IN-VIVO 3T AND EX-VIVO 7T DIFFUSION TENSOR IMAGING OF PROSTATE CANCER - CORRELATION WITH HISTOLOGY

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Introduction: Diffusion Tensor Imaging (DTI) has been successfully applied in prostate cancer diagnosis [1]. It has been well established that the water Apparent Diffusion Coefficient (ADC) has a lower value in the tumours compared to normal prostatic tissue. However, fractional anisotropy (FA) values in prostatic carcinoma have been reported to be higher [2], lower [3], and unchanged [4] when compared to the prostate's normal peripheral zone. We present preliminary data from a study involving DTI measurements in prostate glands, in-vivo and ex-vivo following radical prostatectomy. The values were correlated with whole mount histology slides.

Materials and Methods: Patients with biopsy proven carcinoma received a DTI exam prior to radical prostatectomy procedure. Magnetic resonance imaging (MRI) images were obtained using a 3T Philips Achieva MRI scanner using combined cardiac phased array/endorectal coil. DTI MRI data was acquired using a single shot EPI sequence with field of view (FOV) of 24 cm, a matrix of 128x115 points, 4 mm thick slices without gaps, 6 directions, and b-value of 600. The excised glands were then fixed for at least 24 hours and ex vivo DTI images were acquired with a 7T Bruker Biospin 30 cm bore MRI scanner. The ex-vivo DTI data was acquired using a spin echo sequence with FOV of 6 cm, a matrix of 128x128 points, 4 mm thick with no gaps, 6 directions, and b-value of 750. The specimens were then cut into 4 mm slices using a custom built slicing device [5], and further processed into whole mounts for histological analysis. Tumour areas were manually outlined by a pathologist under microscope, and digital images were generated from the annotated glass slides using a flatbed scanner. ADC and FA maps were generated from the in-vivo and ex-vivo DTI data, and were registered to histology using software developed in our laboratory based on the libraries available on the elastix program [6]. ADC and FA values were calculated for the regions with tumours with Gleason Score 3+3 (GS33), tumours with Gleason Score 3+4 (GS34), normal peripheral zone (NPZ), normal peripheral zone with enlarged glands (NPZEG), and the average of the NPZ and NPZEG (AvPZ) (Figure1). Central gland tumours were not taken into account in this procedure.

Results and Discussion: Thirty-four histology slices from four patient datasets have been registered to in-vivo and ex-vivo DTI, and the average values of FA and ADC have been found for the different tissue regions. The registration algorithm was developed in house and its robustness has been tested showing reliable results. Figure 2 shows the distribution of these values in both ex-vivo and in-vivo. We find that the ADC value in tumours is lower when compared to the AvPZ both in-vivo and ex-vivo. Ex-vivo ADC in NPZ show similar values as the carcinomas, thus calculating average ADC from the AvPZ is required when ex-vivo DTI is used as a diagnostic technique. Ex-vivo FA values are found to be slightly higher in the carcinomas compared to the peripheral zone while the opposite effect is observed in-vivo. Higher and noisier ADC values in-vivo compared to ex-vivo as well as in normal peripheral zone compared to carcinomas, explains why the in-vivo FA values tend to rise [7] for healthy peripheral zone. Partial volume effect, which is higher in ex-vivo than the in-vivo data, has been shown to decreases the FA value of the tissue [4] which may be the case in the GS34 tumours in this study.

Conclusions: Our preliminary results show that there are no significant differences in FA between normal peripheral zone and prostatic carcinoma. This strongly suggests that FA is not likely to contribute significantly to diagnostic capabilities of DTI in prostate cancer.

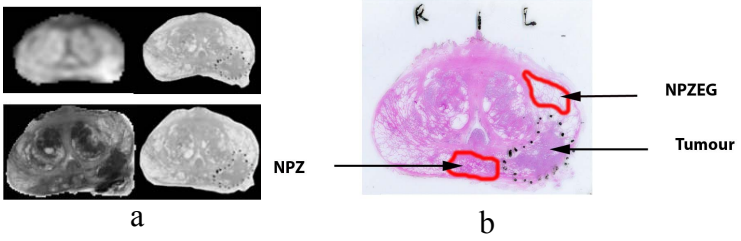

Figure 1: a) A registered histology slice (right column) with in-vivo and ex-vivo dti, (left top and left bottom respectively). b) The original histology slice with outlined regions of interest.

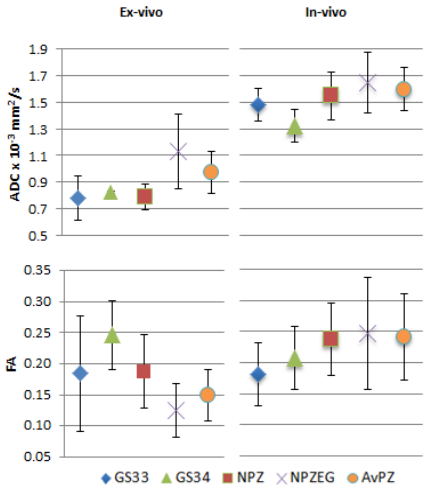

Figure 2: Ex-vivo (left) and in-vivo (right) ADC and FA values for the different types of tissue in the prostate gland of patients with biopsy proven carcinoma.

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Keywords: DTI, Image Registration, Prostate cancer

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