EVALUATING VARIABILITY IN QUANTITATIVE BREAST MRI USING NOVEL PHANTOM

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Purpose: Quantitative MRI is increasingly employed for diagnosis, staging and monitoring of breast cancer, and it is essential that measurements are standardized and reliable mechanisms for quality control be instituted. To this end, we used a novel phantom to assess variability in breast MRI measurements across four scanner/coil configurations.

Methods: The phantom is comprised of two components each with redundant elements: one component mimics T_1/T_2 relaxation times and the other mimics diffusion properties of breast tissue. More details are provided at: http://collaborate.nist.gov/mriphantoms/bin/view/MriPhantoms/BreastPhantom. Variable flip angle T_1-weighted images and diffusion-weighted images were acquired on the phantom in four scanner/coil system configurations and periodic temperature readings were taken. The bore temperature was in the range 19.35-23.01°C during all measurements. The phantom components were swapped and acquisition repeated to gather data from each side of the breast coil, yielding a total of eight datasets. The coefficient of variation (CoV), defined as 100×(Standard Deviation/Mean), was used to assess variability between redundant phantom elements. A Wilcoxon rank sum test was used to compare measurements before and after swapping coil sides. Data acquired at different field strengths was compared using t-tests.

Results: The fibroglandular (FGT) T_1 mimic covered a range of T_1 values from 722-1330 ms; the fat T_1 mimic covered a range of T_1 values from 220-513 ms; and the diffusion component covered a range of apparent diffusion coefficients (ADC) from 594-1996 mm^2/s. CoVs ranging from 0.1% to 27.3% were observed in redundant phantom elements (Table 1).

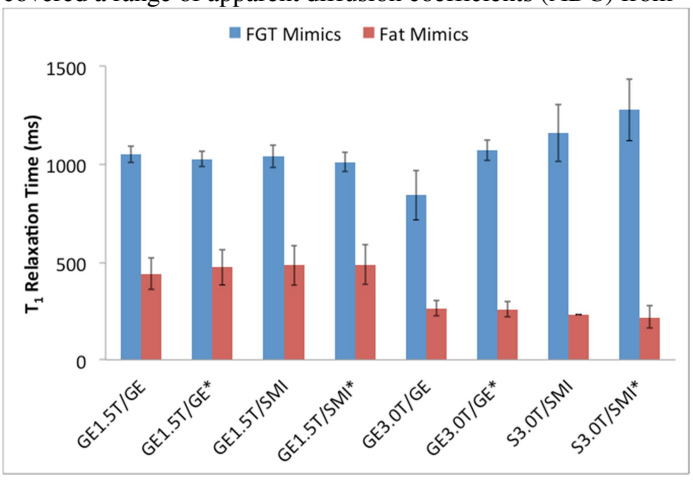

Figure 1. T_1 of FGT and Fat Mimics pre and post swap*

Scanner / Coil	CoV (T_1 of FGT Mimics)	CoV (T_1 of Fat Mimics)	CoV (ADC of Diffusion Mimics)
GE 1.5T / GE	3.8%	18.1%	0.4%
GE 1.5T / GE*	3.8%	18.8%	0.2%
GE 1.5T / SMI	5.4%	20.7%	0.7%
GE 1.5T / SMI*	4.8%	20.9%	0.3%
GE 3.0T / GE	14.8%	15.2%	1.2%
GE 3.0T / GE*	4.9%	15.3%	0.1%
Siemens 3.0T / SMI	12.5%		5.2%
Siemens 3.0T / SMI*	12.2%	27.3%	1.1%

Table 1
*Swapped. SMI=Sentinelle Medical Inc.

Measurements completed before and after swapping phantom components were not statistically different for the T_1 of FGT mimics (W=320, 95% CI=(-103,19) p=0.24), T_1 of fat mimics (W=96, 95% CI=(-70,138) p=0.96) or the ADC of diffusion mimics (W=140, 95% CI=(-327,309), p=0.67).

There was no meaningful difference between pooled T_1 measurements from both 1.5 T scanner/coil configurations (t(9)=0.43, 95% CI=(-23.33,96.87), p=0.68), but pooled ADC measurements on both 1.5 T scanner/coil configurations differed meaningfully (t(7)=-8.6969, 95% CI=(-126.08,-72.17), $p=5.33\times10^{5}$). Pooled measurements on both 3.0 T scanner/coil configurations differed significantly for T_1 (t(9)=-6.68, 95% CI=(-312.29,-154.20), $p=9.1\times10^{-5}$) and ADC (t(7)=3.8, 95% CI=(58.96,247.79), $p=6.3\times10^{-3}$).

Discussion: We observed low CoVs for ADC measurements of redundant diffusion elements, modest CoVs for T_1 measurements of redundant FGT mimics and greater CoVs for T_1 measurements of fat mimics. The greater CoVs of T_1 in fat mimics might be due to the lower number of fat mimics examined relative to FGT mimics (n=4 vs n=7). Curiously, we observed greater CoVs for T_1 measurements of FGT mimics at 3.0 T than at 1.5 T. These trends provide insight into expected spatial variation in breast MRI configurations.

We observed more differences in pooled measurements on the 3.0 T scanner/coil configurations relative to the 1.5 T scanner/coil configurations. This finding is an excellent example of the need for such a phantom and quality control measures, and deserves further investigation.

Conclusion: Using a novel breast phantom, we evaluated variability in T_1 relaxation and ADC measurements across four scanner/coil configurations. The results are encouraging: given a standard protocol, quantitative breast MRI can be compared across various scanner/coil configurations.