High resolution neuro-imaging with reduced SAR using radial GRASE

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

Purpose: At higher fields (≥ 3T), where the specific-absorption-rate (SAR) increases with the field strength ($SAR \sim B_0^2$) and with the flip angle of the RF-pulses ($SAR \sim \alpha^2$), standard clinical turbo-spin-echo techniques (TSE) often require undesired alteration of imaging parameters due to SAR restrictions. The radial hybrid technique of GRAdient—and Spin-Echo (radial GRASE [1]) has the potential to reduce the SAR compared to TSE, because fewer refocusing pulses are required. The aim of this work was to optimize the radial GRASE sequence for T2-weighted high resolution neuro-imaging at 3 T. In-vivo imaging experiments demonstrate the potential of radial GRASE for SAR reduced neuro-imaging.

Methods: The sequence diagram of radial GRASE is shown in Fig. 1. The echo-train-length (ETL) is given by the number of refocusing pulses (turbo-factor, TF) multiplied by the number of readout gradients per refocusing (EPI-factor). In that way, the number of refocusing RF-pulses and therefore the SAR is reduced by the EPI-factor compared to a standard TSE technique with the same ETL. In this work a linear view ordering was applied because it offers uniform k-space coverage and the blipped gradients are small enough to reduce eddy current artifacts. Because every view contains contrast and high frequency information, the contrast can be varied retrospectively by choosing the appropriate views with the desired echo-times. For phase correction, the gradient echoes are separated according to their position after the refocusing pulse, reconstructed using iterative SENSE [2] and finally magnitude combined. The radial GRASE technique was implemented on a clinical 3T scanner and in-vivo experiments were performed on healthy volunteers, after informed consent was obtained. The work was focused on high resolution images of the human brain with a slice thickness of 2 mm. A field-of-view of 250 mm at a base resolution of 512 points offers a spatial resolution of (0.5 x 0.5 x 2) mm. For comparison additional experiments with a TSE-sequence were made. For the reconstruction of the images, the k-space weighted image contrast (KWIC) filter [3] and a gridding algorithm were used.

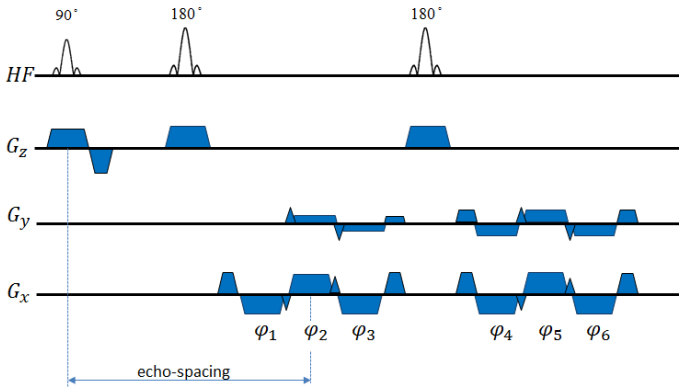

Fig. 1. Sequence diagram of radial GRASE. To acquire different k-space views (i.e. to alter the angle between two subsequent views), blipped gradients in x and y- direction were used.

Results: Fig. 2 shows representative high resolution images of a transverse slice of the human brain. Radial GRASE offers excellent image quality that is comparable to the standard TSE acquisition, but requires 66 % less SAR. With the proposed phase correction it was possible to remove susceptibility artifacts at air-tissue interfaces. Corresponding images of a sagittal slice are shown in Fig. 3.

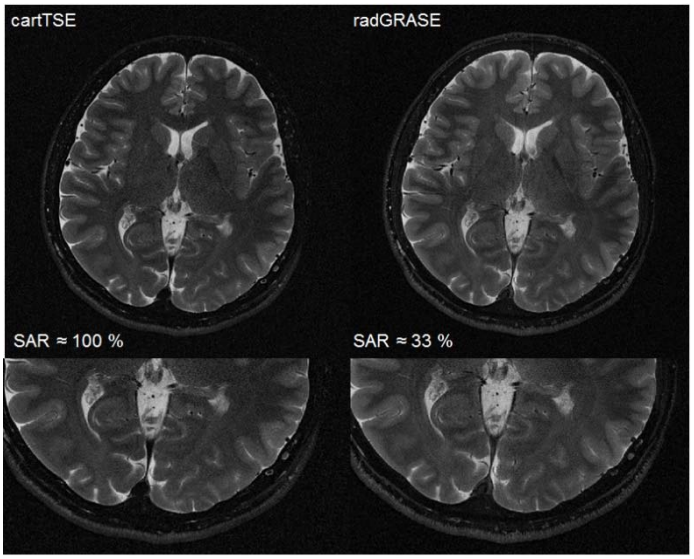

Fig. 2. T2-weighted images of the human brain. Left: cartesian TSE-sequence at TEeff = 95 ms and 2 averages. Right: radial GRASE (1050 views) reconstructed using KWIC (TEeff = 91 ms). Other parameters: ETL = 15 (TF = 15 for TSE and TF=5, EPI = 3 for radial GRASE), Tacq = 5:50 min (both).

Discussion and conclusion:

Radial GRASE allows the measurement of high resolution images for neuro-imaging with T2- contrast. In principle, different T2-weightings can be obtained by adjusting the KWIC filter. The image quality is comparable to the clinical standard techniques. The experiments could be performed without limitations due to restrictions, like reduced number of slices or increased repetition time. Therefore the proposed technique offers an efficient method for SAR reduced neuro-imaging at high field applications.

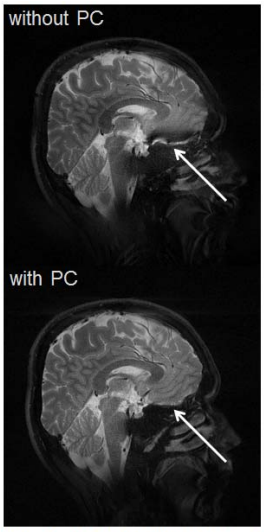

Fig. 3. T2-weigted images of the human brain obtained using radial GRASE without (top) and with (bottom) phase correction prior to gridding.

References:

[1] Gmitro et al. (2005) MRM 53:1363-1371
[2] Pruessmann et al. (2001) MRM 46:638-651
[3] Song et al. (2000) MRM 44:825-832