Thin slice high resolution breast DWI at 3T (RESOLVE): increased separation of benign from malignant tumors among BI-RADS 4/5 lesions

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Introduction: Diffusion weighted imaging (DWI) has shown promise for discriminating malignant from benign lesions on breast MRI, potentially improving the specificity of the breast MRI exam. Clinical utility of DWI improves as DWI resolution approaches that of the post-contrast dynamic contrast enhanced T1 series. Increased resolution at higher field strengths (3 Tesla), however, is tempered by increased field inhomogeneity and image distortion, limiting DWI utility in clinical practice. A readout segmented diffusion technique (RESOLVE)[(1)] permits the use of extremely short echo spacing independent of the spatial resolution, reducing the image distortion. This technique potentially allows improved ADC details within the lesion, potentially sampling lower ADC values in malignant lesions and thereby increasing the separation of malignant versus benign lesions. The purpose of this study was to determine whether RESOLVE improves separation of malignant versus benign lesions by measuring lesion ADC values obtained by RESOLVE versus typical EPI diffusion imaging at 3T on suspicious breast MRI lesions prior to biopsy, and then comparing ADC values to pathology.

Methods: Retrospective search was done under IRB approval identifying consecutive 3T breast MRI studies with BI-RADS 4 and 5 (suspicious) lesions, including foci, masses, and non-mass-like-enhancement, which had both RESOLVE and standard single-shot spin echo EPI (ss-EPI) diffusion imaging between August and October 2011. Only cases with subsequent MR or ultrasound-correlative biopsy procedure were retained. The RESOLVE technique used a readout segmentation factor of 5, with an echo spacing of 0.3 ms. The sequence acquires data from a 2D navigator to perform nonlinear phase correction and control reacquisition of uncorrectable data in real-time The imaging parameters were as follows: TR/TE = 7500-10000/60 ms (ss-EPI) and 8000-12000/64 ms (RESOLVE), averages = 8 (ss-EPI) and 1(RESOLVE), slices = 47-50 (minimum required to cover the entire breast), b-values 0 and 800, resolution = 1.8 x 1.8 x 2.4 mm^3, imaging times of approximately 5 minutes for both techniques. Freehand ROI's were drawn on each suspicious lesion based on the b=800 maps in close reference to the post-contrast T1 series on an Aegis workstation (Sentinelle Medical, Toronto, Canada) by a board-certified radiologist with fellowship training in breast imaging, who was blinded to final pathology. Care was taken to avoid cystic or necrotic areas based on T2-weighted mages. For each lesion, mean, minimum, and maximum ADC values from freehand-drawn ROI's were recorded and then averaged by technique and pathologic outcome (benign or malignant). Significance was determined using Wilcoxon rank-sum test.

Results: To date, 10 patients with 12 suspicious (BI-RADS 4 and 5) lesions have obtained 3T breast MRI with both RESOLVE and standard diffusion at 2.4-mm slice thickness, and have subsequently obtained MRI or ultrasound-guided core biopsy procedures of the lesion in question. Of these, one patient with bilateral lesions was excluded because of water saturation on the RESOLVE sequence. Of the final cohort of 9 lesions, two were shown to be malignant (invasive ductal carcinoma), and the remainder were benign. Two lesions were no longer present at breast MRI biopsy, and were hence deemed benign. Table 1 demonstrates excellent agreement between RESOLVE and standard EPI for mean ADC values of benign lesions. Among malignant lesions, however, RESOLVE demonstrates lower mean ADC values, increasing the separation between benign and malignant lesions (also seen in box plot form in Figure 2). Statistically significant differences between benign and malignant lesion were observed for mean ADC obtained by both methods. Interestingly, minimum and maximum ADC values obtained under REOLVE (but not under standard EPI) also demonstrated statistical significance, and similar increased separation of benign versus malignant lesions.

Conclusions: Preliminary results suggest increased separation of benign from malignant lesions using ADC values obtained by RESOLVE compared to standard EPI DWI. This trend held true not only for mean ADC values, but for minimum and maximum ADC values obtained from lesion ROIs, raising the possibility that these parameters may contain additional useful information regarding tumor pathology. It is expected that additional data will further support RESOLVE as a robust, high-resolution diffusion weighted imaging technique at 3T. The improved detail and decreased image distortion available with this method has potential clinical utility as an adjunct to dynamic-contrast-enhanced breast MRI.

References: (1) Porter DA, et al MRM 2009; 62:468-75.

	Benign	Malignant	p value
Mean ADC			
RESOLVE	1.37 ± 0.07	0.74 ± 0.02	0.040*
Standard EPI	1.37 ± 0.09	0.92 ± 0.06	0.040*
Minimum ADC			
RESOLVE	1.16 ± 0.09	0.39 ± 0.27	0.040*
Standard EPI	1.20 ± 0.12	0.51 ± 0.17	0.056
Maximum ADC			
RESOLVE	1.62 ± 0.06	1.02 ± 0.09	0.040*
Standard EPI	1.92 ± 0.09	1.28 ± 0.01	0.079

Table 1: Apparent diffusion coefficient (x 10^{-3} mm^2/sec) for BI-RADS 4 and 5 lesions with subsequent biopsy.
* significant p values

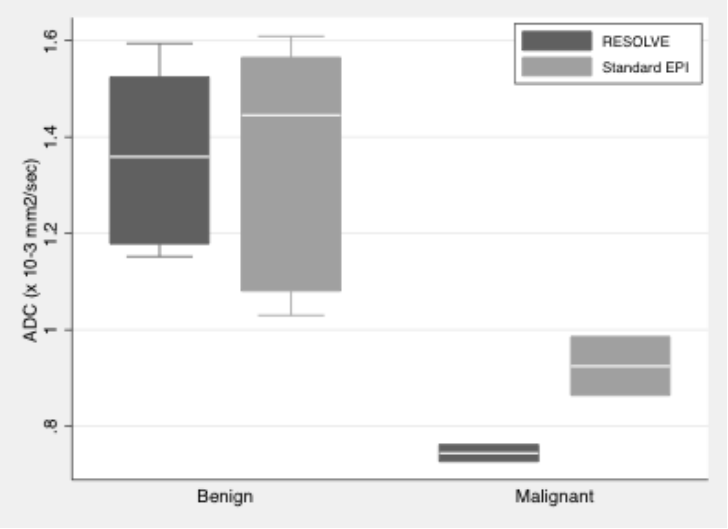

Figure 2: Box plot of apparent diffusion coefficient (ADC) for benign and malignant lesions, obtained by RESOLVE and standard EPI.