High spatial resolution RF Coil for Brain Imaging of Small Monkeys at 11.7 T

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Target Audience: Basic MR researchers with interest in animal imaging as well as RF coil engineers and high-field experts together with applications specialists

Purpose: The squirrel monkey (*saimiri sciureus*) has a similar functional and microstructural organization of the central nervous system to humans. Therefore it holds the potential to provide guidance for further explorations into the brain structure and function especially if investigated at ultrahigh magnetic field strengths. However, the dimensions of the preclinical MR systems, the size of the squirrel monkey's head and the necessary animal handling present considerable constraints for the high spatial resolution imaging. Accepting this challenge, this work presents a design and first results of a dedicated RF coil with a large inner diameter and a thin wall that accommodates the squirrel monkey with the animal handling and provides homogenous signal profile for MR imaging at 11.7 T. The RF coil performance is evaluated in electro-magnetic field simulations and at a workbench. The RF coil applicability for high-resolution MRI is examined *in vivo* at 11.7 T.

Methods: A 32-legged high-pass quadrature birdcage (Figure 1A) [1] was designed within an electromagnetic field (EMF) simulation environment (CST Microwave Studio, CST AG, Darmstadt, Germany). A phantom was placed inside the birdcage ($\varepsilon = 58$, $\sigma = 0.4$ S/m) to approximate the loading of a squirrel monkey's head. The inner diameter of the coil is 63 mm and the length 100 mm. The end rings have a width of 6 mm and the diameter of the shield is 86 mm. The geometry was fixed due to space constrains because of the animal size and the free diameter of the 11.7 T MRI (Biospec 117/20, Bruker, Ettlingen, Germany). Co-circuit simulation was employed to tune and match the birdcage. The same dimensions were used to etch the birdcage layout on a 0.2 mm thick polyimide substrate. Ceramic capacitors (ATC Inc., USA) with values deduced from the co-simulation were soldered to the layout. For matching and tuning variable capacitors (Voltronics, MD, USA) were used. Cable traps were added to each channel. A rigid coil casing, a coil holder, tuning and matching rods as well as dedicated animal handling bed were manufactured by rapid prototyping (BST1200es, Stratasys, USA) (Figure 1C and 1D).

Initial *in vivo* testing was done on Bruker Biospec 11.7T system. The animal was anesthetized with alfaxalone intravenous perfusion and prepared on the animal handling bed. Heating pad was placed below and above the animal and ear bars were used for head fixation. FLASH and FSE sequences were performed to investigate the image quality using the following parameters: FLASH (TR=600ms, TE=5.3ms, FA=30°, 0.25x0.25x1mm³, NEX=1) and FSE (TR=5000ms, TE=13.5ms, 0.4x0.4x0.4 mm³, NEX=2, acquisition time = 21min)

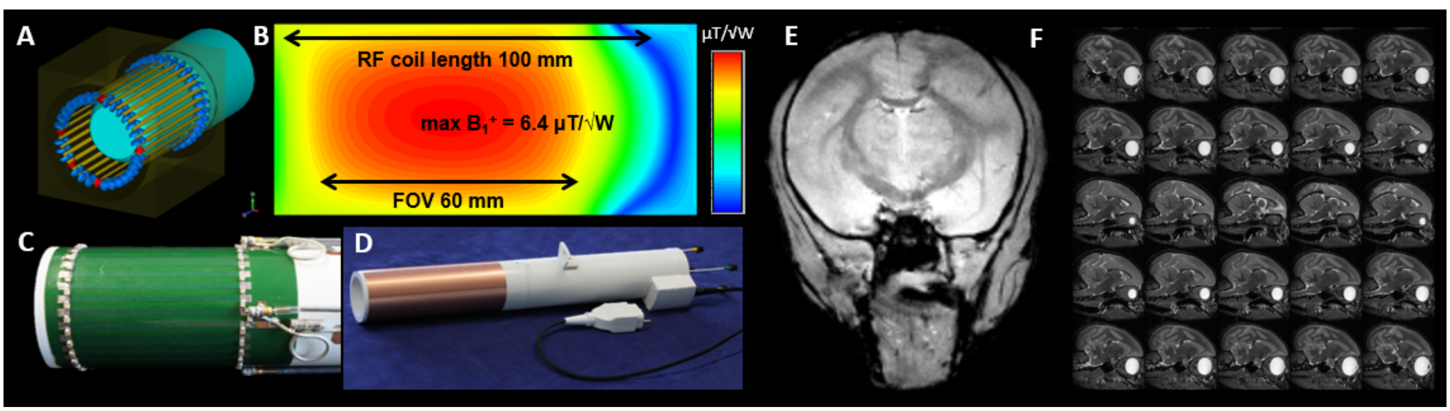

Figure 1: A) 32-legged Birdcage model in the CST Microwave Studio (CST, Darmstadt, Germany); **B)** Simulated B_1^+ field; **C)** picture of the PCB and of the electronics; **D)** picture of the final RF coil with the coil casing, tuning matching rods and coil connector; **E)** coronal slice of squirrel monkey brain, FLASH (0.25x0.25x1mm³); **F)** montage of sagittal slices of squirrel monkey head, FSE (0.4x0.4x0.4 mm³)

Results: The B_1^+ field maps derived from the EMF simulations provided B_1^+ efficiency of 6.4 μT/√W in the center of the phantom (Figure 1B) and a homogeneous field of view of at least 60 mm. The measurements at the workbench of S11/S22 were found to be < -30 dB, decoupling was better than -25 dB while measuring a phantom with similar dielectric properties as used in the EMF simulation. Initial *in vivo* data obtained from an anesthetized monkey are shown in Figure 1E and 1F. Figure 1E shows a T1 weighted coronal slice of the squirrel monkey brain and demonstrates high image quality, B_1^+ homogeneity as well as high level of contrast between the white and grey matter. Figure 1F is a montage of T2 weighted FSE images with 0.4 mm isotropic resolution. Structures like cerebellum, pons, midbrain, corpus callosum and ventricles were very well delineated.

Discussion and conclusion: The proposed high-pass birdcage meets the needs of isotropic, sub-millimeter in-plane spatial resolution brain imaging in squirrel monkeys. The relatively big inner diameter of the RF coil gives necessary space for animal handling and proper animal positioning. Efficacy of the RF coil design in a routine preclinical imaging will be evaluated during the further study.

Acknowledgement: The research leading to these results has received funding from the program "Investissements d'avenir" ANR-10-IAIHU-06, and IPRIAC.

References: [1] Mispelter J. et al, NMR Probehead, 2006