Breast Tumors Characterization using Diffusion Kurtosis Imaging

Yongming Dai[1], Junxiang Zhang[2], and Dongmei Wu[3]

[1]Philips Healthcare, Shanghai, China, [2]Department of Radiology, The First Affiliated Hospital of Bengbu Medical College, Anhui, China, [3]Shanghai Key Laboratory of Magnetic Resonance, East China Normal University, Shanghai, China

Introduction: DKI has the potential to provide both functional and mircrostructural information in breast tumor tissues with simultaneous quantifications of water diffusivity and diffusion kurtosis (1-2). In this study, we hypotesize that DKI could provide additional information about the water diffusion in the breast tumor microenvironment as compared with the conventional DWI. The aim of this study was to investigate and evaluate the role of DKI in characterizing breast lesions by examining the relationship between DKI parameters and tumor types in human patients with breast tumors.

Materials and methods: Bilateral breast MR imaging was performed on 3.0 Tesla MR systems (Achieva TX, Philips Healthcare, Best, The Netherlands) with a maximum gradient strength of 40 mT/m and a maximum slew rate of 200T/m/s. One hundred and twenty-four lesions in 103 patients (mean age: 57 ± 14 years) were evaluated by MR DKI performed with 7 b-values of 0, 250, 500, 750, 1000, 1500, 2000 s/mm2 and dynamic contrast-enhanced (DCE) MR imaging. Breast lesions were histologically characterized and DKI related parameters – mean diffusivity (MD) and mean kurtosis (MK) – were measured. The MD and MK in normal fibroglandular breast tissue, benign and malignant lesions were compared by One-way analysis of variance (ANOVA) with Tukey's multiple comparison test. Receiver operating characteristic (ROC) analysis was performed to assess the sensitivity and specificity of MD and MK in the diagnosis of breast lesions.

Results: The benign lesions (n = 42)and malignant lesions(n = 82)– had a mean diameter of11.4 ± 3.4 mm and 35.8 ± 20.1 mm, respectively.TheMK for malignant lesions (0.82 ± 0.19) was significantly higher ($P<0.001$) than that for benign lesions (0.47 ± 0.14), and, in contrast, MD for benign lesions (1.97 ± 0.35 (10^{-3} mm^2/s)) was higher than that for malignant lesions (1.38 ± 0.53 (10^{-3} mm^2/s)) at DKI performed with b-values of 0, 250, 500, 750, 1000, 1500, 2000 s/mm^2. At a cutoff MD/MK $1.58(10^{-3}$ mm^2/s)/0.69, sensitivity, and specificity of MD/MK for the diagnosis of malignant were 79.3%/84.2% and 92.9%/92.9%, respectively.The area under the curve (AUC)is 0.86/0.92 for MD/MK.
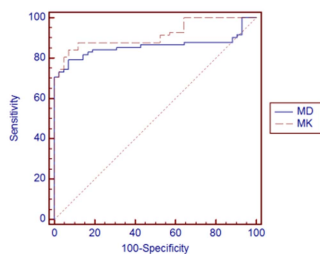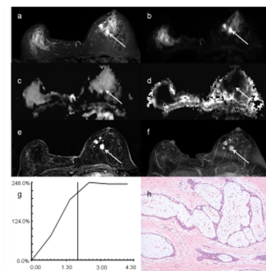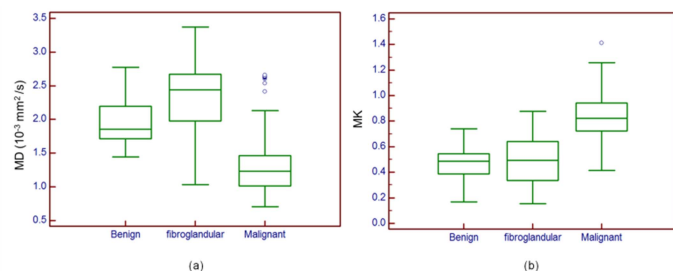

Figure 1

Figure 2

Figure 3

Figure 1. Receiver operating characteristic curve for MD and MK values used as predictors of malignancy in 124 breast lesions in 103 patients. Straight diagonal line spanning the middle of the graph indicates an AUC of 0.5.

Figure 2. A 56 year-in-old woman with fibroadenomas, indicated by the white arrow: a) T2-weighted TSE image; b) DW image at b = 0; c) MD map; d) MK map; e) contrast enhancement map; f) MIP of enhance map; g) contrast enhancement curves and h) histological specimen.

Figure 3. Box plot distribution:a) MD values forfibroglandular tissue, benign and malignant lesions; b) MK values for fibroglandular tissue, benign and malignant lesions. Outliers are also represented. Top and bottom of each box represent 25% and 75% percentiles of the MD and MK values, respectively. Horizontal line inside each box represents median value.

Discussion and Conclusions: DKI could provide valuable information on the diffusion properties related to tumor microenvironment and increase diagnostic confidence of breast tumors.

References:
1) Jensen JH, et al. Magn Reson Med. 2005;53(6):1432-40.
2) Wang JJ, et al. Radiology. 2011;261(1):210-7.