300 MHz receive array setup for high resolution in vitro studies of human brain tissue

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Purpose: Improve RF sensitivity and B_0 homogeneity for *in vitro* brain studies at 7T by adding multiple receive coils and polymer shims.

Introduction: We have been studying various sources of contrast in T_2^* weighted and phase imaging. As part of these investigations we are imaging post mortem human and animal brain samples to allow for more detailed correlation with histology afterwards. The samples are placed in homemade, cylindrical containers to completely immerse them in fluid. We developed a variety of receive element clusters to study specimen of different shape and size with high sensitivity and high resolution. The horizontal arrangement allows for the placement of large numbers of surface coils on the top and bottom face of a short cylinder and for easy rotation with respect to the main field, which is important for the study of susceptibility effects. However, this container shape causes large intrinsic B_0 gradients within the sample and needs particular corrections using external materials. Placement of a long and narrow cylindrical container parallel to B_0 allows for multiple RF array elements surrounding the specimen axially.

Methods: The 3-dimensional sensitivity profiles of several surface coil clusters were simulated using Time-Domain Finite-Difference Finite-Element hybrid method [1]. The preamplifier decoupled arrays were then constructed and its performance verified using saline phantoms and brain specimen. Within this abstract we restrict ourselves to deal with the flat cylindrical sample container and two clusters of 12 member gapped arrays. Figures 1 to 3 show layout of RF array elements, B1 simulation at the space below the top layer and its construction respectively. The magnetization of a cylinder perpendicular to the main magnetic field is equivalent to the field of surface currents in the direction of the cylinder axis with a $\sin(\phi)$ amplitude (ϕ is angle with Z-axis). This results in a homogeneous field for a long cylinder, but an inhomogeneous field for a short cylinder. For the latter case, B_0 can be homogenized with external polymer plates which are positioned adjacent to the sample in z direction. PCV was used as shimming material as its volume susceptibility is close to water and it is easily machined. To homogenize the field we optimized the shape and placement of PVC pieces in simulations using the Fourier method from Salomir et al. [2], we fabricated and then tested the setup with a saline filled flat cylinder using a multi gradient echo imaging sequence on a 7T GE scanner in order to measure the phase as a function of echo time.

Results: The increased brightness at the four corners of the simulations (Fig. 2) is due to sample loading differences which is experimentally verified with the saline filled phantom (not shown here). Figs. 4 and 5 show the measured phase within the sample before and after the polymer B_0 shim correction at constant echo time. The coronal high resolution image (<10 nL voxel resolution within a measurement time of 35 minutes for 20 slices) of a human brain specimen *in vitro* is shown in Figure 6. The intensity variation seen reflect the sensitivity profile of the cluster.

Conclusion: The field homogeneity can be substantially improved by adding the PVC shimming material. The simulated results of the B_0 homogenization resemble the measurements, but are not (yet) identical, likely because the simulated dimensions of the shimming pieces and the container are not exact and the susceptibility of the used PVC was somewhat different than assumed. The use of large number of arrays allow for fast and high resolution images as required for phase application. The intensity profile of the receive array cluster correlates well with the simulation results which in turn can be used to normalize intensity variations within the tissue sample.

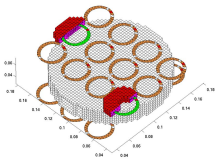

Fig.1: Sample and array

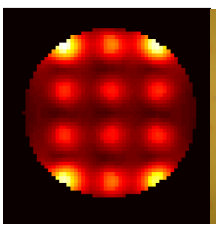

Fig. 2: B_1 simulation

Fig. 3: Built array

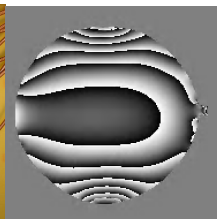

Fig. 4: B_0 before

Fig. 5: B_0 shimmed

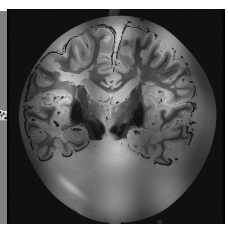

Fig. 6: Human brain tissue

Literature: 1. Wang and Duyn, Phys.Med.Biol. 2008, **53,** 2677-2692, 2. Salomir et al., Concepts in MR, 2003, **19B**, 26-34