Toward the use of DTI and T1 maps to assess the apparent fiber density

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INTRODUCTION AND PURPOSE Both the Diffusion Tensor Imaging (DTI) and the T1 relaxometry have been demonstrated to be techniques capable to provide good information about the structural nature of the white matter (WM). T1 parameter in particular has been extensively demonstrated to correlate with chronic axonal damages in degenerative WM pathologies. The power of such techniques, beyond the ability to offer good radiological images of the brain, lies in their intrinsic reproducibility and, due to the sensitivity of their quantitative nature, in the capability to detect also the little changes in which a tissue undergoes under the influence of a degenerative pathology. This make possible, for example in the multiple sclerosis (MS), to detect abnormalities in the so called normal appearing white matter (NAWM), where the conventional techniques fail in distinguish it from the healthy WM. Although both the techniques give quantitative information about the tissue substrate, they are connected in different way. The T1 measured values are mostly a consequence of the macromolecular content in the examined WM tissue. The DTI parameters furnish an information about the aptitude of the WM structures to hinder water diffusion. This observation suggests that a combined investigation of the two parameter sets could reveal a deeper insight than the use of a single one. We note here that there are other techniques able to assess the WM substrate (for example the spectroscopy, through the measurement of the content of nacytilaspartane, that is a well recognized neuronal marker), but T1 mapping and DTI have a similar technical nature, in fact they are commonly implemented through the use of fast sequences as the echo-planar imaging (EPI), and this makes it easy to realized them together in a single short experimental session. **METHODS** We performed orr measurements on a 3 Tesla Allegra Siemens scanner. Our protocol take about 12 minutes to obtain a T1 map and a good quality DTI. The T1 maps are obtained by 6 inversion times in a 2 minutes scan with use of combined interleaved and concatenated acquisitions. The scheme is shown in figure 1. The TR was 20s, ensuring a 10s recovery of the magnetization between adjacent slices acquisition. The DTI was obtained by a 68 gradient directions running b values of 100 s/mm^2 and 1000 s/mm^2. **RESULTS** We name λ_{max} and v_{max} respectively the eigenvalue and the eigenvector in the direction of maximum diffusivity. Our analysis on the corpus callosum of an healthy volunteer seems to suggest that the mean ADC in the plane normal to v_{max} (ADC⊥) could be the best parameter, between the DTI ones, to give us an estimation of the hindering effect of fibres, figure 1. Correlations of T1 and DTI indices, in the corpus callosum of an healthy volunteer, show that ADC⊥ is the responsibile for the ADC correlation with T1 (see figure 2). So it could be a good candidate as the main input for a model that aspires to extract something like a quantitative apparent fibres density (AFD) index. On the contrary the mean value of λ_{max} doesn't correlate with T1. But we can use it by averaging it over a portion of tissue that could be thought to have the same characteristics in all its extension, and so we can adopt $<\lambda_{max}>$ in our model as the estimation of an 'effective free diffusion' of water in that tissue. In TABLE 1 we show the mean values of DTI and T1 indices in the corpus callosum of an healthy volunteer.

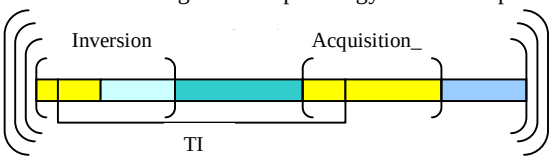

Figure 1. T1 sequence scheme. Parameter are optimized for every TI.

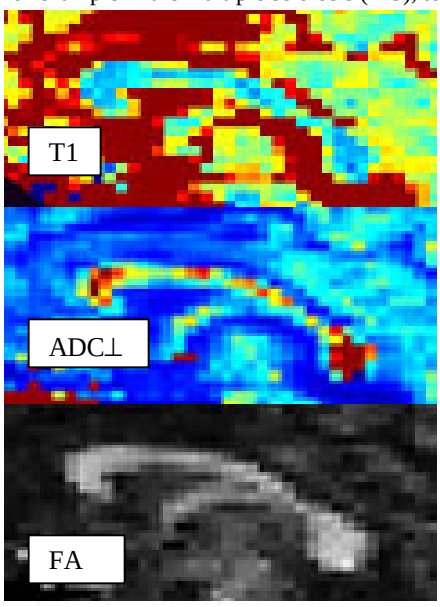

Figure 3. The corpus callosum is shown in a T1 map, in a normal ADC map and in a standard FA map

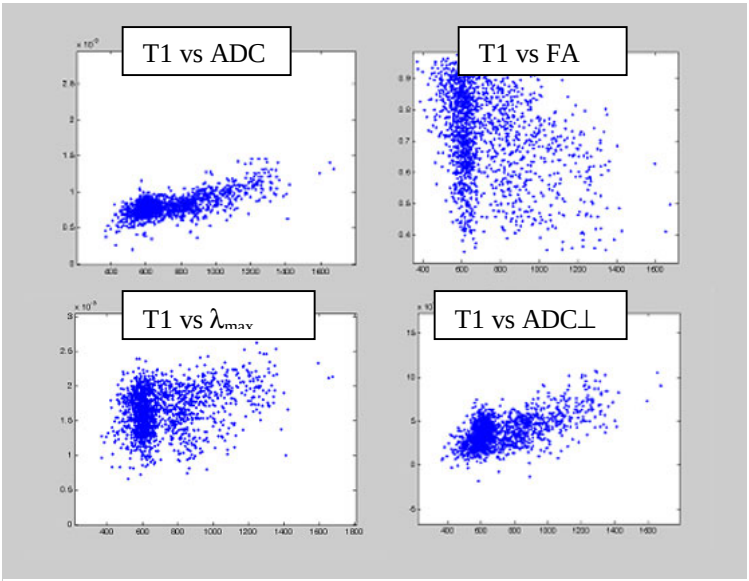

Figure 2. T1 (ms) is shown in abscis; ADC, ADC⊥ and λ_{max} (10^{-3}mm^2/s), and FA (a.u.) are shown in ordinate.

T1	762 ± 312 ms
ADC	830 ± 200 × 10^{-3} mm^2/s
ADC⊥	408 ± 217 × 10^{-3}mm^2/s
λ_{max}	1673 ± 344 × 10^{-3} mm^2/s

TABLE 1

REFERENCES

1 Mult Scler 2002, 8;211

2 Mult Scler 2004: 10; 556