Transceiver double crossed saddle for rodents at 2T

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Introduction: Small animal MR imaging and spectroscopy, where spatial resolution is a limiting factor, requires the use of distinct transmit and receive coils [1]. This approach makes easier the optimization of the RF field homogeneity for transmit-only coils and signal-to-noise ratio (SNR) for receive-only coils. It also requires that RF coils should be electrically decoupled, commonly using PIN diodes. This work describes the development and double crossed coil operating in the transceiver mode for magnetic resonance imaging of rodents at 2T. Experimental and theoretical comparisons of coil performance were carried out using a standard birdcage coil.

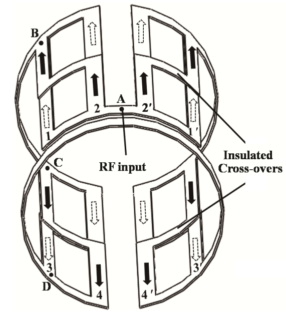

Fig. 1. Schematic of coil design.

Materials and Methods: The standard saddle coil has a single cross with the disadvantage that mutual inductance affects the coil performance. In order to avoid the unwanted effects of mutual inductance due to the proximity of nearby conductors, crossings were inserted at half the electric length on both sides of the coil. Due to this configuration, we called this coil design: double crossed saddle coil (DCS) [2]. Figure 1 shows and schematic of the coil and the current distributions. B1-field maps were calculated using the Biot-Savart law together with specially written programs in Matlab (The MathWorks, Natick, MA). These theoretical results were experimentally compared with maps obtained using the double angle method [3]. For comparison purposes, an 8-rung birdcage coil with the same dimension was constructed, with a 100 mm inner diameter and 200 mm in length. The two coil elements of the coil prototype were then matched and tuned to 50 Ohms and 85.24 MHz (H1 proton frequency). A cylindrical phantom filled (8 cm diameter and 8 cm long) with CUSO4 at 5 mM water solution was used for the in vitro experiments. The quality factors of both coils were measured for the loaded and unloaded cases. All experiments were performed using the pulse sequence RARE (Rapid Acquisition with Relaxation Enhancement) on a Bruker Avance III-MRI spectrometer interfaced with a 2T/31cm 2.0 Oxford magnet. All imaging experiments were acquired with the following parameters: TR/TE=2624/56, FOV= 10cmx10cm, matrix size=256x256, slice thickness= 2mm, NEX=10.

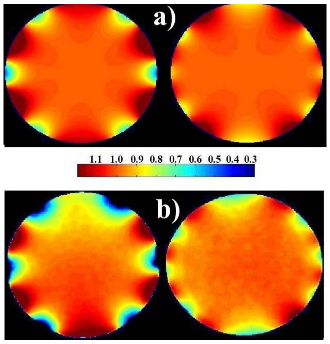

Fig. 2. Normalized B1-field maps: a) theoretical estimates and b) experimental calculations for birdcage (left) and DCS (right) .

Results: Fig. 2 shows the theoretical acquired B1-field maps computed via the Biot-Savart law. The experimentally acquired B1-field maps were calculated using phantom images and the Double Angle Method [3]. The loaded (Q) value of the DCS coil was measured using the cylindrical phantom inside the coil and was approximately 78, whereas for the unloaded (free space) case it was 101. Similarly, the quality factors of the birdcage coil were: Q(loaded)/Q(unloaded)=83/85. Uniformity profiles were computed for all B1-maps and compared, see Fig. 3. Finally, rat images were acquired in different orientations using the parameters above.

Discussion: The B1-maps for both coils showed a very good agreement between the theoretical and experimental computations. Also, they are in good concordance with the results reported in the literature [4]. It can be observed from the uniformity profiles of Fig. 4.a) that the performance of both coils is pretty similar and that the SNR is about the same. The experimental profiles of Fig. 4.b) shows a little disagreement towards the points nearer the coil. This is probably due to construction defect and manipulation of the coil prototype. However, the experimental and theoretical profiles showed a pretty good agreement. The coil design proposed here shows a field homogeneity as good as the 8-rung birdcage coil. This may represent an advantage since the construction and tuning and matching are easier to carry out for the DCS coil.

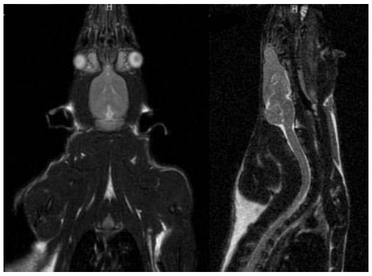

Fig. 3. Rat images in different orientations acquired with the DCS coil.

Conclusions: We have shown that the double crossed saddle coil represents a good alternative for MR imaging of rodents. This coil design can be reliably designed via the simulation of its B1-field. The DCS coil configuration facilitates the tuning and matching at a desired frequency. This is an important advantage since the birdcage coils usually require a great deal of work and effort to develop.

References. [1] Garbow JR, et al. Concepts Mag. Reson. Part B. 2008;33B: 252-259. [2] Papoti D, et. al. Concepts Mag. Reson. Part B. 2010;37B:193. [3] R Stollberger, P Wach. Magn. Res. Med. 1998;35:248. [4]. Jianming J, Electromagnetic Analysis and Design in Magnetic Resonance Imaging, CRC Press, 1998.

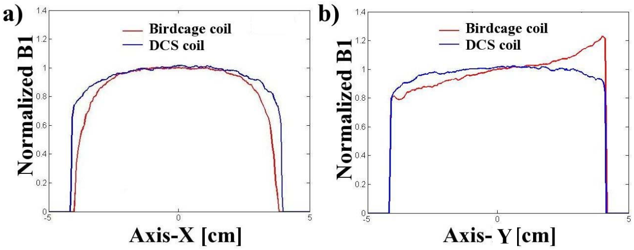

Fig. 4. Comparison of uniformity for experimentally acquired profiles of the Birdcage (Blue) and DCS coil (red) for (a) Axis-X. (b) Axis-Y.