**Effects of Temporal Resolution on Breast Cancer Diagnostic Accuracy by Quantitative Dynamic Contrast-Enhanced MRI**

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**Introduction**

High spatial resolution imaging is needed for accurate breast tumor morphology assessment. Clinical dynamic contrast-enhanced (DCE) MRI data are often acquired with high spatial but low temporal resolution because of trade-off between the spatial and temporal resolutions for the conventional gradient echo sequence. As a result, qualitative or semi-quantitative analysis of the DCE-MRI time-course data is often used in clinical contrast kinetics interpretation. However, the results are often dependent on data acquisition details, contrast reagent (CR) dose and/or injection rate, etc. These contribute to the limited specificity and study irreproducibility characterizing current clinical breast DCE-MRI protocols (1). Quantitative analysis of DCE-MRI time-course using a pharmacokinetic model to extract pharmacokinetic parameters (e.g., Ktrans and ψv) is more desirable. These parameters are physiological quantities, in principle independent of the above factors. It has been shown (3) that, with relatively high temporal resolution DCE-MRI data, Shutter-Speed Model (SSM, accounting for finite transcytolicmmal water exchange kinetics) analysis (4) significantly improves breast cancer diagnostic accuracy compared to Standard Model (SM, assuming effectively infinitely fast exchange kinetics) analysis (5) and the clinical MRI protocol. The SM analysis can also yield CR dose-dependent parameter values (2). Further, the newly discovered DCE-MRI biomarker, ΔKtrans (SSM – Ktrans (SM)), achieves near perfect specificity at 100% sensitivity (2,3). ΔKtrans is a measure of Ktrans underestimation due to the SM’s subject of finite water exchange kinetics (a shutter-speed effect) (2).

Temporal resolutions of 60-120 s are typical for clinical breast DCE-MRI protocols. In this study, by resampling research DCE-MRI time-course data, we sought to evaluate the effects of clinical temporal resolution on quantitative DCE-MRI breast cancer diagnostic accuracy.

**Methods**

In a recent study (3), 74 patients who had 77 suspicious breast lesions (3 patients presented 2 lesions each) underwent IRB-approved research DCE-MRI examinations prior to their clinically scheduled biopsies. These lesions were deemed suspicious based on the previous clinical breast MRI exams that included tumor morphology assessment and qualitative analysis of contrast kinetics. The research DCE-MRI acquisitions were conducted at 1.5T using a 3D SPGR gradient echo sequence. As a result, qualitative or semi-quantitative analysis of the DCE-MRI time-course data is often used in clinical contrast kinetics interpretation. However, the results are often dependent on data acquisition details, contrast reagent (CR) dose and/or injection rate, etc. These contribute to the limited specificity and study irreproducibility characterizing current clinical breast DCE-MRI protocols (1). Quantitative analysis of DCE-MRI time-course using a pharmacokinetic model to extract pharmacokinetic parameters (e.g., Ktrans and ψv) is more desirable. These parameters are physiological quantities, in principle independent of the above factors. It has been shown (3) that, with relatively high temporal resolution DCE-MRI data, Shutter-Speed Model (SSM, accounting for finite transcytolicmmal water exchange kinetics) analysis (4) significantly improves breast cancer diagnostic accuracy compared to Standard Model (SM, assuming effectively infinitely fast exchange kinetics) analysis (5) and the clinical MRI protocol. The SM analysis can also yield CR dose-dependent parameter values (2). Further, the newly discovered DCE-MRI biomarker, ΔKtrans (SSM – Ktrans (SM)), achieves near perfect specificity at 100% sensitivity (2,3). ΔKtrans is a measure of Ktrans underestimation due to the SM’s subject of finite water exchange kinetics (a shutter-speed effect) (2).

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**Results**

As Fig. 1 shows, scatter plots of ROI SM and SSM Ktrans (a), and ΔKtrans (b) obtained from the high (original data) and low (averaged data) temporal resolution data. All benign lesions are marked with red, and all malignant with black, symbols. The lines connect data points from the same patient. There are clear trends of decreasing Ktrans and ΔKtrans from high to low temporal resolution, more so for the malignant lesions, resulting in greater overlap of the malignant and benign lesions at lower temporal resolution. The Table lists mean ± SD values for the SM and SSM Ktrans, and ΔKtrans of the 66 lesions derived at high and low temporal resolutions. Paired t-tests reveal that the decreases of SM and SSM Ktrans, and ΔKtrans at lower temporal resolution are statistically significant. The greater overlap of the malignant and benign lesion Ktrans and ΔKtrans values at lower resolution leads to poorer diagnostic accuracy. The ROC curve analyses show that AUCs at lower temporal resolutions are significantly smaller than those at higher resolution and the decreases in diagnostic accuracy are statistically significant: (a) Ktrans (SM), 0.93 (AUC at high resolution) vs. 0.84 (AUC at low resolution), p < 0.05; (b) Ktrans (SSM), 0.97 vs. 0.87, p < 0.02; (c) ΔKtrans, 0.99 vs. 0.73, p < 0.0005. At higher temporal resolution, ΔKtrans possesses the highest diagnostic accuracy (2.3). At 100% sensitivity, from high to low temporal resolution, the diagnostic specificity decreases from 79% to 34% for Ktrans (SM), 88% to 34% for Ktrans (SSM), and 88% to 38% for ΔKtrans. ψv is significantly increased for the benign lesion group going from high to low temporal resolution, but not significantly altered for the malignant group. However, ψv and Δψv are not good diagnostic markers at either resolution, as their ROC AUCs range from 0.5 to 0.6.

**Discussion**

The results suggest that, if quantitative pharmacokinetic analysis is employed for breast DCE-MRI, high temporal resolution for data acquisition is necessary, not only for accurate derivation of the pharmacokinetic parameters, but also for superior discrimination of benign and malignant lesions. The typical clinical DCE-MRI temporal resolution is clearly not adequate for either purpose. Improved resolution schemes with alternative k-space sampling strategy in combination with parallel imaging acceleration are desirable for quantitative breast DCE-MRI analysis to be adopted in clinical practice, while still maintaining high spatial resolution. However, there is no question that quantitative DCE-MRI for breast cancer diagnosis is already eminently feasible (2,3).

**References**