Rotating frame relaxation imaging of prostate cancer: a feasibility study

Ivan Jambor[1], Timo Liimatainen[2], Harri Merisaari[3], Pekka Taimen[4], Peter Boström[5], Heikki Minn[3], Hannu Aronen[1], and Marko Pesola[1]

[1]Departement of Diagnostic Radiology, University of Turku, Turku, Finland, [2]Department of Biotechnology and Molecular Medicine, A.I. Virtanen Institute for Molecular Sciences, Kuopio, Finland, [3]Turku PET centre, University of Turku, Turku, Finland, [4]Department of Pathology, University of Turku, Turku, Finland, [5]Department of Surgery, Turku University Hospital, Turku, Finland

Introduction

Rotating frame relaxations, $T_{1\rho}$ and relaxation along fictitious field (RAFF) (1) have shown to be promising markers for several pathologies including cancer. We aimed to investigate the feasibility of RAFF and continuous wave $T_{1\rho}$ imaging of prostate cancer (PCa) at 3 Tesla (T).
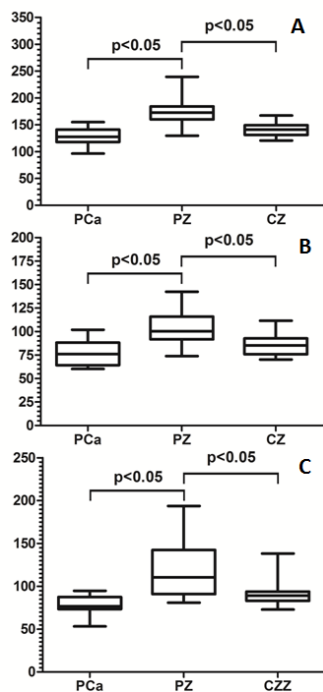
Methods

Twenty-seven patients (mean age 63 ± 7 years) with histologically confirmed PCa underwent two repeated 3T MRI (Philips, Ingenuity PET/MR) examinations using 32 channel surface array coil and 2 channel volume whole body RF coil for RF transmission before radical prostatectomy. After the first examination, a patient was taken out of the MRI bore and asked to rest for several minutes. After re-positioning of the patient on the MRI table, the second MRI examination was performed. Both, T_{RAFF} and $T_{1\rho}$ were measured using 3D T_1FFE sequence (TR/TE 3.2/1.5 ms; FOV: 375x375 mm^2; matrix size 150 x 150) with centric coding and 500 Hz RF peak amplitude. The pulse train duration for RAFF was 0, 45, and 90 ms while 0, 20 ms, and 80 ms were applied for continuous wave $T_{1\rho}$. T_2 was measured using TR/TEs of 686/20, 40, 80,100 ms; FOV 230x183 mm^2, matrix size 256 x 162. T_2 mapping was performed only during the first examination. B_1 was mapped using AFI method (2). Using whole mount prostatectomy sections as reference, ROIs (T_{RAFF} and $T_{1\rho}$: 5.85x5.85 mm^2, T_2:5.39x5.39 mm^2) were placed in the areas of PCa, normal peripheral zone (PZ) and normal central zone (CZ). T_{RAFF}, $T_{1\rho}$ and T_2 values were calculated by fitting mono-exponential function to RAFF, $T_{1\rho}$ and T_2 weighted data. Means of two measurements for T_{RAFF}, $T_{1\rho}$, and individual T_2 values were compared using ANOVA with Bonferroni multiple comparisons test. In order to assess repeatability of the T_{RAFF} and $T_{1\rho}$ measurements, the difference between two measurements (d), mean squared difference (MSD), 95% confidence interval (CI) for changes of the quantitative values of all patients (n) in thestudy cohort and the coefficient of repeatability (CV) were calculated.

$$msd = \sqrt{\sum_{i=1}^{n} d^2 \times (n-1)^{-1}} \quad CI = \pm 1.96 \times msd/\sqrt{n} \quad CV = 1.96 \times msd$$

Results

Both T_{RAFF} and $T_{1\rho}$ mappings were successful (Figure 1) in all 27 patients with reasonably homogenous B_1 field across prostate. Mean T_{RAFF} value of PCa was 128 ± 14 ms, differed significantly (p<0.05) from similar value of normal PZ (174 ± 21 ms) and normal CZ (141 ± 12 ms). Significant difference between mean $T_{1\rho}$ values of PCa (77 ± 12 ms) and normal PZ (103 ± 19 ms) was present while the difference between PCa and normal CZ (85 ± 10 ms) did not reach statistical significance. Mean T_2 values of PCa, normal PZ and normal CZ were 78 ± 11 ms, 119 ± 22 ms and 91 ± 31 ms, respectively (Figure 2). CI and CV are summarized in **Table 1**.

Figure 1: Representative relaxation time maps (T_{RAFF} (A), $T_{1\rho}$ (B) and T_2 (C)) of PCa patient with Gleason score of 5+4. The white arrow points to the area of PCa. A, B and C are scaled to min/max 0/370ms, 0/220ms, 0/300ms, respectively.

	T_{RAFF}			$T_{1\rho}$		
	PCa	PZ	CZ	PCa	PZ	CZ
CI	1.6	2.9	2.7	1.8	2.3	2.3
CV	8.3	14.9	14.2	9.1	11.7	11.8

Figure 2: Box plots with of T_{RAFF} (A), $T_{1\rho}$ (B) and T_2 (C) values. The error bars indicate min and max values.

Conclusions

Rotating frame imaging (RAFF, and continuous wave $T_{1\rho}$) of PCa was feasible using clinical 3T MRI scanner and demonstrated robust repeatability. Both T_{RAFF} and $T_{1\rho}$ of PCa differed significantly from similar value of normal PZ. RAFF method demonstrated improved image quality compared to block pulse which together with smaller specific absorption rate (39%) compared to continuous wave pulse makes RAFF an attractive method for PCa imaging. Further studies are needed to establish the role of rotating frame imaging as a part of multiparametric prostate MRI.

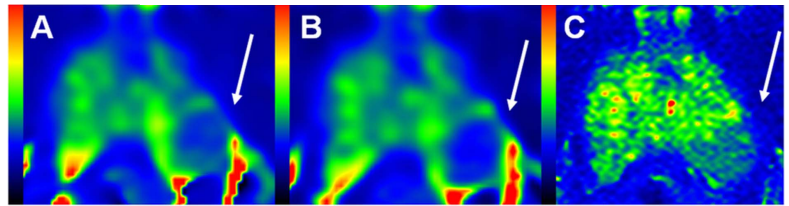**References:** 1. Liimatainen T et al. Magn Reson Med 2010; 64:983-994; 2. Yarnykh VL. Magn Reson Med 2007; 57:192-200