Fast three-dimensional magnetization transfer imaging at 3T

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Introduction

Imaging of the magnetization transfer ratio (MTR) has been widely used as sensitive tool to study white matter changes in various neurodegenerative and inflammatory diseases. Magnetization transfer imaging (MTI) at 3T is expected to improve MTR maps in terms of scan time and resolution. Because of the increased power deposition and limitations by the maximum specific absorptions rate (SAR), however, MT protocols for 1.5T cannot simply be transferred to 3T. We here propose a novel MT sequence for 3T that allows repetition times (TR) shorter than 10 ms and that is therefore ideally suited for fast 3D imaging and time-of-flight angiography.

Material and Methods

All experiments were performed on a 3T Tim Trio system (Siemens Medical Systems, Erlangen) using a 12-element head coil. The implemented MT sequence was based on a RF spoiled 3D gradient echo sequence with a 1ms binomial MT saturation pulse (90-180-90) (Fig.1). To control for the power deposition the power intense saturation pulse was played out only prior to each 4^{th} to 8^{th} excitation RF pulse as defined by a repetition factor (Fig.2). This saturation scheme enabled very short repetition times while keeping the power deposition within the SAR limit. To prevent image artefacts caused by the oscillatory steady state magnetization a low-high k space filling strategy was used, i.e. echoes closer to the saturation pulse were used for central k-lines (Fig.3). Numerical simulations were performed to study the relationship between imaging parameters and the resulting MTR, and to find the optimum flip angle for a given TR. As a proof of concept, the sequence was evaluated in the brain of four healthy volunteers. Each series was performed with a constant TR of 14 ms and with a flip angle ranging from 5 to 25° and a repetition factor of 4 to 8. The sequence was performed with isotropic 1x1x1 mm or alternatively with 1x1x2 mm resolution and provided whole brain coverage. MTR maps were calculated from two acquisitions performed with and without the binomial saturation pulse.

Results

The proposed MT sequence provided artefact free MTR maps with an excellent contrast-to-noise ratio (CNR). Figure 4 shows a representative MTR map with 1 mm isotropic resolution. As predicted by the numerical simulations, MTR was highest for small flip angles and the best CNR for grey and white matter was found for a flip angle around 10°. MTR in white matter was around 50% for a repetition factor of 4. Increasing the repetition factor from 4 to 8 resulted in a MTR reduction of 15% in white matter while the power deposition was halved.

Conclusion

Short TR MT imaging is feasible at 3T and is an attractive alternative to MT sequences where the power deposition is controlled by a prolonged TR (1). The highest benefit of our sequence can be expected for high resolution MT imaging and for tissue signal suppression in time-of-flight angiography.

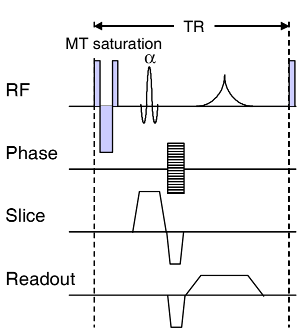

Fig.1.

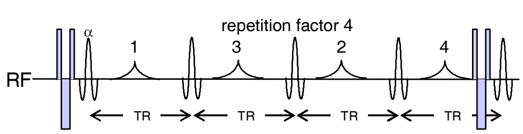

Fig.2

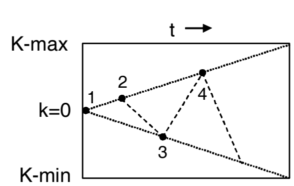

Fig.3

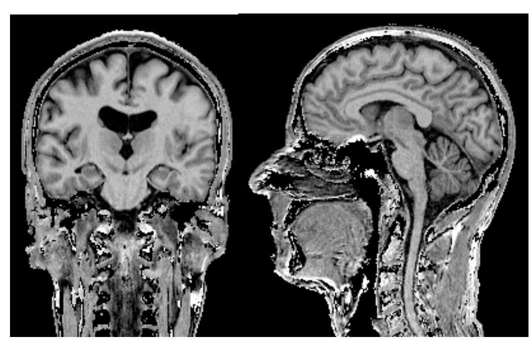

Fig.4

References

1. Smith SA, Farrell JA, Jones C et al. Magn Reson Med 2006;56:866.