Highly Accelerated IDEAL Vs Fat sat acquisition: A Comparison for Volumteric Liver Imaging

A. Shankaranarayanan[1], D. Sodickson[2], A. Madhuranthakam[3], A. Carrillo[4], S. Joshi[5], A. Grant[6], P. Robson[6], H. Yu[7], A. Shimakawa[7], S. Reeder[8], J. Brittain[9], and C. Mckenzie[6]

[1]Global Applied Science Lab, GE Healthcare, Bethesda, MD, United States, [2]Center for Biomedical Imaging, New York University Medical Center, New York, NY, United States, [3]Global Applied Science Lab, GE Healthcare, Boston, MA, United States, [4]Global Applied Science Lab, GE Healthcare, Evanston, IL, United States, [5]GE Healthcare, Waukesha, WI, United States, [6]Dept. of Radiology, Beth Israel Deconess Medical Center, Boston, MA, United States, [7]Global Applied Science Lab, GE Healthcare, Menlo Park, CA, United States, [8]Dept. of Radiology, University of Wisconsin, Madison, WI, United States, [9]Global Applied Science Lab, GE Healthcare, Madison, WI, United States

Introduction:

Contrast-enhanced imaging of the abdomen requires reliable fat suppression, comprehensive volumetric liver coverage, and short scan times to allow scan completion within a breathhold. IDEAL (Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares estimation) is a chemical-shift based fat-water separation method that has been shown to offer more consistent water-fat separation than conventional fat suppression techniques [1,2]. Previous work combined IDEAL with a self-calibrated, highly-accelerated acquisition using a 32-channel system and a 32 element abdominal coil [3]. In this work, we compare image quality and scan times of the 32-channel IDEAL acquisition with conventional fat suppression techniques in the clinical realm of contrast-enhanced, high-resolution breath-held abdominal imaging. Results from volunteer experiments are shown.

Methods:

Data were acquired on a 32 channel 1.5T TwinSpeed MR system (GE Healthcare, Waukesha, WI) using a symmetric body-optimized 32-element array [4]. A 3D gradient echo sequence was modified to acquire three echoes with echo times selected to maximize the SNR of the IDEAL reconstruction [5]. A self-calibrating scheme (16x16 fully sampled points in the Y-Z plane) was used to generate sensitivity maps required for parallel imaging reconstruction. The extra phase encodes required for self-calibration were acquired for only one of the three IDEAL echoes (typically echo with the shortest echo time). Imaging parameters included: 256x160x48 data matrix (after reconstruction), FOV = 38cm, flip = 12^o, BW = ±62kHz, TE1/2/3 = 1.9/3.6/5.2 ms, and TR = 6.4ms. Acceleration factors were optimized based on the requirements of the imaging protocols. The Generalized Encoding Matrix (GEM) approach was used to unwrap the accelerated (Y-Z) plane [6]. Unaliased slices were then processed with the standard 3-point IDEAL on-line processing algorithm [1] to obtain water, fat, in-phase and out-of-phase images. To accelerate the reconstruction, the unwrapping was performed on 16 processors in parallel. For comparison, a 2D accelerated 3D SPGR sequence with spectrally-selective inversion applied once for an optimized number of ky-kz lines was acquired. All imaging parameters were the same for the two acquisitions except for those mentioned below. The following imaging protocols were used to compare the two sequences:

1) A 23s IDEAL acquisition with a net acceleration factor (R) of 5.6. This provides water, fat, in-phase and out-of-phase images. This provided a reasonable breath hold time while allowing the full coverage.
2) A 23s fat-suppressed image using a 2D accelerated fat-sat acquisition. All parameters were retained same except for acceleration factor (R=1.4) and number of echoes (only one) collected.
3) One fat sat and one non-fat-sat acquisition in a total of 23sec (i.e. 13sec fat-sat acquisition and 10sec non-fat-sat acquisition), to compare image quality and information content with the IDEAL sequence utilizing the same total time. The net acceleration factor required to meet these time constraints was 3.8 for both fat-sat and non-fat-sat acquisitions.

After obtaining informed consent, four contrast-enhanced phases were acquired with the highly accelerated IDEAL technique on five volunteers. The fat-sat acquisitions, using the institution's standard clinical protocol, immediately followed each IDEAL acquisition. The slab was optimized to provide complete liver coverage (20-24cm). Acceleration factors were then optimized to meet breathhold scan time constraints and the imaging protocol, as described above. Typically, one pre-contrast 3D data set and three post-contrast data sets corresponding to arterial, venous, and late phase were obtained using IDEAL . The images were qualitatively evaluated for SNR and general image quality with respect to the conventional fat suppressed images.

Results:

Figure 1 shows coronal reformats of post contrast images from the three imaging protocols described above. (a) Water only IDEAL image, (b) image obtained from a 20s fat sat acquisition, (c) image obtained from a 12s fat sat acquisition and (d) image obtained from a 12s non fat-sat acquisition. Note image quality of the highly accelerated IDEAL is comparable to the fat-sat acquisitions even though a significantly higher acceleration factor was used. However, in the same scan time the accelerated IDEAL sequence also provided robust fat, in-phase and out-of-phase images (Fig 2). Lower SNR can be observed in images (c) and (d) because of the reduced scan time leading to higher acceleration factors and g-factor-related noise. Fig3 shows a pre contrast axial image of one location for IDEAL and fat suppression sequence respectively. Note the uniform fat suppression in the IDEAL image. In comparison, uneven fat suppression can be seen in (b) at the same location.

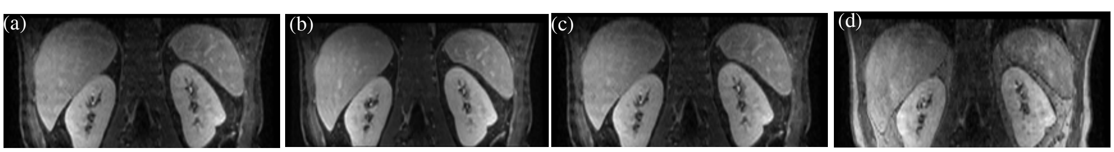

Figure 1: Coronal reformats of post contrast images from the three imaging protocols. (a) Water only IDEAL image (b) fat sat image with 20sec acquisition time (c) fat sat image at 12s and (d) non fat sat image at 12s. Note that the image quality between (a) and (b) and (c) are comparable even though a significantly higher acceleration factor was used in the IDEAL case. Also note the full volumetric coverage obtained in the acquisitions.

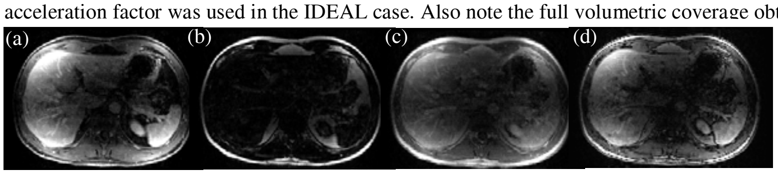

Figure 2: Post contrast axial images from the imaging protocol 1 (IDEAL results) (a) Water (b) fat (c) in-phase and (d) out-of-phase images. Note that the image quality is consistent across all the images.

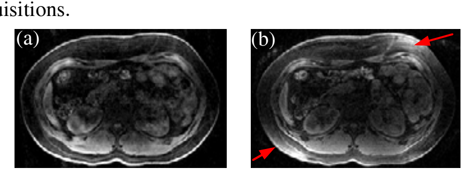

Figure 3: Pre contrast axial image from (a) highly accelerated IDEAL acquisition and (b) conventional fat suppression technique. The arrows point to two places where there is uneven fat suppression. The IDEAL images demonstrated uniform fat suppression.

Discussion and Conclusion:

The ability to achieve high acceleration factors with many-element arrays enables the use of a robust and SNR-efficient but time-consuming fat-water separation technique like 3 point IDEAL. The IDEAL image quality is comparable to that of fat saturated acquisitions while respecting the relatively stringent time constraints of clinical breath-held scanning. In addition, the highly accelerated IDEAL technique also provides robust fat, in-phase and out-of-phase images that can be used for clinical diagnosis. In conclusion, highly accelerated IDEAL imaging is a promising method for contrast enhanced volumetric abdominal imaging.

References:

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