Slotted surface coil for magnetic resonance imaging at 4T

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Synopsis. A slotted surface coil, inspired on the cavity magnetron was developed for magnetic resonance imaging (MRI) at 4T. Imaging tests using a saline phantom demonstrated that the slotted surface coil has deeper RF-sensitivity than the single-loop RF-coil. High quality images of two rats were acquired simultaneously using standard spin-echo pulse sequences, demonstrating that the slotted surface coil can be a good tool for rat images at 4T.

Introduction. The use of mice to study models of human disease has resulted in a surge of interest in developing rat MRI [1-2]. Since the MR coil has a strong influence on SNR, optimized coils are mandatory for rat imaging.It has been theoretically proved that the slotted coil has a significantly improved SNR compared with the circular coil SNR [3]. The objective of this work was to develop a slotted surface coil for rat imaging. A 6-slot surface coil was selected because of its higher SNR compared to the circular-shaped coil SNR. Phantom images were acquired at 4T, using a standard spin echo sequence to test the viability of the coil design, and used to measure the uniformity profile of the coil. Body axial images of mice were also acquired using a standard spin echo sequence.

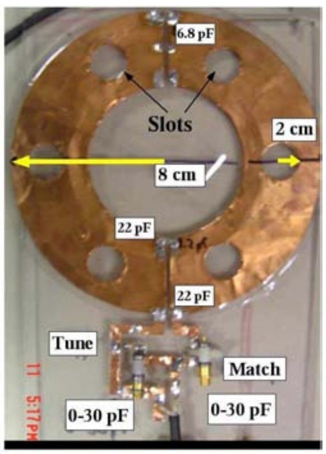

Figure 1. Photo of a 6-slot coil.

Methods. A prototype of the slotted surface coil was built including six 2cm-radius slots, which were machined in a copper circular strip (see Fig. 1). The total coil radius was 8 cm and a strip width of 4 cm. Tuning and matching capacitors (0-30pF) were soldered directly onto the surface: four parallel ceramic capacitors (two 2.2 pF capacitors, one 22 pF and one 6.8 pF) were placed as shown in Fig. 1. To conduct the signal to the coil port of the MR imager, a 50 Ohm-coaxial cable was attached to the prototype and then matched and tuned to 50 Ohms and 170.2 MHz respectively. The quality factor (Q) of the coil was measured with a network analyzer (model 4396A, Hewlett Packard and S parameter test set) divided by the 3-dB bandwidth $\Delta\omega$, with quarter-wavelength coaxial cable at the input of the coil. The loaded (Q) value was measured while the coil was placed on the top of a tap water-filled phantom and was approximately 2212, whereas for the unloaded (free space) case was 1032. Two small rats were anesthetized and placed on the coil. At this stage, cardiac and respiratory gating was not implemented on the mice. All imaging experiments were carried out on a 4T human Varian/Siemens system (Varian, Inc, Palto Alto, CA) interfaced with an INOVA console. T2-weighted axial images of a phantom were acquired with the following acquisition parameters: TE/TR = 60/5000 ms, FOV = 10 cm, matrix size = 256x256, slice thickness = 10 mm, NEX = 20. T1-weighted axial images of two rs were then acquired using a spin echo imaging sequence: TE/TR = / ms, FOV = 10 cm, matrix size = 256x256, slice thickness = 10 mm, NEX = 20.

Results and discussion. An axial phantom image obtained with the magnetron coil is shown in Fig. 2b. The sensitivity profiles of the coil was measured with the aid of phantom iamges, showing that the coil has a large uniform sensitivity profile. This uniformity profile shows a little variation across the phantom. The acquired whole-body images of the rats (Fig. 3) have a high quality despite the fact that no cardiac/respiration gating was implemented in the experiments, and the animals were significantly smaller than the coil; coil sensitivity can be increased by scaling down this coil design to the animal size. Images confirmed the viability of this coil design and its compatibility with high field imagers and standard pulse sequences. Thus, these results make this coil design a good candidate for multi-rat imaging for different MRI and MRS applications.

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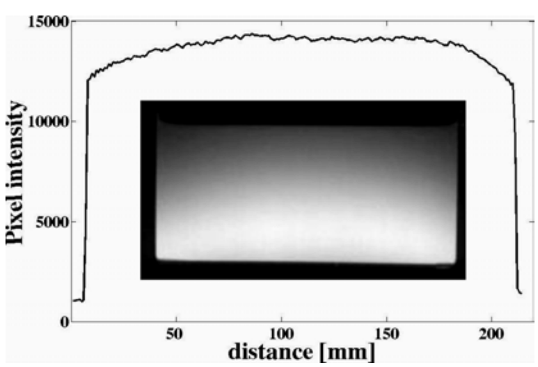

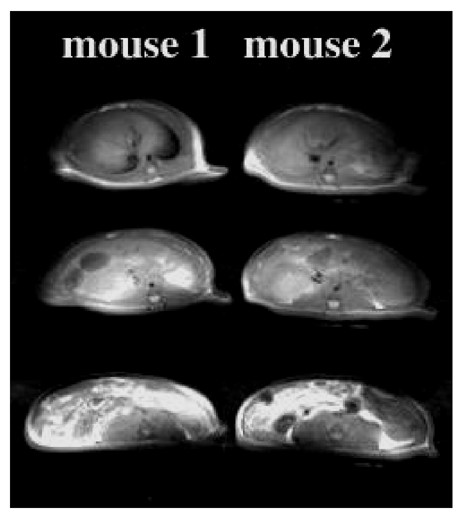

Figure 3. Axial images of two rats acquired with a standard spin-echo sequence.