High resolution MRSI and DTI of prostate cancer at 3T

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Introduction: Magnetic resonance spectroscopic imaging (MRSI) has been shown to provide important metabolic information which improves the MRI detection and characterization of prostate cancer (1-2). It has also been demonstrated that the SNR gain by acquiring prostate MRSI data at 3T instead of 1.5T can be used to improve spatial resolution to provide better metabolic delineation of smaller tumors (3). Diffusion MRI has been shown at 1.5T to also detect significant differences between cancer and normal prostatic tissues (4-5). Prostate cancer has demonstrated a significant reduction in the directionally-averaged apparent diffusion coefficient (ADC) relative to healthy tissues (4-5). The addition of higher spatial-resolution diffusion data to metabolic data at 3T should further increase the accuracy of prostate cancer detection and characterization. Application of EPI based diffusion sequence has been problematic in prostate due to high susceptibility of the air-filled inflatable endorectal coil especially at higher field. By filling the inflatable coil with a susceptibility matched compound and applying parallel imaging techniques allows the acquisition of minimally distorted DTI-EPI data. In this study, a combined high resolution anatomical MRI, 3D-MRSI and SENSE DTI-EPI protocol were applied to 39 prostate cancer patient 3T MR exams.

Methods: All studies were performed on a GE 3T scanner (GE Healthcare, Waukesha, WI) using body coil for excitation and a Medrad inflatable endorectal coil (Medrad, Pittsburgh, PA) filled with Flutec_T14 ™ (F2 Chemicals, UK) in conjunction with a torso phased array coil for signal reception. Flutec_T14 is a fully fluorinated, colorless, odorless, non-toxic fluid with a magnetic permeability similar to tissue and thus is an ideal substitute for air to inflate the endorectal coil. The MRI consisted of sagittal localizer, high-resolution T2-weighted FSE oblique axial and coronal images, and T1-weighted SE axial images. MRSI data was acquired with MLEV-PRESS sequence (3) that allowed the acquisition of completely upright citrate resonance at TE of 85ms with a 0.157cc nominal spatial resolution. An EPI-DTI sequence with parallel imaging and 6 diffusion gradient directions was used. Oblique axial ASSET DTI-EPI images were acquired in 2.5 minutes with a FOV = 24 cm, 256 x 128 matrix, 4mm thick slices, SENSE acceleration factor of two, and b-value of 600, with 8-10 slices typically to cover the prostate. Custom software programs developed at our institution were used for the processing of MRSI data and calculation of DTI parameters.

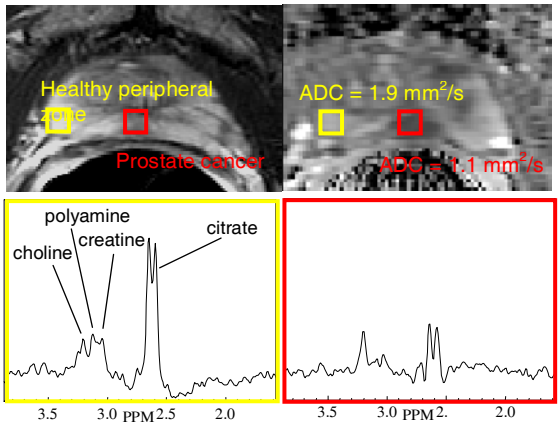

Figure 1. MRI, MRSI and DTI from a prostate cancer patient negative biopsy. High-resolution T2-weighted FSE images (upper left) and MRSI (lower left and right) showed decrease signal intensity in the T2-weighted image and elevated choline and reduced citrate, creatine and spermine in region of prostate cancer as compared to region of healthy peripheral zone.

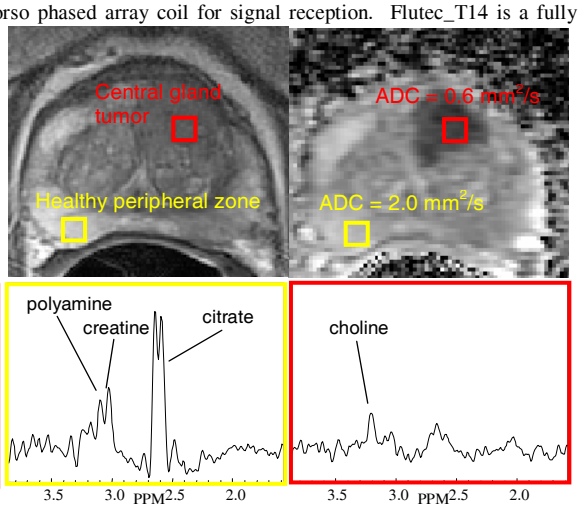

Figure 2. Figure 2. MRI, MRSI and DTI from a patient with biopsy proven cancer (G3+3, Left mid-gland). High-resolution FSE images (upper left) and MRSI (lower left and right) showed decrease signal intensity in the T2-weighted image and elevated choline and reduced citrate, creatine and spermine in region of a central gland prostate tumor as compared to region of healthy peripheral zone. Also decreased ADC (upper right) was observed in the region of cancer compared to healthy peripheral zone.

Results: High-resolution (0.9 mm x 1.8 mm in-plane resolution) DTI data were obtained from 39 prostate cancer patient MRI/MRSI exams (Fig. 1-2) with minimal spatial distortions. High SNR was observed in the 3D MRSI as demonstrated in the representative data in Figure 1 (citrate peak height SNR = 36.5) and Figure 2 (citrate peak height SNR = 28.9) even at half of the voxel resolution typically used at 1.5T (0.157cc at 3T vs. 0.343cc at 1.5T). Reduced ADC as well as reduced citrate and elevated choline were observed in regions of prostate cancer as compared to regions of benign prostate peripheral zone, as shown in the prostate cancer patient in Figure 1. ADC in the region of peripheral zone prostate cancer was 1.1 mm^2/s compare to 1.9 mm^2/s in the healthy peripheral zone, while (choline+creatine)/citrate ratio (CC/C ratio) was 2.06 in the region of cancer and 0.56 in the healthy tissue (Fig. 1). Reduced ADC was also observed in the region of transition zone tumor as compared to benign prostate peripheral zone. In the representative study shown in Figure 2, ADC in the region of transition zone tumor was 0.6 mm^2/s compared to 2.0 mm^2/s in the healthy peripheral zone, while CC/C ratio was 1.03 in the region of cancer and 0.57 in healthy tissue (Fig. 2).

Discussion: By filling the inflatable endorectal coil with a compound that matches the susceptibility of tissue and using a SENSE DTI-EPI sequence, minimally distorted DTI data were obtained from 39 prostate cancer patients. With this multi-parametric high resolution MRI/MRSI/DTI protocol at 3T, characterization of prostate cancer may be greatly improved by the two-fold increase in spatial resolution of MRSI data and the addition of high resolution DTI. While MRSI data provides high specificity for assessing metabolic changes associated with prostate cancer, DTI data can provide higher resolution information related to micro-structural changes differences between tumor and normal prostatic tissues. Furthermore, along with average diffusivity, anisotropy data provided by DTI may also help differentiate transition zone tumor from stromal BPH tissues at a higher spatial resolution than MRSI.

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