Whole Body Diffusion Weighted Imaging/ADC Mapping and MR Spectroscopy for Detection and Monitoring of Metastatic Cancer at 3T:Preliminary Results

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INTRODUCTION: The ability to diagnose metastatic disease without radiation would be an advancement in the initial work-up of cancer[1]. The purpose of this study was to investigate the potential use of whole body diffusion weighted imaging (WB-DWI) coupled with magnetic resonance spectroscopy (MRS) for the detection and monitoring of metastatic disease in patients at 3T.

METHODS: Eight normal subjects and one patient with known malignancy (breast) were scanned with WB-DWI/MRS methods using a Trio-Tim System 3T MRI scanner (Siemens Medical Solutions, Inc). The normal subjects were included to determine the normal range of expected ADC values. MR image planes were determined by the location of the primary lesion. Axial, sagittal, or coronal fat-suppressed T_2-weighted images (TR/TE=6640/84ms, FOV=40x40cm^2, 256x256, slice thickness=4mm) and DWI images (TR/TE=4000/67ms, b=50,400-800 sec/mm^2, 192x192, FOV=40x40cm^2, slice thickness=4mm) using GRAPPA (acceleration factor=2) were acquired[2]. MRS was acquired depending on the location of the metastatic lesion using a PRESS (TR/TE 1500/144ms) sequence or with 2D PACE (Prospective Acquisition Correction) technique. Total data acquisition time for MRS was 2-6 minutes. The echo signal was digitized with 512 data points with a spectral width of 1700 Hz. Total acquisition time (coronal or sagittal) was approximately 40 min. Metastatic disease on MRI was confirmed by clinical standards, e.g., ^{Tc}99m and/or PET/CT. Whole body trace ADC maps and T_2WI were constructed for quantitative analysis and ROIs were drawn in regions of normal and abnormal appearing signal intensity in the DWI images and localized to the ADC map (see figures). MRS metrics were measured using choline SNR. T_2 and T_1 relaxation times were measured in bone in normal subjects. Statistics are presented as mean±SD.

Fig. 1. 47 y/o female with metastatic breast cancer and disease progression into the liver, pancreas, spine, pelvis and femur. Metastatic sites are clearly demarcated by the WB-DWI/ADC mapping (see arrows).

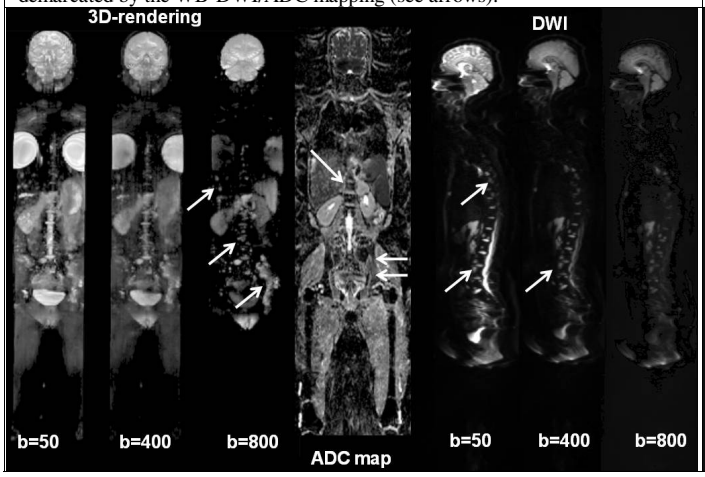
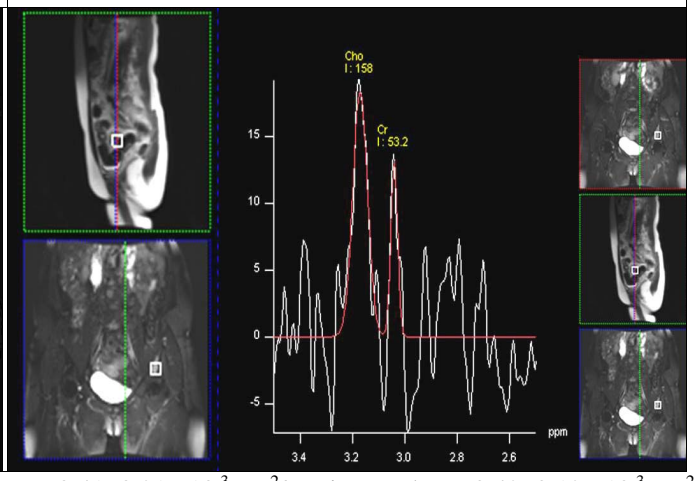


Fig. 2. 47 y/o female with breast cancer. MRS (TR/TE=1500/144) in pelvis at one of the metastatic sites (L iliac crest) demonstrates choline signal.



RESULTS: ADC values for bony structures in normal subjects were 0.41±0.21 x10^{-3}mm^2/sec in vertebrae, 0.42±0.12 x10^{-3}mm^2/sec in iliac crest, and 0.07±0.04 x10^{-3}mm^2/sec in femur. In patients, ADC values were 1.1±0.2 x10^{-3}mm^2/sec in "lesion" (iliac crest) region, 0.68±.017 x10^{-3}mm^2/sec in "normal" iliac crest and 0.97±0.2 x10^{-3}mm^2/sec in metastatic liver region. Similar results were noted in other regions. These ADC values were significantly different (p=0.01) between patients and normal subjects. WB-DWI demonstrated that metastatic disease had progressed from bone to the liver. Figure 1 demonstrates a patient with metastatic breast cancer and disease progression into the liver, pancreas, spine, pelvis and femur. MR spectroscopy performed on the bony metastatic site had increased choline in the region (Figure 2). Normal subjects demonstrated no choline peak in bone. Relaxation parameters for lipids were T2 (94 ms) and T1 (360 ms) from the femur.

DISCUSSION: We have demonstrated the feasibility of using WB-DWI/ADC and MRS at 3T to identify and potentially characterize both bony and visceral metastasis. We have shortened the imaging time from 60 to 40 minutes by practice, thus enabling a more clinical "friendly" scan. Other studies have been performed at 1.5T[3-7]. There were significant differences in the ADC values in areas of metastatic disease compared to normal subjects. Using MRS, the metastatic site showed an increased choline peak which confirms the metastasis progression. However, more optimization is needed for the MRS. In conclusion, our data serve as proof of principle about the use of DWI/ADC mapping combined with MRS to detect metastatic disease and provide a method for monitoring of the therapeutic response.

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