SAR reduced Neuro-imaging at 7T using radial GRASE

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Target audience: Scientists who are interested in high resolution SAR reduced Neuro-imaging

Purpose: For high-resolution T_2-weighted Neuro-imaging turbo spin-echo (TSE) techniques are widely used. They offer a high signal to noise ratio (SNR) and are robust in presence of B_0 field inhomogeneities. However, the specific absorption rate (SAR) increases with field strength and flip angle of RF pulse, limiting applications at higher fields (≥3T). In contrast, the combination of spin- and gradient-echo techniques, GRASE [1], has the potential for SAR reduced Neuro-imaging at ultra-high field (≥7T) [2]. A disadvantage of GRASE is the k-space reordering scheme which may lead to ringing artifacts in the phase-encoding direction. To avoid these artifacts a radial, instead of the commonly used Cartesian readout can be used [3]. Furthermore, using a radial acquisition scheme, different T_2-weighted images from one single measurement could be achieved. The aim of this work was to develop a radial GRASE for high-resolution Neuro-imaging at ultra-high field - 7T.

Methods: The radial GRASE sequence diagram is similar to a TSE, except for the number of refocusing pulses. Hence the SAR is reduced by a reduced number of refocusing pulses, allowing for additional oscillating readout gradients (EPI factor) and acquired lines. Due to the lower RF deposition, it is possible to acquire more slices per TR while other parameters (i.e. total acquisition time) are not affected. In the radial GRASE acquisition scheme the echoes are acquired by gradients with different polarities. Different phase information can lead to offresonance effects and signal dropout near air-tissue interfaces for example. To avoid these artifacts, the echoes are separated according to their position in the echo train (EPI-block) and are individually reconstructed [4]. This is possible since in radial imaging all views cross the k-space center and contain low and high frequency information. Thus, several images from one data set can be reconstructed. The final image is obtained by sum of square combination of images with desired echo times (fig. 1). The sequence was implemented on a 7T whole body scanner and in-vivo experiments with Cartesian GRASE and radial GRASE were performed on healthy volunteers after written informed consent was obtained. For signal detection a 24 channel phased-array head coil was used. To reduce ringing artifacts in the Cartesian acquisition scheme, a phase correction was performed.

Results: Fig. 2 shows two different contrasts of a sagittal slice of the head of a healthy volunteer acquired with radial GRASE at 7T. The images are reconstructed as described above for an effective echo time of 35.7 ms and 71.4 ms and the resolution is (0.4 x 0.4 x 1.8) mm. Compared to a TSE sequence with the same measurement parameters, the SAR is reduced by a factor of 3. In figure 3 coronal slices of a healthy volunteer are shown acquired with Cartesian (left) and radial k-space scheme. Ringing artifacts can clearly be seen in the Cartesian scheme (see black arrows) whereas the radial acquisition is free of such artifacts.

Discussion and conclusion: Radial GRASE employs the advantageous properties of a TSE sequence but deposits less SAR. The proposed reconstruction method allows to obtain images without artifacts near air-tissue interfaces. The radial readout offers different T_2 contrasts from one data set and is robust against phase errors caused by the reordering scheme, flow and motion as compared to the Cartesian k-space scheme. Radial GRASE is therefore a potential candidate for SAR reduced high resolution Neuro-imaging at ultra-high field.

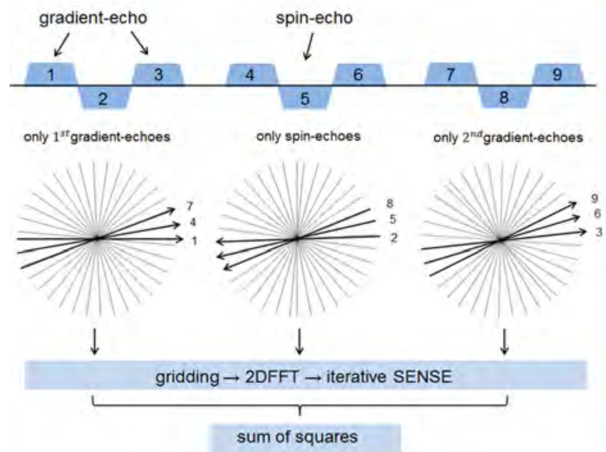

Fig.1. Reconstruction procedure for radial GRASE

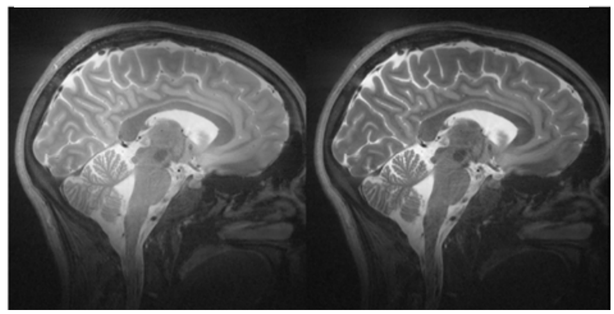

Fig.2. Two contrasts of a sagittal slice of a healthy volunteer acquired with radial GRASE and reconstruct from one data set. Other parameters: TR = 6.2 s, TE = 17.84 ms, TF = 5 and EPI factor = 3.

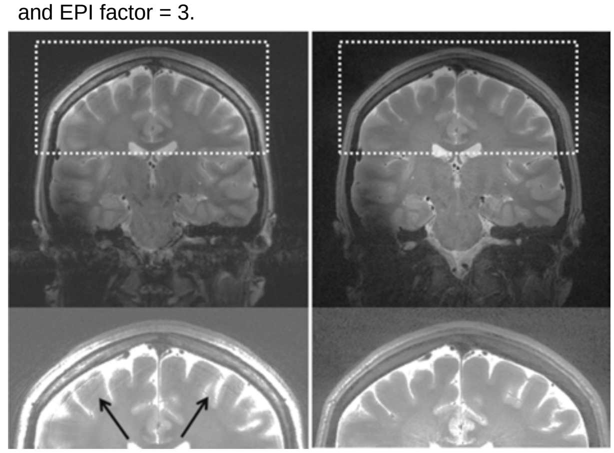

Fig.3. Comparison of two acquisitions schemes: left Cartesian, right radial for the effective echo time of 50 ms and 53 ms.

References: [1] Feinberg et al, (1991) MRM 20:344-349, [2] Trampel et al. (2014) MRM 72:1291-1301, [3] Gmitro et al. (2005) MRM 53:1363-1371, [4] Okanovic et al. 22th ISMRM (2013); 4352