Zone Specific ADC + DCE-MRI Composite Maps to Aid in the Detection and Evaluation of Prostate Cancer

Naira Muradyan[1], Osama Elbuluk[2], Baris Turkbey[2], Sandeep Sankineni[2], Maria J Merino[3], Senthil Periaswamy[1], Marcelino Bernardo[2], Francois Cornud[4], and Peter L Choyke[2]

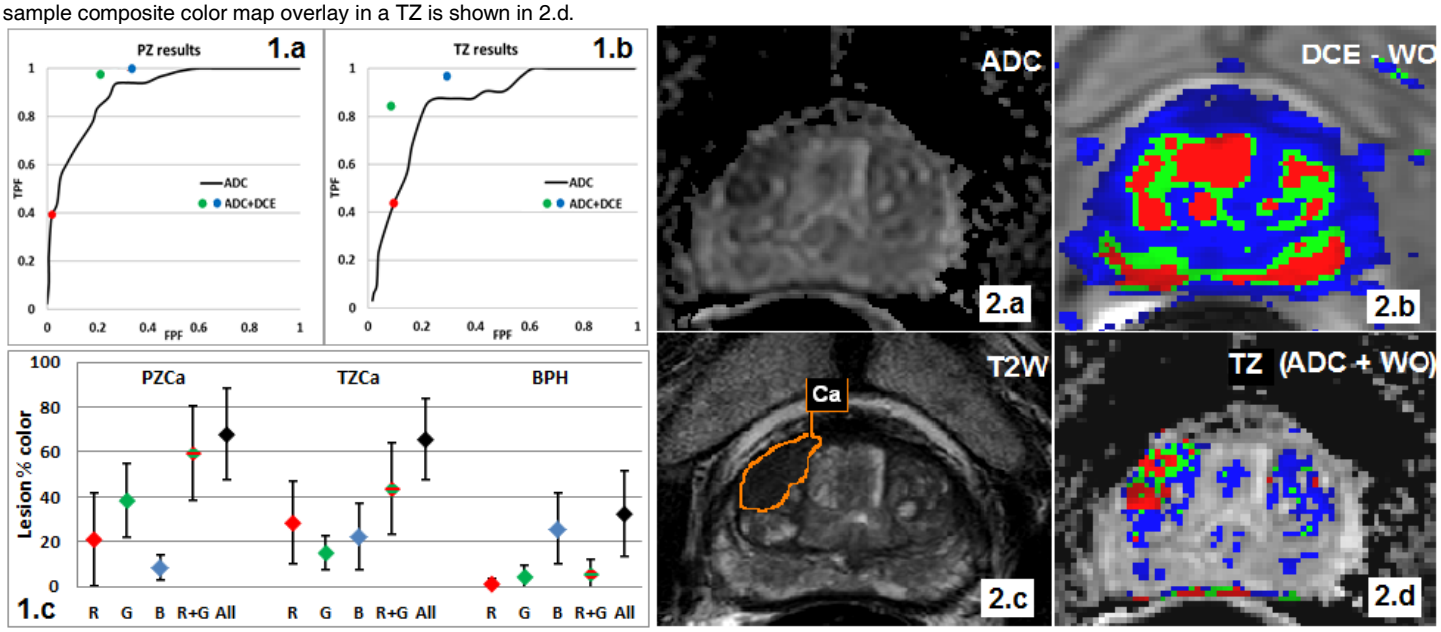
[1]*iCAD, Inc., Nashua, NH, United States,* [2]*Molecular Imaging Program, NCI, NIH, Bethesda, MD, United States,* [3]*Laboratory of Pathology, NCI, NIH, Bethesda, MD, United States,* [4]*Tourville Imaging Centre, Paris, France*

TARGET AUDIENCE: This study will be of particular interest to clinicians including radiologists and urologists, as well as scientists working on various aspects of multiparametric magnetic resonance imaging (MRI) of the prostate.

PURPOSE: The role of MR imaging in routine prostate cancer detection and workup has been growing steadily. Commonly, T2 weighted (T2W), diffusion-weighted (DWI) and dynamic contrast-enhanced (DCE) images are acquired during the exam and evaluated. ADC (apparent diffusion coefficient) has been known for best standalone performance in the peripheral zone. Hence, some automated methods combining ADC with quantitative T2W and/or DCE have been proposed [1,2] and are shown to increase reading specificity [3]. However, often such parameters have limitations, e.g. quantitative T2W, which is not readily available on most scanners, and/or quantitative DCE parameters, e.g. Ktrans, shown to vary widely from site to site due to lack of overall standardization of quantitative DCE acquisition and post-processing methods [4], and are driven by data from a single clinical center, making them site specific. We propose a method of combining ADC and non-quantitative DCE, based on data from 2 sites, which could be easily implemented in routine prostate imaging. The main goal was to create a zone specific composite colormap, minimizing the need for separate evaluation of sequences, dynamic curves, while improving accuracy of standalone ADC outcome.

METHODS: This was a retrospective study using images from two sites of total 105 patients: 97 had subsequent prostatectomy, 8 - MR targeted biopsies. Patients were entered on an IRB-approved study. Both sites used an endorectal coil during the MRI exam and Magnevist (Bayer, Schering) for DCE acquisition. Site 1 employed a 3T Philips scanner, with DCE at 5.4sec/phase and DWI/ADC with b-values: 0, 188, 375, 563, 750 s/mm^2. Site 2 had a 1.5T Siemens scanner, DCE at 8.5sec/phase, b-values: 0, 100, 200, 400, 800 s/mm^2. Axial T2W images were used to identify the lesions seen on prostatectomy samples or targeted biopsies and to draw ROI's, which were further re-directed on to ADC and DCE sequences. The data were divided into 2 groups. The first consisted of 26 exams from site 1 and 39 from site 2 and used for development of the zone specific composite colormaps. The second had 40 exams from site 1 for further testing.

RESULTS: In the first step there were 84 peripheral zone (PZ) and 32 transition zone (TZ) cancerous lesions identified. Other ROI's were also drawn: a) benign lesions on whole mount specimens, also appearing benign on MRI, 66 in PZ, 64 in TZ; b) benign on path specimens, but hypo-intense on ADC and/or DCE with washout, 86 in PZ, 70 in TZ; c) 54 TZ ROI's with common MRI appearance of benign prostatic hyperplasia nodules (BPH). DCE washout (WO), defined as washout between the maximum enhancement within first 50sec post-contrast and 4min post-contrast, showed better performance than the initial enhancement, and therefore was the chosen DCE metric. The average values for ADC (10^{-3}mm^2/s) and DCE-washout (%) for each ROI were determined. ADC standalone (1.a) optimal performance was best using 1.35x10^{-3}mm^2/s cut off with Sensitivity/Specificity=0.929/0.737 in the PZ and 1.05x10^{-3}mm^2/s cut off with Sensitivity/Specificity=0.844/0.787 in the TZ (1.b). To increase accuracy and reflect heterogeneity of lesions, we assigned one of 3 colors to each qualifying voxel as follows: for **PZ** – Red if ADC<0.95x10^{-3}mm^2/s, else Green if (WO+120xADC)/165<1, else Blue if ADC<1.3x10^{-3}mm^2/s OR (ADC<1.7x10^{-3}mm^2/s & WO<-8%); for **TZ** - Red if ADC<0.9x10^{-3}mm^2/s, else Green if ADC<1.06x10^{-3}mm^2/s & WO<2%, else Blue if ADC<1.4x10^{-3}mm^2/s & WO<2%. These are shown as red, green and blue dots on ROC charts 1.a,b. A sample composite color map overlay in a TZ is shown in 2.d.



In the second, test step of the analysis, the per voxel logic described above was applied to 40 exams with whole mount path from site 1, ROI's for 23 PZ (average Gleason 7.5, vol 0.86cm^3), 24 TZ (7.46GI, 2.11cm^3) cancerous and 29 BPH (2.43cm^3) lesions were drawn and analyzed for color composition (1.c). Cancers showed statistically significantly higher red, green and red+green % than BPH (1.c).

DISCUSSION: This pilot study shows the application of a combined DWI and DCE-MRI logic for improved accuracy over ADC alone. Compared with the common evaluation flow, i.e. identifying suspicious areas on ADC (2.a) or DCE (2.b) only driven maps, then checking the behavior of the respective area on the other image type/s, the suggested method highlights areas that are suspicious based on automated composite analysis of both image sequences in their respective anatomical zones (2.d). Red voxels being more specific and blues more sensitive indicators of cancer possibility (2.d).

CONCLUSIONS: Objective display of composite ADC and DCE information may be useful for depicting tissue/lesion heterogeneity, minimizing intra and inter-reader variability and eventually aid in overall standardization of lesion evaluation process during multiparametric prostate imaging. Future studies will be carried out using data from other sites to further test and refine, as needed, the suggested method. Automated prostate segmentation will be used to automatically combine zone specific composite colormaps in one.

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