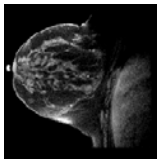
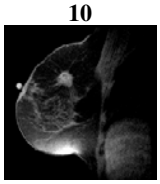
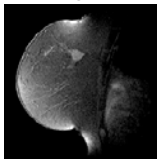
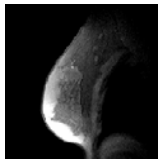
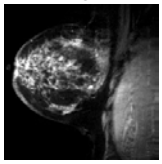
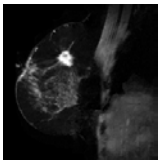
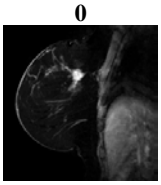
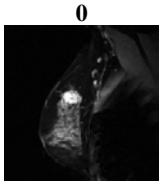
Comparison of T1 fat saturation vs. high spectral and spatial resolution MRI of breast lesions

X. Fan[1], G. Newstead[1], M. Medved[1], S. Foxley[1], M. Zamora[1], S. Arkani-Hammad[1], F. Olopade[1], H. Abe[1], G. S. Karczmar[1]
[1]Radiology, University of Chicago, Chicago, IL, United States

Introduction: Early and accurate diagnosis of breast cancer greatly improves survival and reduces morbidity. Conventional MR imaging has no spectral resolution and represents each spatial location or voxel using a single complex number. To improve breast imaging, high spectral and spatial resolution (HiSS) data are acquired with detailed water and fat spectra for each voxel at the spatial resolution of conventional imaging or greater. Previous comparisons of HiSS water peak height images to conventional fat-saturated images were not optimal because of significant differences in image acquisition parameters for the conventional and experimental images. In the present study, we directly compared HiSS water peak height images and fat-saturated images of identical slices acquired in close succession with the same in-plane spatial resolution.

Material and Methods: 17 female patients, age 53±18 years, were imaged on 1.5 Tesla GE SIGNA scanners. Sagittal T_1-weighted fat-saturated MR images (TR/TE = 175 ms/Min Full, FOV = 24 cm, array size = 256×256, flip angle = 80˚, BW = 31.25 kHz, slice thickness = 3 mm) were acquired first. Then the EPSI data (TR = 250 ms, FOV = 36×18 cm, flip angle = 60˚, BW = 62.5 kHz) were acquired from two slices from T_1-saturated images with 192 phase encoding steps and 64 gradient echoes sampled at 384 points. The resulting EPSI data had the same in-plane spatial resolution as T_1 fat-saturated images, with spectral resolution of 5.2 Hz and spectral bandwidth of 333 Hz. Both sets of images were acquired pre-contrast injection. Each water peak height image and T_1 fat-saturated image was normalized to its own average intensity calculated in a small region of chest wall muscles with high signal-to-noise ratio. HiSS water peak height and fat-saturated images were co-registered and clipped to the same size (192×192).

Table 1. Quality of fat suppression classified in each category.

	Excellent	Good	Fair	Poor
T_1 Fat-Sat	1	10	5	1
				
EPSI	15	2	0	0
				

To qualitative evaluate the quality of fat suppression in both EPSI and T_1 fat-saturated images, four scores - 'Excellent', 'Good', 'Fair', and 'Poor' - were used by the experienced radiologists to grade each image. The Radiologists were not told whether they were evaluating conventional or HiSS images. For quantitative evaluation of the quality of fat suppression, ROIs over the whole lesion, nearby suppressed fat, and noise just outside of breast were selected manually and the average intensity over each ROI was calculated. Finally, the ratio of signal from tumor-to-suppressed-fat (TS_fR), the ratio of signal-from-suppressed-fat-to-noise (S_fNR), the tumor-to-noise ratio (TNR), image texture (S_r) measured by surface variation, and coefficient variance (CV) over the tumor were all calculated for both HiSS water peak height and T_1 fat-saturated images.

Results: The Radiologist's evaluations of the quality of fat suppression are summarized in Table 1. Fat suppression was excellent in almost all HiSS images. By contrast, fat suppression was 'good' in only 2/3 of the T_1 fat-saturated images, and fair or poor in 1/3. The 1st row shows typical conventional T_1 fat-saturated images of breast lesions in each category. The 2nd row shows that the corresponding HiSS water peak height images provided better quality of fat suppression and more clearly demarcated tumor boundaries. The S_fNR (Table 2) was almost the same for both conventional and HiSS images ($p > 0.8$), but the fat suppression ratio TS_fR and and signal-to-noise ratio in the tumor ($TNR = TS_fR*S_fNR$) were both four times higher in HiSS water peak height images than in T_1 fat saturation images ($p < 3\times10^{-6}$; see Table 2). The texture (Sr) was four times higher in HiSS water peak height images than in T_1-weighted fat-saturated imsages ($p < 0.003$).

Table 2. Calculated average values for 17 patients.

	TS_fR	S_fNR	TNR	Sr	Mean(tumor)	CV(tumor)
T_1 Fat-Sat	1.7	5.3	9.3	3.0	1.76	0.23
EPSI	6.6	5.2	34.3	12.4	1.84	0.51

Discussion: HiSS images showed enhanced anatomic detail, improved lesion conspicuity, and more uniform and complete fat suppression compared to conventional T_1 fat-saturated images. Conventional images provided variable fat suppression and sometimes failed, especially near the edge of the breast, primarily due to non-uniformities in the magnetic field. Inhomogeneous broadening of the fat resonance may have further compromised conventional fat suppression. HiSS shows tumor morphology before injection of contrast agents. This is useful because contrast media can change the appearance of tumor anatomy and boundaries. In addition, HiSS shows the position of lesions pre-contrast, and thus allows optimal prescription of dynamic contrast enhanced MRI scans so that suspicious areas of the breast can be sampled with high resolution during the early phase of contrast media uptake, while other areas of the breast are surveyed with lower resolution.