Fast bilateral breast coverage with SENSE-accelerated high spectral and spatial resolution (HiSS) MRI

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TARGET AUDIENCE: 1) Breast radiologists; 2) breast oncologists; 3) medical physicists developing breast MRI techniques

PURPOSE: High spectral and spatial resolution (HiSS) MRI was shown to provide excellent diagnostic images of breast cancer, even without use of contrast agent. [1,2] This is achieved by obtaining and post-processing spectral information in each small image voxel to separate water and fat resonance signal and study their detailed structure. HiSS images, having superior fat suppression, [1,3] could potentially replace the pre-contrast T2-weighted images and visualize lesion morphology without artifacts resulting from contrast agent administration. However, full bilateral coverage has been prohibitively slow, mainly because SENSE acceleration of HiSS imaging is not commercially available. Earlier work produced full unilateral breast coverage in clinically feasible times. Here we demonstrate the feasibility of fast HiSS imaging with full bilateral axial coverage and higher in-plane resolution, with implementation of SENSE via a software patch. [4]

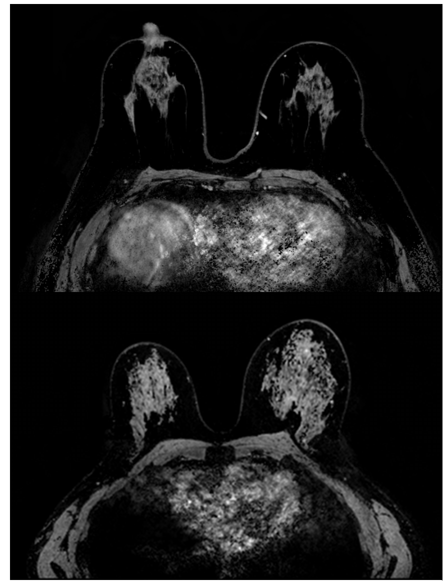

Figure 1: Representative slices of the full coverage HiSS water integral image set, through the breasts of two healthy volunteers.

METHODS: This study was HIPAA compliant and IRB approved, and all the subjects gave informed consent to participate. Three healthy volunteers and one cancer patient were scanned using a 16-channel dedicated breast coil. High-resolution echo-planar spectroscopic imaging [5] was used (384 mm field-of-view, 1 x 1 x 2 mm^3 voxels in 78 slices, 23 echoes for a 28 Hz spectral resolution, scan time 8.75 min, SENSE acceleration factor 3 in the left/right direction). Another two healthy volunteers were scanned at 1.5T, with 0.8 mm in-plane resolution in 2 and 3 mm thick slices, spectral resolution of 14.5 Hz, and other parameters being the same as at 3.0T. HiSS and SENSE acceleration were implemented via a software patch, and data were processed off-line. Pure water proton signal was obtained in post-processing by fitting the fat peak in each voxel to a Lorentzian function and subtracting the fit from the full water and fat proton spectrum. Images proportional to water resonance peak height and integral were generated.

RESULTS: Figure 1 shows representative slices from full bilateral SENSE-accelerated HiSS acquisitions obtained at 1.5T (top) and 3.0T (bottom). For comparison, Figure 2 shows a representative slice from a whole-breast acquisition achieved with a HiSS sequence without the use of SENSE acceleration (1.6 x 1.6 x 3 mm^3 voxels). 1) With application of the SENSE-accelerated HiSS patch, a two-fold acceleration of bilateral acquisition, with up to a 6-fold decrease in voxel size was achieved. 2) Excellent fat suppression and high dynamic range of HiSS images were preserved, with typical contrast-to-noise ratio in fat-suppressed water peak height images of ~12. 3) Signal-to-noise ratio was satisfactory for robust application of post-processing algorithms with a typical value of 15-45 in the frequency domain. 4) No SENSE-related artifacts were visible on HiSS images at SENSE acceleration factor of up to 3.

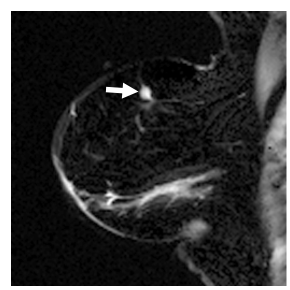

Figure 2: A representative slice of unilateral coverage HiSS water peak height image set, showing an invasive lesion (arrow).

DISCUSSION AND CONCLUSION: Full-coverage axial bilateral HiSS images were acquired at high spatial resolution, in clinically feasible times, by implementing SENSE acceleration. A full-breast HiSS sequence could replace existing T2-weighted pre-contrast sequence and also provide high-resolution fat-suppressed *pre-contrast* morphologic imaging of lesions, without artifacts resulting from contrast agent administration. Potentially, HiSS could guide localized dynamic contrast-enhanced scans. Also, by providing spectral information on the water resonance, full bilateral HiSS images would allow identification of small quantities of water-bearing tissue, and thus provide more reliable calculation of breast parenchymal density.

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[2] Medved et al., "Non-contrast enhanced MRI for evaluation of breast lesions: comparison of non-contrast enhanced high spectral and spatial resolution (HiSS) images versus contrast enhanced fat-suppressed images", Acad Radiol. 2011 Dec;18(12):1467.
[3] Fan et al., "Fat suppression with spectrally selective inversion vs. high spectral and spatial resolution MRI of breast lesions: qualitative and quantitative comparisons", J Magn Reson Imaging 2006 Dec;24(6):1311.
[4] Medved et al., "Echo-planar spectroscopic imaging (EPSI) of the water resonance structure in human breast using sensitivity encoding (SENSE)", Magn Reson Med. 2010 Jun;63(6):1557.
[5] Mansfield P., "Spatial mapping of the chemical shift in NMR", Magn Reson Med. 1984 Sep;1(3):370.