High Resolution T2 Breast Imaging using FADE

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Introduction

High-resolution 3D imaging is useful for improving the specificity of breast MRI since morphological characteristics, such as spiculations and heterogeneity, vary with histology [1]. The specificity of breast MRI can be further improved by considering physiological information such as diffusion [2]. Unlike T1-weighted contrast-enhanced imaging, it is difficult to acquire high-resolution T_2 and diffusion-weighed images in reasonable scan times due to SNR and SAR limitations. We evaluate a simple, fast, 3D sequence that can provide information about T_2 and diffusion for breast imaging.

Theory

The FADE (fast acquisition double echo) sequence [3] (also known as DESS and MENSA) consists of a steady-state imaging sequence with a second readout following spoiler gradients, which can be played on any axis (Figure 1). The gradient applied between the two acquisitions causes the FID to be dephased before the SSFP-Echo and then refocused for the SSFP-Echo acquisition of later TRs. The SSFP-FID has higher SNR and the SSFP-Echo is heavily T_2-weighted [3]. In addition to rephasing the signal for the SSFP-Echo, the spoilers also provide some diffusion weighting; the strength of the diffusion weighting increases with gradient area and TR.

Methods & Results

We scanned two patients at 3T using the FADE sequence (TE_2=47ms, TR=30ms, 30° flip angle, spatial-spectral excitation, 2:38 scan time) with a spoiler area of 8000 Gμs/cm on the L/R axis (the direction of smallest expected motion), parallel imaging in the L/R direction, and an eight-channel breast coil. We acquired 28 3-mm axial slices with a 30×30cm FOV and $0.8\times1.2mm^2$ resolution in-plane. For comparison, we show MIP images from the T2-weighted diagnostic scan (TE/TR=106/5000ms, ETL 16, $1.1\times1.3mm^2$ resolution in-plane, 5mm slices). The SSFP-Echo MIP image from the FADE acquisition shows contrast similar to that of the T_2-weighted image (Figure 2). Lymph nodes and cysts (small arrow) appear bright on both images. It is interesting to note that blood vessels visible in the T_2-weighted image do not appear in the SSFP-Echo image (large arrow).

To study the effects of T_2 and diffusion on the signal in the two echoes, we imaged water (long T_2/high diffusion) and oil and gel (both with short T2/low diffusion) using spoiler gradients of 8000 and 4000Gμs/cm. The SSFP-Echo signal is affected by both T_2 decay and diffusion [4]. Species with shorter T_2 experience a larger signal decrease between the two echoes (large arrow). Tissues with higher diffusion have lower signal when a larger crusher is played (small arrow).

Discussion

The FADE sequence allows the acquisition of high-resolution, 3D T_2-weighted images in a short scan time with low SAR. While the relationship between diffusion, sequence parameters, and signal intensity is complicated [4], we are able to generate images with diffusion weighting, as evidenced by the lack of signal from the blood vessels.

Since tumors with high cellular density have less diffusion than healthy tissues, we expect a larger signal decrease between the two echoes in healthy tissue than in tumors. By acquiring images with different gradient areas, we can further distinguish the effects of T_2 and diffusion. Although motion can degrade the quality of diffusion-weighted images, the patient data shows that we are able generate diagnostically useful images of the breast in spite of bulk, respiratory, and cardiac motion.

Conclusion

We have found that FADE (DESS/MENSA) is potentially useful for breast imaging as it is sensitive to both T_2 and diffusion and, thus, may help distinguish benign and malignant lesions.

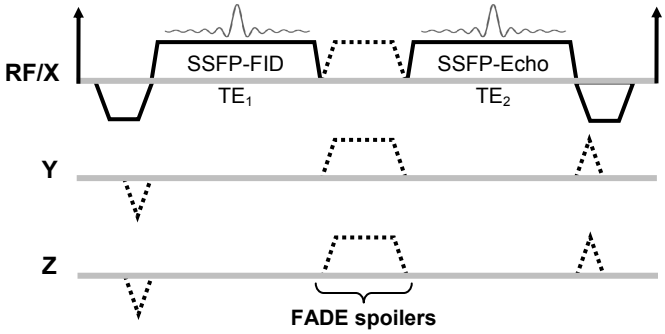

Figure 1 FADE Sequence Diagram

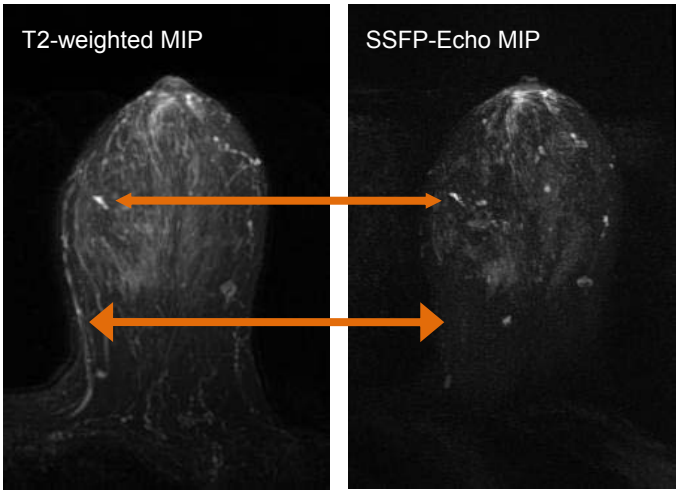

Figure 2 50mm MIP images from a T_2-weighted acquisition and the FADE acquisition. The SSFP-Echo image shows T_2 weighting similar to that of the T_2-weighted sequence. Notable differences include the higher resolution and contrast in FADE image and the lack of signal from blood vessels (large arrow).

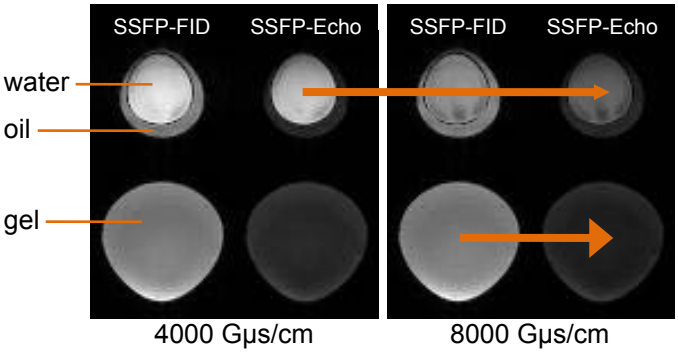

Figure 3 Phantom images acquired using FADE with two different spoiler areas showing the effects of T_2 and diffusion: signal decreases in the oil and gel between the two echoes (large arrow) are due to short T_2 values and decreased signal in the water between the two acquisitions (small arrow) is due to diffusion.

References

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