On the necessity of flip angle correction for fast T1mapping using DESPOT 1

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Introduction: An adjusted version of DESPOT 1 has recently been proposed for fast T1mapping in the human gastric (abdominal) region (1). With this technique, T1 is calculated from multiple T1-enhanced fast field echo (T1-FFE) images of different flip angles (2). The correct calculation of T1 requires a constant nominal flip angle over the whole field of view (FOV). However, especially for high magnetic field strengths B1 is strongly non-uniform. The aim of this study is to show the necessity of flip angle correction for precise and fast T1 quantification using DESPOT 1 in the human abdomen. T1maps were generated *in vitro* and *in vivo* and T1 values compared for measurements with and without flip angle correction. For flip angle correction, a previously described fast B1 mapping technique was applied (3).

Methods: Measurements were performed on a 1.5T and a 3.0T whole-body MRI scanner (Intera, Philips Medical Systems, Best, The Netherlands). A sinc-gauss RF pulse with a time-bandwidth product of 137rad was applied for optimal slice excitation. RF spoiling and crusher gradients were applied to destroy residual transverse coherencies. Steady state of magnetization was reached before image acquisition by adjusting the number of start-up cycles. T1mapping and B1mapping were alternately performed. Identical RF power and image geometry was applied for both scans assuring identical flip angle distribution over the excited volume. *Fast T1mapping sequence*: flip angles = 5° and 30°, 12 and 18 startup cycles, FOV=360x288mm^2, Δz=15mm, matrix=128x102, TR/TE=8.9/3.6ms (1.5T) and TR/TE=9.1/3.4ms (3.0T), 2s/T1map. *Fast B1mapping sequence*: flip angle = 30°, 14 startup cycles, FOV=360x288mm^2, Δz=15mm, matrix=64x51, TR1=20ms, TR2=100ms, TE=3.6ms (1.5T) and TE=3.4ms (3.0T), 7s/B1map.

In vitro measurements: Five concentrations (300µM, 500µM, 800µM, 1000µM, and 1200µM) of Gd-DOTA (DOTAREM®, Laboratoire Guerbet, France) homogenously mixed with a solution of 10% glucose (@ 20°C) and 1% locust bean gum (LBG) were prepared in small bottles (150 ml).

Conc. [µM]	T1mapping @ 1.5T Corrected T1 [ms]	T1mapping @ 1.5T Uncorrected T1 [ms]	SPECTRO @ 1.5T T1 [ms]	T1mapping @ 3T Corrected T1 [ms]	T1mapping @ 3T Uncorrected T1 [ms]	SPECTRO @ 3T T1 [ms]
1200	127 ± 4	123 ± 3	131 ± 4	171 ± 5	141 ± 5	160 ± 4
1000	154 ± 4	151 ± 3	157 ± 4	198 ± 6	171 ± 8	186 ± 4
800	193 ± 6	176 ± 5	199 ± 4	227 ± 5	180 ± 8	217 ± 4
500	306 ± 11	272 ± 6	300 ± 4	341 ± 10	273 ± 9	320 ± 4
300	478 ± 16	434 ± 15	470 ± 4	507 ± 21	419 ± 20	493 ± 4

An inversion recovery MR spectroscopy sequence was applied as reference measurement at 3.0T and 1.5T. Fast T1 and B1mappings were performed using phased array coils. Mean ± SD T1 values of each concentration were calculated within a region of interest (ROI) of 7x7 pixels for each bottle.

In vivo measurements: Two healthy volunteers were imaged in prone body position with an *in vitro* sample (as reference) attached to the back (1200µM Gd-DOTA @ 3.0T and 1000µM Gd-DOTA @ 1.5T). After drinking a marked test meal (10% glucose at 37°C, 1% LBG, 1200µM Gd-DOTA) T1mapping (6 transversal image slices, one breathhold) followed by B1mapping (6 transversal image slices, two breathholds) were performed. This was repeated every 5 min over 45 min. Phased array coils were used for signal detection at 3.0T and 1.5T. Mean ± SD T1 values of *in vitro* sample and test meal in the stomach were calculated (ROI of 7x7 pixels).

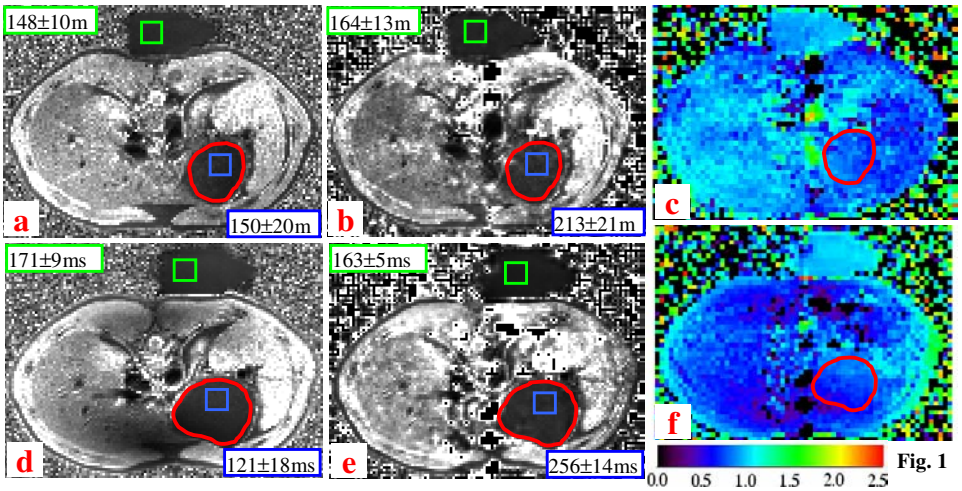

Fig. 1

Results: *In vitro*: For 1.5T and 3.0T, corrected and uncorrected T1 values for fast T1mapping as well as reference T1 values are summarized in the table. Corrected and reference T1 values are in good agreement. Uncorrected T1 values are constantly underestimated. *In vivo*: Fig. 1 shows the calculated T1maps for uncorrected (a. 1.5T, d. 3.0T), corrected flip angles (b. 1.5T, e. 3.0T) and corresponding color-coded B1maps (c. 1.5T, f. 3.0T) 5 min after drinking. Stomach wall is outlined by a red line. Mean± SD T1 values of *in vitro* sample (green) and test meal (red) are indicated. For the uncorrected case, T1 values are too low especially for the test meal. This is highlighted in the B1maps showing weighting factors of ~1.0 at the *in vitro* sample and below 1.0 at the gastric region. After flip angle correction, expected T1 values are observed for the test meal (concentration of 1200 - 1000 µM @ 37°C ≅ 215 – 260 ms). The maps further highlight the advantage of higher SNR provided by 3.0T, but also the disadvantage of more pronounced B1 inhomogeneity compared to 1.5T.

Discussion: This study demonstrates the necessity of flip angle correction for quantitative T1 determination using the DESPOT 1 technique (2). Especially for large FOVs and at high field strengths, RF inhomogeneity becomes a significant issue resulting in an underestimation of T1 values. A method for fast and accurate T1 quantification is presented using a combination of a fast T1mapping and B1mapping sequence. This offers new possibilities for T1mapping in non-static tissues as is the case for the abdominal region.

References: 1) Treier R. et al., Proc. Intl. Soc. Magn. Reson. Med. 13, 2005. 2) Deoni S.C.L. et al., Magn Reson Med, 49: 515-26, 2003. 3) Yarnykh V.L. et al., Pro. Intl. Soc. Magn. Reson. Med. 11, 2004.