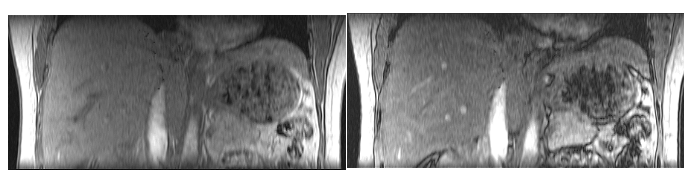

Figure 3. Coronal Reformat of volumetric data set shown in figure 1

References

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