Modular 4-Element coil array constructed of simple coil loops without extra shielding for the simultaneous MRI of multiple small animals

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1. Introduction

Animal models with small animals like rats and mice are common in the research on diseases and its treatment. For those studies the simultaneous examination of multiple small animals is preferable to avoid an overall long scan time for large numbers of animals. Different coil arrays consisting of shielded volume coils were developed for this purpose [1,2]. The aim of this project was to develop a simply constructed modular array system for the examination of rat brains on a clinical MRI scanner.

2. Methods

The four elements of the array were built from 50 µm thick copper tape (PPI Adhesive Products, Lindlar, Germany). The copper tape was coiled once around an acrylic glass tube with a diameter of 38 mm. The array consists of receive only coils with active detuning via PIN diodes. The decoupling of the coils is achieved solely by preamplifiers [3] without any extra shielding. Decoupling is thus realized with low impedance preamplifiers which properly phase matched create high impedance at the coil connectors and thus eliminate induced currents from adjacent coils [4].

The simple construction of the coils provides a fast configuration of adapted coils depending on the examination. This modular concept is furthermore realized by connecting the array via modified flexible coil interfaces (Siemens Medical Solutions, Erlangen, Germany) with the MR scanner. These flexible coil interfaces, which contain the cost intensive preamplifiers, can be used for a various set of home-made four-channel coil arrays.

The quality factor Q, detuning and preamplifier decoupling of the coils were measured using an Agilent E5061A network analyzer (Agilent Technologies, Santa Clara, CA, USA). Q_{loaded} was determined with a phantom loading (Fig. 2 a)). The homogenous phantom consists of a centrifuge vessel filled with sodium chloride solution doped with nickel sulfate. Coupling between coils and signal to noise ratio (SNR) were determined from phantom images measured with a FLASH 2D Sequence (TR/TE 25/11 ms, α=30°, FOV=200 mm, matrix = 512x512, slice = 1 mm, 5 acquisitions, t=5 min). The SNR was compared with a commercial Siemens one-channel coil with similar dimensions. Phantom imaging was performed on a Siemens Magnetom Vision 1.5T scanner.

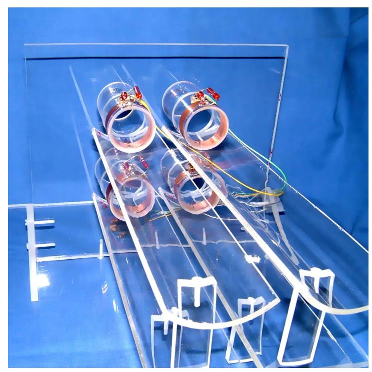

Fig. 1: Four Channel Coil Array for small animal brain examination. Animals are positioned on acrylic glass tables.

3. Results

The quality factor (Q_{loaded} / $Q_{unloaded}$) of the coils was 156 / 122 and the ratio was 1.3. Therefore sample loss was dominating. Detuning during RF transmission was > 52 dB, preamp decoupling was > 25 dB. Due to the good decoupling the minimum isolation between adjacent coils was -15.2 dB. This means that the signal intensity of ghost images was under 17% of the phantom in the examined coil. SNR determined from phantom images averages 45.5 ± 2.1 in comparison to a mean value of 92.4 ± 8.2 of the commercial one-channel coil.

The implementation of the modular array at a clinical MR-scanner worked without further modifications using the avaible four receive channels.

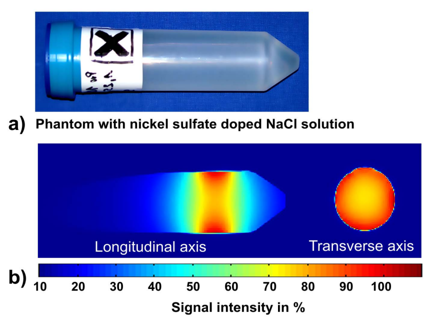

Fig. 2: One channel magnitude picture b) of a sodium chloride phantom a) doped with $NiSO_4$.

4. Discussion and conclusion

N. A. Bock [1] achieved with his mice array constructed of shielded birdcages isolation values < -24 dB for adjacent coils. The isolation of the presented array with solely preamp decoupling has satisfying values < -15.2 dB. Compared to the non array situation a loss in SNR is observed for this design. This needs further improvements of the matching und detuning circuit. The implantation of a sensitivity-encoding like postprocessing will further reduce ghost images [1]. These methods will provide the theoretical achievable increase in time efficiency by simultaneous scanning a large quantity of small animals while keeping image quality on high level.

The design without shielding, resulting in an inexpensive and simple array construction, allows time effective building of individual coil setups. Theoretically it can be expanded with further elements for multi channel receive systems up to 32 channels, if state-of-the-art scanner technology is used. The limitative factor is the open bore dimension of the MR scanner as well as the handling of such a number of animals.

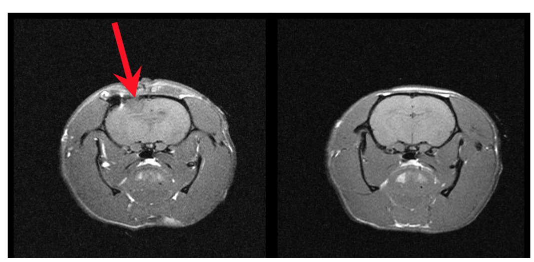

Fig. 3: Simultaneously acquired transverse slices through the brain of two living anesthetized rats (Spinecho TR/TE=600/14 ms, α=90°, FOV=2x50 mm, 0.2 x 0.2 x 1 mm slice, 7 acquisitions, t= 35 min). The left animal has a cerebral trauma which is clearly visible at the marked area.

5. Refercences

[1] Bock, N. A., N. B. Konyer, et al. (2003). Magn Reson Med 49(1): 158-67.
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