Quantifying variability in DCEMRI of the breast between 1.5T and 3T

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TARGET AUDIENCE: Radiologists; medical physicists developing quantitative DCEMRI techniques

PURPOSE: MRI has become a valuable tool in the detection and staging of breast cancer. The enhancement pattern of lesions from a dynamic contrast-enhanced MRI (DCEMRI) acquisition can be a strong indicator of malignancy[1]. However, differences in acquisition parameters and scanner properties can lead to variability in the enhancement pattern seen in lesions. In this study we quantify the variability of parameters related to signal enhancement of lesions in repeated scans of the same patients at two field strengths, 1.5T and 3T. Quantitative analysis of DCEMRI has the potential to provide absolute, standardized measures of kinetic parameters; this requires converting signal intensity to concentration of contrast media. Therefore variability in the data was also assessed after conversion of signal intensity to contrast concentration.

METHODS: Eleven patients were scanned on both Philips Achieva 1.5T and Achieva 3T-TX scanners with 16-channel bilateral breast coils and standardized acquisition protocols under an IRB-approved and HIPAA compliant study. T1-weighted DCEMRI sequences (3D gradient echo) were acquired with 0.8x0.8x1.6mm voxels (interpolated to 0.8mm isotropic), TR/TE = 5/3 ms, FA = 10°, and a temporal resolution of 1min 15s. All patients received a dose of 0.1mM/kg gadodiamide (Omniscan, GE, Waukeesha, WI). Signal intensity time curves were obtained by drawing ROIs over the entire volume of the lesion under radiologist guidance, and then converted to signal enhancement curves expressed in % increase in signal intensity compared to baseline value. Time series were fit to a 3-parameter empirical mathematical model (EMM)[2]. Conversion to contrast agent concentration was performed with both a linear reference signal method, and the non-linear analytic solution to the gradient echo signal model [3,4]. The reference signal used for the linear conversion was from calibration phantoms placed in the breast coil during the acquisition. For the non-linear conversion to concentration, native T1 values were found with a variable flip angle T1-mapping sequence (TR/TE = 10/2.4ms, FA = 5,10,15,20°).

RESULTS: Table 1 contains the mean differences in the EMM parameters between 1.5T and 3T for all 10 lesions present (6 benign, 4 malignant), as well as the time to the maximum enhancement as derived from the EMM. Percent difference was calculated as the subtraction of the parameters at 1.5T and 3T divided by the average of the two. Uptake rate and time to peak enhancement had the lowest variability. Table 2 summarizes the results for SER and maximum signal enhancement and concentration. SER had the lowest variability among these measurements.

EMM Parameter	Signal Enhancement	Linear concentration	Non-linear concentration
Enh./conc. upper limit	64% ± 40%	61% ± 43%	117% ± 52%
Uptake rate	48% ± 57%	51% ± 48%	71% ± 49%
Washout rate	66% ± 49%	98% ± 69%	79% ± 77%
Time to peak	18% ± 14%	35% ± 44%	43% ± 42%

Table 1. Mean differences and standard deviations of EMM parameters between values at 1.5T and 3T

	Average value		Average of differences
	1.5T	3T	
Signal Enhancement	86% ± 16%	138% ± 31%	47% ± 29%
SER	0.668 ± 0.293	0.673 ± 0.286	21% ± 27%
Concentration (Linear)	0.17 ± 0.09	0.26 ± 0.22	44% ± 43%
Concentration (Nonlin.)	0.30 ± 0.19	0.70 ± 0.46	83% ± 56%

Table 2. Average maximum values and percent differences for all lesions

DISCUSSION & CONCLUSIONS: Conversion to concentration did not significantly reduce the variability seen in the measurements based on signal enhancement alone. B1 corrections were not included in concentration measurements; this could account for the increased variability associated with these calculations. In general, linear concentration measurements were less variable than non-linear ones, probably due to errors in estimation of native T1. Time to peak enhancement (derived from the EMM parameters) and SER were the measurements with the lowest variability from the signal time-series, suggesting their importance as primary diagnostic variables. Of the EMM parameters, the uptake rate had the lowest variability. Accrual of more data is ongoing, as well as refinement of measurements including B1 corrections.

1. Kuhl et al., J Magn Reson Imaging 2000; **12**: 965
2. Fan et al., Magn Reson Imaging 2007; **25**:593
3. Medved, et al., J Magn Reson Imaging 2004, **20**: 122.
4. Schabel, et al., Phys. Med. Biol. 2008, **53**: 2345