Use of DW Imaging as an Adjunct to Dynamic Contrast Enhanced MRI in Breast Cancer at 3T

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Introduction: MR imaging is currently the most sensitive technique for the detection of breast cancer. Contrast enhanced (CE) MRI can achieve a sensitivity of 95%-100% and a specificity of 80%-97% in breast cancer detection (1). In recent years, diffusion weighted imaging (DWI) has demonstrated potential to discriminate malignant tumors from benign breast tumors (2, 3), and to improve positive predictive value (PPV) (4, 5). The purpose of our study is to explore if DWI can improve the PPV of breast malignancy at 3.0T and be used as an adjunct to CE MRI. Histology was used as the reference standard.

Methods: This HIPAA-compliant retrospective IRB-approved study included 301 patients undergoing 3T Breast MR imaging for pre-operative staging and high risk screening. Review of the radiology database and electronic medical records identified 209 lesions categorized as BI-RADS 4 and 5. Exclusion criteria included: lesions smaller than 0.8 cm; biopsy proven cancer; lesions undergoing neoadjuvant chemotherapy; and poor fat suppression/ artifacts limiting DWI evaluation. Based on these criteria, 185 women (mean 49 years; range: 23-81 years) with 209 lesions were identified. Among them, 74 were mass and 135 lesions were non-mass lesions and 71 were malignant (53 were invasive carcinomas and 18 DCIS) and 138 benign (including 16 high risk lesions). **MRI:** All studies were conducted with 3T GE Excite Systems. DWI sequence included a 2D DW single-shot dual spin echo EPI; axial imaging plane; TR/TE: 6000/56.4-120.7 ms; 90° flip angle; NEX 3; matrix 128x128; field of view 28-38 cm; slice thickness 4-5 mm; slice gap 0-1 mm; number of slices 17-23; fat suppression enhanced; parallel imaging ASSET; b values:0, 600 s/mm2; acquisition time is about 2 min. Axial delayed CE MRI sequence 3D T1- weighted gradient echo VIBRANT; imaging plane axial; TR/TE: 4.30-5.11/2.1-2.39 ms; 10 or 15° flip angle; NEX 1; matrix 320x320 to 420x420; reconstructed matrix 512x512; field of view 28-38 cm; slice thickness 0.8 mm; number of slices 204-306; fat suppression on; parallel imaging ASSET; acquisition time 1.5-2.5 min; **ADC Data Analysis**: ADC maps were calculated with GE's Functool. Regions of interest (ROIs) were manually drawn by a experienced radiologist, well within the enhancing lesions on diffusion images. All ADC values are represented in units of mm2/s. Mean and standard deviation (SD) were calculated for all malignant and benign lesions, and their subgroups (**Table 1**). The predictive accuracy of ADC as a measure of benign versus malignant tumors was assessed by calculating the area under the ROC curve (AUC). An optimal threshold was calculated based on Youden's index and was used to calculate PPV, NPV, specificity, and sensitivity.

Results: Mean ADC value is significantly lower in malignant lesions compared with benign lesions ($p < 0.05$). DCIS lesions have higher ADC values compared to invasive carcinomas, and high risk benign lesions have smaller ADC values compared to other benign lesions (**Table 1**). A representative plot of DW image, and the parametric ADC of malignant lesion (IDC) and benign (sclerosing adenosis) lesion was shown (**Figure 1**). Calculated ADC of IDC lesion= 0.00106 mm2/s and ADC of benign lesion= 0.00139 mm2/s. The predictive accuracy of ADC as a measure of benign versus malignant tumors was assessed by calculating the area under the ROC curve (AUC=0.83) (Figure 2). The optimal absolute ADC cutoff value derived was 1.3 x 10^{-3} mm2/sec, with a sensitivity of 86%, a specificity of 73%, a PPV of 86%, and NPV of 73%. Based on CE-MRI, the PPV was calculated as 34%.

Table 1: ADC values (Mean and SD) of malignant and benign lesions and their sub-groups

Group	N	Mean (mm2/s)	SD (mm2/s)
Malignant	71	0.00122	0.00022
IC	53	0.00115	0.00016
DCIS	18	0.00141	0.00027
HR Benigns	16	0.00139	0.00034
Other Benigns	122	0.00154	0.00025
Benign	138	0.00152	0.00027

Conclusion: DW imaging of lesion assessment improves the PPV when compared to CE MRI, and thus can be used as an adjunct to avoid unnecessary benign biopsies. Further work needs to be focused on the specificity assessment through the exclusion of high risk benign lesions.

References: 1) Kriege M et al., Breast Cancer Res Treat 100, 109 (2006). 2) Guo Y et al., JMRI 16, 172 (2002). 3) Tsushima Y et al., JMRI 30, 249 (2009). 4) Partridge SC et al., AJR Am J Roentgenol 193, 1716 (2009). 5)El Khouli RH et al., Radiology 256, 64 (2010).