Quantification of Transversal Relaxation Time $T_2$ using an Iterative Regularized Parallel Imaging Reconstruction

M. Kraiger¹, F. Knoll¹, C. Clason², and R. Stollberger¹
¹Institute of Medical Engineering, Graz University of Technology, Graz, Austria, ²Institute for Mathematics and Scientific Computing, University of Graz, Graz, Austria

Introduction
Nonlinear parallel imaging reconstruction using an iterative regularized Gauss Newton method (IRGN) has shown its potential in several applications [1]. This technique determines both the coil sensitivities and the image from undersampled multi-coil data. It enables high acceleration factors without pronounced local enhancement of noise. The numerical implementation of this sophisticated method requires data normalization steps which are usually performed individually for each slice and echo. In this study it was investigated if this type of reconstruction is applicable for quantitative imaging despite the complex reconstruction including individual normalization. For that purpose high resolution multi-echo imaging with different acceleration factors was used for the quantification of the transverse relaxation time ($T_2$).

Methods and Results
Three multi Spin-Echo (SE) datasets from a phantom and a healthy volunteer were acquired on a clinical 3T scanner with different acceleration factors (fully sampled, AF=2 and AF=4) using a 32CH tx/rx head coil and a 8Ch tx/rx knee coil. The phantom consisted of 6 samples with varying Gd-DTPA (Magnevist®) concentration ranging between 0.95 and 6.7 mM. Scanning parameters were TR=1800 ms, 10 echos, 150 mm FOV, 256x256 matrix, 10 slices, echo spacing=20/9.2 ms, slice thickness=5/2 mm for the phantom/in vivo respectively. To estimate the coil sensitivities 24 parallel imaging reference lines were used in the Cartesian k-space. Rawdata were exported from the scanner, and offline reconstructed using the IRGN method. Special care was taken to track all data normalization steps and to reverse their effect in the final step of image reconstruction. All $T_2$ maps were computed using monoexponential linear least squares curve fitting on a pixel-by-pixel basis. The initial spin-echo was excluded from the fitting procedure to minimize artifacts in the $T_2$ calculation due to non-ideal slice profile or B1-inhomogeneities [2].

Our experiments show that the image quality of all accelerated scans is visually comparable to the fully sampled data. No residual aliasing artifacts or local noise amplification were observed up to AF=4. At an acceleration factor of 4 the general noise enhancement introduces noisier $T_2$ maps compared to the fully sampled data. Samples #3 and #6, situated nearby the center of the coil assembly, exhibit higher SD due to the inherent SNR characteristic of phased array coils [3]. However, the comparison of the mean values show that $T_2$ computed from the accelerated scans all lie in the interval mean ± SD of the fully sampled data, and the values are generally in agreement with literature values [4,5] for the in-vivo experiment. In this study we successfully demonstrated that nonlinear parallel imaging IRGN is applicable to quantitative MRI. To our best knowledge in condition of low SNR regime its homogenous noise distribution characteristic makes IRGN a valuable alternative to conventional parallel imaging for quantitative applications.

Acknowledgements
This work is supported by SFB F3209-18.

References

Fig. 1: Representative images of different reconstruction techniques for different acceleration factors and their corresponding $T_2$ maps.

Fig. 2: Comparison of the $T_2$ values from the different reconstruction methods and acceleration factors for the ex-/in-vivo experiments. $T_2$ mean values and standard deviations are shown.