Initial experience with SPIral Non Selective (SPINS) RF pulses for homogeneous excitation at 7T

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MOTIVATION The increased SNR at high field strength (here 7T) allows volumetric brain imaging at isotropic resolutions well below 1 mm. However, these images are currently not accepted for clinical use, due to the decreased image uniformity when compared to 1.5 and 3T images. The well-known central brightening effect, which is already appearing at 3T, is the main reason for this lack of clinical acceptance. Recently, a method based on SPIral Non Selective (SPINS) RF pulses [1] was introduced at 3T to overcome this effect. Here, we explore the effectiveness of this method for 7T T1W (MP-RAGE) imaging.

METHODS Data in three subjects was acquired with a Philips 7T MR scanner using a Nova Medical 2-channel T/R head coil in combination with a 32-channel receive array. The 2 channels of the transmit coil were driven independently. The scanner software was expanded with an RF and gradient pulse interface to allow for easy transfer between externally calculated RF and gradient waveforms and the scanner software. After image based B0-shimming over the brain, B1 maps of the 2 individual channels of the transmit coil were acquired using the DREAM method [2]. After brain extraction, these maps served as input for the RF pulse design software. Details of the RF-pulse design can be found in ref. [1]. In short, the method is based on the small tip angle approach [3] using a spiral excitation k-space trajectory of 3ms in combination with a magnitude least square method to optimize the RF waveform with respect to image uniformity. The complete 3D brain volumes provided by the B1 maps were used as the transmit fields of the individual RF channels. Given the good B0 homogeneity (typical 50 Hz standard deviation over the brain), a uniform B0 field was assumed in the pulse design. To evaluate the pulse performance, 3D low flip angle (~1 degree) gradient echo (GE) images (TR=10ms, TE=1.4ms) were acquired. To correct these 'surrogate B1 maps' for the receive sensitivity of the 32-channel array, an identical GE sequence using an 1 degree standard Sinc-pulse in quadrature mode was acquired together with an additional quadrature DREAM B1 (quadB1) map with the same FOV and resolution. Division of the 1-degree GE image by the quadB1 map provides the receive sensitivity map that was used to create the 'surrogate B1 maps'. T1W MP-RAGE images with a standard 8 degree pulse were compared with an 8 degree SPINS pulse. Imaging parameters were: 3D sagittal TFE sequence with isotropic 0.8mm resolution, shot interval 3500ms, TR=9ms, TE=2.9ms, linear profile order, SENSE APxRL 1.3x2, CLEAR no, adiabatic inversion, TI=1200ms. Total imaging time was just under 10 min.

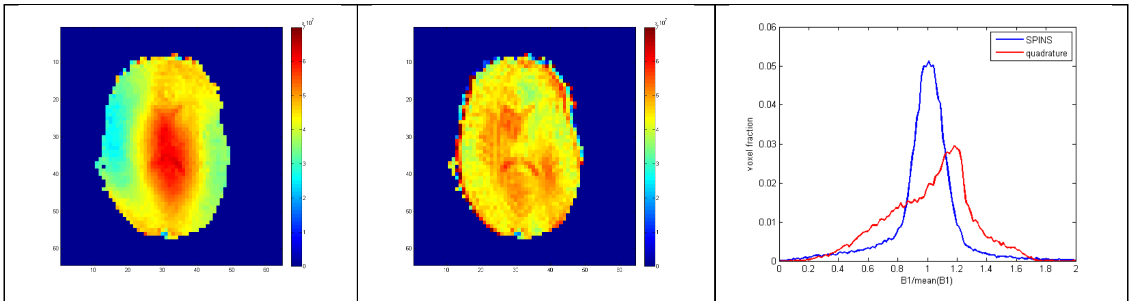

Fig A: Transverse slices of 'surrogate B1 maps' for a quadrature sinc (left) and SPINS (center) excitation pulse. Histograms of whole brain achieved 'surrogate' B1 values are shown on the right.

RESULTS A comparison of excitation homogeneity using a quadrature sinc-pulse and a SPINS pulse is shown in Fig A. A clear improvement of excitation homogeneity is visible. Fig. B shows the same comparison for the MP-RAGE sequence in a different volunteer.

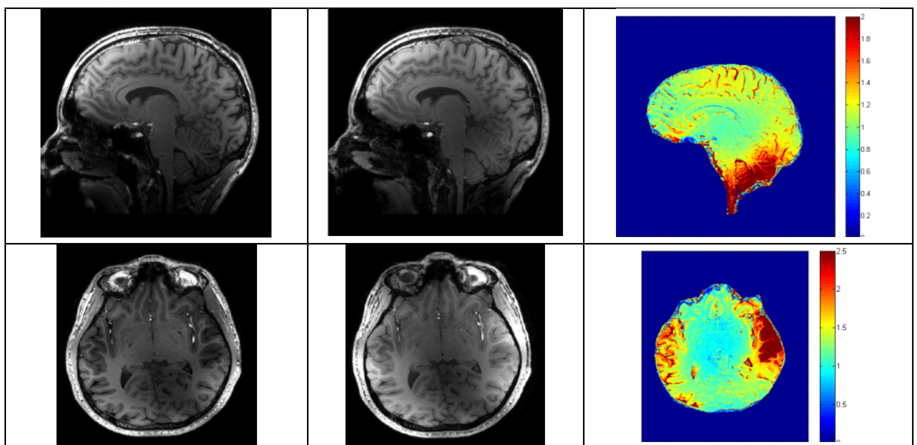

Fig B: Comparison of MP-RAGE with quadrature sinc (2 images on the left) and SPINS (2 images in the center) excitation pulse. The images on the right are ratios of SPINS and quadrature sinc images and show the change in the RF excitation field. Areas in red indicate where the biggest change in image contrast and signal can be seen.

DISCUSSION As can be seen in Fig B, the variation in image contrast between gray and white matter along the cortex in the MP-RAGE images is less variable when using the SPINS pulses (see for example the insula and the cerebellum). In the MP-RAGE images this effect is in part obscured by the non-uniform receive sensitivity of the 32 channel receive array. To get a better impression of the increased transmit homogeneity, the ratio of the SPINS and the quadrature sinc pulse MP-RAGE images is shown on the right: the centre of both images are the same however at the periphery the SPINS image has 50-100% more signal. Clear gray/white matter differences in this ratio support the assertion that tissue contrast as well as overall signal have been changed.

CONCLUSION Initial results using a SPIral Non Selective RF pulse in an MP-RAGE sequence to compensate for the central brightening effect at 7T show a clear improvement in excitation homogeneity.

REFERENCES [1] Malik et al. MRM 67:1303-1315 (2012), [2] Nehrke and Bornert MRM 68: 1517-1526 (2012), [3] Pauly et al., JMR 81:43-56 (1989).