T2-Prepared Segmented 3D-Gradient-Echo for Fast T2-Weighted High-Resolution Three-Dimensional Imaging of the Carotid Artery Wall at 3T: A Feasibility Study

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Introduction: The multi-contrast assessment of the carotid artery wall has become an important diagnostic tool for the characterization of atherosclerotic plaque. For providing the required T1-, T2-, and proton density weighted contrast, multi-slice turbo spin echo (TSE) techniques are normally applied. Volumetric imaging of the carotid arteries is limited by the long acquisition times. It is the objective of this study to investigate the potential of T2-prepared spoiled gradient echo (GE) techniques for enabling in vivo high-resolution T2W contrast of the carotid artery wall at isotropic spatial resolution in reasonable acquisition times.

Theory: The application of a T2-preparation sequence (T2P) is well known e.g. from MRI coronary angiography for improving the contrast between blood and the myocardium[1, 2]. The signal intensity of a T2P gradient echo sequence can be approximated by $S = \frac{M_0 \sin\theta(1-e^{-TR/T1})}{(1-\cos\theta e^{-TR/T1})} e^{-T_E/T_2^*} e^{-T_P/T_2}$, if complete relaxation between subsequent T2P is assumed. In case of sufficiently short TE, T2* effects can be neglected and the resulting signal is governed by the T2 decay of the tissue superimposed by additional T1 relaxation.

Methods: Ten patients were enrolled in this feasibility study. Each patient underwent our conventional carotid artery wall MRI protocol comprising three-dimensional high-resolution PDW (TE/TR = 10ms/3RR), T1W (TE/TR = 10ms/1RR) and T2W (TE/TR = 52ms/3RR) double-inversion recovery multi spin echo sequence (3D-TSE). Additionally two gradient echo sequences with and without T2P (TE/TR/α = 3.3ms/6.4ms/20°) were acquired. For the segmented T2P-GE sequence the acquisition parameters were as: interval between subsequent T2P ΔT = 750 ms, TE = 3.3 ms, TR = 6.4 ms, shot length = 193.1 ms, and α = 20°. 3 signal averages were used for ensuring sufficient SNR. All images were acquired in axial orientation centered at the bulbus. For suppression of swallowing motion artifacts, a pencil beam navigator positioned at the epiglottis was applied. All data were acquired with a prototype two times two-element carotid artery coil sized 120 × 50 mm. The two segments were located on either side of the neck aligned with the course of the carotid artery and fixated with a Vac-Lok neck cushion.

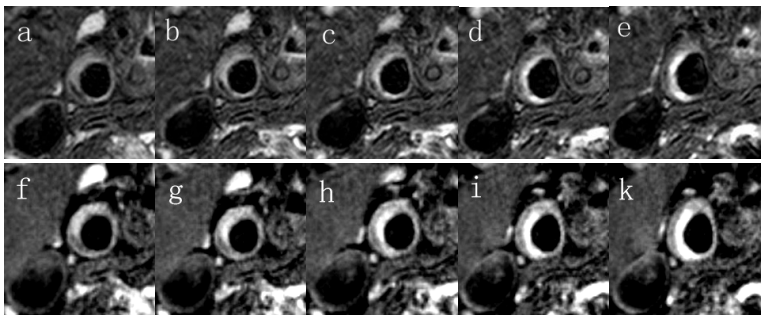

Figure 1: Consecutive slices of an atheroma acquired with the T2W-3DTSE (top) and the T2P-3DGE (bottom) technique

Results: The protocol could be completed in all patients. Acquisition time per slice for the T2W-3DTSE resulted to 23sec. Respective acquisition time for the T2P-GE approach resulted to 16.2sec (5.4sec, one signal average only). Fig. 1 shows 5 consecutive slices of a substantially enlarged vessel wall acquired with the T2W-3DTSE (fig. 1 a-e) in direct comparison with the T2P-3DGE (fig.1 f-k) technique. A very similar contrast in the lesion can be appreciated by both techniques. The SNR and CNR values (see Table I) revealed a significant ($p<0.05$) increase in SNR for both the vessel wall and the lumen, as well as in CNR for the T2 prepared gradient echo technique.

Table I: Quantitative analysis of the SNR and CNR properties of the T2P-3DGE and the T2W-3DTSE technique.

	T2W-3DTSE		T2P-3DGE		
	mean	σ	*mean*	σ	*p*
SNR(wall)	*6.84*	*1.61*	*12.92*	*7.05*	*0.03*
SNR(lumen)	*1.24*	*0.17*	*2.46*	*0.75*	*0.001*
CNR(wall,lumen)	*1.82*	*0.33*	*2.74*	*1.12*	*0.04*

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.

References: (1) Brittain JH, et al. Magn Reson Med. 1995;33:689-696. (2) Kellman P, et al. Magn Reson Med. 2007;57:891-897.