

# EFFECT OF THIN-SECTION DIFFUSION-WEIGHTED MAGNETIC RESONANCE IMAGING ON DIAGNOSIS OF MALIGNANT BREAST LESIONS

A. M. Chow<sup>1</sup>, P. S. Cheung<sup>2</sup>, R. Lee<sup>3</sup>, K. M. Chan<sup>3</sup>, S. F. Liu<sup>1</sup>, S. K. Yu<sup>1</sup>, and G. G. Lo<sup>3</sup>

<sup>1</sup>Medical Physics & Research Department, Hong Kong Sanatorium & Hospital, Happy Valley, Hong Kong SAR, China, People's Republic of, <sup>2</sup>Breast Care Center, Hong Kong Sanatorium & Hospital, Happy Valley, Hong Kong SAR, China, People's Republic of, <sup>3</sup>Department of Diagnostic and Interventional Radiology, Hong Kong Sanatorium & Hospital, Happy Valley, Hong Kong SAR, China, People's Republic of

## INTRODUCTION

Diffusion-weighted imaging (DWI) characterizes the random microscopic motion of molecules and enables assessment of tissue microstructure<sup>1</sup>. Restricted diffusion has been observed in regions of high cellularity, intracellular and extracellular edema, high viscosity and fibrosis<sup>2,3</sup>. Malignant lesions, including breast carcinomas, exhibit a higher cellular density and hence lower diffusivity when compared to benign lesions and normal breast tissues<sup>4,5</sup>. Increased signal intensities in DW images and reduced apparent diffusion coefficient (ADC) values have been reported for malignant lesions. This technique has been widely used to characterize malignant and benign lesions at 1.5 T<sup>2,6</sup>. Recently, our group also demonstrated DWI at 3 T is highly sensitive in differentiating malignant and benign breast lesions<sup>7</sup>. However, conventional DWI uses 5 - 8 mm slice thickness<sup>8,10</sup>, partial volume averaging may occur if a small lesion is occupying only part of a voxel<sup>11</sup>, leading to difficulty in distinguishing it from neighboring normal tissue. Moreover, if its surface is not along the slice-selection direction, blurring of the apparent border of a lesion may also occur and hence hinders delineation<sup>12</sup>. Use of thinner slices for DWI acquisition may allow small, low-contrast lesions to be detectable, improving the depiction of small tumors. Improved diagnostic accuracy has been shown in detecting brain lesions with thin-section DWI<sup>13-15</sup>. In this study, we aim to evaluate the effect of thin-section DWI in detecting malignant breast lesions at 3 T.

## METHODS

**Subjects and Lesions:** This study was conducted with the approval of the institutional review board and with informed consent. Fifty female patients (age: mean = 46.6 years; range = 31 - 64 years) with known biopsy-proven malignant lesions were prospectively evaluated. **MRI:** All MRI examinations were performed on a 3 T Siemens MRI scanner (MAGNETOM Tim Trio; Siemens Medical Solutions, Erlangen, Germany) using a dedicated 4-channel phased array coil (In Vivo Devices, Pewaukee, Wis). High resolution anatomical  $T_1$ -weighted and  $T_2$ -weighted images were acquired. A single-shot echo-planar imaging (EPI) DWI protocol was performed to obtain images axially. Sensitizing diffusion gradients were applied sequentially in the x, y, and z directions. Conventional DWI was acquired with TR = 3900 ms, TE = 78 ms, b-values = 0 and 1000 s/mm<sup>2</sup>, FOV = 35 × 35 cm<sup>2</sup>, slice thickness = 6 mm, spatial resolution = 1.82 × 1.82 × 6 mm<sup>3</sup>, NEX = 5 and total scan time of 1 min 31 sec. Similarly, thin-section DW images were obtained with TR = 4832 ms, TE = 78 ms, b-values = 0 and 1000 s/mm<sup>2</sup>, FOV = 35 × 35 cm<sup>2</sup>, slice thickness = 3 mm, spatial resolution = 1.82 × 1.82 × 3 mm<sup>3</sup>, NEX = 5 and total scan time of 1 min 53 sec. Note that both DWI was acquired with parallel imaging technique using acceleration factor = 2. Dynamic contrast-enhanced MRI (DCE-MRI) was then performed to confirm the localization of the malignant lesions. **Data Analysis:** Apparent diffusion coefficient (ADC) maps were generated. A circular ROI was defined in the DW images to encompass the breast malignant lesions. The same ROI was then used for ADC measurements. Care was taken to avoid adjacent normal tissue or cystic components. Similarly, circular ROI with same size was also placed over normal breast parenchyma for ADC measurements. Normalized ADC was then calculated as the ratio between ADC of malignant lesion and that of normal breast parenchyma. Two-tailed paired Student's *t* tests were performed between conventional and thin-section DWI for normal tissues and malignant lesions respectively, while two-tailed unpaired Student's *t* tests were performed between normal tissues and malignant lesions using the same protocol, with *p* < 0.05 considered as statistically significant. Using the threshold ADC value of 1.21 × 10<sup>-3</sup> mm<sup>2</sup>/s at 3 T for malignant lesions determined by our group previously<sup>7</sup>, sensitivities of conventional and thin-section DWI were calculated and compared. To compare image quality, signal-to-noise ratios (SNR) were computed using the following equation: SNR =  $S_{\text{lesion}}/\sigma_n$ , where  $S_{\text{lesion}}$  denotes signal intensity of malignant lesion in DW images at b = 1000 s/mm<sup>2</sup> and  $\sigma_n$  is the standard deviation of noise estimated from background air.

## RESULTS AND DISCUSSIONS

All breast lesions were identified on DW images. The mean size of the lesions along the slice-selection direction (measured on DCE-MRI) was 1.7 ± 1.2 cm. Note that a lesion has to be larger than twice the slice thickness in order not to be subject to partial volume effect. Fig. 1 shows a representative inverted DW images and ADC maps from the same patient using conventional and thin-section DWI. Typical ROIs used for ADC measurements are illustrated, with size of 0.17 mm<sup>2</sup> in all patients. Note that the measured ADC of malignant lesion was 1.26 × 10<sup>-3</sup> mm<sup>2</sup>/s using conventional DWI, which was higher than 1.21 × 10<sup>-3</sup> mm<sup>2</sup>/s. This would be a false-negative case if only conventional DWI was performed. ADC values of normal breast tissues and malignant lesions using conventional and thin-section DWI are shown in Fig. 2. Significant decrease (*p* < 0.001) in ADC of malignant lesions was found with thin-section (0.94 ± 0.16 × 10<sup>-3</sup> mm<sup>2</sup>/s) and conventional DWI (1.04 ± 0.21 × 10<sup>-3</sup> mm<sup>2</sup>/s). Meanwhile, no significant differences were observed in ADC of normal breast parenchyma between thin-section (1.73 ± 0.17 × 10<sup>-3</sup> mm<sup>2</sup>/s) and conventional DWI (1.73 ± 0.19 × 10<sup>-3</sup> mm<sup>2</sup>/s). The higher ADC values of malignant lesions using conventional DWI likely cause by the partial volume averaging in consequence to the thick slices acquired. Moreover, significant decrease (*p* < 0.001) in normalized ADC was found with thin-section (0.55 ± 0.11) and conventional DWI (0.61 ± 0.14), indicating higher lesion conspicuity for thin-section DWI. Using 1.21 × 10<sup>-3</sup> mm<sup>2</sup>/s as the threshold ADC value, sensitivities of conventional and thin-section DWI were 80% and 98% respectively. There would be 10 false-negative cases for conventional DWI and 1 false-negative case for thin-section DWI. SNR of conventional and thin-section DWI were not statistically different, likely due to the higher signal intensities of malignant lesions and longer TR used in thin-section DWI.

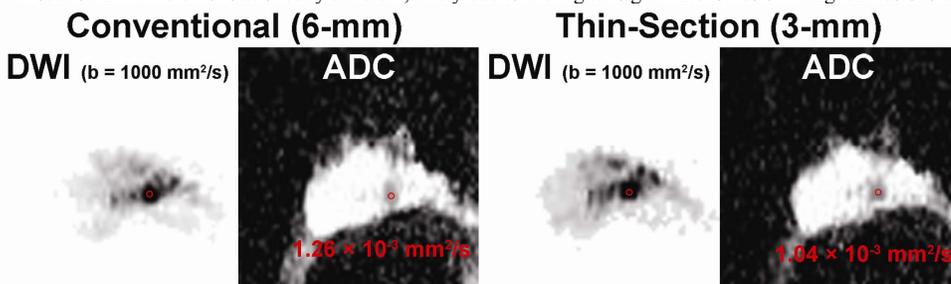


FIG. 1. Representative inverted DW images ( $b = 1000 \text{ s/mm}^2$ ) and ADC maps from the same patient using conventional and thin-section DWI. Note that reduced ADC values of malignant lesions in thin-section DWI. This would be a false-negative case if only conventional DWI (6-mm) was performed.

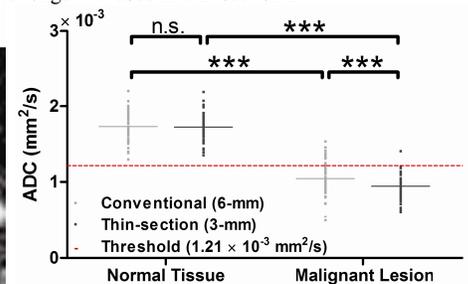


FIG. 2. ADC values of normal breast tissues and malignant lesions with conventional and thin-section DWI. Statistical tests were performed with \*\*\* for *p* < 0.001 and n.s. for insignificance.

## CONCLUSIONS

In this study, we evaluated the effect of thin-section DWI in detecting malignant breast lesions at 3 T. Reduced ADC values were observed and characterized in malignant lesions, compared to normal breast tissues. Differential ADC values were demonstrated between conventional and thin-section DWI in malignant lesions. Higher sensitivity was achieved using thin-section DWI in diagnosis of malignant lesions. Work is currently underway to characterize the ADC values of benign and malignant lesions. These results indicate that thin-section DWI may be more sensitive in detecting malignant lesions at 3 T.

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