Evaluation of 3D Extended Echo Train T2-weighted Imaging for the Characterization of Breast Lesions

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Introduction: T2-weighted imaging contributes to differential diagnosis in breast MRI [1,2,3]. As an adjunct to Dynamic Contrast Enhanced (DCE) MRI, both lesion morphology and signal intensity on T2-weighted images can help to characterize a lesion as benign or malignant. In conventional T2-weighted sequences, balancing the necessary long repetition times with RF power deposition and T2 blurring limits the data acquisition efficiency of the sequence; thus conventional Fast and Turbo Spin Echo (FSE, TSE) sequences are acquired in 2D with low through-plane resolution. Recently, 3D T2-weighted sequences have been developed that utilize modulated flip angle schedules and parallel imaging to provide higher resolution T2-weighted images in clinically feasible scan times [4,5]. While utilization of modulated flip angles allows for improved acquisition efficiency, contrast is potentially less purely T2-weighted. In this work we investigate the performance of the 3D T2-weighted CUBE sequence in comparison to a conventional FSE sequence in 27 breast patients. Our goal is to assess the potential diagnostic implication, in terms of contrast and depiction of lesion morphology of 3D T2-weighted acquisitions in the breast.

Materials and Methods: Twenty-seven patients undergoing clinical MRI were scanned with both FSE and CUBE sequences as part of their exam. Indications were high-risk screening (12), staging (5), treatment response (5), diagnostic (5). All patients signed IRB consent. A total of 16 lesions were identified based on pathology (9 lesions) or on contrast-enhanced image assessment and/or stability from prior studies (7 lesions). Six lesions were malignant (all IDC) and 10 were benign (5 fibroadenomas, 4 cysts, 1 papilloma). Scans were performed on a GE Discovery MR750 3T scanner with an 8-channel GE HD breast coil. Imaging parameters: FSE: 32-38 cm FOV, 320 x 256 matrix, 4 mm slice thickness, ~46 slices, ETL 16, TR between 3000 and 4300 ms, 2x acceleration, scan time 5 min; CUBE: 30-33 cm FOV, 320 x 256 matrix, 2 mm slice thickness, ~192 slices, ETL 64, TR 2500 ms, 2x acceleration, scan time 5 min.

Lesion-to-fibroglandular tissue contrast ratios (S_L/S_F) were calculated for both sequences. Lesion signal intensity (S_L) was measured in an ROI placed in a central slice of each lesion and fibroglandular tissue signal intensity (S_F) was measured in an ROI placed in a region of fibroglandular tissue in the same breast as the lesion. Placement of ROIs was the same for each FSE-CUBE pair. Ability to distinguish benign from malignant lesions based on S_L/S_F was assessed for each method with an unpaired t-test. A radiologist with breast MRI expertise also assessed each FSE-CUBE pair for depiction of lesion morphology and alignment between the T2-weighted images and DCE images.

Results: Linear agreement between S_L/S_F of FSE and CUBE in the breast is demonstrated in a scatter plot (Figure 1) with a correlation coefficient of $R^2 = 0.93$. Ranges of S_L/S_F were: FSE malignant: 0.57 ± 0.11 to 1.30 ± 0.05, FSE benign: 0.84 ± 0.14 to 4.29 ± 0.08, CUBE malignant: 0.48 ± 0.29 to 1.39 ± 0.21, CUBE benign: 1.30 ± 0.21 to 4.14 ± 0.16. Mean values of S_L/S_F were FSE malignant: 1.01 ± 0.21, FSE benign: 2.05 ± 0.65, CUBE malignant 0.99 ± 0.25, CUBE benign 2.16 ± 0.62. The p-values for using S_L/S_F to discern benign from malignant lesions were 0.03 and 0.01 for FSE and CUBE respectively. Depiction of lesion morphology and signal intensity in small lesions improved in the CUBE images due to the reduced partial voluming in the slice direction (Figure 2). Alignment of structures between T2-weighted and DCE images was facilitated with CUBE due to the higher through-plane resolution and the ability to reformat the images in orientations other than the acquisition plane (Figure 3).

Discussion: The agreement between S_L/S_F of FSE and CUBE, demonstrates that contrast between tissues of interest is not adversely affected by the modified echo train utilized for the acquisition of higher resolution images with CUBE. The large range of S_L/S_F amongst benign lesions is likely due in part to the multiple pathologies included in this group. In this small sample size with fairly large standard deviation, both FSE and CUBE demonstrated equivalent ability to discriminate benign and malignant lesions based on T2 signal intensity as evidenced by the equivalent p-values as well as the distribution of data in Figure 1. The case with the largest difference in S_L/S_F between the two techniques (arrow Figure 1, images Figure 2) was a very small lesion surrounded by fatty tissue. This specific case demonstrates that 3D T2-weighted images may improve the diagnostic contribution of T2-weighted images not only through the depiction of lesion morphology but also through better representation of signal intensity particularly in small structures. Similar analysis of 3D T2-weighted sequences in a broader dataset of patients and lesions is necessary to confirm these initial findings.

Conclusion: CUBE provides equivalent contrast, improved resolution, and equivalent discrimination of benign and malignant lesions in the breast in comparison to FSE. While T2-weighted images will continue to be an adjunct to DCE images, 3D T2-weighted sequences like CUBE have the potential to expand the contribution of T2-weighted images to the characterization of benign and malignant lesions in the breast.

References: 1.Kuhl CK, et al., *JMRI*, 1999; 9(2):187-96. 2.Kawashima, H, et al., *JMRI*, 2010; 32(5): 1117:1123. 3.Baltzer PA, et al., J *Comput Assist Tomo*, 2011; 35(3):361-66. 4.Mugler JP 3rd, et al., *Radiology*, 2000; 216:891-99. 5.Busse RF, et al., *MRM*, 2006; 55:1030-37.
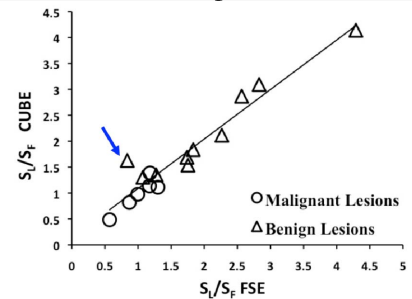
Figure 1. *Linear correlation of contrast ratio measurements performed with FSE and CUBE indicate good agreement. Data also demonstrates the known tendency of benign lesions to be hyperintense and for malignant lesions to be hypo or isointense in T2-weighted images. Arrow indicates values from lesion shown in Figure 2 where signal intensity of lesion varies between FSE and CUBE.*
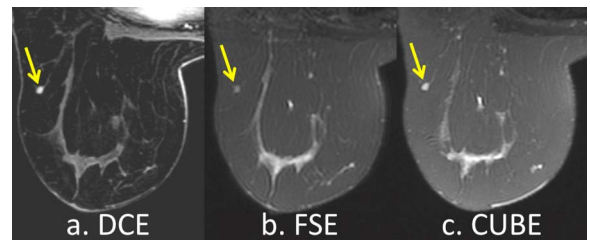

Figure 2. *A small presumed fibroadenoma based on 3 years of follow-up (arrows) demonstrates contrast uptake on DCE image (a). With FSE (b), lesion signal is isointense or hypointense, a possible indication of malignancy. With CUBE (c) higher through-plane resolution reduces the effect of partial voluming, providing a more accurate representation of lesion signal and morphology: the smooth lesion margins in CUBE corroborate lesion margins in DCE image and hyperintense lesion signal aligns with expected T2-weighted appearance of a fibroadenoma.*
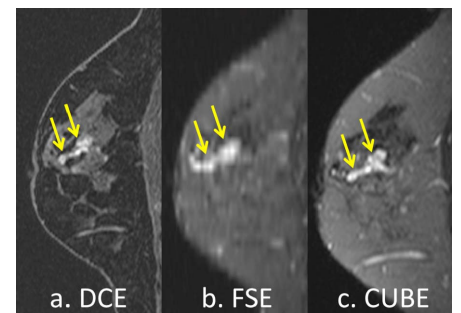

Figure 3. *Characteristic elongated structure of benign papilloma (arrows) is depicted on sagittal reformat of DCE image (a). Clear depiction of lesion morphology in sagittal reformat of FSE (b) is not possible because of 4 mm slices. The higher through-plane resolution (2 mm) of CUBE (c) provides clear depiction of lesion morphology in sagittal reformat and thus facilitates alignment of findings with those in DCE image.*