

Initial Evaluation of T2 Shine-Through Elimination with Relax DWI

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Target Audience: Oncology Radiologists

Purpose: The long echo times used in diffusion weighted imaging (DWI) may allow tissues with long T2s, such as the prostatic peripheral zone (PZ) to mimic lesions or reduce lesion contrast due to “T2 shine-through”, thus requiring the reader to verify the presence of suspected low diffusivity at sites of DWI hyperintensity by assessment of apparent diffusion coefficient (ADC) maps calculated from images of two or more diffusion weightings. An alternative approach (Relax DWI) ¹ uses four or more echo time and diffusion weighting combinations to isolate T2 and ADC effects. We have evaluated the impact of Relax DWI on prostate tumor contrast in ADC maps and in high b-value images calculated for TE=0 to avoid T2 weighting.

Methods: 17 patients (mean age ± sd: 64 ± 8 yrs) with prostate carcinoma underwent Relax DWI as part of a prostate multiparametric (mp)-MRI at 1.5T (Avanto, Siemens Medical System, Erlangen, Germany) under ethics committee approved procedures for patient research and informed consent. The mp-MRI examination involved conventional DWI (convDWI, b-values 0, 500 and 1000 s/mm², TE 69ms), T2-weighted (T2W) images, and a dynamic contrast enhanced (DCE) T1-weighted scan. Using the same imaging geometry as convDWI, images for Relax DWI were acquired with b = 50, 50, 300, 800 s/mm², and TE = 47, 80, 57, 66 ms respectively in a scan time of approximately 5 minutes. ROIs were drawn by a radiologist on the T2W images for clinically significant lesions, healthy prostate and PZ.

Expressing the effects of T2 and diffusion on signal intensity (S) as: $S=S_0e^{-TE/T_2}e^{-bADC}$, the Relax DWI images were subjected to logarithmic transformation and successive linear fittings for T2 (using the b=50 s/mm² images), and then for ADC along with S₀. Subsequently, a simulated b = 800 s/mm², TE = 0 ms image was calculated. convDWI ADC maps were calculated by the scanner. Relax DWI fitting with calculation of the b800 TE0 and ROI drawing were performed using a custom plugin and native imageJ respectively. ²

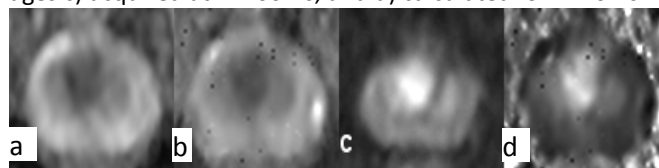
The convDWI b=0 image was registered to the T2W scan with elastix ³ and the transformation applied to all diffusion weighted images and the calculated maps. The ROIs were then used to extract values from convDWI and Relax DWI ADC maps, as well as signal intensities from the acquired b=800, TE=66 and calculated b=800, TE=0 images. The mean tissue ADC and signal intensity values across subjects were assessed for significant difference (p<0.05) between tissues and between convDWI and Relax DWI with R. ⁴

Results: Figure 1 shows a zoomed image of the prostate in ADC maps, b=800 images without and with T2-shine through elimination via Relax DWI. Tumor was distinct from both prostate and PZ in ADC maps from both convDWI and Relax DWI as well as the b=800 TE=0 image calculated from the Relax DWI fitting results, but not on the acquired b=800 image (Table 1). The difference between acquired and calculated b=800 image contrast was significant.

Table 1: Comparison of ADC and Signal Intensity

	ADC (x10 ⁻³ mm ² /s)		b=800s/mm ² Signal Intensity*	
	convDWI	Relax DWI	Acquired: TE=66ms	Calculated: TE=0ms
Prostate	1.44 ± 0.10 [^]	1.54 ± 0.11 [^]	1.00 ± 0.16	1.00 ± 0.13 [^]
Peripheral Zone (PZ)	1.71 ± 0.29 [^]	1.86 ± 0.32 [^]	1.06 ± 0.29	0.81 ± 0.23 [^]
Tumor	1.16 ± 0.23	1.21 ± 0.21	1.16 ± 0.29	1.28 ± 0.34

Figure 1: ADC maps a) cDWI and b) Relax DWI and b=800s/mm² images c) acquired at TE=66ms, and d) calculated for TE=0ms.



*Signal intensities scaled to Prostate mean. [^]Significantly different (p<0.05) from tumor

Discussion: There was a high correlation between ADC values calculated with convDWI and Relax DWI approaches that led to no significant difference in their ability to distinguish tumor from prostate or PZ. When T2 values were accounted for in the calculation of a high-b-value image on the other hand, Relax DWI showed better contrast between tumor and both prostate and PZ than convDWI, with particular improvement seen relative to PZ, but the calculated images are inhomogeneous away from the prostate and subject to issues of noise propagation and motion. Evaluation of use in radiological practice is needed to establish whether the potential benefits of Relax DWI are realized.

Conclusion: The use of Relax DWI to calculate high b-value images without T2 weighting is promising for prostate imaging and may facilitate prostate mpMRI reporting.

References:

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