Highly Accelerated IDEAL-SPGR Breast Imaging

C. A. McKenzie[1,2], R. O. Giaquinto[3], A. Grant[1,2], A. Shankaranarayanan[4], D. Gurr[5], A. Madhuranthakam[6], H. Yu[4], A. Brau[4], A. Shimakawa[4], S. Joshi[5], V. V. Menon[5], A. Carrillo[5], T. Steger[5], S. M. LaRuche[1], N. Farrar[1], C. L. Dumoulin[3], J. H. Brittain[4], S. B. Reeder[7,8], N. M. Rofsky[1,2], D. K. Sodickson[1,2]

[1]Radiology, Beth Israel Deaconess Medical Center, Boston, MA, United States, [2]Radiology, Harvard Medical School, Boston, MA, United States, [3]GE Global Research, Niskayuna, NY, United States, [4]Global Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States, [5]GE Healthcare, Waukesha, WI, United States, [6]Global Applied Science Laboratory, GE Healthcare, Boston, MA, United States, [7]Radiology, University of Wisconsin Medical School, Madison, WI, United States, [8]Biomedical Engineering, University of Wisconsin Medical School, Madison, WI, United States

Introduction: Dynamic T1 weighted spoiled gradient recalled echo (SPGR) imaging following administration of relaxivity contrast agents is a crucial tool for the detection of breast cancer with MRI. Robust fat suppression is essential to maximize the conspicuity of suspicious lesions. Traditional fat-suppression approaches for SPGR include fat-selective RF pulses that saturate or invert the fat signal or water-selective RF excitation pulses. Unfortunately these methods are sensitive to both B0 and B1 inhomogeneities, resulting in inhomogeneous fat suppression. The Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares estimation (IDEAL) method (1) provides excellent separation of fat and water signals despite the presence of B0 and B1 inhomogeneities, a feature desirable for breast imaging. IDEAL has been demonstrated in combination with SPGR (2), but applying IDEAL to dynamic imaging has been limited by the requirement that three images with different fat-water phase shifts must be collected, tripling acquisition time relative to an equivalent non-fat-suppressed sequence. One advantage of IDEAL is that the separated images have SNR equivalent to an acquisition with three averages (2, 3). This makes IDEAL an excellent candidate for acceleration with parallel MRI, since the additional SNR of IDEAL offsets SNR losses inherent in parallel MRI reconstruction. In this work we demonstrate the use of large parallel imaging acceleration factors for dynamic IDEAL T1W SPGR imaging of the breast with spatial and temporal resolution equal to or exceeding traditional fat suppressed SPGR imaging.

Methods: This study was approved by our Institutional Review Board and written consent was obtained from six volunteers. We performed all scans on GE Signa 1.5T TwinSpeed MR imaging systems (GE Healthcare, Milwaukee, WI, USA) equipped with a 32 channel acquisition system (4). Images were acquired using a new twenty-eight element breast imaging array. The elements of this array were arranged in two pairs of two parallel plates, with the plates in each pair placed on the medial and lateral sides of each breast. The lateral plates of each pair were moveable and were used to provide mild compression of the breast. The coil elements in each plate were grouped into two rows running parallel to the chest wall. The anterior row had four elements and the posterior row had three.

Dynamic 3D T1 weighted IDEAL-SPGR imaging was performed with the following protocol: TR=8.5ms, TE1,2,3 =2.0,3.6,5.2 ms, Flip=25°, BW= ± 22.7 kHz, 16x16x32 cm sagittal FOV, 256x256x132 voxels, 0.75 fractional sampling in the slice direction, voxel volume 0.94 µl. Dynamic imaging was performed after injection of 0.1 mM/kg of Gd-DTPA (Magnevist, Berlex Laboratories, Wayne, NJ). A non-accelerated acquisition at these resolutions would have taken an unusable 15min 55s. We used self-calibrated Generalized Encoding Matrix (GEM) reconstruction (5) to accelerate the acquisitions by factors between 7.6x-14.5x so that the acquisition times were between 66-126 s, a useful range for dynamic imaging.

Results: Figure 1 shows water-only and fat-only images from a pre-contrast 7.6-fold accelerated IDEAL-SPGR 126 s acquisition. Excellent separation between water and fat was achieved. Figure 2 shows a post-contrast 7.6-fold accelerated water-only IDEAL-SPGR image demonstrating an enhancing lesion (circle) anterior to the chest wall. Figure 3 shows water-only and fat-only images from a pre-contrast 9.6-fold accelerated IDEAL-SPGR 99 s acquisition. Excellent separation between water and fat was achieved.

Discussion: When combined with large parallel imaging accelerations, IDEAL has significant advantages for breast MRI. GEM accelerated imaging eliminates the scan time penalty of IDEAL. Because IDEAL water-fat separation is SNR efficient, the accelerated IDEAL images have SNR similar to equivalent fat-saturated images, but with the advantage of robust fat-water separation. None of the images showed significant g-factor noise amplification. The SNR of the 9.6-fold accelerated IDEAL images is low but acceptable. The SNR of equivalent post-contrast images would be significantly improved. This suggests that there is additional room for further acceleration to improve the spatial and/or temporal resolution of contrast enhanced IDEAL-SPGR acquisitions.

Conclusion: We have demonstrated the advantages of highly accelerated IDEAL SPGR over more traditional fat suppressed SPGR techniques for imaging the breast. By accelerating the acquisition with GEM we have eliminated the time penalty for IDEAL imaging. Thus the benefits of IDEAL can be extended to dynamic contrast enhanced imaging of the breast while maintaining resolution and SNR.

References: 1. Reeder et al, MRM, 2004;51:35-45. 2. Reeder et al, Proc. ISMRM, 2005;105. 3. Pineda et al MRM, 2005;54:625-35 4. Sodickson et al, Acad Radiol 2005;12:626-635. 5. McKenzie et al, MRM, 2002;47:529-538

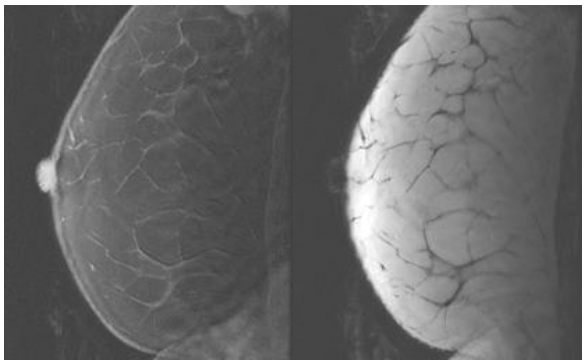

Figure 1: Sagittal pre-contrast IDEAL-SPGR images, acceleration factor 7.6x
Left: Water-only image Right: Fat-only image

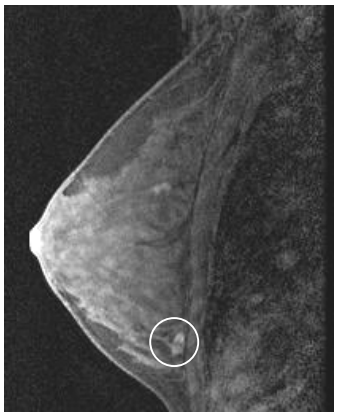

Figure 2: Sagittal pre-contrast IDEAL-SPGR image. Circle indicates enhancing fibroadenoma.

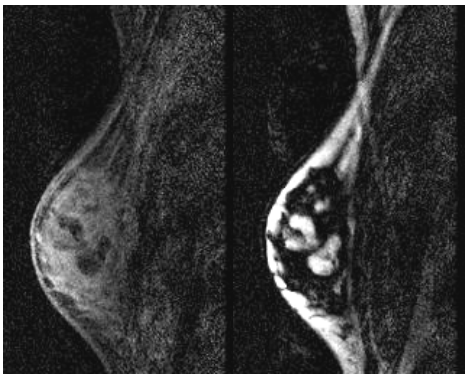

Figure 3: Sagittal pre-contrast IDEAL-SPGR images, acceleration factor 9.6x
Left: Water-only image Right: Fat-only image