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Towards the origin of the signal offset in T2 relaxometry

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Nowadays the T2 time is used in diagnosis and therapy control as an important parameter. For T2 determination, data from T2 relaxometry investigations is often fitted by mono exponential curve fitting (Equation 1) and some groups add an offset (Equation 2), although there is no further explanation which effects the offset should account for. Some groups use the offset parameter to compensate long T2 components (Pell *et al.*, 2004; Pell *et al.*, 2006) and some use it to compensate Rician noise at low SNR level (Feng *et al.*, 2013; Wood *et al.*, 2005). Furthermore, there has been no published explanation for the offset and its use within this formula.

The aim of this work, therefore, is to show that the offset is predominately compensating for imperfections of the 180° refocusing pulse and that there is no correlation between the offset and noise or long T2 times.

Measurements were performed using a 3T MR-Scanner and the data was fitted with the Levenberg-Marquardt nonlinear least squares algorithm (Kanzow *et al.*, 2004) provided by levmar (Lourakis, 2004) using the EPG algorithm using four different techniques: using Formula 1 with and without discarding the first echo and using formula 2 with and without discarding the first echo. To determine a possible effect of T2 on the offset I used agarose phantoms with increasing agar concentration. From these sequences the offset, T2 and FA were measured. A possible correlation between the offset and noise was investigated by using a spherical phantom. The SNR was measured at 9 different ROIs and for each ROI the offset was measured. To determine a possible biological effect on the offset a group of subjects was examined and both thighs of each subject were measured. At all subjects FA and offset value were measured at different tissue types.

With increasing offset values the FA values are decreasing and the agarose gel phantoms measurements indicate that there is an influence of T2 on the offset. The spherical phantom measurements indicate that the offset is not predominately influenced by noise. At the subject measurements, there are different results at intramuscular fat and muscle tissue, therefore a mono-exponential fitting might be the improper method and a bi-exponential fitting might be the better method for fat tissue because of the different proton pools.

The offset value therefore predominately indicates if there is a problem with incorrect FA values, but noise and long T2 components may also play a role.

This work shows that these T2 times might be inaccurate because of imperfect FA. In order to detect potential inaccuracies, it is mandatory to calculate the actual FA and its deviation from 180°. The offset can be used as an indicator for FA inhomogeneities leading to incorrect T2 times. Therefore we suggest to always calculate and analyse the offset when monoexponential fitting of T2-relaxometry is performed. A further method to increase accuracy of T2 calculation is to discard the first echo and to use the offset as an additional fitting parameter. This method can be implemented easily and should be used in clinical practice as well as in research, whenever T2 is determined from multi-echo sequences.