Hybrid T2 and diffusion weighted MRI for prostate cancer detection

Shiyang Wang[1], Yahui Peng[1], Milica Medved[1], Ambereen Yousuf[1], Marko Ivancevic[2], Ibrahim Karademir[1], Yulei Jiang[1], Tatjana Antic[3], Steffen Sammet[1], Aytek Oto[1], and Gregory Karczmar[1]

[1]Radiology, University of Chicago, Chicago, IL, United States, [2]MR clinical science, Philips Healthcare, Cleveland, OH, United States, [3]Pathology, University of Chicago, Chicago, IL, United States

Abstract: A novel, hybrid MR imaging method was implemented for prostate cancer detection. The proposed hybrid imaging acquires diffusion weighted MRI (DWI) data at three echo times (TE's), and allows calculation of ADC and T_2 as functions of TE and diffusion weighting factor (*b*-value), respectively. Preliminary results showed that both ADC and T_2 calculated from the hybrid imaging data can help differentiate normal tissue regions and cancer foci. ADC at higher TE showed better differentiation than ADC at lower TE. The two dimensional $1/T_2$ map improved separation of cancer and normal voxels relative to a 1D comparison.

Introduction: Previous MRI studies of prostate cancer demonstrated advantages of combined T_2/ADC imaging, but measured T_2 and ADC independently, and thus implicitly assumed that ADC and T_2 in each voxel are independent. However, studies of neurological model systems demonstrated that ADC and T_2 are frequently coupled.[1] In this research, we studied the dependency of ADC and T_2 on *b*-value and TE, respectively, in normal prostatic tissue and prostate cancer.

Methods: This IRB-approved study included ten patients with biopsy proven prostate cancer. The average age of the patients was 64.8 years (range 48–74); median serum prostate-specific antigen level was 7.06 ng/mL (3.53–20.34). Fifteen cancer and 10 normal regions of interest (ROIs) were outlined on ADC images by an experienced radiologist after reviewing both ADC and T_2-weighted images and the biopsy reports. DWI were acquired in the axial plane with free breathing, using a standard pelvic spin echo sequence with EPI readout (Philips 3T AchievaTX). Data were acquired with *b*-values of 0, 750, and 1500s/mm^2; TE's of 47, 75, and 100 ms; in-plane resolution of 2.5x2.5mm^2, slice thickness of 3 mm, TR of 3000 ms, and 4 averages. The total scan time was 7.0–8.7 minutes. ADC and T_2 were calculated for each TE and *b*-value, respectively, using least squares fitting to a mono-exponential decay model. The Mann-Whitney U test was performed to compare ADC or T_2 values between prostate cancer and normal prostate ROIs. The Friedman test was used to compare ADC and T_2 values at different TE's and *b*-values.

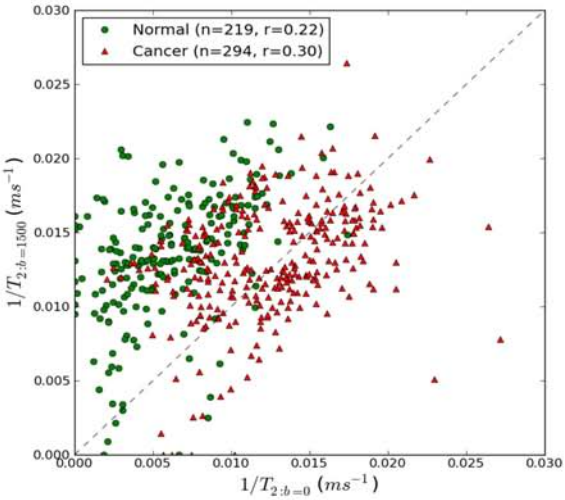

Fig.1 Scatter plot of voxel-wise $1/T_2$ at two *b*-values for cancer (red) and normal tissue (green). Dashed line is the identity line.

Results: ADC values were significantly different between prostate cancer ROIs and normal ROIs, p = 0.00009, 0.00009, and 0.00006, for TE = 47, 75, and 100 ms, respectively. ADC of normal prostate ROI's increased significantly from 1.4 ± 0.18 at TE = 47 ms to 1.66 ± 0.19 at TE = 100 ms (p=0.0003). In cancer ROIs, ADC changes as a function of *b*-value were much smaller, and in many pixels ADC increased as a function of TE, the opposite of normal prostatic tissue. T_2 values at *b*=0 in normal prostatic tissue ROI's and cancer ROI's were significantly different (p=0.003); 330 ± 208 ms in normal prostate vs. 106 ± 52 ms in cancer. T_2 in normal prostate decreased significantly with increased *b*-value: T_2 values at b = 0 and 1500 s/mm^2 were 330 ±208 and 113±77 ms, respectively (p = 0.001). T_2 values of cancer ROIs did not change significantly as a function of *b*-value (p = 0.42), but in many cancer voxels, T_2 increased as a function of *b*-value, the opposite of normal voxels. The 2D scatter plot of $1/T_2$ (b=0 s/mm^2) vs. $1/T_2$ (b=1500 s/mm^2) improves differentiation of cancer from normal ROIs (Fig.1), compared to the conventional 1D method. Figure 2 demonstrates that cancer (red arrow) is more conspicuous in ADC map at TE = 100 ms, and in the difference image, compared to the ADC map at TE = 47 ms. This was typical of the studied lesions.

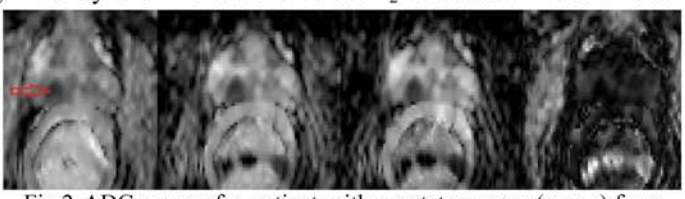

Fig.2 ADC maps of a patient with prostate cancer (arrow):from left to right, ADC at TE=47, 75, 100 ms and the absolute value of ADC_{TE47}-ADC_{TE100}. Scale is the same for first three images, and the last image is scaled [0, maximum].

Conclusion and Discussion: ADC and T_2 change significantly as functions of TE and *b*-value in normal prostatic tissue, respectively, and the changes are much smaller and sometimes may have the opposite sign in cancer. Cancers are more conspicuous in ADC maps at longer TE. This new hybrid approach has the potential to produce combined parameters that may increase diagnostic accuracy, and to help optimize non-hybrid imaging parameters.

References: 1. Burdette JH, Elster AD, Ricci PE. Radiology 1999;212(2):333-9.