Breast MRI Using a Balanced Steady-State Free Precession Imaging with a Two-Point Dixon Fat-Water Reconstruction Algorithm: Preliminary Experience and Comparison with 2D FSE

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INTRODUCTION: Balanced steady-state free precession (b-SSFP) techniques yielding high SNR images in short scan times with T_2-like image contrast have several appealing attributes for clinical breast MRI [1]. Clinical T_2 imaging in the breast is routinely performed using a fat suppressed 2D Fast Spin Echo (FSE) pulse sequence with high in-plane spatial resolution. The 3-5 mm slice thickness obscures fine structures and renders reformatting sub-optimal. Using a new ultrafast 3D technique that combines balanced steady-state free precession imaging with a two-point Dixon fat-water reconstruction algorithm [2], near isotropic sub-millimeter in-plane and through-plane resolutions can be achieved in about a quarter of the time typically needed for 2D FSE. We investigated the performance of a dual echo 3D b-SSFP DIXON sequence in comparison to conventional 2D FSE in 50 patients.

METHODS AND MATERIALS: A dual echo bipolar readout 3D balanced steady-state free precession pulse sequence [3] followed by 2-point Dixon fat-water reconstruction algorithm was developed and optimized. Sequence parameters for the bipolar 3D b-SSFP sequence include: axial acquisition, FOV 26-32cm, section thickness 1.6mm interpolated to 0.8mm, matrix 320x320, opposed-phase/in-phase TE values 2.2/3.8 ms, TR 5.5ms, $\pm$125 KHz bandwidth. Conventional three-point Dixon based 2D FSE was performed with the following parameters: axial acquisition, FOV 26-32cm, section thickness 5mm, matrix 256x320, TR/TE 5300/94 ms, ETL=8, $\pm$62.5 KHz bandwidth. For the 3D b-SSFP acquisitions, MIP images were also obtained.

For each of the 50 patients, both 3D b-SSFP and 2D FSE acquisitions were obtained on a 1.5T GE Signa HDx scanner using an 8-channel breast phased array coil with an IRB approved protocol. Images were evaluated qualitatively to assess visualization of pathology (if present), SNR, lesion contrast, image artifact, and overall image quality on a scale of 1 (uninterpretable) – 5 (ideal). In addition, a preferred sequence was also selected.

RESULTS: Clinical indications for breast MRI included, staging of breast cancer, high-risk for breast cancer, implant integrity, and challenging diagnostic evaluations. Preliminary results demonstrated no overt confounding diagnostic features of the T_2/T_1 weighting of 3D b-SSFP compared to conventional 2D FSE. The benefits of 3D b-SSFP are more evident in evaluation of ductal pathology, saline implant integrity, and demonstration of associated vascularity. Banding artifacts particularly in the infra-mammary regions on the b-SSFP sequences can sometimes make this area a more diagnostically challenging area to evaluate. Figs. 1-4 illustrates the performance of b-SSFP in the breast.

CONCLUSION: The 3D SSFP Dixon acquisition yields uniform, robust fat suppression and high SNR with a T_2 like contrast in the breast. A near-isotropic sub-millimeter in-plane and through-plane resolution enables high quality multi-planar reformats. The ultra-short scan time (<90s) makes this an ideal sequence for patients who are unable to lie still. Evaluation of saline implants becomes more straightforward with its near-isotropic resolution. Ductal pathology as well as internal septations, which can be associated with fibroadenomas, are better depicted using 3D b-SSFP. For the first time, an option to survey breast and tumour vascularity can be performed without intravenous contrast.

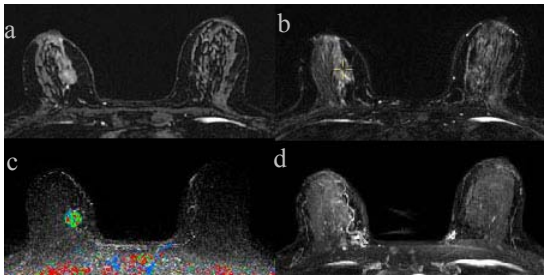

Fig. 1. Biopsy-proven cancer in the right breast illustrated with b-SSFP (a), 2D FSE (b), contrast-enhanced MIP (c), and MIP of b-SSFP (d). Note the improved sharpness and vascular detail provided by b-SSFP.

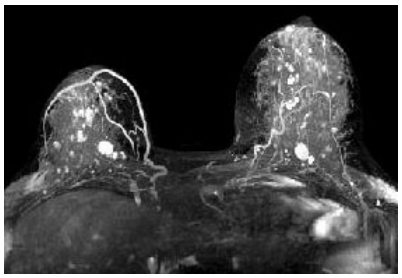

Fig. 2. Right breast cancer in the setting of fibrocystic change; vascularity is nicely demonstrated in this non-contrast enhanced scan using b-SSFP.

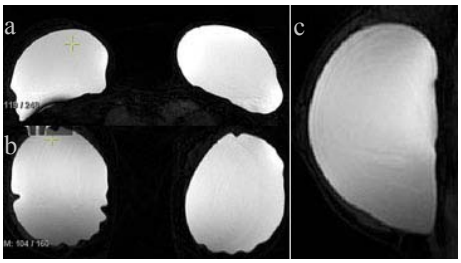

Fig. 3. Original axial acquisition using b-SSFP (a) in a patient with saline implants. Near-isotropic resolution allows for multi-planar reformats without a separate acquisition, thereby improving total scantime..

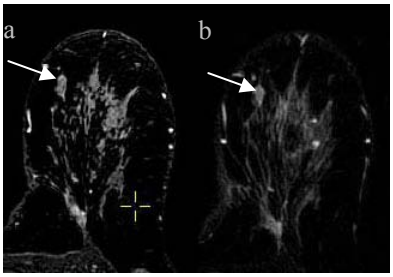

Fig. 4. Internal septations (white arrow) of a sonographically concordant fibroadenoma are better seen in b-SSFP (a) than in 2D FSE (b).

REFERENCES: 1. Klifa et al. JMRI 25:502–510 (2007) 2. Ma et al. MRM. 52:415-419 (2004) 3. Bayram et al Proc. ISMRM, p 4050 (2009)