# Achieving Consistent, Homogeneous, Dark Fat Suppression on Bilateral Breast MRI at 3.0 Tesla in the Clinical Setting

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## Introduction

Good fat suppression is a fundamental aspect of diagnostic quality breast MR for cancer screening. However, obtaining homogeneous, dark fat suppression for bilateral T1-weighted breast MR is particularly challenging at 3T due to higher B0 and B1 inhomogeneities compared with 1.5T. These fat suppression challenges present a significant limitation to widespread acceptance of clinical breast MR at 3T, often overshadowing the potential advantages afforded by the increased signal to noise at 3T. In this abstract we describe a technique to achieve consistent homogeneous, dark fat suppression for T1 breast MR imaging at 3T.

## Methods

Over 100 clinical patients have been scanned on a wide-bore 3T Magnetom Verio (Siemens Medical Solutions) with a Sentinelle 8-channel breast coil during the 6 months period between May and October, 2010. MR Technique: One pre-contrast and two post-contrast 3min. axial VIBE scans were acquired for dynamic (and simultaneously high-resolution) T1 imaging of bilateral breasts. Contrast agent (Magnevist, Berlex) was injected using a power injector at 1.2 ml/sec with the start of the first post-contrast scan. Segmented linear reordering was used in the VIBE sequence in the partitions direction and linear reordering in the lines direction. The imaging parameters were as follows: imaging time = 3 min., resolution = 0.73 x 0.73 x 1.6 (interpolated to 0.8) mm$^3$, TR/TE = 7.1 ms/4.9 ms, flip angle = 12 deg., readout bandwidth = 540 Hz/pixel, lines per fat saturation pulse = 24. A long TE, 4.9 ms in this case for water-fat in-phase behavior at 3T, is extremely beneficial for consistent and superior background suppression. Based on initial experiments, it was determined that the background signal exhibits characteristic signal behavior of low SNR at opposed-phase TE and higher signal at the first in-phase TE, indicating a water content in the background fat. This decreases the T2* of the background, which leads to a loss of signal with a long TE. An in-phase TE is not necessary, but preferable to minimize phase cancellation and partial volume artifacts.

MR Image Assessment: Two experienced readers independently reviewed 20 consecutive pre- and post-contrast breast MR exams during the study period. Readers were blinded to all MR exam information and each reviewed the cases in a different randomized order as presented by a nonradiologist researcher. Homogeneity of fat suppression was rated on a 5-point scale defined as follows: 1=significant water saturation, 2=some water saturation and/or significant amount of unsuppressed fat, 3=moderate amount of unsuppressed fat, 4: minimal unsuppressed fat, 5: perfect homogeneity. Degree of fat suppression was also rated on a 5 point scale based on how light or dark gray the fat appeared relative to breast fibroglandular tissue where 1=20% (light gray fat), 2=40%, 3=60% (Gray fat), 4=80%, 5=100% (Dark gray fat).

## Results

Fig. 1 shows a comparison of images acquired in the same patient at different TE's, with all other imaging parameters kept constant. One can see the dark background at opposed phase TE's and increased background signal at the first in-phase TE. However, it is important to note that the background signal is significantly lower at the second in-phase echo time, most likely due to T2* relaxation.

Fig. 2 shows T1 (VIBE) images from 6 patients demonstrating homogeneity and degree of fat suppression across different subjects. All images show homogenous, dark gray fat suppression. Homogeneity of fat suppression was rated at 4.15 ± 0.88 (Reader 1) and 4.25 ± 0.64 (Reader 2) indicating overall minimal unsuppressed fat. Degree of fat suppression was rated at 4.95 ± 0.22 (Reader 1) and 4.80 ± 0.41 (Reader 2) indicating dark gray fat.
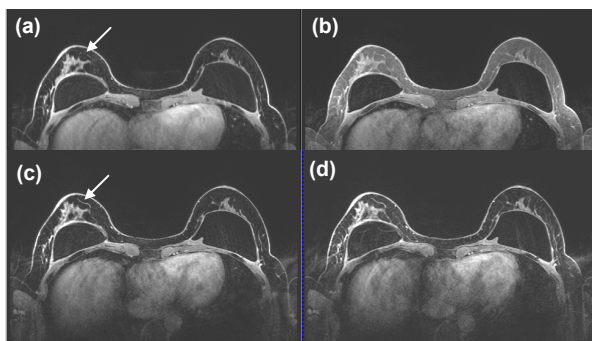


**Fig. 1.** Segmented linear reordering with TE (ms) (a) 1.23 (b) 2.45 (c) 3.69 (d) 4.9 in patient with silicone implants. Note darker background signal at opposed phase TE's (a&c) (but phase cancellation artifacts – arrows) and higher signal at in-phase TE (b). At a long in-phase TE (d), the background suppression is better and minimal phase cancellation artifacts.
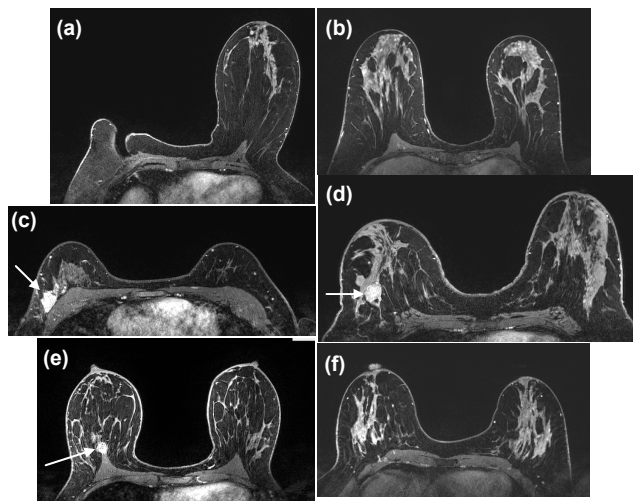


**Fig. 2.** Examples of homogeneity of fat suppression and degree of fat suppression in 6 different patients: (a) mastectomy; (b,f) normal; (c,e) invasive ductal carcinoma; (d) probable recurrence in patient with history of invasive ductal carcinoma.

## Discussion

The technique for T1 dynamic breast MR imaging at 3T presented in this abstract offers excellent fat suppression based on a reader study showing consistent homogeneity with minimal unsuppressed fat and consistent dark gray appearance of fat relative to fibroglandular tissue. A large number of patients were scanned with this technique which has become our standard clinical protocol with excellent results. A limitation of using linear k-space reordering is sensitivity to motion artifact. However, it may be possible to overcome this artifact with a different reordering scheme, which is the subject of ongoing work. In conclusion, we have demonstrated that homogeneous, dark fat suppression on bilateral breast MRI can be obtained at 3T consistently in the clinical setting.