Fast bilateral breast coverage with high spectral and spatial resolution (HiSS) MRI at 3T

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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 is a small-voxel (2 mm^3 or less) implementation of spectroscopic imaging, in which fat and water are the resonances of interest. Even without use of contrast agent, HiSS MRI was shown to provide excellent diagnostic images of breast cancer. [1,2] To achieve this, water and fat resonance signal are isolated, and their detailed structure is studied by obtaining and post-processing spectral information in each small image voxel. Due to superior fat suppression, [1,3] HiSS images could potentially replace the pre-contrast T2-weighted images and could visualize lesion morphology without artifacts resulting from contrast agent administration. However, HiSS imaging is not commercially available, and requires a software patch. Here we further improve imaging speed over our earlier results [4] by implementing parallel imaging at higher field strength (3T). We demonstrate fast HiSS imaging with full bilateral axial coverage, higher speeds and in-plane resolution, and a 6-fold decrease in voxel size. [5]

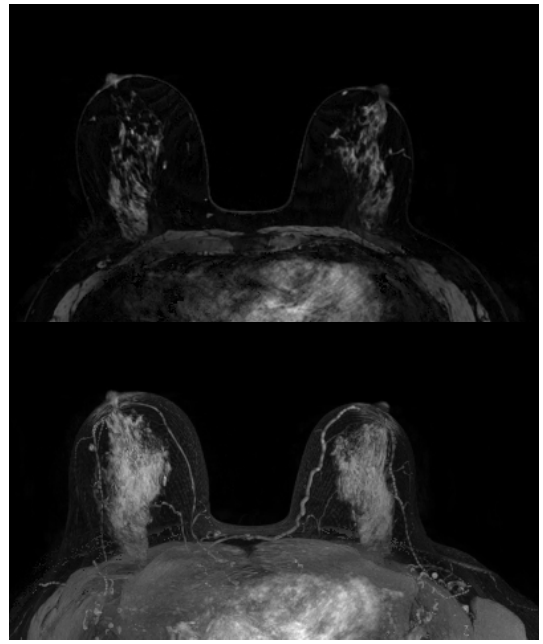

Figure 1: A representative slice of the HiSS water peak image set (at nipple level, top), through the breasts of a healthy volunteer, and the corresponding MIP image (bottom).

METHODS: In this HIPAA-compliant and IRB-approved study, all the subjects gave informed consent to participate. Twenty nine subjects (13 healthy volunteers, 8 patients with suspicious findings, and 8 cancer patients) were scanned using a 16-channel dedicated breast coil (InVivo, Gainesville, FL), on an Achieva 3T-TX magnet (Philips, Best, Netherlands). High-resolution echo-planar spectroscopic imaging [6] was used (384 mm field-of-view, 0.8 x 0.8 x 3 mm^3 voxels in 50-60 slices, TR/TE 2350/23 ms, 23 echoes for a 23.9 Hz spectral resolution, scan time 6.5-7.5 min, SENSE acceleration factor 3 in the left/right direction). HiSS and SENSE acceleration were implemented via a software patch and complex SENSE-accelerated images of individual echoes were reconstructed on the console. Data were post-processed off-line: pure water proton signal was obtained by fitting the fat peak in each voxel to a Lorentzian function and subtracting the fit and baseline from the full water and fat proton spectrum. Images proportional to water resonance peak height and integral were generated.

RESULTS: Figure 1 shows a pre-contrast HiSS water peak height image of a slice at nipple level (top) and a corresponding maximum intensity projection (MIP) image (bottom) from full bilateral HiSS acquisitions obtained at 3.0T, for a healthy volunteer. 1) A two-fold decrease in imaging time, with bilateral as opposed to unilateral [4] coverage was achieved, with concurrent up to 6-fold decrease in voxel size. 2) In 21 subjects, HiSS water peak height images and a corresponding T1-weighted pre-contrast examination were quantitatively compared. Average parenchymal signal to suppressed fat signal ratio was 3.9 ± 0.6 in fat-suppressed T1-weighted images and 7.6 ± 2.1 in water peak height images (94% improvement in parenchymal conspicuity, $p < 0.001$). Thus excellent fat suppression and high dynamic range of HiSS images were preserved in this setup. 3) Signal-to-noise ratio was satisfactory for application of post-processing algorithm (fat/water separation and peak fitting) within the breasts, with typical values of up to 45 in the frequency domain in the central area of the breast at nipple level. 4) No parallel imaging-related artifacts were visible on HiSS images.

DISCUSSION AND CONCLUSION: By implementing parallel imaging at 3T, full bilateral coverage HiSS images were acquired at high spatial resolution in under 6.5-7.5 minutes. This is well within clinically feasible acquisition times, and thus HiSS could be used as part of the imaging protocol. The T2*-weighted HiSS sequence could potentially replace the existing T2-weighted pre-contrast sequence, yielding some acquisition time savings. HiSS could provide high-resolution fat-suppressed *pre-contrast* morphologic imaging of lesions as well, eliminating artifacts resulting from contrast agent administration. Importantly, by utilizing spectral information, bilateral HiSS images would allow detection and characterization of small quantities of water-bearing tissue, and could be used to improve calculation of breast density in risk-assessment studies.

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