IDEAL Breast MRI

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Introduction: Robust fat suppression is critical for breast MR imaging. Traditional fat-suppression approaches include fat-saturation RF pulses, water-selective RF pulses, or Short Tau Inversion Recovery (STIR). The former two methods are sensitive to both B0 and B1 inhomogeneities. STIR can be easily combined with IDEAL (2) for silicone implant imaging and provides robust homogeneous fat suppression, but it increases scan time and decreases SNR. In addition, STIR is not suitable for T1 weighted contrast enhanced imaging. Iterative 'Dixon' water-fat separation with Echo Asymmetry and Least-squares estimation (IDEAL) (1) provides excellent separation of fat and water signals despite the presence of B0 and B1 inhomogeneities, features desirable for breast imaging. IDEAL can be combined with a variety of pulse sequences useful for breast imaging, including FSE and SPGR. In this work we demonstrate IDEAL for STIR, T2W FSE and T1W SPGR dynamic contrast enhanced imaging, in protocols for evaluating breast implants and for breast cancer screening/evaluation.

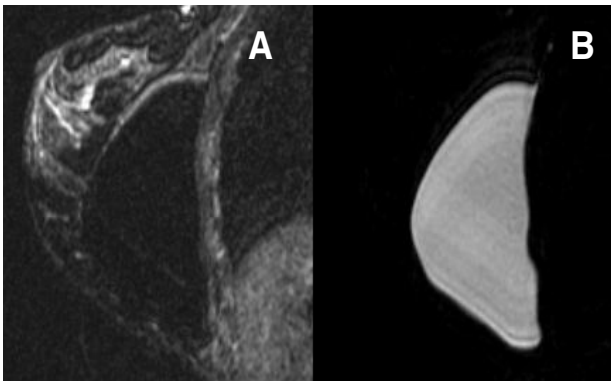

Figure 1: Sagittal STIR-IDEAL imaging of a silicone implant A- Water only image B-Silicone only image

Methods: We obtained images from adult volunteers at SUMC and BIDMC. The study was approved by the sites' Institutional Review Boards and written consent was obtained from all volunteers. We performed all scans on GE Signa 1.5T TwinSpeed MR imaging systems (GE Healthcare, Milwaukee, WI, USA) using four element breast imaging arrays.

For imaging women with silicone breast implants, the addition of a STIR pulse to IDEAL-FSE (TR/TE 8s/80ms, ETL 16, BW= ± 32kHz, 256x192, 5mm sagittal slice, 20cm FOV) was used for suppressing fat (2). IDEAL was used to separate water and silicone, allowing direct simultaneous visualization of water and silicone. Without IDEAL, this protocol would require two separate STIR acquisitions, one with water suppression and the second with silicone suppression.

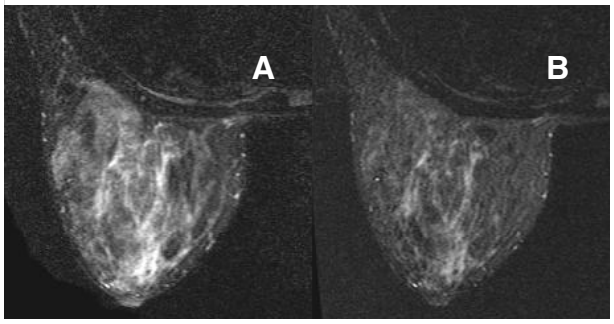

Figure 2: A- Axial T2W IDEAL FSE B- Axial STIR

For the cancer screening/evaluation protocol, pre-contrast imaging was performed with 2D T2W IDEAL-FSE (TR/TE 6s/(85,86.6,88.2ms), ETL=16, BW= ± 62kHz, 512x256, 4mm axial slice, 30-36cm FOV, 100 s acquisition time) and 3D T1W IDEAL-SPGR (TR/TE1,2,3/flip 8.5ms/2.0,3.6,5.2 ms/10° BW= ± 62kHz, 256x256, 3mm axial slice, 30-36cm FOV, 120s acquisition). Conventional T2W FSE (TR/TE 6s/85ms, ETL 16, BW= ± 62kHz, 512x256, 4mm axial slice, 30-36cm FOV, 100 s acquisition time), STIR (TR/TE/TI 8s/85 ms/140ms, ETL 16, BW= ± 32kHz, 256x192, 5mm sagittal slice, 20cm FOV, 130 acquisition time) and fat saturated SPGR (fs-SPGR) (TR/TE/flip 7.4ms/4.2 ms/10° BW= ± 31kHz, 256x256, 3mm axial slice, 30-36cm FOV, 120s acquisition) were acquired for comparison.

Both SPGR protocols (IDEAL-SPGR and fs-SPGR) were used for dynamic imaging after injection of 0.1 mM/kg of Gd-DTPA (Magnevist, Berlex Laboratories, Wayne, NJ). 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-IDEAL sequence. However, one advantage of IDEAL is that the separated images have SNR equivalent to an acquisition with three averages (1). 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. Array spatial sensitivity encoding (ASSET) was used to accelerate all pre contrast IDEAL images three-fold, achieving acquisition times and SNR for IDEAL-SPGR that are comparable to fs-SPGR.

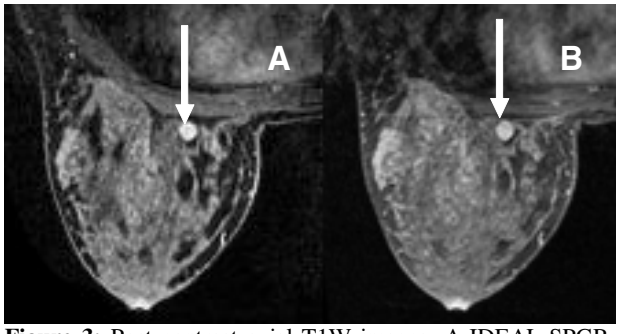

Figure 3: Post contrast axial T1W images: A-IDEAL-SPGR, B-fs-SPGR. The arrowed enhancing lesion is better visualized on IDEAL-SPGR due to its superior fat suppression

Results: Figure 1 shows images from an IDEAL-STIR acquisition in a breast with a silicone implant. Excellent separation between water and silicone was achieved, with uniform suppression of fat from the STIR pulse. Figure 2 shows an axialT2W IDEAL-FSE water image and the corresponding STIR image. Excellent separation between water and fat has been achieved, with uniform fat suppression comparable to STIR. Figure 3 shows a post-contrast water IDEAL-SPGR axial image acquired with a three-fold ASSET acceleration and the corresponding fs-SPGR image. An enhancing lesion (arrowed) is clearly seen anterior to the chest wall of the right breast in both images. The lesion-background contrast of IDEAL-SPGR is superior to fs-SPGR due to superior uniformity of fat-suppression.

Discussion: IDEAL has significant advantages for breast MRI. ASSET 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 near perfect fat-water separation. Another advantage of IDEAL is the availability of the fat image for visualization of fatty masses such as lipomas, hamartomas, galactoceles, oil cysts or fat necrosis. This information is lost in fat suppressed imaging, necessitating additional imaging without fat-saturation for direct visualization.

Conclusion: We have demonstrated the advantages of IDEAL over more traditional fat suppression techniques for imaging the breast. By accelerating the acquisition with ASSET 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. Ma et al JMRI, 2004, 19:298-302