Improved Characterization of Breast Lesions with Relative ADC Accounting for Tissue Composition Variation

J. Huang[1], L. Hoisington[1], T. Hahn[1,2], A. Babayan[3], and K. Berger[1]

[1]Department of Radiology, Michigan State University, East Lansing, MI, United States, [2]Department of Physics and Astronomy, Michigan State University, East Lansing, MI, United States, [3]College of Osteopathic Medicine, Michigan State University, East Lansing, MI, United States

Introduction: Diffusion-weighted imaging (DWI) has been used recently to investigate the potential application of the apparent diffusion coefficient (ADC) in the characterization of breast lesions [1-3]. These studies found that the ADC of malignant tumors was significantly smaller than that of benign lesions, demonstrating the potential for using ADC to characterize breast lesions. Studies showed that the reduction in ADC in malignant tumors correlated with and was attributed to increased cellularity of the malignant tumors. [2]. However, these studies also revealed a substantial overlap in ADC between benign and malignant lesions, limiting its sensitivity and specificity in the characterization of breast lesions. It is well recognized that breast tissue composition varies substantially from person to person and is clinically categorized into four groups from almost entirely fat to extremely dense tissue. This substantial tissue composition variation may contribute to the large ADC variation, causing the overlap between the two lesion groups. In this study we investigated the correlation between the ADC of breast lesions and the ADC of the immediate surrounding tissues and then examined the effect of tissue composition variation on the characterization of the breast lesions.

Methods and Materials: Fifteen patients (age from 34 to 63 years) with breast lesions ≥7 mm received an additional DTI scan during their clinical breast MRI exam. The breast MRI exam was acquired on a GE clinical 1.5T scanner using a dedicated 8-channel breast coil with ASSET technique, and included a dynamic contrast-enhanced (DCE) FSPGR 3D scan (FOV 32 cm, flip angle 10°, matrix 320×320, slice thickness 2 mm, slab location 116, and ZIP2). The DTI scan was acquired prior to the DCE scan with FOV 32 cm, TE/TR=min/10000ms, matrix 160×160, slice thickness 4 mm, gap 0 mm, 33 sections, NEX 2, and b=600 s/mm^2. The diffusion encoding was accomplished in six non-collinear directions. The DTI images were computed to yield mean ADC and fractional anisotropy (FA) maps. The slice locations for DCE and DTI imaging were carefully prescribed to make sure they matched. The DCE images were used to accurately depict each breast lesion. In-house software designed to automatically detect the boundary of manually selected contrast-enhanced lesions was used to delineate the lesion and its immediate surrounding tissue. The region of interest (ROI) of the surrounding tissues was established to have the same total area as the lesion ROI. The mean value of ADC was computed for both the lesion and surrounding tissue ROI, and the correlation of ADC between the lesion and the tissue was determined. Then, a relative ADC change was computed as the ratio of the difference between the lesion ADC and the surrounding tissue ADC to the tissue ADC, accounting for the tissue composition variation from subject to subject.

Results and Discussion: All breast lesions were grouped as either benign (1 fibroadenoma and 4 fibrocystic changes) or malignant (10 infiltrating ductal carcinomas) according to pathology reports. (Note that all these lesions were radiologically reported as highly suspicious for malignancy, and subsequently core biopsies were performed.) Fig. 1 shows a scatter plot of ADC for the lesions and their immediate surrounding tissues. As can be seen, the ADC of the surrounding tissues varied substantially from subject to subject, indicating a large breast tissue composition variation. Although the ADC of the lesions also varied substantially from subject to subject, the scatter plot demonstrated a positive linear trend with the surrounding tissues (R^2=0.21; p<0.09), suggesting a confounding effect due to the tissue composition variation. Accordingly, this tissue composition variation could mask the effect of lesion cellularity on ADC, rendering a large overlap in ADC between benign and malignant lesions. As can be seen in Fig. 2, the distributions of ADC overlapped between the benign and malignant lesions, and there was no significant difference in ADC between the benign and the malignant lesions (p>0.23). When selecting the immediate surrounding tissue as a reference, however, the overlap in the relative ADC between the two groups was significantly reduced as shown in Fig. 3. The difference in the relative ADC between the benign and the malignant lesions was significant (p<0.006). Relative to the immediate surrounding tissues, all of the malignant tumors showed a reduced ADC, reflecting an increased cellularity in these malignant tumors that was consistent with the previous study [2]. Four out of the five benign lesions, however, showed an increased ADC, suggesting a decreased cellularity and/or an increased extracellular space in comparison to the immediate surrounding tissues. In conclusion, ADC varied substantially from subject to subject, reflecting the well-known large variation in breast tissue composition. This study showed that the effect of tissue composition variation on ADC might be effectively reduced by the introduced relative ADC, providing a better measure than conventional ADC for improving the characterization of breast lesions.

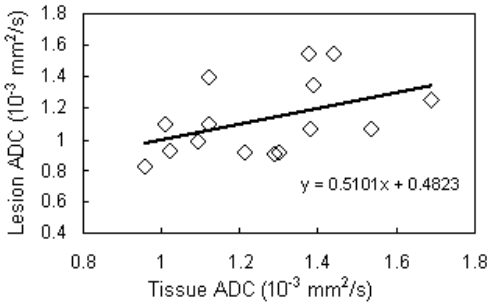

Fig.1 Correlation of ADC of the lesions with their immediate surrounding tissue.

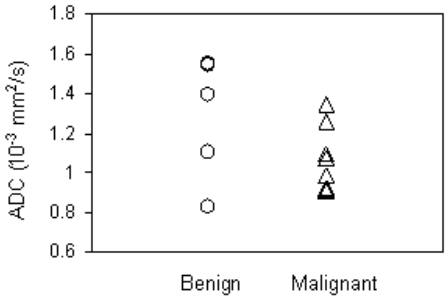

Fig. 2 Distributions of ADC for the benign lesions and the malignant tumors.

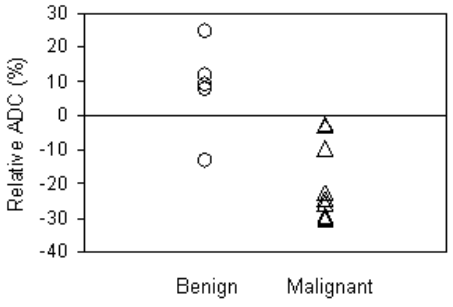

Fig. 3 Distributions of relative ADC for the benign lesions and the malignant tumors.

References: 1. Sinha, S, *et al*, JMRI, **15**: 693-704, 2002. 2. Guo, Y, *et al*, JMRI, **16**: 172-178, 2002. 3. Kuroki, Y, *et al*, Magn. Reson. Med., **3**: 79-85, 2004.