Relaxation Corrected Diffusion Weighted Imaging

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Target audience: Clinician and researchers working with diffusion-weighted imaging (DWI).
Purpose: To propose a novel DWI data acquisition scheme to measure both T_2 and ADC simultaneously in attempt to correct for T_2 shine through or T_2 black out effect.
Methods: DWI is known to be affected by relaxation time[1]. Practically only T_2 relaxation effect is of concern and can be represented[2] as $S = S_0 \cdot \exp\left(-\frac{TE}{T_2}\right) \cdot \exp(-b * ADC)$. The proposed schema here uses minimum echo time (TE) for each b value measurement to increase SNR and also to provide varying TE. In addition, a data point at low b value and long TE is added to provide stability to fit to the equation. Once ADC and T_2 have been fitted, it is possible to remove T_2 shine through effect by removing the T_2 dependent component. Abdominal DWI measurement with b=100, 100, 400, and 800 s/mm2 and corresponding TE=34, 80, 42 and 49 ms on 1.5T Siemens Aera.
Results: *Figure 1* shows the difference between Relax DWI and normal DWI, and that they also agree with each other as the data points falls on the same b value and TE plane. Relax DWI has the advantage of higher SNR due to shortened TE. *Figure 2* shows a peritoneal metastasis ADC and T_2 images. It is clear that the metastasis is a longer T_2 and hence T_2 shine through effect on the high b value and long TE DWI images. This can be corrected by substituting TE 0 ms to the equation and surrounding tissue become more visible on the high b value DWI. *Figure 3* shows S_0, ADC and T_2 map for abdominal organs, liver, kidney and spleen. Liver is demonstrated here to have a shorter T_2 than surrounding organs and hence liver DWI typically have T_2 blackout effect. This can be corrected with the above method.
Discussion: Relax DWI only require additional scan time equivalent of an additional b value for DWI and gain T_2 maps in addition to ADC maps. Relax DWI as proposed now only works for tissue with single ADC component. Therefore, b value was used from b 100 s/mm2 onwards to avoid perfusion component. It is possible to consider tissue with multiple ADC components in further study.
Conclusion: Relax DWI is able to correct for T_2 related effects on DWI by provided T_2 map along with ADC map.

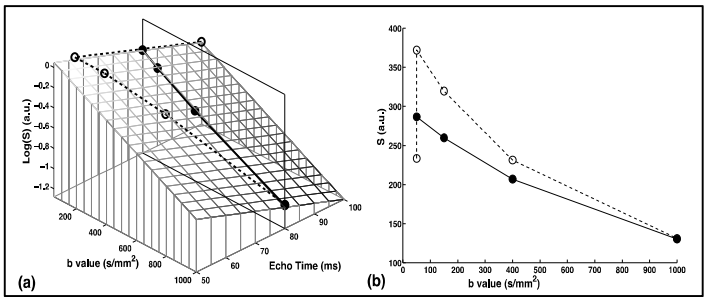

Figure 1 Diffusion weighted data points for Relax DWI (empty circle) and normal DWI (filled circle) for brain grey matter. (a) All data plotted in b value and TE space. They all falls on the same plane which corresponds to their ADC and T_2 relaxation time. (b) All data projected to TE 80ms plane.

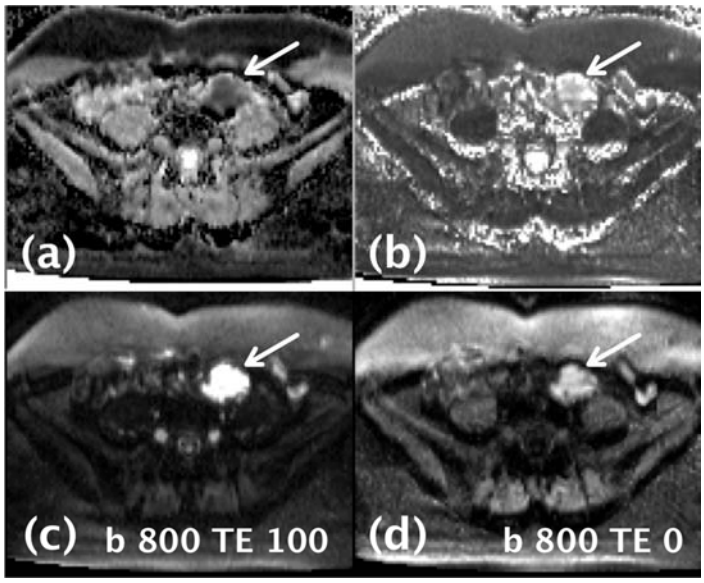

Figure 2 Peritoneal Metastasis (a) ADC and (b) T_2 maps. DW images with different b value and TE combination (c, d) show how the metastasis contrast appears.

References:
1. Staroswiecki et. al., Magn Reson Med. Apr 2012;67(4):1086-1096
2. Burdette et. al., Radiology. Aug 1999;212(2):333-339.

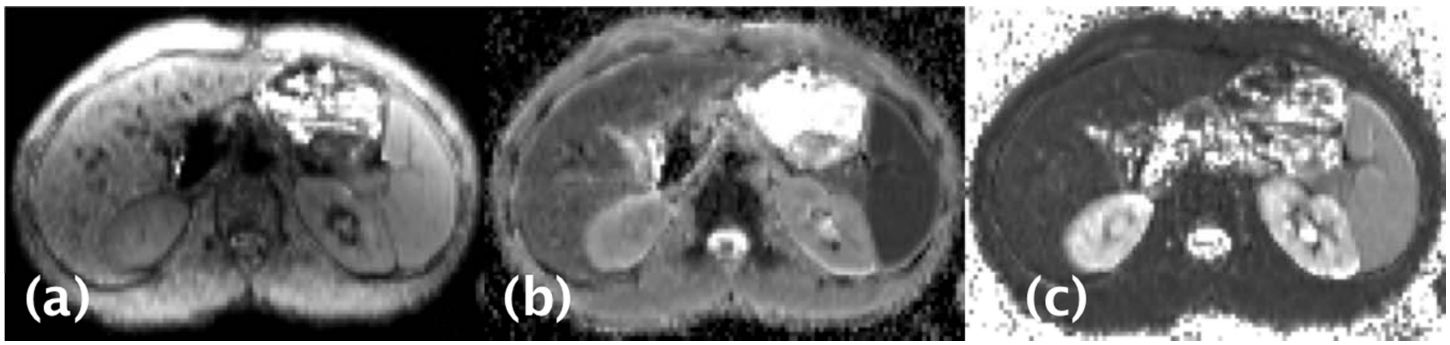

Figure 3 Abdominal (a) S_0, (b) ADC and (c) T_2 maps calculated using Relax DWI