Improving the diagnosis of prostate cancer using multiparametric magnetic resonance imaging

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PURPOSE

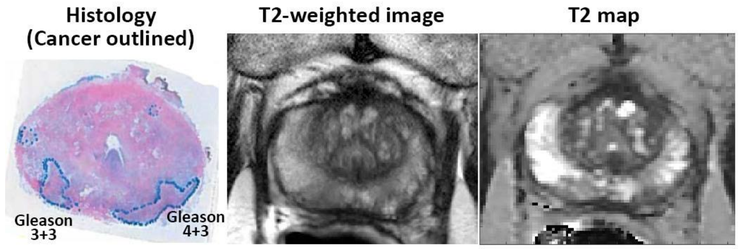
Prostate cancer (PCa) is the second leading cause of death among men in the United States. Multiparametric magnetic resonance imaging (mpMRI) is used in the detection, characterization, and staging of PCa. However, a large number of PCa often go undetected on MRI and further studies are needed to improve the diagnostic accuracy in PCa detection and staging.

PCAMP REVIEW DEVELOPED BY RCC

PCampReview is a software module developed by RCC, that provides a platform for Visualization of mpMRI sequences, Registration, Annotating Region of interests (ROIs) and propagating ROIs to other MR sequences. It can be customized for each project. Subsequent analysis were performed using MATLAB on **RCC Midway**. RCC Resources: PCampReview and RCC Midway were used in the following research studies

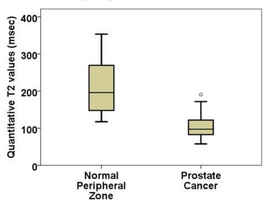
OBSERVER STUDY

We compared the performance of T2 maps with conventional T2-weighted (T2W) MR images in detection of PCa. Two radiologists working independently, marked regions of interests (ROIs) on PCa lesions separately on T2W images, and T2 maps obtained from mono-exponential signal decay of multi-echo Turbo Spin Echo images using **PCampReview** for 45 patients. Each ROI was assigned a score 1-5 based on the confidence level in accurately detecting cancer, with 5 being the highest confidence. Our study shows that review of T2 maps by radiologists has similar sensitivity and confidence score but higher positive predictive value compared to traditional T2-weighted MR images. Additional quantitative information obtained from T2 maps is also helpful in differentiating cancer from normal prostate tissue.



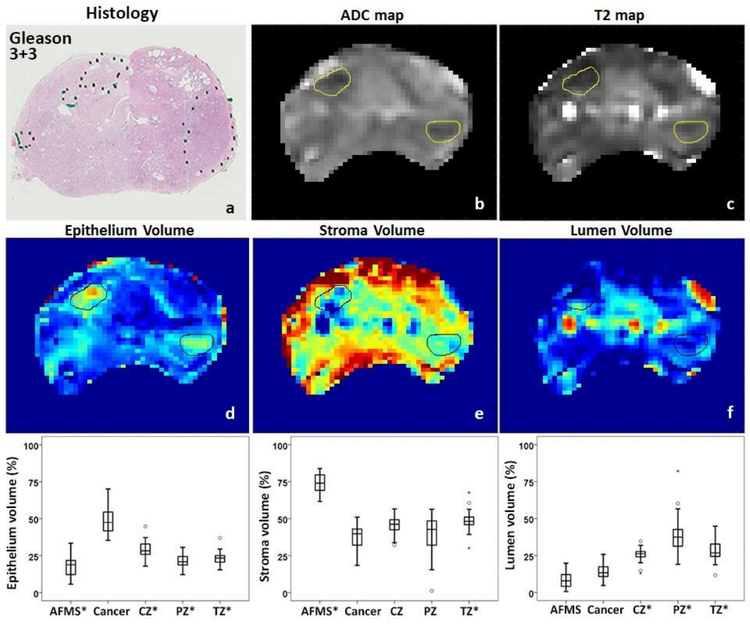
MRI sequence		Sensitivity	Positive Predictive Value	Mean Confidence Score
T2-weighted vs T2 maps				
T2W		51 %	72 %	2.3±2.3
T2 map		52 %	88 %	2.3±2.3
Endorectal coil usage				
T2W	*No endorectal coil*	47 %	71 %	2.0±2.3
	Endorectal coil	54 %	72 %	2.5±2.3
T2 map	*No endorectal coil*	48 %	89 %	2.2±2.3
	Endorectal coil	54 %	87 %	2.4±2.3

Quantitative T2 values from T2 maps: T2 values are significantly lower for prostate cancer compared to normal peripheral zone tissue



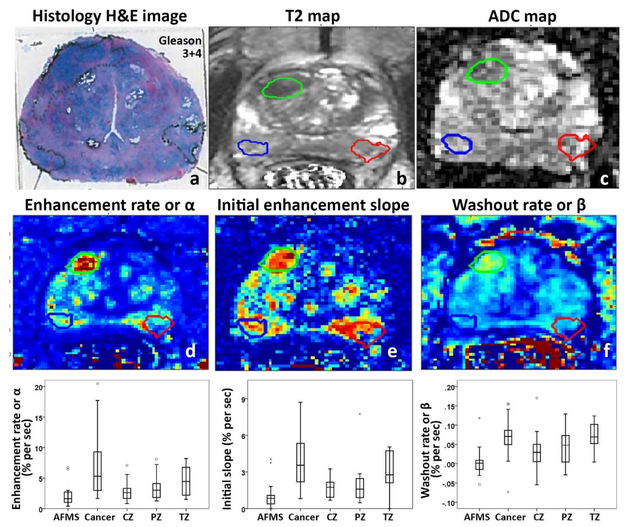
HYBRID MULTIDIMENSIONAL MRI (HM-MRI)

HM-MRI measures the change in ADC and T2 as a function of TE and *b*-value, respectively. This interdependence is used as a source of information about the underlying tissue microstructure. Specifically, we analyzed HM-MRI data to identify signal contribution from epithelial, stromal and luminal compartments in each image voxel by fitting the hybrid data to a three compartment signal model using MATLAB on **RCC Midway** in 21 patients. PCa (*n*=28) showed significantly increased fractional volumes of epithelium (48.8±9.2 vs 23.2±7.1%) and reduced volume fractions of lumen (14.0±5.2 vs 26.4±14.1%), and stroma (37.2±9.1 vs 50.5±15.7%), as compared to normal tissue (*n*=71). These trends are similar to those reported in previous histological studies. The volume fractions of epithelium (0.65), stroma (-0.44) and lumen (-0.39) show significantly higher Spearman correlation coefficient with Gleason score as compared to T2 (-0.29) and ADC (-0.32). Prostate tissue composition estimated non-invasively using HM-MRI (epithelium 0.99, lumen 0.80, stroma 0.79) have better diagnostic accuracy of detecting PCa over traditional T2 and ADC values (AUC 0.71).

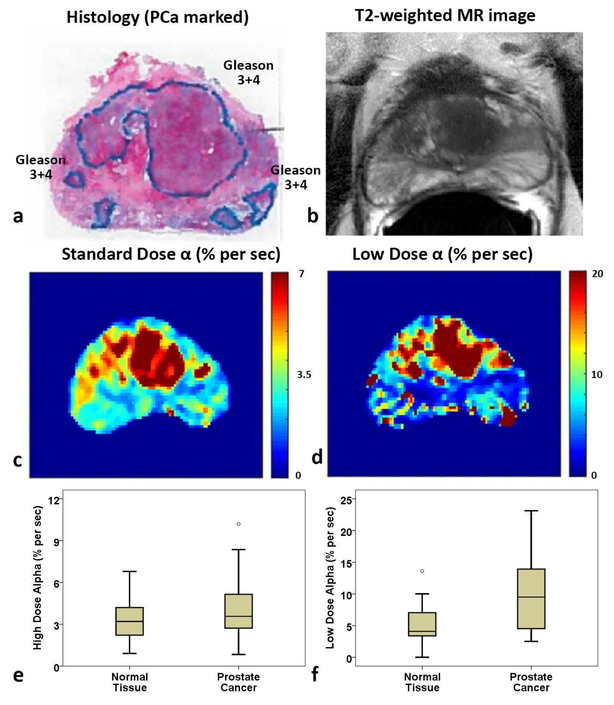


DYNAMIC CONTRAST ENHANCED (DCE) MRI

ULTRAFAST DCE: We evaluated the performance of high temporal resolution (~ 2.2s) DCE-MRI in diagnosis of PCa . DCE data was analyzed by fitting signal intensity with an empirical mathematical model (EMM) on **RCC Midway** to obtain parameters: signal enhancement rate (α), washout rate (β), and initial enhancement slope for 20 patients. Cancer (α=6.8±4.8 s^{-1}, β=0.070±0.042 s^{-1}, slope=3.8±1.9 s^{-1}) showed significantly (p<0.05) faster signal enhancement and washout rates than normal tissue (α=3.2±2.2 s^{-1}, β=0.037±0.051 s^{-1}, slope=1.9±1.5 s^{-1}). Additionally, combining DCE with ADC and T2 increased AUC by ~30%, further improving the diagnostic accuracy of PCa detection. DCE-MRI with shorter temporal resolution allow capturing helpful information for PCa diagnosis that would be otherwise missed by longer temporal resolution DCE-MRI.



IS LOW DOSE DCE-MRI FEASIBLE: We investigated whether administration of low doses of Gd (0.015 mmol/kg) for DCE MRI can be effective as a standard dose of Gd (0.085 mmol/kg) in distinguishing PCa from benign tissue in 17 patients. Quantitative DCE-MRI with low Gd dose (10.0±5.8 vs 5.1±2.9 s^{-1}) better distinguishes PCa from benign prostate tissue than standard Gd dose (4.3±2.2 vs 3.4±1.5 s^{-1}), based on signal enhancement rate (α). Area under the ROC curve for differentiating PCa from benign tissue using α was higher for low dose (0.77) compared to standard dose (0.63).



FUTURE PROJECTS

1. mpMRI features of different types of benign prostatic hyperplasia (BPH)
2. Prostate cancer risk maps- Fusion of ADC, T2 and DCE parameters