T2-Prepared Segmented 3D-Gradient-Echo as Alternative to T2-Weighted TSE for Fast High-Resolution Three-Dimensional Imaging

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Introduction: MRI has proven its potential in non-invasive plaque characterization. By combining the information retrieved from MRI images acquired with different image contrasts including T1W, T2W and PDW, the major plaque components can normally be identified. Most studies so far combine multi spin echo (MSE) techniques with multi-slice acquisition for providing coverage of the required region-of-interest (ROI). A major limitation of the multi-slice approaches results from its non-isotropic spatial resolution and the extension of the technique to isotropic three-dimensional (3D) data acquisition appears appealing. However, the straightforward extension of the MSE techniques to high-resolution 3D imaging is limited by the resulting long acquisition times due to the required long repetition times to ensure sufficient longitudinal relaxation, especially at higher field strengths. It is the objective of this study to investigate the potential of T2-prepared spoiled gradient echo (GE) techniques for providing T2 contrast at isotropic spatial resolution in reasonable acquisition times.

Theory: The application of a T2-preparation pulse (T2PP) is well known from MRI angiography for improving the contrast between blood and e.g. the myocardium. Assuming complete longitudinal relaxation between subsequent T2PP, the resulting signal intensities can be approximated according to $S = \frac{M_0 \sin\theta\left(1-e^{-TR/T_1}\right)}{\left(1-\cos\theta e^{-TR/T_1}\right)} e^{-TE/T_2} e^{-TP/T_2}$, with TP being the T2PP preparation time. Assuming that by choosing a sufficiently short TE, T2* effects can be neglected, the resulting signal is governed by the T2 decay of the tissue superimposed by some additional T1 relaxation.

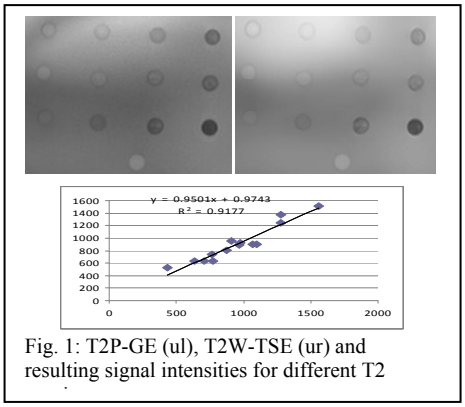

Fig. 1: T2P-GE (ul), T2W-TSE (ur) and resulting signal intensities for different T2

Methods: The study comprised a) the optimization of the acquisition parameter including shot duration ΔT (interval between subsequent T2PP), preparation time TP, acquisition duration TGE (number of gradient echoes per shot times TR) and the excitation flip angle α; b) quantitative comparison of the resulting intensities (SI) with conventional T2W-MSE for different T2 species in a phantom (agarose phantom with different concentrations of iron-oxide); c) qualitative comparison of the resulting contrast in a carotid sample.

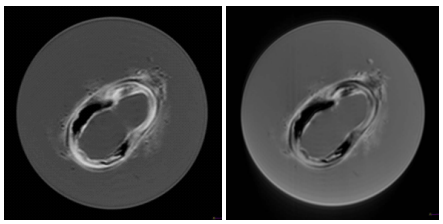
Fig.2: Overview images of a carotid sample acquired by T2P-GE (left) and T2W-MSE (right).

Results: Optimization of the sequence parameter suggested ΔT = 1000 ms, TGE = 128.4 ms and α = 20° for providing a final image contrast similar to a T2W-MSE technique with TE = 50 ms. Resulting images and signal intensities are provided in Fig. 1. Direct comparison yielded a R^2 value of 0.92 but also an offset between the T2P-GE and the T2W-MSE data. After correction for the offset, a paired student's t-test revealed a P-value of 0.06 indicating an almost insignificant difference for the two approaches. Fig. 2 shows the direct comparison of the two approaches for the carotid sample. Although the contrast in the resulting images appears quite similar, at a single location the signal intensity is clearly enhanced in the T2P-GE approach. This is likely caused by some short T1 component such as fat, which are more affected by the intrinsic T1-weighting of the GE-readout. The overall image acquisition time for high-resolution isotropic T2-weighted 3D imaging can be reduced by a factor of 8 by applying the T2P-GE technique instead of the conventional T2W-MSE approach.

Conclusion: The T2-prepared gradient-echo approach can be applied for providing similar T2-weighted contrast as known from the conventional T2W-MSE imaging technique. The substantial reduction of acquisition time may especially be advantages for high-resolution 3D imaging, for which the resulting long acquisition time of the conventional techniques is limiting. To what extent the slight signal enhancement of short T1-components limits the diagnostic value of the technique has to be further evaluated.