MR relaxometry of silicone breast implants at 3.0T

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INTRODUCTION: The U.S. Food and Drug Administration currently recommends that women with silicone-gel breast implants (SBI) get screenings for silent ruptures three years after implant and every two years after that (*1*). Early detection of SBI rupture is essential for avoiding pain, deformity, and disease (*2*). MRI is thought to be the most sensitive imaging modality to detect flaws in breast implants in vivo (*3*). Modern MRI pulse-sequences have been optimized for silicone imaging at 1.5 Tesla (*4*). With the increasing use of 3T MRI systems, there is a need to characterize the relaxation properties of SBI and to optimize pulse sequences for 3T. Additionally, the introduction of cohesive gel implants makes it important to understand if the protocols that have been developed on 1.5T systems for the conventional SBI need to be modified for the cohesive-SBI to obtain optimal image contrast.

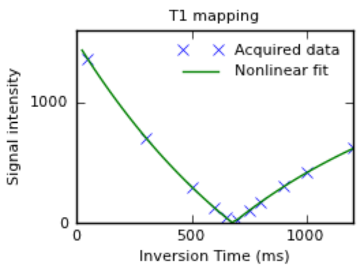

Figure 1: An example plot of the T1 mapping data shows how signal intensity within a single voxel varies as a function of the inversion time. Equation 1 was used to determine a T1 value for the data by a nonlinear fitting algorithm (line).

METHODS: Three SBIs were imaged on a 3T Siemens Trio system. For T1 measurement, an IR-prepared single shot sequence with inversion times of 50, 300, 500, 600, 650, 700, 750, 800, 900, 1000, and 1200 ms was acquired for a single slice. Scan parameters were as follows: 136x256 acquisition matrix, TE =11 ms, flip angle = 180°, TR = 5 s, field of view (FOV) = 89x150 mm, slice-thickness = 5 mm, 8-channel receive-only head coil. For T2 measurement, a multi-echo spin echo sequence was acquired with echo times TE = 15 to 480 ms at 15 ms increments, pixel bandwidth = 130 Hz, 96x128 acquisition matrix, FOV = 150 x 150 mm, and TR = 2 s. A hand drawn region-of-interest (ROI) within the implant was selected for T1 and T2 calculations on a voxel-wise basis. A phantom containing all three SBI samples from various vendors was used for the experiments. In order to optimize the pulse sequences for contrast to noise of silicone relative to fat and water a multi-compartment phantom containing lard, egg-white, and silicone was utilized to measure relaxation times.

The T1 and T2 values were calculated from a "magnitude monoexponential" fit (Equations 1 and 2) (*5*) using a nonlinear fitting routine implemented in Python (OpenOpt, openopt.org using ralg, (*6*)) for each voxel. For T1 estimation S_0, α, and T_1 were the parameters optimized (Figure 1) and for T2 estimation S_0, T_2, and C (Figure 2) were determined.

$$S(TI) = \left| S_0\left(1 - 2\alpha e^{-TI/T_1} + e^{-TR/T_1}\right) \right| \qquad \text{(Equation 1)}$$

$$S(TE) = S_0 e^{-TE/T_2} + C \qquad \text{(Equation 2)}$$

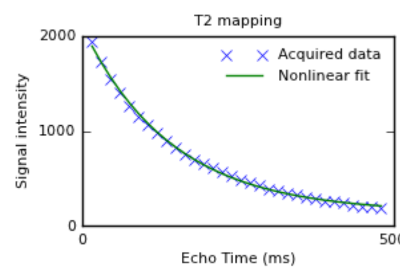

Figure 2: Signal intensities from a variety of echo times (Tes) were recorded for each voxel within an ROI. T2 was determined by a nonlinear fitting algorithm of exponential

RESULTS: Three SBI were examined, two were first generation (non-cohesive) and one a more recent design (cohesive gel). Regions-of-interest consisting of 50 voxels located away from the edges of the implants were selected for analysis. The calculated T1 and T2 values are in Table 1.

DISCUSSION: Known T1 and T2 values of silicone-gel breast implants will assist pulse-sequence development for silicone gel implants to assess implant integrity. Along with the lack of experience at 3T and the utilization of MRI for screening asymptomatic women (as opposed to a diagnostic tool), there is a need for improved diagnostic specificity and hence better image quality. To date, the relaxation times of SBI have not been reported in the literature. One limitation of the reported relaxation times of other phantom making materials is the multispectral nature of these materials reported as aggregate T1 and T2. Alongside existing T1 and T2 information for breast tissue (*5*), the information about the T1 and T2 of SBI provided in this abstract is necessary for improved MRI sequences that enhance the sensitivity and specificity of the diagnosis of breast implant damage or degradation. These results indicate that the T1 and T2 rates are quite similar for the three different types of SBI and therefore it is not necessary for the patient or the technologist to understand the kind of implant to tailor the 3T MRI study.

Table 1: Summary T1 and T2 values for the SBI and other materials

	T1 (mean ± std dev) ms	T2 (mean ± std dev) ms
Implant 1 – older small	962.6 ± 49.3	131.7 ± 1.01
Implant 2 – older large	852.3 ± 23.1	142.4 ± 0.90
Implant 3 – newer cohesive	987.8 ± 49.3	119.6 ± 0.9
Cooked egg whites	2912.2 ± 68.7	109.9 ± 7.2
Raw egg whites	2905.5 ± 14.2	157.1 ± 11.5
Unsalted butter	363.5 ± 3.0	37.6 ± 0.7
Crisco	362.5 ± 2.4	36.8 ± 0.5
Cooked basmati rice	1379.2 ± 108.6	53.2 ± 7.6

DISCLAIMER: The mention of commercial products, their sources, or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products by the Department of Health and Human Services.

ACKNOWLEDGEMENTS: The Office of Women's Health, U.S. Food & Drug Administration.

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