Generation of proton-density- and T2-weighted images with and without fluid suppression from a single radial turbo spin echo acquisition

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Target audience: Researchers who are interested in the efficient acquisition of multi-contrast images and radial sampling

Purpose: Radial turbo spin echo sequences (RARE, TSE, FSE) allow for an efficient data acquisition of images with different contrasts (1,2). By applying the k-space weighted image contrast (KWIC) filter (3), images with the clinically important proton-density (PD) and T2 contrast are obtained from a single radial TSE acquisition. The purpose of this work is to extend the method towards an efficient suppression of the cerebrospinal fluid (CSF). This is accomplished by Fourier-analysis of the multi-contrast image series. In that way, CSF suppressed images with T2 contrast can be obtained in addition to the standard PD and T2 weighted images from a single radial TSE measurement.

Methods: In-vivo experiments were performed on healthy volunteers using a clinical 3 Tesla system after informed consent was obtained. Radial TSE data were acquired using a golden angle reordering approach (4,5) (Parameters: TR=5000ms, ESP=8ms, ETL=25, FOV=220x220mm², N_{proj}=1375, $N_{Readout}$=320). For comparison, a conventional Cartesian FLAIR data set was acquired (Parameters: TR=9000ms, TI=2500ms, TE=81ms, ETL=16, FOV=213x220 mm², matrix=224x320). The raw data were exported and reconstructed offline. Multi-contrast images with different T2-contrast (i.e. different TE_{eff}) using a combination of narrow-band KWIC and iterative SENSE (6) were generated and Fourier-transformed along the TE_{eff} direction (Fig. 1).

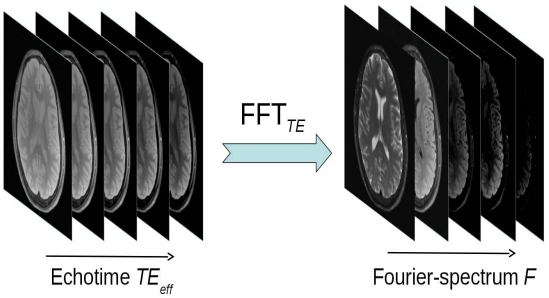

Figure 1: Data processing scheme.

Results: Fig. 2 presents three exemplary images obtained from a single radial TSE acquisition including PD and T2 contrast. After Fourier-transform of the multi-contrast image series, the first Fourier component (F=0) contains mean pixel values (i.e. average T2 contrast, see Fig. 2b). The magnitude combination of additional Fourier components (F>0) contains information on highly dynamic regions (i.e. regions with short T2 components) in which the near static CSF signal is removed (Fig. 2c). On a visual scale, the image quality is similar to that of a standard FLAIR image (Fig. 2d).

Discussion and conclusions: In this work, fluid suppression is achieved by Fourier-analysis of a multi-contrast image series obtained from a single radial TSE data set. This feature is inherent in radial TSE acquisitions and therefore does not require extra measurements. In contrast to many T2-model-based methods, this approach works also in presence of partial volume effects within pixels. For the special case of two contrasts, F=0 is the sum of both images and F=1 is the difference between the images similar to previously presented methods (7,8). However, these methods either require two separate measurements (7) or 3D imaging (8). The contrast achieved by our approach is different to FLAIR. Here, the CSF signal is suppressed due to the very long T2 values, whereas CSF suppression in conventional FLAIR is achieved by magnetization preparation via RF inversion pulse and takes advantage of the long T1 values of CSF. In conclusion, CSF suppression can be achieved in an efficient way by Fourier-analysis of a multi-contrast image series obtained from a single radial TSE data set. Clinical evaluation of this approach is currently work in progress.

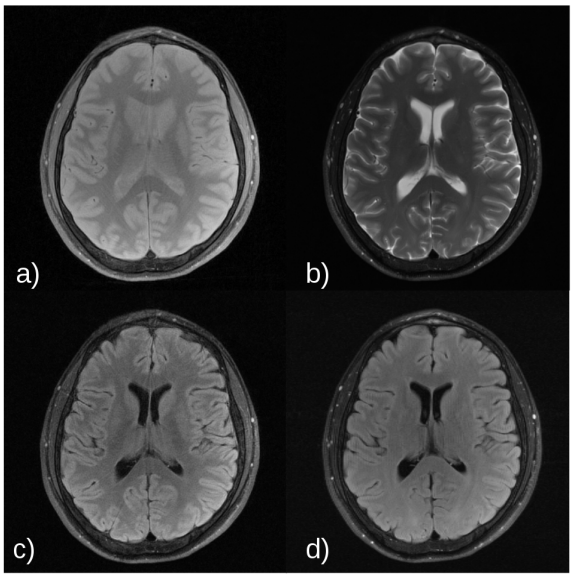

Figure 2: Images with proton-density contrast (a), T2 contrast (b) and T2 contrast with CSF suppression (c) obtained from a single radial TSE acquisition. For comparison, a standard FLAIR image is shown (d).

References:

(1) Rasche V, et al. Radial turbo spin echo imaging. Magn Reson Med. 1994;32(5):629-38.
(2) Altbach MI, et al. Radial fast spin-echo method for T2-weighted imaging and T2 mapping of the liver. J Magn Reson Imaging. 2002;16(2):179-89.
(3) Song HK, Dougherty L. k-space weighted image contrast (KWIC) for contrast manipulation in projection reconstruction MRI. Magn Reson Med. 2000;44(6):825-32.
(4) Winkelmann S, et al. An optimal radial profile order based on the Golden Ratio for time-resolved MRI. IEEE Trans Med Imaging. 2007;26(1):68-76.
(5) Völker M, et al. High resolution T2 weighted Lung Imaging with a radial Turbo Spin-Echo Sequence. Proceedings ISMRM 2010; Abstract 2509.
(6) Pruessmann KP, et al. Advances in sensitivity encoding with arbitrary k-space trajectories. Magn Reson Med. 2001;46(4):638-51.
(7) Essig M, et al. Assessment of cerebral gliomas by a new dark fluid sequence, high intensity REduction (HIRE): a preliminary study. J Magn Reson Imaging. 2000;11(5):506-17.
(8) Park J, et al. Phase-sensitive, dual-acquisition, single-slab, 3D, turbo-spin echo pulse sequence for simultaneous T2-weighted and fluid-attenuated whole-brain imaging. Magn Reson Med. 2010;63(5):1422-30.