Diffusion Weighted Imaging of Androgen Deprivation Hormone Therapy for Prostate Cancer

S. Riches[1], V. Morgan[1], G. S. Payne[1], D. Dearnaley[2], and N. deSouza[1]

[1]Clincal Magnetic Resonance Research Group, Royal Marsden NHS Trust and Institute of Cancer Research, Sutton, Surrey, United Kingdom, [2]Department of Academic Urology Unit, Royal Marsden NHS Foundation Trust, Sutton, Surrey, United Kingdom

Introduction: Diffusion-weighted MRI (DW-MRI) has been used to aid detection of cancer within the prostate gland [1]. It is known that androgen ablation therapy shrinks the prostate and reduces the metabolite content [2,3], but its effects on the apparent diffusion coefficient (ADC), which may prove useful in monitoring the development of hormone refractory disease, have been less well investigated. The purpose of this prospective study was to measure the ADC after the first 3 months of treatment to evaluate changes relative to baseline values as an essential first step in exploring the use of ADC for monitoring treatment response.

Method: 13 men (mean age 69 ± 6 years) with TRUS-guided biopsy-confirmed prostate cancer who had been prescribed androgen deprivation hormone therapy were scanned using a 1.5T Intera clinical MR scanner (Philips Medical Systems, Best, Netherlands) with an endorectal receive coil, inflated with 55ml of air. Patients were imaged on diagnosis (Gleason scores: 4+5(n=1), 4+3(3), 3+4(4), 3+3(5); PSA 17±10 ng/mL (mean ± SD)) and after three months of hormone therapy (mean PSA 0.9 ± 0.8 ng/mL). In addition to standard 3-plane imaging (FSE, TR/TE=2000/90, 20 slices, 3mm thickness, 256x512 matrix, 140mm FOV), 12 axial slice diffusion-weighted images (TR/TE 2500/69, 4mm thickness, 200mm FOV, 128x128 matrix, 4 b-values 0,300,500,800 s/mm2 in three directions) were acquired. Isotropic ADCs were calculated using all b-values. An experienced radiologist drew regions of interest (ROI) on the T2-weighted images around the entire gland, the central gland (CG) and tumour (TU), defined as regions of low T2 signal-intensity. The ROIs were registered with the ADC maps and mean ADC values calculated for the peripheral zone (PZ), CG and TU over all slices for each patient. The ratios TU/PZ and CG/PZ were calculated for the pre-hormone and 3 month time points.

Results: Before and after hormone therapy, the ADC values can discriminate between TU and PZ (p=0.01 both pre-hormone and 3-months) and between TU and CG (p=0.002 pre hormone and p=0.011 at 3-months). Comparison of the values show a slight reduction in the ADC values of PZ and CG, and a slight increase in TU ADC after three months of hormone therapy (Table 1), but these were not significant at the 5% level. Plots of the pre-hormone and 3-month ADCs for each patient (Figure 1) show that the mean ADC was reduced by androgen deprivation therapy in 9/13 CGs, and 8/13 PZs and in both CG and PZ in 7/13 patients. Eight patients showed an increased TU ADC. However, there was a statistically significant (p=0.002) increase in the mean ratio of TU/PZ ADCs from 0.78 ± 0.09 (mean ± SD) before androgen deprivation therapy to 0.86 ± 0.07 after 3 months of treatment (Figure 2). The mean CG/PZ ratio showed no statistical difference at the 5% significance level.
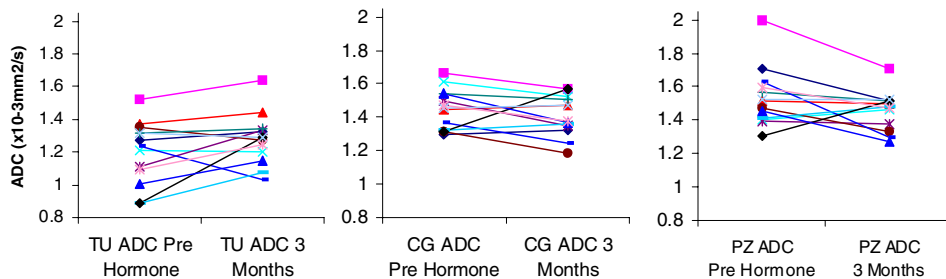

Figure 1: ADC for TU, CG and PZ for individual patients pre-hormone therapy and at 3 months

ADC	Pre - Hormone	3 Month Hormones	Pre vs 3 Month (p-value)
TU	1.2 ± 0.2	1.3 ± 0.2	0.087
CG	1.5 ± 0.2	1.4 ± 0.1	0.116
PZ	1.6 ± 0.2	1.5 ± 0.1	0.133
TU/PZ	0.78 ± 0.09	0.86 ± 0.07	**0.002**
CG/PZ	0.95 ± 0.11	0.97 ± 0.06	0.434

Table 1: ADC values & ratios for 13 patients (mean ± SD)

Discussion: The variation in the ADC values across the patient population is much greater than the individual changes in the ADC values after three months of hormone therapy resulting in no significant changes in the mean calculated ADCs. However the statistically higher TU/PZ ADC ratio after 3 months of androgen deprivation in comparison to the lack of change in the CG/PZ ratio indicates that the effect of androgen deprivation on the tumour is greater than its effect on the rest of the gland. This may be due to greater structural changes within tumour tissue. The ratio of CG/PZ remaining static also suggests the changes in PZ and CG are caused by previously seen gross changes [1,2] in the gland.

Conclusion: DW-MRI indicates differences in water diffusivity in normal and TU tissue before and at 12 weeks after anti-androgen therapy. The effects of androgen ablation on the structure of tumour tissue is different to that of normal tissue indicating that ADCs may prove to be a useful predictor of response to androgen ablation.

References: [1] Shimofusa R et al J Comput Assist Tomogr 2005; 29(2):149-153. [2] D'Amico, A. *et al*, 1998, Urology, 51, 287; [3] Padhani, A. *et al*, 2001, Radiology, 218, 365
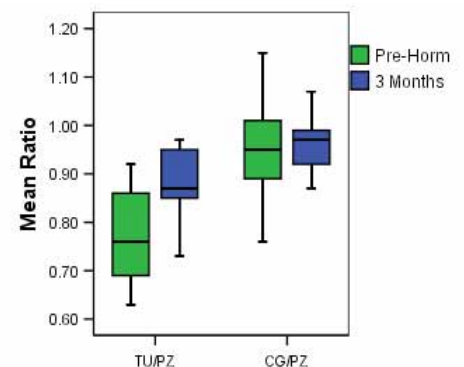
Figure 2: TU/PZ and CG/PZ ratios pre-hormone therapy and at 3 months