Accurate, B_1-Insensitive Fast T_1-Measurements at 3T

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Introduction

Fast T_1-measurements can be acquired in a few seconds using the Look-Locker principle in conjunction with echo-planar imaging. [1,2] Accurate calculation of T_1, however, requires knowledge of the true mean flip angle through a slice [3], which varies throughout the imaged volume due to B_1-inhomogeneities. The flip angle cannot be estimated by fitting the signal model to measured data since it is strongly correlated to other parameters in the model. However, by repeating the T_1-measurement with multiple flip angles, it is possible to estimate the flip angle along with T_1, M_0 and the degree of inversion, β. This allows accurate and fast measurement of T_1 in the presence of B_1-inhomogeneities.

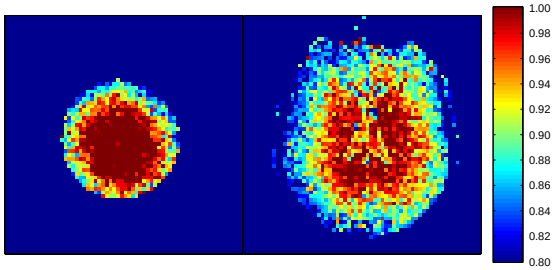

Figure 1: The ratio between the actual and the nominal flip angles in a phantom (left) and in-vivo (right).

Methods

Look-Locker T_1-measurements were acquired in a single slice in both a homogenous gel phantom and a human subject. All measurements were done on a Siemens Magnetom Trio 3T-scanner. GE-EPI was used for imaging and a non-selective hyperbolic secant adiabatic inversion pulse was used for inversion with TI=50ms. The measurements were repeated with two flip angles. For the phantom measurements, flip angles, α of 10° and 15° were used and the time between slices, δTI, was 75ms. For the in-vivo measurements α was 15° and 25° and δTI was 200ms.

A four-parameter model with the unknowns T_1, M_0, α and β was fit to the data acquired with both flip angles. It was assumed that the ratio between the actual flip angles in the two measurements was constant regardless of the B_1-inhomogeneities.

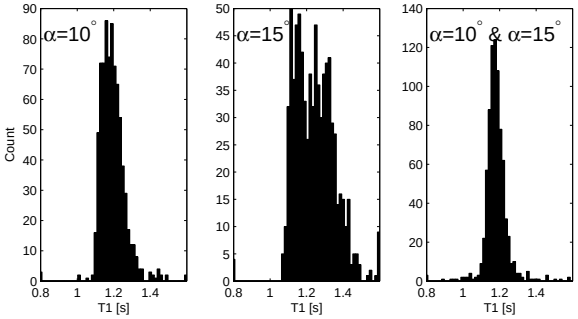

Figure 2: Histograms of the fitted T_1 values in a phantom with the single-flip-angle LL method (left and middle) and with the proposed 2-flip-angle method (right).

Results

Figure 1 shows the fitted ratio between the actual and nominal flip angles in both the phantom and in-vivo measurements. The ratio shows good agreement with a typical B_1-map. Figure 2 shows histograms of the fitted T_1 values in the homogenous phantom with the normal single-flip-angle Look-Locker method (for α=10° and 15°) as well as with the proposed 2-flip-angle method. The proposed method clearly has a narrower histogram indicating more robust T_1 estimation. Figures 3&4 show the corresponding T_1-maps and histograms for the in-vivo measurements where it can be seen that the histogram with the 2-flip-angle method is narrower than with the single-flip-angle method. The accuracy of the fitted T_1-maps could potentially be further improved by constraining the B_1-maps to be smooth, e.g. by using a masked polynomial fit to smooth the fitted flip-angles.

Conclusions

It was shown that B_1-insensitive fast T_1-measurements can be acquired using the Look-Locker method by using two flip angles and fitting an appropriate model to the measured data. This improves the accuracy of T_1-measurements at especially high field where B_1-inhomogeneities are pronounced.

References

[1] Look,DC and Locker,DR. Rev Sci Instrum 1970;41:250-1.

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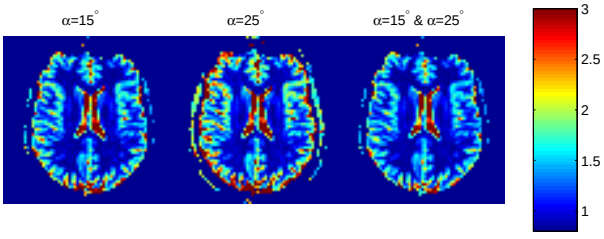

Figure 3: T_1-maps [s] obtained with the single-flip-angle LL method (left and middle) and with the proposed 2-flip-angle method (right).

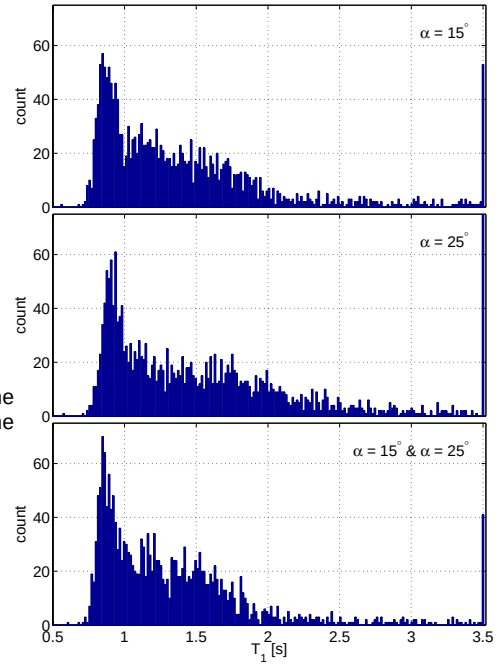

Figure 4: Histograms of the fitted T_1 values shown in the maps in figure 3.