Small-voxel high spatial and spectral resolution (HiSS) MRI of human breast: a pilot study

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Introduction: Improvements in sensitivity and especially specificity of breast MRI are needed. [1] This laboratory has proposed use of high spectral and spatial resolution (HiSS) imaging of the water and fat proton resonances, at spatial resolution of conventional anatomic MR images or better. HiSS-derived images of water-bearing tissue offer uniform and complete fat suppression, high dynamic range, excellent image contrast and excellent tissue and lesion margin delineation, which can improve sensitivity and specificity of breast MRI. [2] In addition, spectroscopic data can provide new sources of image contrast. [3] Previously reported HiSS images were produced at approximately the spatial resolution of conventional images – 2-3 mm thick slices with 0.65-1 mm in-plane resolution. Here we demonstrate clinically the feasibility of small voxel HiSS imaging, at 0.5-0.75 mm spatial resolution in 1 mm thick planes (voxel volumes of 0.25-0.56 mm^3). Even at small voxel sizes, adequate signal-to-noise ratio (SNR) is achieved, HiSS image advantages are maintained, and higher spatial resolution yields better morphological information.

Materials and Methods: Twelve women (10 healthy volunteers, 2 patients with invasive lesions) were scanned with informed consent on a Philips Achieva 1.5T scanner, using an echo-planar spectroscopic imaging-based sequence. [4] Two sets of acquisition parameters were used: (TR/TE, in-plane spatial / spectral resolution, number of acquired slices, and number of acquisitions) was either SET 1: (650/50 ms, 0.5 mm / 5 Hz, 4, 3); or SET 2: (1000/40 ms, 0.75 mm / 18 Hz, 12, 2). Slice thickness was 1 mm, and acquisition time 8 min in either case. Post-processing included SNR-dependent filtering in k-space, fitting the water and fat peaks to Lorentzian lineshapes and subsequent elimination of the fat and baseline signal, and generation of water resonance peak height images, which are combination of T1- and T2-weighted. [5]

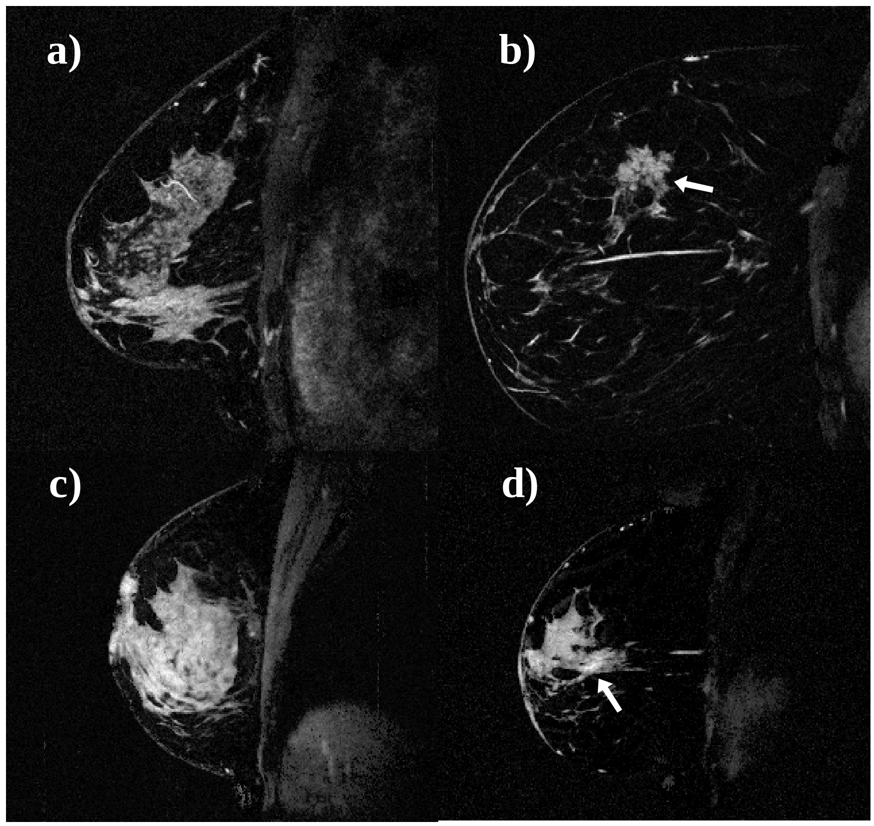

Figure 1: Water peak height HiSS images are constructed in small voxels, with adequate SNR, high dynamic range, and complete fat suppression. Parenchyma and lesion are depicted with high contrast against the background and excellent margin definition in all cases. An invasive lesion is depicted in b) (arrow), with excellent morphologic detail. In d), a biopsy site of an invasive lesion is visible (arrow). Imaging parameters were SET 1 (top row) and SET 2 (bottom row).

Results: Figure 1 shows typical water peak height images obtained with SET 1 parameters (top row) and SET 2 parameters (bottom row). High SNR, high dynamic range, and complete separation of water and fat signal are achieved. Water peak height images show parenchyma and lesions clearly against a dark background of highly suppressed fat, with excellent lesion and parenchyma margin delineation.

Discussion: The prolonged sampling of the proton free induction decay allows HiSS images a number of advantages over conventional MRI, including high dynamic range, better lesion delineation, uniform and complete fat suppression, and providing spectroscopic information. Our results demonstrate clinical feasibility of small-voxel HiSS imaging, with sub-millimeter in-plane resolutions in 1 mm thick slices (voxel volumes 0.25-0.56 mm^3), and high SNR, while maintaining HiSS imaging advantages. Predictable improvements in technology (e.g. higher field strength, improved detectors) will result in even higher SNR, faster acquisition times, and/or higher spectral resolution. In addition, spectral data may allow high-resolution B0 mapping – possibly sensitive to micro-calcifications or blood vessels. [3,6] Small-voxel HiSS is a novel approach to MRI of the breast that is likely to increase its diagnostic utility of MRI.

1. Heywang-Köbrunner, Bick, Bradley Jr, *et al.*, EJR 11:531-546, 2001.
2. Medved, Newstead, Abe *et al.*, AJR 186:30-37, 2006
3. Medved, Newstead, Fan, *et al.*, MRM 52:193-196, 2004.
4. Mansfield, MRM 1:370–386, 1984.
5. Medved, Du, Zamora, *et al.*, JMRI 18:442-448, 2003.
6. Foxley, Fan, Mustafi, *et al.*, PMB 53:4509-4522, 2008.