Predictive Value of 3T mpMRI: Correlation with MRI-guided Transperineal Targeted Prostate Biopsy Outcomes

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Introduction

Transrectal ultrasound (TRUS)-guided sampling biopsy of the prostate gland, the standard of care for the diagnosis of prostate cancer can be falsely negative in 30% of cases [1]. Multiparametric MRI (mpMRI) using 3 Tesla (3T) scanners may help detect cancer in the prostate gland [2]. This information can be used to guide targeted biopsy under 3T MRI to increase yield. Purpose of this study was to assess the value of mpMRI to predict cancer outcome of MRI-guided targeted prostate biopsies.

Materials and Methods

Patient Population: Between January and October of 2011, 12 eligible patients (age range: 63-81 y.o.) had MRI-guided prostate biopsy under an institutional review board (IRB) approved prospective clinical trial compliant with the Health Insurance Portability and Accountability Act. All patients in the study cohort had elevated serum prostate specific antigen (PSA). Seven had multiple prior TRUS-guided prostate biopsies with negative outcome. Three patients had prior prostate brachytherapy treatment and suspected recurrence with elevated PSA. Two had no rectum and required a transperineal approach for biopsy.

mpMRI, Target Selection and Rating: All 12 patients had mpMRI using a 3T system (GE Medical Systems) with an endorectal coil used in 10. Imaging sequences included T2WI (FSE), DWI (EPI; b0-500; b0-1400), and DCE sequence (3D SPGR) using intravenous contrast administration (Magnevist; 0.1 mmol/kg) with CineTool research software (GE Global Research) used for generating pharmacokinetic (PK) maps (K^{trans}, v_e, time to peak, max slope, area under the curve) **(Fig.1a-c)**. Three radiologists with Abdominal Imaging Fellowship training and at least five years prostate MRI expertise, independent from each other, rated each of the MR sequences in an integrated prospective fashion, selecting targets for biopsy. Rating was based on degree of suspicion on a scale of 1 through 5 (1: Definitely not cancer, 2: Probably not cancer, 3: Indeterminate, 4: Probably cancer, 5: Definitely cancer). The three individual reader's targets were then consolidated as one target (and the ratings averaged) whenever they were within 10mm of each other in the craniocaudal direction (the direction of the core biopsy sampling length) and 7mm in the axial plane (based on previous needle placement accuracy study). ROC curves for each MR parameter were calculated based on cancer or no cancer outcome on biopsy. To calculate biopsy outcome metrics, ratings were converted to binomial data with rating of ≤ 3 taken as not cancer, and > 3 as cancer.

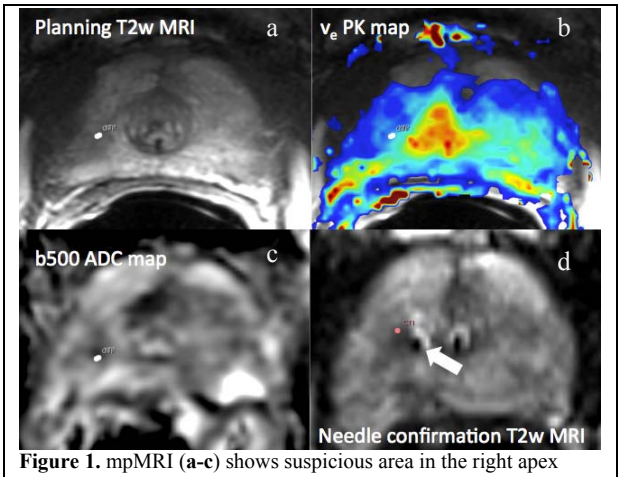

Figure 1. mpMRI (**a-c**) shows suspicious area in the right apex marked for biopsy (white dot), with decreased T2 signal (**a**), low extracellular extravascular space (**b**), and reduced diffusivity (**c**). Intraprocedural T2WI (**d**) shows biopsy needle artifact (white arrow) ~4 mm from the registered target (red dot). Pathology confirmed 3+3 Gleason grade prostate cancer.

Biopsy Procedures: All biopsies were performed as previously described [3] but modified for 3T [4]. Patients were placed into the 70cm bore 3T interventional MRI (Siemens MAGNETOM Verio) in the lithotomy position. The scrotum was taped away from the perineum and 3T Body Matrix Coil (Siemens) placed over the lower pelvis anteriorly. No endorectal coil was used. Perineum was prepped in the usual sterile fashion and a sterile needle guidance template was placed up against the perineum. The patient table was moved into imaging position with the rear of the scanner providing direct access to the perineum for biopsy needle placement. Using anteriorly placed Body Matrix Coil (6-channel) with posteriorly located Spine Matrix Coil elements (6-channel) incorporated in the table top, 3D FLASH (TR/TE: 12/1.97 ms; matrix: 256×256×20; flip angle: 45°; slice thickness: 2 mm; acquisition time: 2 min) was performed to calibrate the perineal template to imaging coordinates. Then, 2D turbo spin echo (TSE) T2WI (TR/TE: 5250/100 ms; flip angle: 150°; matrix: 320×320; slice thickness: 3 mm; acquisition time: 4 min) was performed through the prostate gland. These images were processed with image fusion, target selection, and needle placement planning software (3D Slicer). Through non-rigid registration of diagnostic MRI to intraprocedural T2W images, targets selected were mapped and access to these targets was computed by prescribing the location of the needle hole on the template and the needle depth. Utilizing this information, needles were placed and location confirmed using axial and coronal real-time 2D FISP (TR/TE: 402/1.45 ms; flip angle: 48°; matrix: 128×128; slice thickness: 6 mm) or axial TSE T2WI (TR/TE: 5250/100 ms; flip angle: 150°; matrix: 320×320; slice thickness: 3 mm; acquisition time: 44 sec). Biopsy sample was taken only when the needle artifact was confirmed to be within 7 mm of the intended target **(Fig.1d)**. Using an MRI-compatible 18-gauge spring-loaded side-cutting needle device (EZ-EM), two core samples were obtained from each target and sent for site specific pathological analysis in formalin. Patients received local anesthesia together with intravenous procedural sedation during the procedures that lasted 1-2 hours. Following two hour postprocedural observation, all patients were discharged home accompanied by escort.

	ROC AUC
T2WI	0.75
ADCb500	0.80
ADCb1400	0.81
Ktrans	0.61
v_e	0.81
MaxSlope	0.60
TimeToPeak	0.67
AUC90	0.57
Subtraction	0.69

Table 1. ROC area under the curve (AUC) for the nine prostate MRI parameters.

Results

Seven patients had prostate cancer on biopsy; five had no cancer. A total of 67 targets were selected and biopsied in these 12 patients (Mean targets per patient: 5.6, range: 3-8). Pathology showed prostate cancer from 18 targets (27%) while 49 targets (73%) had no cancer. 9 targets were selected and rated by all three readers, 16 by two, and remaining 42 by one. ROC curve analysis revealed highest area under the curve for ADC, v_e, and T2WI **(Table 1)**. Biopsy outcome metrics for these three individual parameters and their combinations are given in **Table 2**. High test metrics were achieved when both ADCb500 and v_e predicted cancer, or when all three suggested cancer.

	Sens.	Spec.	PPV	NPV
T2WI	0.57	0.78	0.88	0.40
ADCb500	0.45	0.78	0.85	0.34
v_e	0.65	0.67	0.84	0.41
T2WI & v_e	0.78	0.56	0.83	0.48
T2WI & ADCb500	0.65	0.67	0.84	0.41
ADCb500 & v_e	0.80	0.67	0.87	0.55
T2WI & v_e & ADCb500	0.84	0.56	0.84	0.56

Table 2. Test metrics using three MRI parameters.

Conclusion

Multiparametric 3T MRI can help increase the yield of cancer diagnosis when it is used to guide targeted prostate biopsy. To increase sensitivity and PPV for detecting prostate cancer through imaging-guided targeted biopsy, at least two parameters, ADCb500 and v_e, should be combined to select targets.

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