Silicone Prosthesis Imaging Using an Inversion Recovery Fast Spin Echo and Fast Dixon Technique

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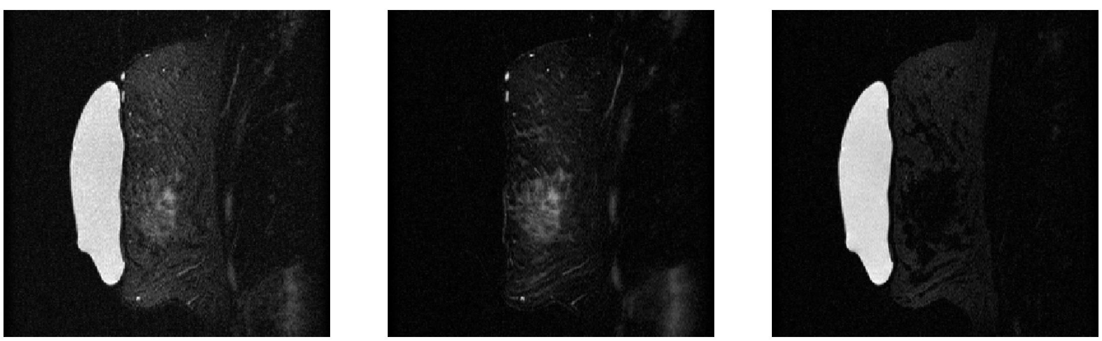
Synopsis
This research presents a technique for silicon-specific imaging using a fast spin-echo based, fast 3-point Dixon acquisition for separation of silicone and water with inversion recovery fat suppression. A breast and silicone prosthesis were imaged in a volunteer. Excellent fat suppression and separation between silicone and water were demonstrated across the field of view using acquisition parameters comparable to existing clinical techniques. We conclude that this technique is capable of overcoming several intrinsic limitations of the previously-published techniques and can be used for robust and more efficient silicone-specific imaging.

Introduction
Magnetic resonance imaging can be used to acquire "silicone-specific" images in the breast, permitting unequivocal determination of extracapsular ruptures of silicone-based prostheses. Two previously-reported methods are the SOS technique (a combination of chemical shift water saturation and inversion recovery fat suppression) [1] and the multi-point Dixon (MPD) technique [2]. While these techniques have the potential to provide clinically acceptable images, each one has its own intrinsic limitations. The SOS technique is inherently sensitive to magnetic field inhomogeneities. The MPD technique, on the other hand, is based on the approximation that the resonance frequency separation between silicone and water is twice that between silicone and fat. Additionally, the MPD technique requires relatively long acquisition times, often leading to reduced slice coverage, compromised imaging parameters or exacerbated motion artifacts. The goal of this research is to demonstrate a robust and more efficient silicone-specific imaging technique which combines inversion recovery fat suppression with a fast spin-echo based, fast 3-point Dixon technique.

Methods
In the current approach, a fast spin-echo based inversion recovery pulse sequence was modified to incorporate a fast 3-point Dixon data acquisition. As in the SOS technique, robust fat suppression is achieved before excitation using an adiabatic inversion pulse and by selecting an inversion time (TI) optimized for nulling the fat signal. Separation between water and silicone is achieved through Dixon acquisition and processing. In order to increase the time efficiency, a fast 3-point Dixon implementation was used for data acquisition [3]. In comparison to a previous Dixon implementation in which readout gradients are shifted in position [4], the new implementation effects echo shifts by inserting a pair of gradient lobes with opposite polarity before and after the readout gradient. Consequently, no increase in echo spacing is necessary and spatial coverage of significantly more slices can be achieved for given scan time and scan parameters.

Experiment and Results
Data acquisition was performed on a clinical 1.5T scanner (GEMS, Waukesha, WI). Sagittal images of a healthy volunteer and silicone breast prosthesis (Mentor, Santa Barbara, CA) were acquired with a bilateral phased-array breast coil (MR Devices, Waukesha, WI). Imaging parameters were TR/TE/TI: 3350/68/150ms, echo train length (ETL)=12, FOV=18cm, slice/skip=4/1mm, acquisition matrix= 256x192 and receiver bandwidth=16kHz. Echo shifts were set according to a measured water and silicone frequency separation of 240 Hz. For one acquisition, 20 slices were collected in 5:35minutes.



Raw data were saved and processed off-line using an algorithm [5] written in Matlab (MathWorks, Natick, MA). Fig. 1a) shows an unprocessed Dixon image corresponding to the zero phase shift between water and silicone. Although signals from both species are present as expected, fat signal is well-suppressed by inversion recovery. The water and silicone-specific images (Fig. 1b and 1c, respectively) afforded by the Dixon technique demonstrate excellent separation between the two distinct chemical species.

Conclusions
By combining the inversion recovery for fat suppression with the fast spin echo based, fast Dixon technique for water and silicone separation, we demonstrated that high-quality silicone-specific images can be obtained efficiently with imaging parameters comparable to conventional techniques. In comparison to the previously-known techniques, no assumption about the inter-relationship among the water, fat and silicone resonances is made. The magnetic field inhomogeneity effect, which often renders the chemical saturation-based techniques sub-optimal, can be easily compensated for in the current technique.

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