

Dual Echo Steady State Quantitative T2-mapping in the Breast

Catherine Judith Moran¹, Kristin L Granlund^{1,2}, Bruce L Daniel¹, Bragi Sveinsson^{1,2}, Ernesto Staroswiecki^{1,2}, Marcus T Alley¹, and Brian A Hargreaves¹
¹Radiology, Stanford University, Stanford, CA, United States, ²Electrical Engineering, Stanford University, Stanford, CA, United States

Introduction: Dual-echo steady state (DESS) sequences provide a means to efficiently acquire high-resolution, 3D quantitative T2 maps [1]. These methods have been demonstrated for the acquisition of sub-millimeter T2-mapping in the knee in less than 5 minutes; also, the alignment of DESS T2 values with known T2 values of musculoskeletal tissues has been validated [1,2]. T2-weighted images are routinely utilized in breast MRI as an adjunct to dynamic contrast enhanced (DCE) imaging for differential diagnosis. The determination of specific T2-values of breast tissue has been sporadically investigated in the past; however, the long scan times of conventional T2-mapping methods along with the complexity of both normal and pathological breast tissue, have made such investigations challenging, particularly in cancer patients. The efficient high-resolution T2-maps acquired with DESS methods may help to better characterize the T2 behavior of in-vivo breast tissue and by doing so increase the contribution of T2-weighted data to breast MRI. In this work we investigate the feasibility of DESS T2-mapping in the breast. We present in-vivo T2-maps of both normal and pathological breast tissue and compare the T2 values of these tissues to those previously reported.

Materials and Methods: DESS acquisitions were performed in 11 patients as part of a research MRI protocol that also included T1-weighted, T2-weighted and DCE acquisitions. All patient volunteers signed IRB informed consent. DESS imaging parameters were as follows: 34 cm FOV, 2.5-3 mm slice thickness, 384 x 256 matrix, FA₁/FA₂ 15/35, 2x2 parallel-imaging acceleration, and 5 minute scan time. Ten malignant (8 IDC, 1 ILC, 1 DCIS) and 6 benign (2 UDH, 1 ALH, 2 hematomas, 1 cyst) pathologies were identified. In all cases except for the cyst and hematomas, pathology was confirmed through core or excisional biopsy or mastectomy. DESS T2-maps are calculated with an Osirix plugin that allows for processing of a single or multiple slices. A threshold based on the source images was used to suppress background and areas of fat since fat was suppressed in the DESS acquisitions. Processing time to calculate the T2-map for a single slice was 2-4 minutes depending on the amount of tissue to be processed. T2-values were measured for all pathologies (n = 16) and in fibroglandular tissue in nine patients (n = 9); fibroglandular tissue measurements were not possible in two patients due to mostly fatty breast tissue. ROI placement for T2 measurement was determined based on the respective DCE images so placement was not biased by appearance of T2 maps. Lesion T2 was measured in an ROI placed in a central slice of the lesion while a single ROI was also utilized for measurement in fibroglandular tissue.

Results and Discussion: The average T2 value of fibroglandular tissue was 44.2 (STD 15.6). This value is lower than a recently reported value of 54.4 (STD 9.4) measured at 3T in for fibroglandular tissue in 5 healthy volunteers [3]. However, this difference may be accounted for by the small sample size of each study and measurement in healthy volunteers versus patients with pathology. Analysis of the distribution of our fibroglandular measurements show a range of values from 27.6 (STD 8.9) to 64.2 (STD 11.7) and two clusters of data around 30 ms and 60 ms. While this variability is likely partially due to ROI placement, the respective T2-maps from two of these discordant measurements demonstrate this difference across large regions of fibrous tissues (Figure 2). The clustering of the data around two values is also seen in the malignant lesions in our data (Figure 1). However, we found no correlation between the clustering of the malignant and fibroglandular T2 values. In our study, the range of T2 values in benign and malignant pathologies is similar to the range of T2 values in the fibroglandular tissue (Figure 1). This finding aligns with previous studies indicating that T2-values of pathological and normal tissue in the breast can overlap [4,5]. The noted exception to this overlap is the cyst that accounts for the benign lesion with the highest T2 value in comparison to all other tissue types. Though in this initial study we see overlap in values of these different pathologies, DESS T2 maps have the potential to (Figure 3) give more explicit information about the range of T2 values and distribution of these values in breast tissue.

Conclusion: The DESS T2 acquisition provides high-resolution 3D quantitative T2-maps in the breast in clinically feasible scan times. The method can be utilized to better characterize in-vivo T2 characteristics of both normal and pathological tissue in the breast. Better understanding of the in vivo T2 behavior of these tissues may ultimately improve the contribution of T2-weighted data for the discernment of benign and malignant lesions.

Acknowledgments: Support provided by NBIH T32 CA09695, GE Healthcare

References: 1. Welsch GH, et al., *MRM*, 2009; 62(2):544-49. 2. Staroswiecki E, et al., *Proc. of 19th ISMRM Mtg*, 2011; Prgm Num 500. 3. Rakow-Penner R, et al., *JMRI*, 2006; 23:87-91. 4. Heywang SH, et al., *J Comput Assit Tomo*, 1986; 10(4): 615-20. 5. El Yousef SJ, et al., *AJR Am J Roentgenol*, 1985; 145:1-8.

DESS T2 values for Pathological and Normal Breast Tissues

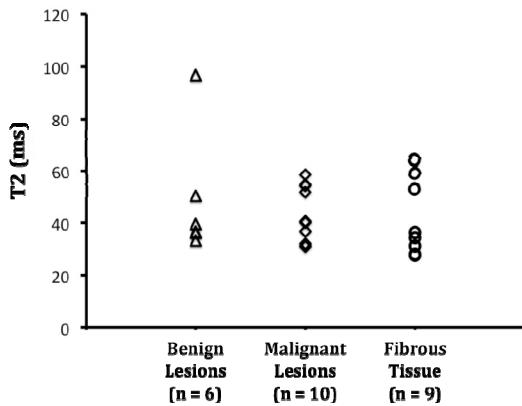


Figure 1. T2-values for pathological and normal breast tissue measured from high-resolution DESS T2-maps. Overlap of T2 values from the three different categories of data demonstrate the non-specificity of in-vivo T2-values determined from placement of a single ROI. Perhaps most interesting are the distribution of points within each category demonstrating the potential of T2-values to help characterize different types of benign, malignant and normal tissues.

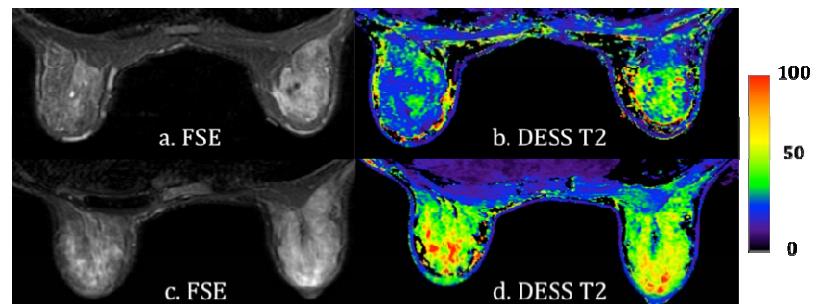


Figure 2. Fast Spin Echo (FSE) T2-weighted images (a,c) and DESS quantitative T2 maps (b,d) from two cases. The T2-maps reflect the range of measured T2-values shown in Figure 1. The fibroglandular tissue T2-value measured in case 1 (a,b) is 31.1 (STD 5.9) while the value in case 2 (c,d) is 64.2 (STD 11.6).

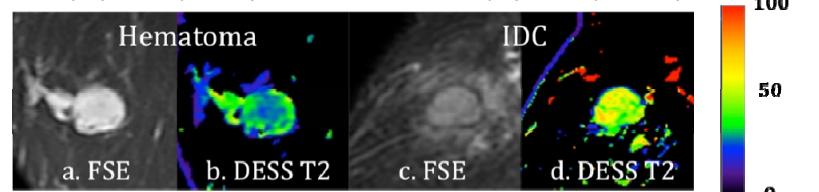


Figure 3. FSE (a,c) and DESS quantitative T2 maps (b,d) for a hematoma (a,b) and IDC (c,d). High-resolution T2 maps allow for assessment of the range of T2 values in each pathology as well as the distribution of the T2 components of the tissues.