A Solenoid Receive Array for Multi-Mouse Imaging at 1.5 T

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Introduction

The increasing interest in small animal MRI and the need for large scale studies has led to several MRI methods of concurrent imaging. To enable high-throughput screening of mice in a clinical MR scanner most approaches use some variation of a 'mouse-hive' in the magnet bore [1]. Salient features are housing each animal in its shielded transmit/receive volume coil, preferably a birdcage, and stacking these coils hexagonally their axes being aligned with B_0.

If all mice are to be imaged simultaneously this coil assembly can produce 2D-image slices in a single orientation only. A second disadvantage of transmit/receive coils is the requirement for power splitters to separately drive each coil. Furthermore if quadrature birdcage coils are used, coil production and impedance matching for a variety of different loads is complicated.

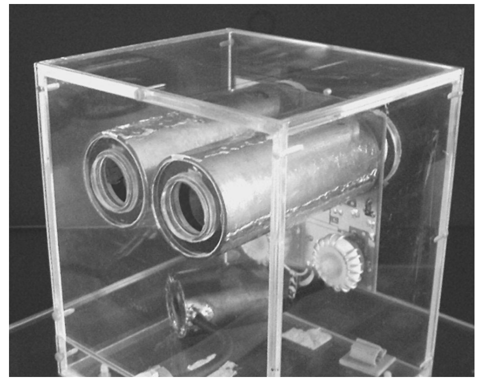

Fig. 1: *Prototype of the solenoid receive array with two separate coil elements.*

Instead we propose an add-on-system of receive-only coils (Fig. 1) which has no need for power splitters and which fits into a standard clinical 1.5 T MR scanner. Due to its configuration which is similar to conventional phased array coils, only minimal modification to scanner hard- and software is necessary. Concurrent mouse imaging is possible in two orientations since all coil axes are located in the same plane. Considering their inherently high sensitivity, similarity of shape with the mouse, simplicity of fabrication and impedance matching, a coplanar row of receive-coil solenoids was designed and manufactured. To avoid post-processing for signal separation, coil shielding was integrated into the receive array.

Materials and Methods

Each individual solenoid receive coil element consists of 9 turns of adhesive-backed copper foil (3M, 5mm, 35µm) wound on a cylindrical Plexiglas tube (∅ 30mm, length 80mm). The winding is interrupted at halfway by a capacitance for ease of balancing and impedance matching to the preamplifier. A coaxial copper foil shielding on a second outer cylinder (∅ 48mm, length: 106mm) is cut along a 1mm stretch so that the B_1-field of the whole body resonator can sufficiently penetrate during rf excitation. In receive mode this shield attenuates the coil-to-coil crosstalk. Each coil is connected to a separate preamplifier and rf receiver. The coils are initially tuned and matched to an average mouse of 20 g, and in the later animal experiments no further adjustment was performed. Coil element dimensions are chosen to allow for 8 coil elements in a row, taking into account the homogeneous imaging field-of-view of 400 mm. Each solenoid coil can be connected with a dedicated plug on one side to an anaesthetizing device, the other being the mice insertion side.

In a prototype array consisting of 2 coil elements the mutual coupling of the coils was assessed. Therefore, the artefact signal intensities in neighbouring coils were measured and related to the signal intensity within the coil. Finally, the performance of the coil array was tested in different animal studies.

Results and Discussion

The phantom experiments showed, that the shielding reduced the artefact intensity to 3% which is a level where further image post-processing is unnecessary. In Fig. 2 a transverse section of a T1-weighted spin echo image through the hind legs of two tumour-bearing mice are shown. Here, the standard sum-of-squares image reconstruction algorithm was used for signal combination.

We have shown that it is possible to acquire multi-mouse images concurrently with a receive-only no-tune solenoid array in a clinical 1.5 T MRI system (Fig. 2). Despite the simple coil concept high image quality was achieved at acquisition times which are comparable to those of clinical MRI studies. At present, a coil array with 4 coplanar elements is constructed which will further help to increase animal throughput and/or image signal-to-noise ratio.

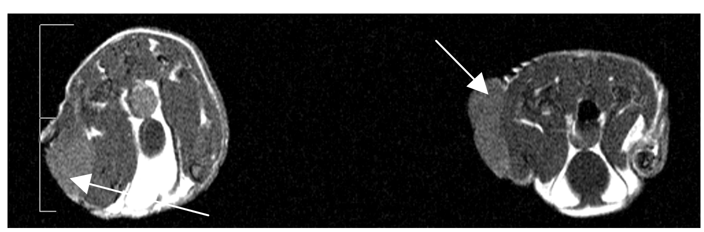

Fig. 2: *T1-weighted 2D-spin-echo image of two mice, simultaneously acquired with TR = 600 ms, TE = 17 ms, matrix = 512 × 256, FOV = 40 mm × 80 mm, slice thickness = 1 mm, acquisition time = 2.5 min. The tumours are marked with arrows. In the tumours an SNR of 4.6 was measured.*

References

[1] Bock N, et al. *Multiple-Mouse MRI*, Magn Reson Med 49: 158-167 (2003)