A 1-Channel Transmit Birdcage and 8-Channel Receive Array for In Vivo Rodent Imaging on a 7 T Human Whole-Body System

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Introduction

Since Roemer et al. [1] introduced the concept of phased array coils to MRI, these concepts have become widely used in human imaging as well as small animal imaging [2] to enhance SNR while maintaining an overall large FOV. Another benefit of phased array coils is the ability to use parallel MRI. A 1-channel birdcage transmit / 8-channel receive rodent coil for a 7 T human scanner was therefore built to achieve high resolution images in an acceptable amount of time.

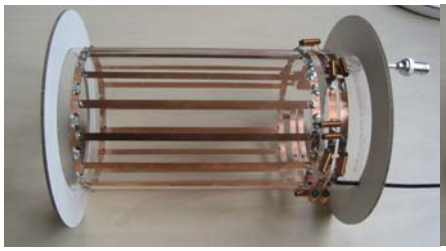

Figure 1: 1ch birdcage transmit coil.

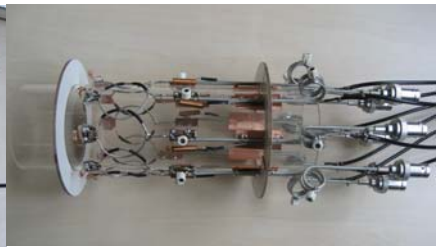

Figure 2: 8ch receive coil insert.

Materials and Methods

Since even at 300 MHz the wavelength is long compared to the size of the animal sample, the transmit coil used is a linearly polarized 16-rung high-pass birdcage coil (Fig. 1). The length of the transmit coil is 15 cm. It is made from 35 µm adhesive copper-foil cut into strips with a width of 5 mm. The strips are affixed to a PMMA tube with an outer diameter of 100 mm and a wall thickness of 3 mm, so the usable inner diameter is 94 mm. For active detuning purposes, one end-ring is divided into four sections by PIN diodes.

The eight-channel receive array consist of 8 detunable symmetric loops formed with semi-rigid cable (Fig. 2). Since the loops are symmetric, there is no need for a cable trap close to the loop feeds. The loops are attached to a PMMA tube with an outer diameter of 60 mm and a wall thickness of 3 mm, leaving a usable inner diameter of 54 mm. The loops are arranged circumferentially around the tube and are geometrically decoupled; each has a diameter of 30 mm to provide the necessary overlap. During transmit, the loops are actively detuned by an inductance parallel to the tuning capacitor so that the tuning capacitor and the inductance form a parallel resonant circuit (Fig. 3).

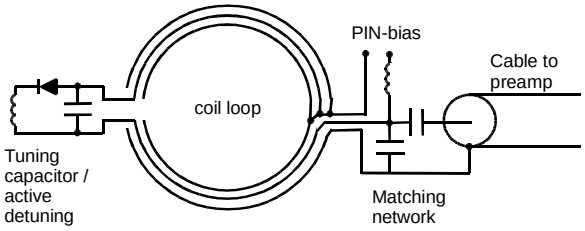

Figure 3: Principle sketch of a loop element.

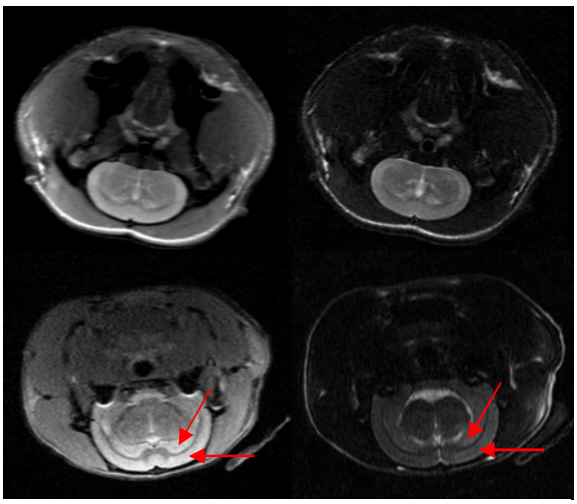

Figure 4: PD- (left) and T2- (right) weighted TSE images of a Zambian mole-rat (*Fukomys anselli*, upper row) and a Wistar rat (lower row). These weightings were acquired simultaneously with a double-echo readout in both animals with a voxel size of 0.17x0.17x1.2 mm³ in 2:40 minutes. GRAPPA parallel image reconstruction with an acceleration factor of 2 was employed.

The cables to the preamps have cable traps just outside the transmit birdcage to prevent outflow of transmit power. The eight preamps are situated in a box 20 cm away from the array.

PMMA is used because its transparency makes positioning of the rodent simple; also, it is possible to visually monitor breathing signs without taking the rodent out of the coil. And lastly, a halogen lamp driven by direct current can be used keep the rodent warm.

All images were acquired on a Siemens 7 T whole body-system (Magnetom 7 T Siemens Healthcare, Erlangen, Germany) using gradients with maximum amplitude of 40 mT/m and maximum slew rate of 200 mT/m/ms. Animals were anesthetized intravenously.

Results and Discussion

Figure 4 shows initial in vivo brain images in a Zambian mole-rat (*Fukomys anselli*) and a Wistar rat. Fine structural details are visible, and even a distinction between hippocampus and cerebrum is possible. The transmit B1 homogeneity is good as expected for a small birdcage coil; the receive sensitivity is greater close to the receive insert tube than in the middle, which is normal for multichannel receive systems which use such a circular arrangement, so the SNR changes by a factor of about 2 from the periphery to the middle of the insert. The array provides sufficient SNR for parallel imaging at these small voxel volumes (35 µL). The resolution is primarily limited by the gradient performance of the 7 T whole-body human scanner and not by sensitivity.

[1] P. B. Roemer et al. MRM 16, 192-225 (1990). [2] D. Gareis et al. NMR Biomed. 20, 326-334 (2007)