High-Resolution 3D T2-Weighted Spin-Echo Imaging With a 16-Channel Breast Coil

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Introduction: Contrast and morphology in T2-weighted images can contribute to differential diagnosis in breast MRI (1). In the past few years, high-resolution breast receive coils and high-resolution T2-weighted sequences have been developed which may improve the diagnostic contribution of T2-weighted images in the breast, in particular by providing T2-weighted data with resolution comparable to that achieved in Dynamic Contrast Enhanced (DCE) images. The purpose of this work is to show that a custom-fitted 16-channel surface coil in combination with a 3D T2-weighted acquisition facilitates high spatial resolution T2-weighted breast imaging in reasonable scan times in comparison to the same acquisition utilizing a commercially available 8-channel breast coil.

Materials and Methods: Acquiring 3D high-resolution T2-weighted images is challenging due to long TR times required to allow for full T1 recovery, blurring due to T2-decay, and SAR constraints resulting from high flip angles. The 3D-FSE-Cube sequence (2) is a Fast Spin Echo sequence in which variable flip angle schedules are used to lessen RF power deposition and blurring, thus allowing for increased echo train length. In combination with parallel imaging, this technique provides high-resolution T2-weighted image volumes in clinically feasible scan times. 3D-FSE-Cube is utilized clinically in other regions of the anatomy but has yet to be fully utilized in the breast (3,4).

A 16-channel breast receive coil prototype (5) has been shown to achieve 3-4x improvement in SNR in comparison to an 8-channel HD Breast Array (GE Healthcare, Waukesha, Wisconsin) in T1-weighted breast MRI. The prototype is a close fitting coil with geometry that facilitates acceleration in two dimensions and high SNR. Alternatively, the 8-channel commercially available array is biopsy-compatible and features larger coil elements for better homogeneity.

To investigate the combination of 3D-FSE-Cube and the prototype 16-channel breast coil for T2-weighted breast MRI, we scanned a normal volunteer with each of the coils using the following protocol: 32 cm FOV, 512x384 matrix, 2500 ms TR, 64 ETL, 0.5 mm slice thickness, 28 slices, 83.33 kHz receive bandwidth, 6.3 minute scan time. The acquisitions were bilateral, were acquired in the axial plane on a 3T Discovery MR750 scanner (GE Healthcare, Waukesha, Wisconsin) and did not utilize parallel imaging for acceleration. SNR was calculated for each experiment and a radiologist with expertise in breast MRI analyzed the images. The SNR was calculated by the "pseudo multiple-replica" method, which consists of adding appropriately scaled and correlated noise to the image prior to reconstruction (6). We repeated this process 100 times, each time reconstructing with a SENSE reconstruction with R=1 (7). The SNR was the mean divided by the standard deviation across the real part of the 100 synthesized images. A 3D-FSE-Cube dataset was also acquired with the 16-channel coil in a patient with a biopsy-proven carcinoma using 3.7x acceleration, 512 x 384 matrix size, and 1.5 mm slice thickness to investigate the image quality of this protocol with full coverage in a clinically feasible scan time of 4 minutes. Recruitment and scanning of volunteers and patients followed IRB policies and procedures.

Results and Discussion: Resolution of the 3D-FSE-Cube data for the coil comparison in the volunteer was 0.6 mm x 0.8 mm x 0.5 mm (Figure 1a,c) and overall image quality was higher with the 16-channel coil (Figure 1c). Improvement in SNR with the 16-channel coil is also evident in the SNR maps (Figure1b,d). Also, depiction of fine detail within the fibroglandular tissue was more evident in the 16-channel coil images in comparison to the 8-channel coil images. The robust image quality of this protocol (3D-FSE-Cube with 16-channel coil) was further demonstrated in the patient images (Figure 2) in which tumor structure is depicted clearly in axial, sagittal and coronal reformats.

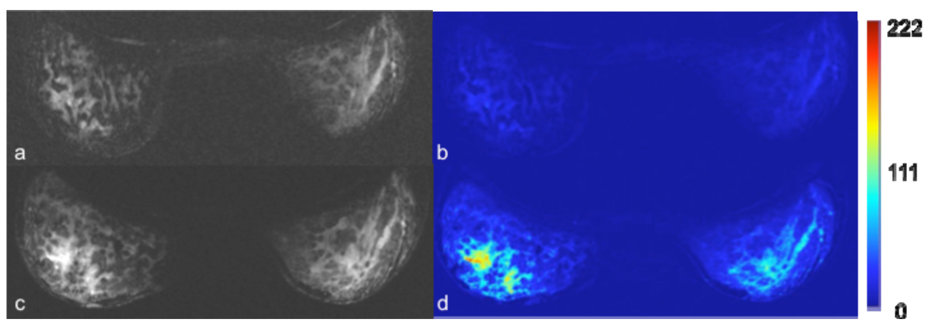

Figure 1. Image quality of 3D-FSE-Cube images is degraded at very high resolution (0.6 mm x 0.8 mm x 0.5 mm) with 8-channel coil (a). Utilization of 16-channel coil recovers SNR (c) and allows for clear depiction of fine structures at this very high resolution. Respective SNR maps (b: 8-channel coil, d: 16-channel coil) quantify the improvement in SNR achieved with the prototype breast receive coil.

Conclusions: The combination of 3D-FSE-Cube with the 16-channel prototype breast coil achieves high resolution and improved SNR in comparison to the standard 8-channel coil. Scan times may be further shortened or resolution increased in existing scan times with the 16-channel coil as higher levels of acceleration have been demonstrated with this coil in T1-weighted images (5). These initial experiments demonstrate the high image quality that is available for T2-weighted imaging of the breast by incorporating recent software and hardware advances. Future studies will investigate the depiction of lesion morphology with these techniques and the alignment between 3D-FSE-Cube and DCE images in the breast.

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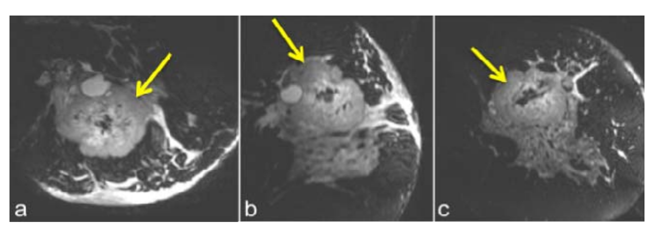

Figure 2. Bilateral, 3D-FSE-Cube images acquired with 16-channel breast coil and 3.7x acceleration (4 minute scan time) in a patient with a locally advanced biopsy-proven invasive ductal carcinoma (arrows). The main tumor has similar signal intensity to fibroglandular tissue. Fine morphological detail including pushing margins, central low-signal fibrosis, perilesional high-signal edema, and skin edema are depicted clearly in axial (a), sagittal (b), and coronal (c) reformats. An adjacent incidental simple cyst is also noted along the posterior border of the mass.