Evaluation of Magnetization Transfer Effects of lower flip angle TSE sequences at 3T

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Purpose

Clinical routine MRI often relies on 2D turbo spin echo sequences (TSE) with a large number of slices for good volume coverage. One undesirable side effect of this acquisition is that adjacent slices act like an off-resonance excitation pulse [1]. This leads to an "artificial" magnetization transfer (MT) effect and, hence, undesired MT contrast [1-5]. Recently, lower flip angle TSE sequences with constant and varying flip angles have become popular to limit SAR. This investigation examines how the MT effect of TSE sequences with constant low and varying flip angles using hyperechoes [6] and TRAPS [7] relates to the TSE 180° MT effect. Performed experiments point out that the MT effect at 3T is inversely linear to the mean refocusing flip angle of a TSE sequence.

Subjects and Methods

All experiments were performed on a 3T whole-body imaging system (Siemens Trio, Erlangen, Germany). Different schemes of flip angle variations were implemented in a common TSE sequence (TR/TE=5000/80ms, MATRIX=256x208, ESP=6.6ms, slth=5mm): constant flip angles (180°, 150°, 120°, 90°, 60°), hyperechoes (90°, 60°), TRAPS (90° and 60° with linear and optimized ramps). A protocol with two different echo train lengths (ETL=17, ETL=27) was employed. For MT investigations comparative measurements between single- and multi-slice acquisitions (5 slices, dist.=5mm) were performed. Signal intensities ($I_{single\text{-}slice}$ and $I_{multi\text{-}slice}$) were evaluated in ROIs of cerebral WM, GM, and CSF. MT effect was quantified via MT = $I_{multi\text{-}slice} / I_{single\text{-}slice}$.

Results

Figure 1 presents the assessed mean MT effect versus the refocusing flip angles used by the TSE sequences (ETL=27). In the upper row only the MT effect of the constant flip angle sequences for GM and WM is displayed. An inversely linear behavior between MT effect and constant flip angle can be observed (R=0.998 and R=0.991 for GM and WM, respectively). Additionally, the MT effect of WM for each sequence is constantly stronger than of GM. This is due to a higher content of macromolecules in WM tissue and well known from literature. In the bottom row the MT effect of all acquired sequences is presented. For TSE with varying flip angles the arithmetic mean of the corresponding flip angles was used. Both, hyperechoes and TRAPS with different schemes of flip angle variation also demonstrate an inversely linear behavior between MT effect and flip angles applied (R=0.994 and R=0.988 for GM and WM, respectively). Results for the protocol with ETL=17 were found to be similar (not shown). Thus, both TSE sequences with constant and varying flip angles at 3T may be described by the same linear model. This is pointed out in **Table 1** again. The MT effect in CSF was negligible for each sequence and therefore not shown.

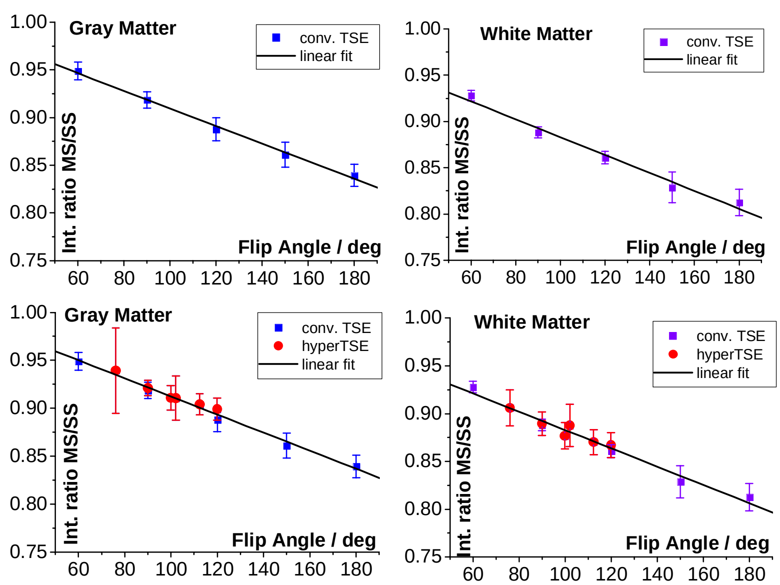

Figure 1: The MT effect vs. flip angle for GM and WM is presented (ETL=27). All sequences show a very linear MT behavior. For varying flip angles the arithmetic mean of the flip angles was used.

lin. reg. coeff. R	GM	WM
conv. TSE	0.998±0.003	0.991±0.007
conv. + hyperTSE	0.994±0.004	0.988±0.005

Table 1: The assessed linear regression coefficients R ± SD for ETL=27 are shown. Conventional and conventional and hyperTSE together are compared. All values are close to 1.

Discussion and Conclusion

It could be shown that the MT effect at 3T correlates inversely linear with the refocusing flip angles used. For varying flip angles the mean flip angle of the rf pulse train can be used. This is a partially surprising result since it is also known from literature that MT effect behaves proportional to the rf power deposition (RFP) of a sequence [1,4]. The RFP is proportional to the square of the flip angle which would result in a quadratic behavior between MT effect and refocusing flip angles. For the future a model is planned that can explain this MT behavior. Further experimental studies are in progress as well.

References

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