Improved Diagnostic Performance of 3T Breast MRI using Perfusion-Adjusted ADC Values

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Purpose: Dynamic contrast-enhanced (DCE) MRI of the breast has proven to be the most sensitive screening technique for women at high risk for breast cancer, with 90-95% sensitivity for breast cancer detection. However, the technique has a modest positive predictive value (PPV) for diagnosis of MRI-detected breast lesions (21-40%).[1,2] Improved methods to distinguish benign and malignant lesions on MRI are needed to reduce the number of unnecessary biopsies.[3] Diffusion-weighted MRI (DWI) has shown promise for reducing false positives on conventional breast MRI based on apparent diffusion coefficient (ADC) values. However, standard DWI approaches can result in ADC values strongly influenced by perfusion as well as diffusion,[4] which may increase overlap in ADC measures of malignant and benign pathologies. The purpose of this study was to compare the diagnostic performance of ADC values calculated with and without perfusion weighting for differentiating benign from malignant suspicious breast lesions on MRI, and to identify significant independent DCE and DWI predictors of malignancy.

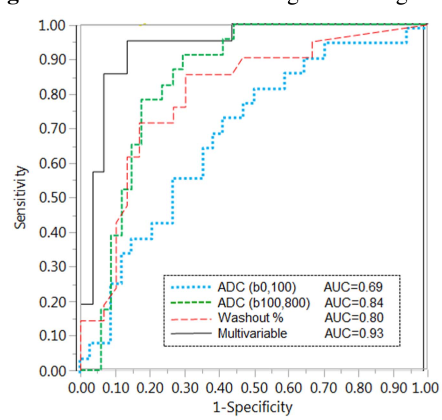
Methods: This study was IRB approved and all patients provided informed consent. We evaluated MRI characteristics in 50 consecutive women with suspicious breast lesions detected on MRI (BIRADS 4, 5). All MR examinations were performed on a 3T Philips Achieva scanner with a 16-channel breast coil, and included both DCE and DWI (b=0, 100, 800 s/mm^2). Lesion DWI features were measured using in-house software developed in Image J (NIH),[5] and DCE kinetic features were analyzed using a commercially-available computer-aided assessment program (CADstream, Merge Healthcare). Lesion ADC values were calculated from ADC maps generated by monoexponential fits for 3 different b value combinations: 'standard' (b= 0, 800 s/mm^2; $ADC_{0\text{-}800}$), 'perfusion corrected' (b=100, 800 s/mm^2; $ADC_{100\text{-}800}$), and 'perfusion weighted' (b=0, 100 s/mm^2; $ADC_{0\text{-}100}$). DCE parameters included lesion type (focus, mass, nonmass), size (mm), peak initial enhancement (PE; %), and percentage of washout (%). Correlations between perfusion corrected and perfusion weighted ADCs were assessed. Differences in MRI parameters between benign and malignant lesions were evaluated by Wilcoxon rank sum test. Univariate and multivariate logistic regression modeling were used to identify features that significantly discriminated benign and malignant lesions. Diagnostic performance was determined by area under the receiver operating characteristic curve (AUC); $p < 0.05$ was considered statistically significant.

Results: 57 biopsy-proven lesions (34 benign, 23 malignant) were included in the study. Mean ADC values were significantly lower for malignant lesions compared to benign lesions for all three b value combinations (p<0.05), Table 1. While the perfusion-weighted ADC measures ($ADC_{0\text{-}100}$) weakly correlated with the standard ADC measures ($ADC_{0\text{-}800}$, r = 0.29, p=0.03), there was no significant correlation between $ADC_{0\text{-}100}$ and perfusion-corrected ADC measures ($ADC_{100\text{-}800}$, r=0.18, p=0.17). A multivariate model combining the distinct $ADC_{0\text{-}100}$ and $ADC_{100\text{-}800}$ measures produced higher AUC (AUC = 0.89) than the standard $ADC_{0\text{-}800}$ measure (AUC = 0.85) for predicting malignancy. In addition to differences in ADC measures, univariate analyses showed malignant lesions exhibited higher percentage washout (p=0.003) and larger lesion size (p=0.08, trend) on DCE than benign lesions (Table 1). Multivariate analysis showed $ADC_{0\text{-}100}$, $ADC_{100\text{-}800}$, and DCE washout were significant independent predictors and together produced the highest diagnostic performance in predicting malignancy (AUC = 0.93), Figure 1.

Table 1: Comparison of benign and malignant lesions, data given as mean ± SD or N (%)

MRI Parameter	Malignant N=23	Benign N=34	Wilcoxon P value	AUC	Multi LR P value
$ADC_{0\text{-}800}$ (x10^{-3} mm^2/s)	0.1 ± 0.18	0.2± 0.35	<0.0001	0.85	-
$ADC_{100\text{-}800}$ (x10^{-3} mm^2/s)	0.9 ± 0.28	1.3 ± 0.32	<0.0001	0.84	0.012
$ADC_{0\text{-}100}$ (x10^{-3} mm^2/s)	1.3 ± 0.16	2.5± 0.21	0.015	0.69	0.0024
Washout (%)	41.2 ± 26	11.9± 18	0.0003	0.80	0.033
PE (%)	286 ± 234	192± 62	0.20	0.61	0.94
Lesion Size (mm)	25 ± 30	13± 10	0.08	0.64	0.69
Lesion type: Mass Non mass	10 (43%) 13 (56%)	20 (59%) 14 (41%)	0.29	0.58	0.68

Figure1. ROC Curves for Benign vs. Malignant



Discussion: Separation of perfusion and diffusion-weighted components of lesion ADC measures using a simplified approach improved the ability to distinguish benign and malignant breast lesions. These findings suggest that more rigorous intravoxel incoherent motion (IVIM)[4] techniques hold potential to improve the diagnostic performance of breast DWI, warranting further study. Furthermore, multiparametric combination of quantitative DWI and DCE features can provide more accurate assessment of suspicious MRI-detected breast lesions and may help to improve PPV and reduce unnecessary biopsies in MRI-screening.

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