Three images from two echoes: Reconstruction of water, fat and silicone images using a combined one-point and two-point Dixon approach. Application to 3D GRE in breast implant imaging.

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Introduction:
MR imaging of breast implants has emerged as an important tool basically due to two reasons a) the difficulty to diagnose lesions in augmented or reconstructed breasts solely using mammography and ultrasound b) the necessity to assess the intactness of the implant on a regular basis [1]. A conventional complete exam of a patient with silicone implants to detect possible ruptures consists of several 2D-TSE acquisitions with selective excitation resp. saturation to display or eliminate signal from water, fat and silicone. Typically 2D measurements are performed in at least two slice orientations resulting in a total exam time of 20-40min.
A new method to reduce the exam time was suggested recently by [2] who used a 3-pt IDEAL reconstruction to acquire all images from a single 3D-TSE sequence of 11 min acquisition time. Furthermore, Ma [3] suggested the use of a single-point Dixon approach to be used in GRE sequences for imaging of silicone alone. In this work, a GRE-based Dixon method is introduced that allows for high resolution 3D imaging of water, silicone and fat from a single dual-echo acquisition in approx. 2 min.

Methods:
Several improvements of the Dixon technique have been introduced mainly for the separation of water and fat signals [4-6]. Typically, two or three echoes at different TE are acquired and water and fat images are reconstructed using iterative or region growing reconstruction algorithms. A clinical evaluation of the use of IDEAL for breast imaging in 2D-TSE has been shown in [7].
In silicone implant imaging, the additional signal of silicone gel can be separated without the need to acquire an additional readout within one TR: based on a conventional GRE type sequence, two echoes are acquired. For one of the echoes, water(W) and fat(F) signals are in phase while the signal of silicone gel(S) is in opposite phase (W+F-S). This is possible because the chemical shift of the silicone gel (~1.7 ppm) is approx. half of the chemical shift of fat (~3.3 ppm). The second echo contains signal from fat in opposite phase to the signal of water ($W-F+S*\exp(j\psi)$). The main idea of this work is to use the W+F-S image for separating the silicone signal S into one image. This can be done using 1-pt Dixon reconstruction. 1-pt Dixon reconstruction can only distinguish voxels with dominant silicone signal from voxels with dominant water+fat signal. Subsequently, both original images W+F-S and $W-F+S*\exp(j\psi)$ are used to separate the water signal from the fat signal by applying the 2-pt Dixon technique. Here, the signal from silicone gel can appear in both images, but this is solved by the final reconstruction when the silicone image is used to remove silicone signal from the fat and water images.
Data were acquired at 1.5T (Magnetom Espree, Siemens Healthcare) from a healthy volunteer with bilateral silicone implants. 104 slices of 1.5mm slice thickness were acquired using a 320 matrix and a FOV of 340mm. Echo times were 2.4ms resp 4.8ms within a repetition time of 7.2ms. A 4-channel breast matrix coil was used with parallel imaging (GRAPPA) acceleration of factor 2 in the phase encoding direction. The total imaging time was 2:12 min, the reconstruction for the complete data set required 2 min.

Results:
Fig. 1 shows images of all components, an MPR of water as well as a MIP of silicone in three orientations. A good separation of all signals could be achieved with minor signal contamination from areas such as heart and spine that can be seen in the silicone MIP.

Discussion:
Combining one-point and two-point Dixon techniques, signals of water, fat and silicone can be separately reconstructed from a fast 3D-GRE sequence using only two echoes in very short measurement time. However, the clinical use of this approach has to be evaluated especially concerning the T1-contrast of this application as well as its practical reliability in case of implant ruptures.

References
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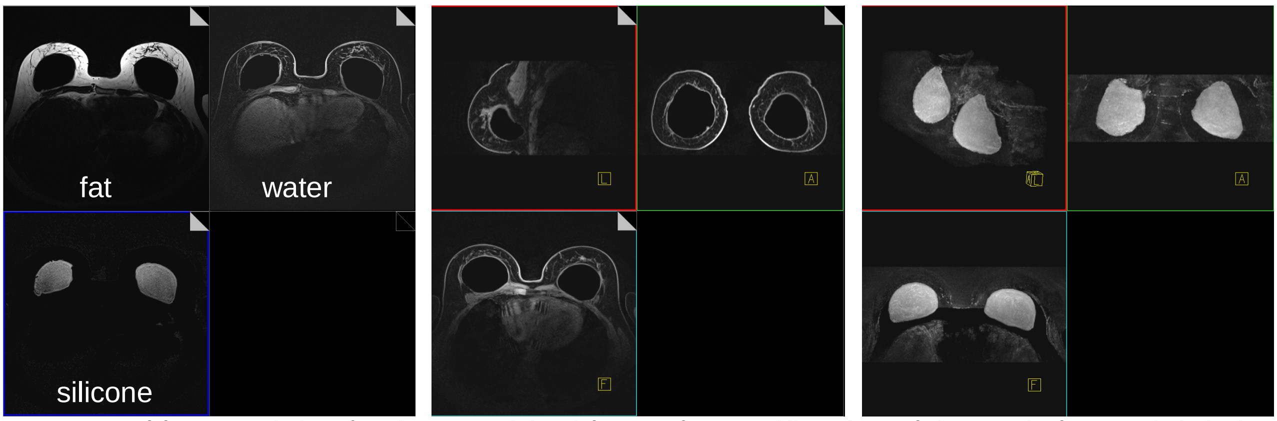

Fig. 1: images of fat, water and silicon from the same axial slice (left), MPR of water (middle) and MIP of silicone (right) from a single dual-echo GRE acquisition (2:12min)