T2rho-Measurement with a Hyperecho-T2rho-Sequence: Principles and First Results on Humans at 3T

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Introduction

The hyperecho mechanism has so far mainly been used to reduce SAR in TSE-sequence in particular at high fields (1). The much more general nature of this refocusing mechanism has been further implemented in diffusion imaging, where hyperechoes can be applied to increase the efficiency of the signal acquisition at a given b-factor or and/or may even shed new insight into the physiological basis of water diffusion in tissues (2,3). The purpose of this paper is to investigate the use of a hyperecho-based sequence sensitive for T2rho. Spatially selective T2rho-measurements in solids have been previously reported in (4). The MARF(magic angle in the rotating frame) has been used to measure T2rho of solids in the range of several microseconds. No implementations of T2rho-sensitive sequences adapted to in vivo-applications have been reported so far contrary to the quite abundant literature on T1rho-measurements based on spin-locking (see (5) and references therein).

Methods.

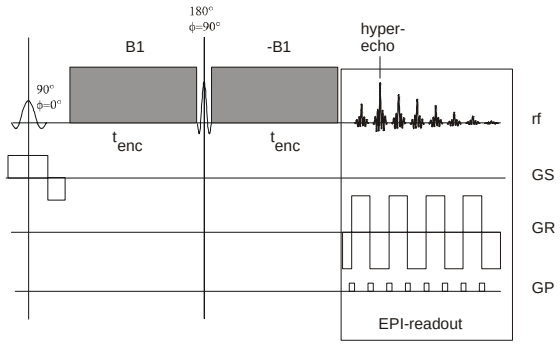

Fig.1 Sequence diagram for hyperecho-t2rho-measurements.

The hyperecho-conditions require, that a pulse sequence is set up such, that RF-pulses are placed with anti-symmetrical phase and amplitude around a central 180°-pulse. For T2rho-measurements this can be translated into the sequence shown in Fig.1. T2rho-encoding is performed by applying antiphasic B1-fields of duration t_{enc} symmetrically around a 180°-pulse. Signal is then read out using an EPI-imaging module. During the T2rho-encoding B1-fields magnetization, which has originally prepared by a 90°-pulse and subsequently dephased in the transverse plane, will rotate around B1 and decay with T2rho. The T2rho-effect can then by quantified by comparison with an experiment were B1 is set to zero.

Experimental

Experiments were performed on a 3T system (Siemens Magnetom Trio) and a 4T system (Bruker MedSpec 4T), both equipped with an 8-channel head receiver coil. B1-field was varied between 0 and 0.2349 G corresponding to resonance frequency in the rotating frame up to 1 kHz. t_{enc} was varied between 1 and 40 ms. TR was 4s, examinations were performed in single slice technique with an EPI-imaging module to produce a 128x128 image (25 cm FOV, SLTH 4 mm). At maximum the SAR was < 20% of the maximum value allowed by the SAR-monitor of the system.

Results

Fig.2 shows the results of measurements performed on the head of a normal volunteer. It is demonstrated, that relative signal intensity scaled to B1=0 first increases, than decreases with increasing B1. Fig.2 shows further examinations into the nature of this initial increase at low B1. It is demonstrated, that the initial increase depends on both the amplitude of the B1-field and the encoding time t_{enc}.

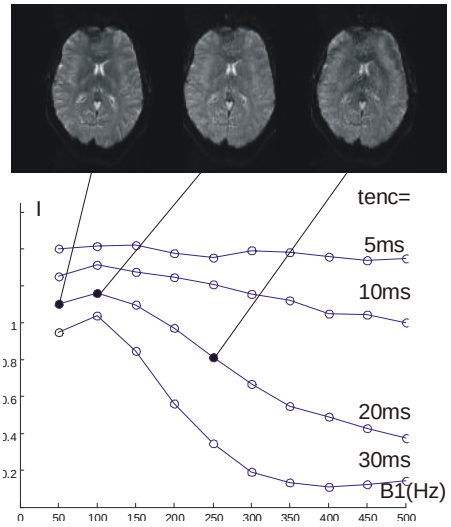

Fig.2(top) and 3(bottom). Rel.signal intensity I as a function of the B1-field (in Hz) for different B1-encoding times for strong (Fig.2) and weak (Fig.3) B1.

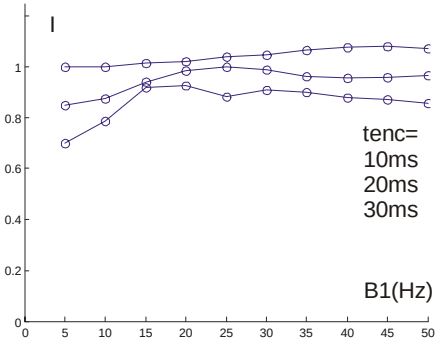

Fig.3

Discussion

There are several potential mechanisms which may contribute to T2rho. One possible explanation for the observed increase at very low B1 may be spin-locking of off-resonance spins. In a conventional T2-experiment (corresponding to B1=0) diffusion in inherent microscopic field gradients will lead to a T2'-effect, which shortens T2 compared to measurements with a CPMG-multiecho experiments. The T2rho-encoding can be regarded as a multiecho experiment with infinitely short echo spacing. T2'-effects are thus avoided due to spin locking.

Conclusions

The feasibility of T2rho-measurements at 3T using a hyperecho-T2rho-sequence has been demonstrated. Measurements at low B1 may enable a closer look at the nature of the internal gradients in tissues and thus offer a new contrast mechanism for characterization of tissue microstructure. Further measurements are necessary to elucidate the nature and usefulness of the observed effects.
Hyperecho-T2rho-encoding may be combined with other imaging modules to look at effects in different tissue compartments with increased spatial resolution and without the susceptibility effects inherent to EPI.

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