Clinical implementation of 3D high spectral and spatial resolution imaging

A. M. Wood[1], G. M. Newstead[1], H. Abe[1], M. Medved[1], and G. S. Karczmar[1]
[1]Radiology, University of Chicago, Chicago, IL, United States

Abstract: The purpose of this pilot study was to develop and test a 3D high spectral and spatial resolution (HiSS) pulse sequence on a 3T scanner. Previous studies have used a 2D HiSS pulse sequence at 1.5T, yielding high quality images with superior fat suppression to conventional images. In this work, we tested a very high resolution (350 μm in-plane) 3D multi-fast field echo (M-FFE) pulse sequence and used the resulting data to produce images of the peak heights of the water and fat resonances.

Introduction: High spectral and spatial resolution (HiSS) MR imaging has previously been implemented in the clinical setting at 1.5T using 2D multislice echo planar spectroscopic imaging (EPSI). Images of the peak height of the water resonance show improved morphology and near-complete fat suppression[1]. In previous work, we focused on the use of details of water resonance lineshapes to improve image contrast and diagnostic accuracy[2]. The present work demonstrates the use of a 3D multi-fast field echo (M-FFE) pulse sequence at 3T to sample the proton free induction decay (FID) with optimal signal-to-noise ratio per unit time, and produce images of the fat and water resonances, at very high spatial resolution.

Methods: Six patients were imaged on a Philips 3T Achieva using a dedicated 16-channel breast coil (Philips Invivo). A 3D M-FFE pulse sequence was used with the following imaging parameters: TR/TE/ΔTE=98ms/3.16ms/2.82ms, 16 echoes, spectral resolution=22 Hz, FOV=180x180x8mm^3, flip angle=20°, in-plane resolution=350μm, five 1.6 mm thick 'slices'. HiSS imaging was performed post-contrast injection, following a standard dynamic sequence. The raw data was exported from the scanner and offloaded for post-processing. Post-processing was performed with IDL, and involved assembly of the 3D kspace data from binary raw data, 3D Fourier transformation (FT) of the kspace data yielding an FID per voxel, followed by a 1-dimensional FT in the time direction resulting in a proton spectrum per voxel. Additional post-processing steps involved identification and labeling of the fat and water peaks, correction for spectral ghost peaks, and fitting of the fat and water peaks with Lorentzian lineshapes. The fitted fat peaks and baseline were subtracted from the spectrum in each voxel, and the peak height of the water resonance was used to generate 'water peak height' images. Signal from different coil elements was combined using the square root of the sum-of-squares technique. SNR measurements were performed for manually drawn ROIs in the central slice; noise was measured in the spectral domain after subtracting the fitted spectral peaks. Fat suppression factor (FSF) of the water peak height images was measured by taking the ratio of ROI signal averages in breast parenchyma to that in regions that contain primarily fat.

Results: The 3D M-FFE pulse sequence produced high quality HiSS water peak height images with great morphological detail. Small blood vessels (~700μm in diameter) and mottled texture of the breast parenchyma was observed in the water peak height images. The SNR of parenchyma in the water peak height images was 10.6±2.02 and SNR of fat in the fat peak height images was 15.3±3.77. Fat suppression factor in the water peak height images was 7.23±0.86

Discussion: This work demonstrates the first use of a 3D pulse sequence to acquire HiSS data, which is a step towards creating a fully bilateral HiSS imaging technique. The HiSS images produced here were of high quality and exhibited morphological detail unseen in conventional fat suppressed images. This imaging technique could be used to target and produce detailed images of suspicious enhancing areas of the breast, or could be adapted to be a fully bilateral sequence by incorporating SENSE acceleration. Such high quality images may help improve the specificity of breast MRI.

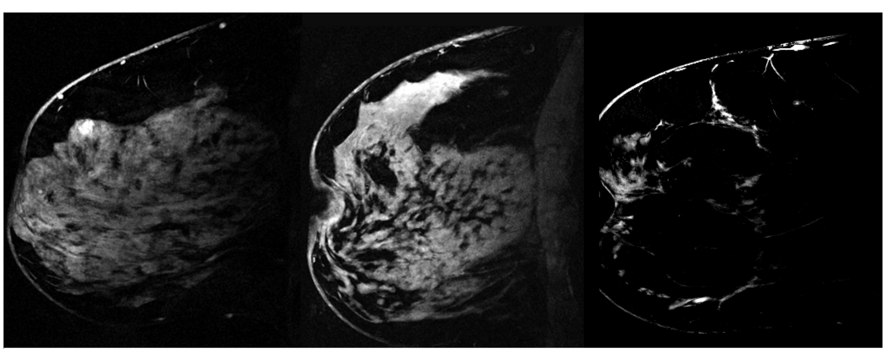

Figure 1. Sagittal water peak height images generated in this study.

References:
[1]Fan et al. JMRI 2006; 24:1311-1315.
[2]Wood et al. RSNA 2009; *abstract* LL-BR4078-H03.