Design and Comparison of Two 8-Channel Transmit/Receive Radiofrequency Arrays for In Vivo Rodent Imaging on a 7T Human Whole-Body MRI System

S. Orzada[1,2], S. Maderwald[1,2], S. L. Göricke[2], N. Parohl[2], S. C. Ladd[1,2], M. E. Ladd[1,2], and H. H. Quick[1,3]
[1]Erwin L. Hahn Institute for Magnetic Resonance Imaging, Essen, NRW, Germany, [2]Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, Essen, NRW, Germany, [3]Institute of Medical Physics, Friedrich-Alexander-University Erlangen-Nurnberg, Erlangen, Germany

Introduction

Magnetic resonance imaging of rodents can be expected to be a growing field of interest, particularly when translatory imaging research "from mouse to man" is envisioned. Many high-resolution MR imaging studies on genetically manipulated mice and rats have been performed on clinical whole-body MR systems instead of dedicated animal scanners with higher gradient performance, since human whole body systems often are the only option available and provide immediate access to the complete breadth of clinical sequences and software (1-4). In this study, a 1-channel birdcage transmit / 8-channel radiofrequency (RF) receive loop array coil and an 8-channel transmit/receive RF stripline array have been designed for high-resolution rodent imaging on a 7T whole-body human MRI system.

Materials and Methods

The 1-channel birdcage transmit / 8-channel RF receive loop array coil consist of a detunable 16-rung linear polarized high pass birdcage for transmit (Fig. 1A) and a detunable 8-channel loop array for reception (Fig. 1B). The birdcage has a diameter of 10 cm, the usable inner diameter of the inner loop array is 54 mm. The loops have a diameter of 30 mm. The carrier material for the electrical structures is PMMA, making the whole arrangement transparent.

The 8-channel transmit/receive RF stripline array (Fig. 1C, D) consists of 8 inverted microstrip lines with a strip width of 3 mm and length of 40 mm on boards with a length of 60 mm and a width of 20 mm, resulting in a minimum inner diameter of 48 mm.

All images were acquired on a Siemens 7T whole-body system (Magnetom 7T, Siemens Healthcare, Erlangen, Germany) using gradients with maximum amplitude of 40 mT/m and maximum slew rate of 200 mT/m/ms.
For phantom measurements, a cylindrical agar phantom was used with a diameter of 26 mm and a length of 105 mm filled with 2% agar and 0.9% NaCl. SNR measurements were done using a dual acquisition and subtraction method (5).

The study was approved by the local animal protection committee. The two rats (Wistar Wou) for in vivo measurements had a mean length of 20 cm and a mean bodyweight of 300 g. All in vivo images are turbo spin echo (TSE) images with a repetition time TR = 5000 ms. GRAPPA acceleration with R = 2 and 32 autocalibration lines was used in all images, further imaging parameters are given in **Table 1**. All images were interpolated to twice the in-plane resolution.

Results and Discussion

The in vitro measurements show a greater homogeneity for the loop array, which is due to the large size of the transmit birdcage and the bigger diameter of the receive part. The SNR of the smaller strip array is between 30% (center) and 120% (outer regions) higher in the phantom, but shows larger variation.

Figure 2 shows in vivo brain images of a female rat. Fine structural details in all parts of the brain are recognizable. The lower row images acquired with the stripline array show a subjectively better contrast and a better SNR.

Figure 3 shows in vivo body images of a female rat. Motion artifacts due to breathing are visible in all images. The images of the stripline array (lower row) show a subjectively better contrast, but they also reveal flip angle overshoots caused by the proximity of the rat's body surface to the stripline elements, while the birdcage of the 1-channel RF transmit / 8-channel RF receive coil is substantially bigger than the subject, rendering the transmit B_1 field much more homogeneous within the animal.

The 8-channel loop RF array, with its larger inner diameter and transparent layout, provided better overall signal homogeneity and enabled easy visual monitoring and is more suitable for larger animals; the 8-channel stripline RF array provided overall higher SNR and better parallel imaging acceleration performance and is more suitable for smaller rodents and head imaging.

References

[1] Seierstad et al, Phys. in Med. and Biol. (2007); [2] Johnson et al, J Mag. Reson. Imaging (2002); [3] Graf et al, Medical Physics (2003); [4] Thorsen et al, Journal of neuro-oncology (2003), [5] Firbank et al, Phys. in Med. and Biol. (1999)

	TE [ms]	ETL	Voxel size [mm³]	FOV [mm²]	AV	TA (min)
PD ax. head	16	3	0.16 x 0.14 x 1.2	41 x 70	3	7:06
T2 sag. head	85	7	0.27 x 0.14 x 1.2	41 x 70	1	2:45
T2 ax. body	45	9	0.14 x 0.14 x 1.2	42 x 70	3	5:11
T2 cor. body	45	7	0.13 x 0.14 x 1.2	45 x 70	1	3:05

Table 1: TE, echo train length (ETL), voxel size, field of view (FOV), number of averages (AV) and acquisition times (TA). Note: The voxel sizes are non-interpolated.

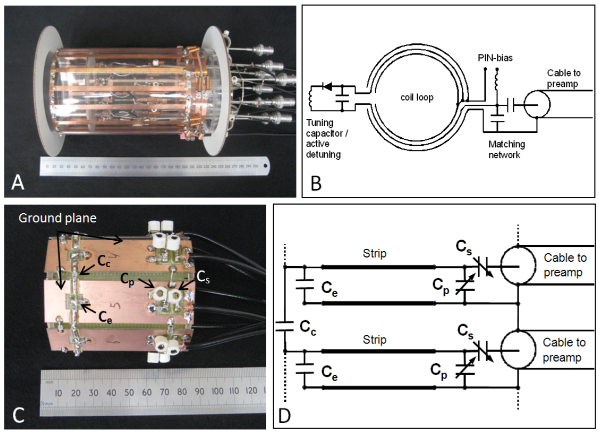

Figure 1: Mechanical and electrical design of the 1-channel RF transmit/8-channel RF receive coil **(A and B)** and 8-channel transmit/receive RF stripline array **(C and D)**. C_s is the series capacitor, C_p the parallel capacitor, C_e the end capacitor and C_c the decoupling capacitor.

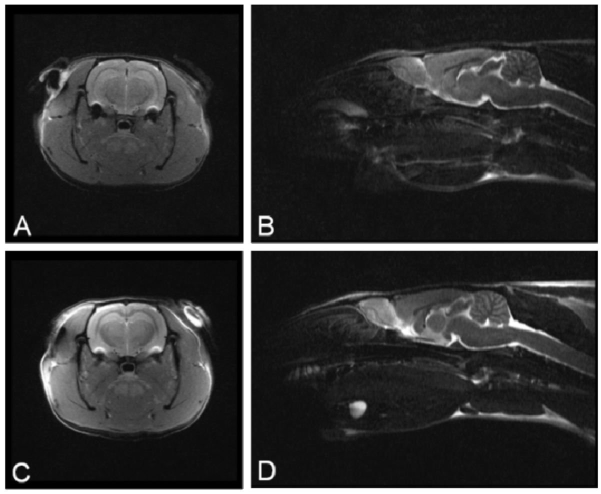

Figure 2: High-resolution in vivo head imaging in a female rat. **(A)**, **(B)** and **(C)**, **(D)** show images acquired with the loop coil and the stripline array, respectively. All images were acquired with spin echo sequences.

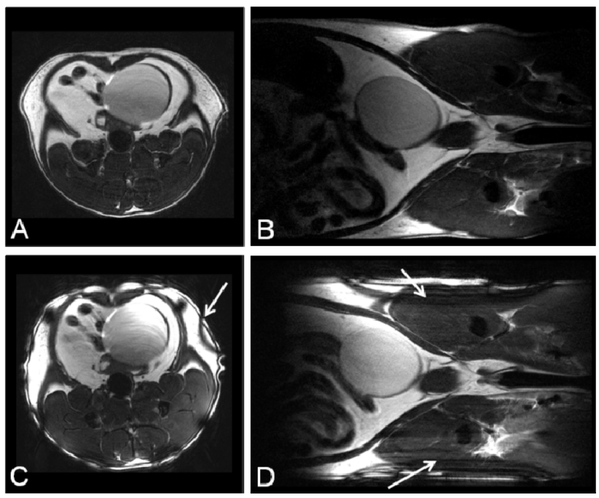

Figure 3: High-resolution in vivo abdominal imaging in a female rat. **(A)**, **(B)** and **(C)**, **(D)** show images acquired with the loop coil and the stripline array, respectively. The arrows **(C, D)** indicate flip angle overshoots.