The 5 Minutes MR Examination using Rapid Quantification of T1, T2 and Proton Density

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Introduction. Rapid quantification of MR parameters such as the longitudinal T_1 relaxation time, the transverse T_2 relaxation time and the proton density has been the subject of active research over the recent years. Besides the immediate clinical benefits quantification may allow to alter the way clinical MRI is performed. Tissue characterization with a single quantification scan may suffice to synthesize contrast images for a complete MR examination [1,2]. The main challenge with this approach, however, was to decrease the required scan time to clinically acceptable times.

An imaging method called QRAPTEST [3], Quantification of Relaxation times and Proton density by Twin Echo Saturation recovery TFE, allows the quantification of spatially resolved longitudinal T_1 relaxation times, the transverse T_2* relaxation times, the proton densities and the applied local flip angles with high resolution covering the brain in only 5 minutes.

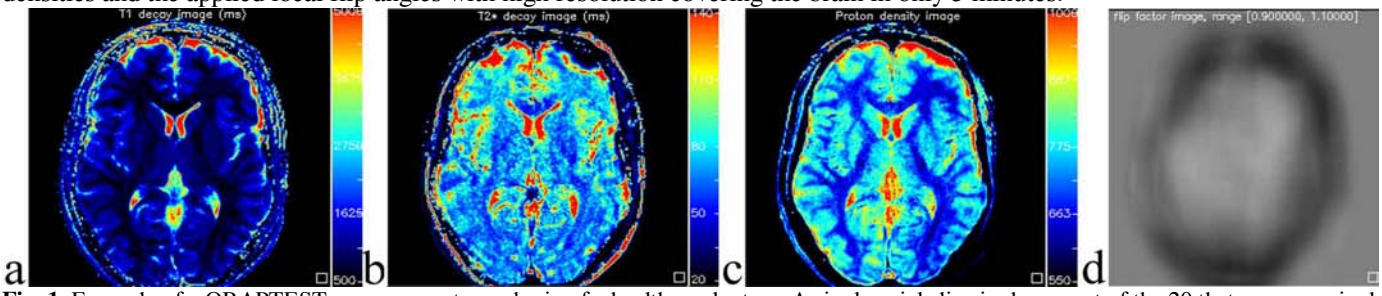

Fig. 1. Example of a QRAPTEST measurement on a brain of a healthy volunteer. A single axial slice is shown out of the 20 that were acquired (scan time 5:12 min, in plane resolution 1 mm^2, thickness 5 mm): **a**. Absolute T_1 (scale 500-5000ms), **b**. Absolute T_2* (scale 20-140ms), **c**. Absolute proton density (scale 550 – 1000, where 1000 corresponds to pure water at 310K) and **d**. the correction factor for local flip angle (scale 90-110%)

Method. The sequence consists of a saturation pulse followed by a TFEPI acquisition with two echo acquisitions per shot (TE1 = 7.5 ms, TE2 = 21.3 ms, TR = 31.4 ms, WFS = 2.7 pixels, EPI factor = 5). All subsequent shots over a total time of 4 s are arranged in 6 time phases (TFE factor 21). The T_1 relaxation time was determined using a mono-exponential fit over all time phases, T_2* was estimated by a mono-exponential fit of each set of echoes. The flip angle was determined by calculating the effect of the saturation pulse on the difference in intensities at 4 s (just before the pulse) and at 0 s (just after the pulse). The absolute proton density can be derived from the acquired images by compensating for T_1 and T_2* effects. The scanner is a 1.5T Achieva (Philips Medical Systems, Best, the Netherlands)

Results and discussion. In fig. 1 quantification data is shown of an axial slice of the brain out of the 20 slices that were acquired. In fig. 2 several contrast images are shown that were synthesized out of the quantified data shown in Fig. 1. These were not directly measured, nevertheless they are very similar to the images obtained in the conventional manner. With only 5 minutes acquisition time QRAPTEST is rapid enough for clinical usage. A significant advantage of using the quantification and subsequent synthesis of MR images is that one can choose the scanner parameters for most optimal contrast for each patient individually.

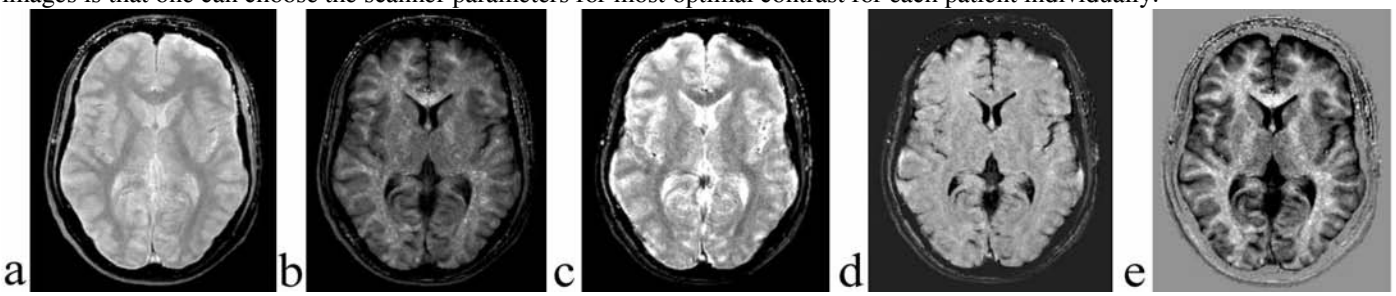

Fig. 2. Synthesized contrast images out of the quantified data showed in Fig. 1. **a**. Proton density weighted image (TE = 5 ms, TR = 9000 ms, flip angle = 90°), **b**. T1 weighted image (TE = 5 ms, TR = 15 ms, flip angle = 30°), **c**. T2* weighted image (TE = 50 ms, TR = 9000 ms, flip angle = 90°), **d**. FLAIR image (TE = 50 ms, TR = 9000 ms, flip angle = 90°, IR delay 2200 ms), **e**. Real image with short IR delay (TE = 5 ms, TR = 9000 ms, flip angle = 90°, IR delay 600 ms).

[1] Zhu XP, Hutchinson CE, Hawnaur JM, Cootes TF, Taylor CJ, Isherwood I. Magnetic resonance image synthesis using a flexible model. Br J Radiol 1994:67 976-82

[2] Gulani V, Schmitt P, Griswold MA, Webb AG, Jakob PM. Towards a single-sequence neurologic magnetic resonance imaging examination: multiple-contrast images from an IR TrueFISP experiment. Investig radiol 2004:39; 767-74.

[3] Warntjes JBM, Dahlqvist O, Lundberg P. A Novel Method for Rapid, Simultaneous T_1, T_2* and Proton Density Quantification. Magn Reson Med. Accepted 2006/10/25