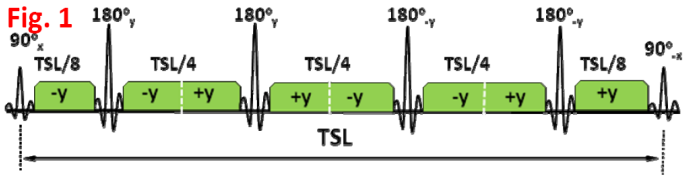
MR T1ρ Imaging on Human Prostate Cancer

Xiang He[1], Serter Gumus[1], Ayaz Aghayev[1], Jie Zheng[2], and Kyongtae Ty Bae[1]

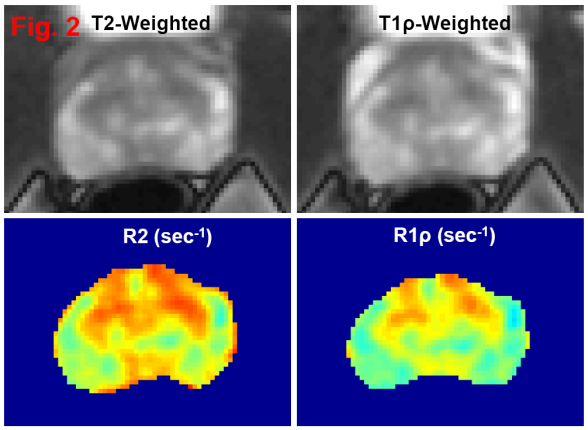
[1]*Department of Radiology, University of Pittsburgh, Pittsburgh, PA, United States,* [2]*Mallinckrodt Institute of Radiology, Washington University in St Louis, St Louis, Missouri, United States*

Introduction: Prostate cancer is the second leading cause of death in men and the most commonly diagnosed malignancy. MRI has the advantage of determining the location, extension and metastatic involvement of prostate tumors (1,2). In clinical MRI, prostate cancer is usually detected as hypo-intensity in the prostate peripheral zone on T2-weighted images (3). However, benign conditions such as hemorrhage, prostatitis, hyperplastic nodules and previous radiation may also show similar T2 hypo-intensity. Diffusion weighted MR (4), MR spectroscopy imaging (5) and DCE MR imaging (6) may increase the accuracy of the diagnosis and staging of prostate cancer. T1ρ describes the longitudinal relaxation of MR signal in the rotational frame. T1ρ is sensitive to the tissue compositions and to the slow motion interactions between macromolecular protons and bulk water (7). It has been successfully used in the characterization of various physiologic and pathologic conditions such as brain tumors, myocardial metabolism, knee cartilage degradation, liver fibrosis and kidney function. In this study, we will assess the efficacy of T1ρ sequence for morphologic and quantitative imaging of the prostate in both healthy volunteers and patients diagnosed with prostate cancer.

Methods: All experiments were performed on a 3T Siemens Trio scanner using a body transmit RF coil and spine/body matrix coils. Four healthy volunteers and two patients diagnosed with prostate cancer (based on PSA measurement and biopsy) were enrolled in the study. The previously reported T1ρ preparation technique (8) was further modified to minimize sensitivity to both B0 and B1 field inhomogeneities. Four refocusing blocks were employed, as shown in Fig. 1. Each 180-degree refocusing RF pulse was configured with composite pulses to reduce artifacts. The time of spin-locking (TSL) varied from 10 to 100 msec. B1 for spin-locking was chosen at 8 μT (350 Hz). After T1ρ preparation, a 2D single-slice TrueFISP image was acquired. The MR parameters were: FOV of 256x256 mm^2; slice thickness of 8 mm; in plane resolution of 1.0x1.0 mm^2; TR of 4 to 6 s (limited by SAR); TE of 1.43 ms; and centric reordering. Acquisition time for each TSL was 2 to 3 min with 30 repetitions. Six to seven T1 ρ weighted image were acquired. For T2 measurement, B1 was set to be zero.



Results: Fig.2 shows typical T2- and T1ρ-weighted prostate images acquired from a healthy subject. The estimated relaxation rate maps for R2 and R1ρ are also displayed. As expected, the peripheral zone (PZ) has longer T2 and T1ρ than that of the central zone (CZ), which shows a significantly higher degree of heterogeneities. Both T2 and T1ρ maps show remarkable uniformity in PZ for this subject. Studies other our healthy subjects also indicate that the T1ρ decay may not be exactly symmetric between the left and right PZ, as illustrated in Fig. 3, potentially due to the variations on granular structure.



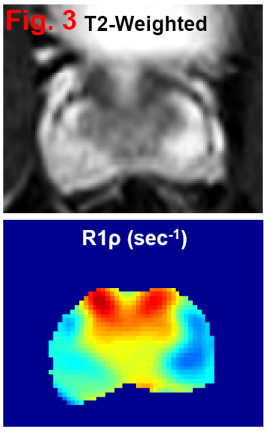
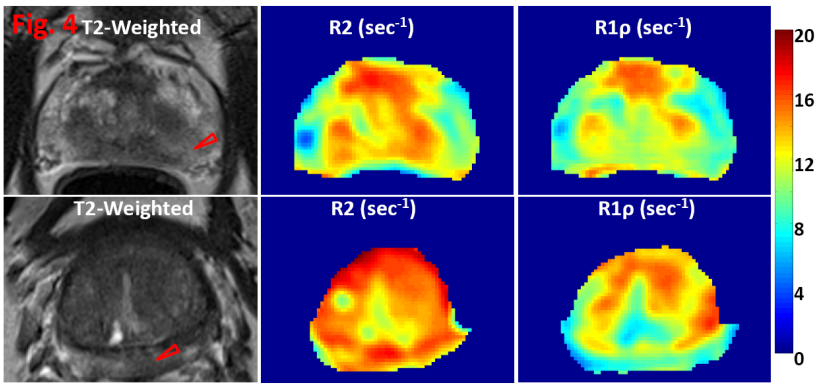


Fig. 4 illustrated the T2-weighted image and the corresponding estimated T2 and T1ρ maps for patients diagnosed with prostate cancer. These patients had high PSA levels, but only one biopsy confirmed the presence of tumor cells. Compared to healthy subjects, patients demonstrated an elevated level of T2 heterogeneities in PZ. For patient 1 (first row), the lower right PZ shows a faster T2 and normal T1ρ decay. For patient 2 (second row), T2 and T1ρ maps suggest an abnormally fast T2 decay and normal T1ρ decay at the middle and lower part of the right PZ. The discrepancy between T2 and T1ρ in the suspected tumor lesion ROI may reflect its higher level of cellular contents.



Discussion: We have developed and applied a T1ρ sequence that was designed specifically to desensitize B0 and B1 field inhomogeneity to acquire in vivo human prostate T1ρ-weighted images and T1ρ mapping. Our study demonstrated that robust T2 and T1ρ quantification is feasible at 3T without the utilization of an endorectal coil. When combined with T2 measurement, the T1ρ quantification of the prostate may provide additional information to improve the diagnosis of prostate cancer.

References: **(1)** Huzjan, et al, NatClinPractUrol 2005;2:434. **(2)** Mazaheri, et al., JMRI 2011; 33:258. **(3)** Bezzi, et al., Radiology 1988; 169:339. **(4)** Haider, et al., AJRAmJRen 2007; 189:323. **(5)** Reinsberg, et al., AJRAmJRen 2007;188:91. **(6)** Jackson, et al., BrJRadiol 2009; 82:148. **(7)** Jokivarsi, et al., Stroke 2010; 41:2335. **(8)** McCommis, et al, MRM 2010; 63:1442.