Improvement of Fat Suppression in Breast Imaging

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PURPOSE

Breast imaging suffers from B_0 and B_1 problems due to strong susceptibility effects, which can be attributed to the shapes of breasts and RF inhomogeneity due to the breast coils, respectively. The breast dynamic study using segmented 3D FFE type sequence requires not only both high resolution and temporal resolution, but also good fat suppression. A short inversion time SPIR technique [1] is generally used in dynamic studies to minimize the inversion time (TI) to reduce the scan time by means of applying fat suppression pulse exclusively at the center of k space in a segmented manner. However, insufficient fat suppression due to difficulties associated with breast imaging, can lead to misdiagnosis of the patient, possibly concealing cysts or cancers. In this study, we have proposed a new technique, known as double-fat suppression (DFS), which is comprised of spectral-selective SPIR and CHESS pulses. DFS was compared with SPIR in a segmented 3D FFE dynamic sequence (QUICK, equivalent to VIBE and LAVA) on healthy volunteers.

MATERIALS and METHODS

The DFS technique, consisting of the first SPIR pulse with a flip angle of 95 deg and the second CHESS pulse with 90 deg, was implemented in 3D FFE QUICK with interleaved ordering (the slice encode (SE) direction sequential and the phase encode (PE) direction centric). In order to study the effect of fat suppression, the number of segmentations (ie, the number of fat suppression pulses applied) was varied from 1 to 8 segments using a safflower oil phantom with a T1 value of about 230 ms. In addition, the SPIR pulse with a flip angle of 95 deg was used and compared to DFS. All imaging experiments were performed using a clinical 1.5-T system, equipped with a 7-ch breast coil. For axial dynamic, the following parameters were used: TR/TE=5.5/2.5 ms, FA= 15 deg., matrix=320 (PE) x 256 (RO), FOV of 36 x 26 cm, about eighty 2.2-mm section slices (interpolated to one hundred sixty 1.1-mm slices), resolution of about 1.1x1.0x1.1 mm, parallel imaging factor=2.0, 1 to 8 segments, and a dynamic scan time of about 90 sec. For sagittal dynamic, the parameters are as follow; TR/TE=5.5/2.5 ms, FA= 20 deg., matrix=224 (PE) x 256 (RO), FOV of 20 x 20 cm, about one hundred forty 2.5-mm section slices (interpolated to two hundred eighty 1.25-mm slices), resolution of about 0.9x0.8x1.25 mm, parallel imaging factor=2.0, 1 to 8 segments, and a dynamic scan time of about 90 sec. For the volunteer scans, 4 segments were used for both imaging planes in consideration of scan time.

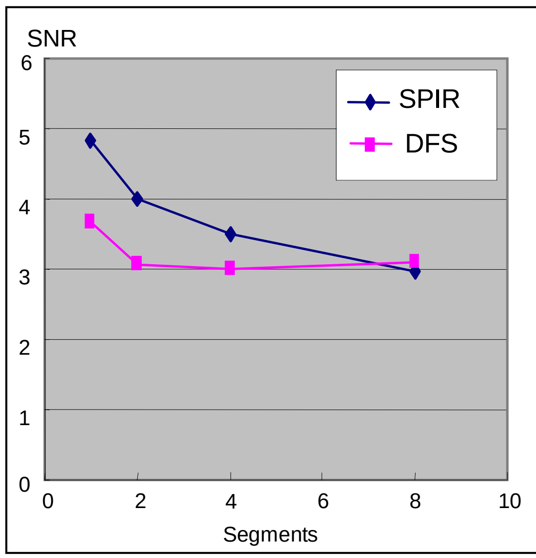

Fig. 1 The fat suppression effect in segments of SPIR and DFS. As increasing the number of segments, fat suppression is improved in both the SPIR and DFS techniques. However, DFS gives superior fat suppression with a few segments.

RESULTS and DISCUSSION

Figure 1 shows the effect of fat suppression measured by the signal-to-noise ratio (SNR) in the safflower oil phantom as the number of segments is increased. As seen, increasing the number of segments results in improved fat suppression for both SPIR and DFS. However, the fat suppression in DFS is sufficient even with 2 segments. Figure 2 shows the axial breast images obtained using SPIR and DFS. The SPIR resulted in non-uniformed fat suppression, whereas DFS provided uniform suppressed fat in the breasts throughout the axial image. On the sagittal images, SPIR did not provide the sufficient fat suppression, as shown in Fig. 3a. On the other hand, DFS suppressed fat signals evenly. Note that not only the breast fat but fat signals around the chest wall are also superbly suppressed on the DFS image.
The idea behind the DFS is that the first SPIR pulse suppresses the most of the fat signals and the following CHESS pulse suppressed remaining fat signals. The TR and the number of segments need to be considered in terms of T1 recovery. The drawback of DFS is an extra pulse (16 ms) duration requirement; however, a reduction in the number of segments can be used while maintaining superb fat suppression without compromising the scan time.
In conclusion, even in the breast region of poor homogeneity due to the shape, DFS in 3D FFE provides uniform fat suppression in both axial and sagittal breast images.

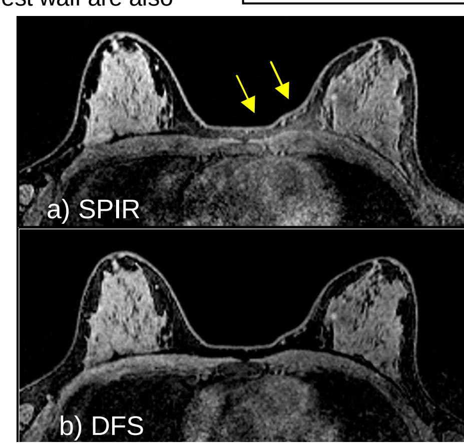

Fig. 2 The axial breast images with SPIR and DFS fat suppression. a) SPIR gives uneven fat suppression, as showing by arrows. b) DFS provides a uniform fat

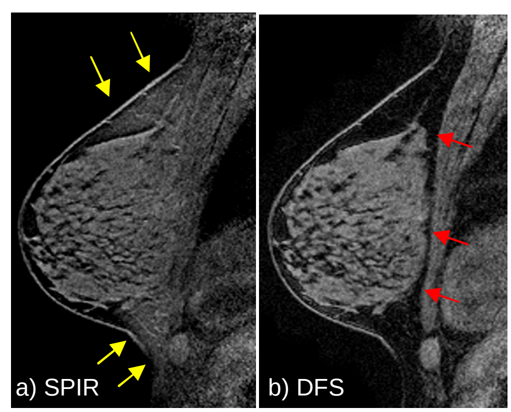

Fig. 3 The sagittal breast images with SPIR and DFS fat suppression. a) SPIR provides non-uniform fat suppression, as showing by yellow arrows. b) DFS provides an excellent fat suppressed image. Note that the fat signals near the chest wall are also suppressed (red allows).

REFERENCES

1] Kaldoudi E, et al., MRI 11:341-345, 1993.