Homogeneous neuroimaging at 7 tesla with short tailored radiofrequency pulses using high permittivity dielectric bags

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Target audience. MR physicists and users of high field MR scanners

Purpose. Neuroimaging at 7 tesla is complicated by the high degree of B_1-inhomogeneity within the brain. Specialized RF pulses that take this B_1 distribution into account can compensate for the inhomogeneous field.[1,2,3] However these pulses are generally much longer than the regular pulses, leading to increased sensitivity to B_0 deviations, limiting their applicability. Using dielectric pads[4], part of the B_1 in homogeneities can be reduced, potentially leading to the design of shorter RF pulses to compensate for the remainder of the inhomogeneities. In this study the combination of specialized 3D RF pulses in combination with dielectric pads is investigated.

Method. All experiments were performed on a 7T whole body system equipped with a quadrature transmit head coil and a 32 channel receive coil array. Six healthy subjects have been included with mean age 29 and the study was approved by the local institutional review board. Two $BaTiO_3$ dielectric pads, 18 cm by 18 cm, as described in [4] are positioned on either side of the head. Tailored RF pulses with three different lengths of 1.7 ms, 2 ms, and 3 ms have been designed aimed at homogeneous RF excitation in the head using a 3D spiral gradient trajectory. The trajectories contain 4, 7 and 11 revolutions and extend in k-space to 50, 60 and 100 rad /m, respectively. These tailored RF pulses are designed using the small tip angle approach: the input to the tailored RF pulse is the flip angle distribution produced by the DREAM[6] sequence, both with and without the dielectric pads in place. The resulting flip angle distribution as function of the three tailored RF pulses was imaged using a dual TR (AFI) sequence.[5] The DREAM (flip angle 50^o, scan time 9 s) and AFI (flip angle 40^o, TR 30/150 ms, 59s) both have a field-of-view of 240 x 240 mm with 5 mm isotropic resolution. A high resolution whole brain T2 weighted 3D turbo spin echo sequence with the tailored pulse was run to show the clinical value of the approach presented here. The 3D TSE (flip angle 90^o, 5m33s, FOV 250 x 168 x 250 mm at 0.8 mm isotropic resolution, TR 3000 ms with SENSE factors 2 in AP and 2.8 in RL direction.

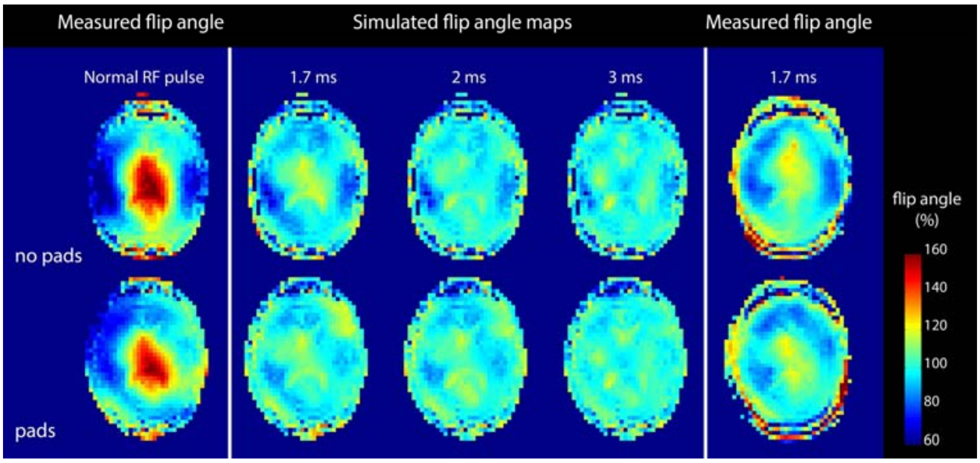

Figure 1. The **'Normal RF pulse'** flip angle maps with and without pads are the base images for the tailored RF pulse calculation and simulation. The three **simulated flip angle maps** of increasing length of the tailored RF pulse lengths are showing an increased homogeneity. The scans with pads have superior homogeneity over the 'no pads' case. The last images are the **measured flip angle** maps of the 1.7 ms tailored RF pulse which are similar to the simulated maps.

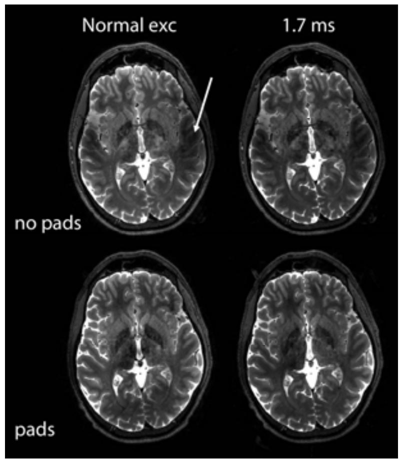

Figure 2. 3D Turbo Spin Echo images, normal excitation versus 1.7ms tailored RF pulse. With and without dielectric pads.

Results. *Figure 1* shows the simulated field maps using the tailored RF pulses based on the DREAM with normal RF pulse. The homogeneity of the maps increases with pulse length, which is in line with theory.[1,2,3] In addition, the simulated 'with pads' cases show an extra increase in homogeneity over the 'no pads' case. Therefore, a reduction of the pulse length can be achieved using the high permittivity dielectric pads. Experimental in-vivo flip angle maps of the same 1.7 ms pulse in *Figure 1* show similar flip angle distributions as the simulations. The increase in homogeneity and alleviation of voids from using the dielectric pads and tailored pulses in *Figure 2* show the clinical utility of this approach.

Conclusion. The combined methods of tailored RF and dielectric bags can create more homogeneous excitation than with a tailored RF pulse alone.

References. [1]Yip et al. MRM 2005. [2]Setsompop et al. MRM 2008. [3]Malik et al. MRM 2012. [4]Teeuwisse et al, MRM 2012. [5]Yarnykh MRM 2007. [6] Börnert et al, MRM 2012