SWIFT dual breast imaging sequence and coil with interleaved adiabatic fat suppression

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Target Audience Researchers, Technicians, and Clinician/Scientists interested in emerging breast imaging methodology, and related applications.

Purpose Breast MRI is increasingly indicated as a diagnostic tool for breast cancer and as a screening tool in high risk populations including younger women with dense breasts or women with breast implants [1]. We are interested in improving Breast MRI in order to provide more and higher quality imaging information in less total scanning time. This could provide greater effectiveness and access, and reduce cost for breast MRI.

Currently, fat suppressed T_1 weighted images are the preferred method for evaluating contrast enhanced dynamic and morphological breast images. We report here an optimized T_1 weighted SWIFT (SWeep Imaging with Fourier Transform) sequence [2] with interleaved adiabatic fat suppression for dual breast imaging using an in-house designed dual breast transmit receive coil on our 4 Tesla, Agilent console, 90 cm bore human imaging system.

Methods SWIFT is an emerging MRI method utilizing a broad bandwidth gapped frequency swept pulse for excitation, and simultaneously reading out the signal in the gaps. Since excitation is broad band, and in the presence of the readout gradient, other novel excitation based fat suppression strategies cannot be used [3]. In addition, since there is no phase evolution during an echo time (SWIFT yields FID type signal after processing), Dixon type techniques cannot be used [4][5]. We have previously developed an interleaved CHESS pulse strategy utilizing a 4 ms Gaussian pulse every 8-16 SWIFT views [6] at 4 Tesla. This has been suitable for single breast imaging in our previous transmit/receive coils [7].

Dual breast imaging introduces additional challenges, including management of inhomogeneous B_0 due to the larger field of view. In addition SWIFT requires local transmit receive coils to be used due to rapid switching requirements, introducing B_1 variations in transmit, in addition to more familiar inhomogeneous B_1 receive artifacts. We have recently began testing of a 4 channel, SWIFT compatible dual breast transmit/receive coil. To overcome potential B_1 issues when the breast is near the edge of the coil volume, we have investigated a fat suppression scheme using frequency swept pulses, in the adiabatic regime [8]. Frequency swept pulses can be described by a shape function (HS, hyperbolic secant), stretching factor (we use 2 for excitation and 4 for the suppression pulse) and time x bandwidth product, R [8]. **Figure 1** shows the SWIFT sequence using an 2.048 ms HS2 R128 gapped pulse (25% transmit duty cycle) with acquisition continued after the pulse [9][10]. Excitation bandwidth is 62.5 kHz, and TR for one SWIFT readout is 4.4 ms including 300 μs of gradient update delay. The HS4 R8 pulse used for fat suppression has length 20ms and nominal bandwidth of 400 Hz, and is placed 600 Hz off resonance at the 4 T lipid peak region.

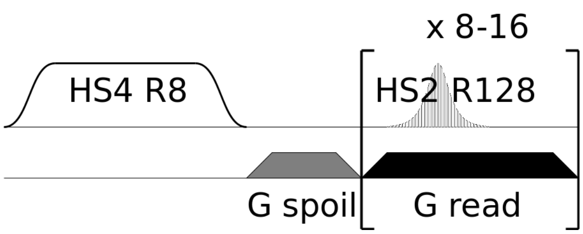

Figure 1: SWIFT Pulse Sequence with interleaved adiabatic fat suppression.

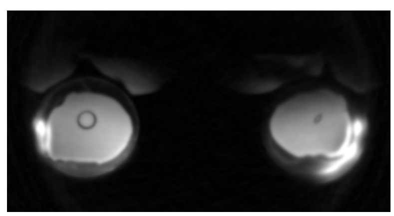

Figure 2: Phantom image with 4 ms Gaussian fat suppression. Hot spots with failed fat suppression from high B_1.

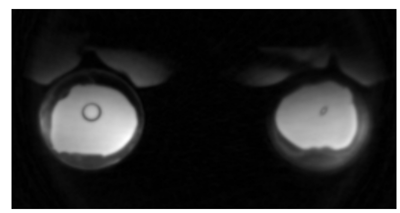

Figure 3: Phantom image with HS4-R8 fat suppression. Hot spots gone.

Results We show here phantom results using the initial suppression scheme with 4 ms gauss pulse in **Figure 2**. The phantoms have an area of lipid (Lard) in the outer radius, and are water (Agar) in the inner radius. Saline bags are placed above the breast phantoms to mimic chest wall and provide loading similar to *in-vivo* conditions. Additionally there is a water bulb at the center of each phantom mimicking a tumor. There is severe hot spot in the Lard next to areas of high B_1 near the transceiver coil elements. **Figure 3** shows the identical phantom coil setup with the HS4R8 fat suppression scheme, while there is increased signal level, fat suppression is still maintained.

Discussion Further options for pulse shape and optimization may be possible, to reduce time required for the fat suppression pulse and improve selectivity [11][12]. Because the coil utilizes loco-regional transmit, the SAR threshold limit could be relaxed over body coil transmit. Even with more conservative global SAR limit (4W/kg) the sequence stays well within FDA guidelines.

Conclusions We have demonstrated initial results with an optimized SWIFT dual breast imaging sequence using adiabatic fat suppression and ultra-short T_2 compatible dual breast coil, successfully eliminating hot spot artifacts from failed fat suppression near transmit/receive coil elements.

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