Can ex-vivo MRI be used for correlating diffusion weighted imaging parameters to pathology for validation of in-vivo multiparametric MRI

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Purpose: To prospectively investigate the feasibility of correlating the in-vivo diffusion weighted imaging (DWI) with Apparent Diffusion Coefficient (ADC) mapping and T2-weighted imaging (T2WI) to the ex-vivo prostate MRI at high magnetic field strengths (≥3T) and to the final histopathology in patients with prostate cancer (PCa) undergoing prostatectomy for the purpose of a better understanding of the radiological-pathological underpinning of MR imaging.

Methods: We recruited 10 patients with PCa Gleason score ≥6 scheduled for prostatectomy for our prospective, IRB-approved study. In-vivo MR imaging consisted of T_2WI, DWI, MRS, and DCE before prostatectomy. After prostatectomy, ex-vivo MR imaging was acquired with either a 3T or 9.4T unit; Analyzed MR sequences were T_2-WI (TR/TE-3000/30, FOV=100mmx100mm, Matrix=385x335, Slice thickness(ST)=3mm, NEX=3), Trace DWI (TR/TE=2000-3000/70-42, FOV=221x250, Matrix=256x256, ST=3mm, b-values = 0, 400, 700, 1200. Trace ADC maps were constructed for region of interest analysis in the peripheral zone (PZ), central gland (CG) and areas of Benign Prostatic Hyperplasia (BPH). The multiparametric values were compared between the studies.

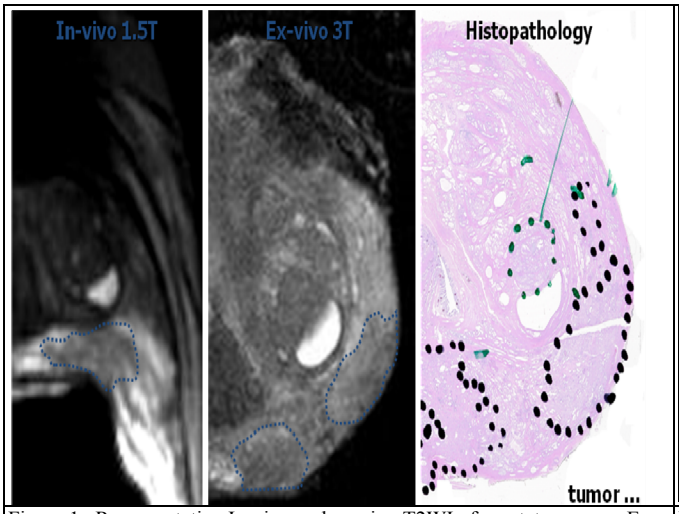

Figure 1. Representative In-vivo and ex-vivo T2WI of prostate cancer. Ex-Vivo T2 images correlates closely with histopathology.

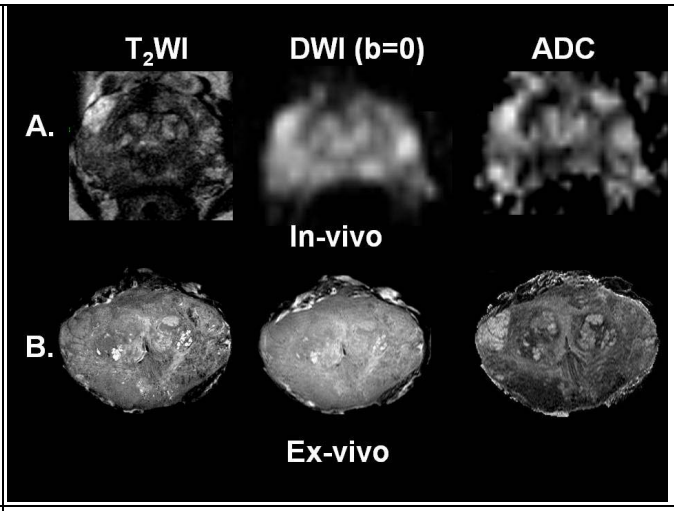

Figure 2. Example of multiparametric in-vivo and ex-vivo imaging of prostate cancer. Close correlation is noted between the T2 and DWI/ADC imaging.

Results: On ex-vivo MRI, PCa confluent areas of low T2 signal replacement of the glandular tissue with tumor margins being irregular or spiculated, findings correspond to the histological regions of high cellular density of PCa. Cancer involving both PZ and CG show similar morphological characteristics. PIN lesions and inflammatory changes could not be differentiated from cancer tissue. BPH nodules show circumscribed margins and may have both T2 high and T2 low signal characteristics. Normal prostate tissue in the PZ shows intermediate to high T2 signal characteristics with loosely packed glandular tissue. The average "in-vivo" ADC map values for normal PZ were $1.61\pm0.26\times10^{-3}$mm^2/s and $1.59\pm0.22\times10^{-3}$mm^2/s in the CG. In cancerous regions dark T2/ADC areas,, the ADC map value was $0.83\pm0.17\times10^{-3}$mm^2/s in PZ and $1.01\pm0.15\times10^{-3}$mm^2/s in the CG. Notably, there was a decrease in the ADC map values on ex-vivo data, $0.72\pm0.11\times10^{-3}$mm^2/s and $0.54\pm0.12\times10^{-3}$mm^2/s, for the normal and cancerous tissue in PZ. Similar results were found in the CG. In BPH, the in-vivo ADC was $1.84\pm0.12\times10^{-3}$mm^2/s and $1.31\pm0.130\times10^{-3}$mm^2/s ex-vivo. The ratio between ex-vivo/in-vivo was between 48%-36% and consistent with the temperature dependence (37°C to 23°C) of the ADC values (~2% per 1°C)[1-3]. Figures 1 and 2 demonstrate the excellent co-localization between in-vivo and ex-vivo prostate structures and cancer and BPH regions with histopathology.

Discussion: We have demonstrated the feasibility of obtaining high resolution MR images of ex-vivo specimens and comparing them with in-vivo imaging parameters. The ex-vivo T2WI and DWI are able to differentiate normal from cancerous tissue when correlated to pathology. Despite of known temperature dependence of DWI, there was a predictable ADC value change that allowed differentiation between tissues [1-3]. Ex-vivo imaging of specimens allows a thorough multiparametric examination of the prostate gland that is not time-limited and permits the assessment of the tumor microenvironments. By using a multiparametric approach to investigate the in-vivo and ex-vivo characteristics of prostate cancer a better understanding of the features of prostate cancer aggressiveness and possibly tumor biology can be realized.

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[3]. D'Arceui *NeuroImage*, (2007) 35 (2), pp. 553-565.
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