Performance comparison with 15cm long and 23cm long birdcage coil on 7T

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Introduction

Head loading, rather than coil geometry, dominates the B1 distribution at 7T, as indicated by FDTD simulations (1). Hence, at 7T, coil geometry should be optimized with respect to SNR, excitation power, or B1 distribution under loading conditions, as opposed to the more usual optimization with respect to unloaded conditions. This experimental and numerical study focuses on the role of the axial coil length on the performance of a 7T high-pass birdcage coil.

Methods and Material

Two 32 element high-pass shielded birdcage coils were built with identical geometry other than their axial lengths, which were 15cm and 23cm respectively. The radii of the coil and shield were 150mm and 165mm respectively. The coil element width was 25.4mm. The axial length of the RF shield was 4cm longer than that of the coil elements. The RF shield was composed of 32 copper strips aligned with the birdcage coil elements. The adjacent RF shield strips were electrically connected by 12.6mm copper tape at positions of 0mm, 45mm & 90mm, and 0mm & 40mm from the ends of the coils, for the 23cm and 15cm long birdcage coils, respectively. The connecting copper tape was replaced with 1000pF ceramic capacitors at one of gaps between the copper strips to quench gradient eddy currents. The m=1 mode of the two birdcage coils was tuned to 298MHz in the presence of a human head load.

Two 18cm diameter spherical phantoms were used for the experiments. One, silicon oil with a dielectric constant of 2.8, was used to imitate the unloaded condition, and the other, filled with a NiCl solution, which has a dielectric constant of 86, was used to imitate a human head-loading situation. Volunteer scan was also performed to compare B1 uniformity in human brain images.

The FDTD (2) simulations used a cell size of 3mm, within a 45cm cubic space bounded by an eight cell thick perfect matching layer. Visible-man data, with electrical properties appropriate for 7T (3), were used to simulate the human head.

Results and Discussion

A HP 4396A network analyzer was used to measure the Q values. Table.1 shows the results. The 15cm birdcage coil had higher Q values under both unloaded and loaded conditions. However, the ratio of unloaded to loaded Q was greater with the 23cm birdcage coil.

	15cm long BC		23cm long BC	
	measured	simulated	measured	simulated
unload	101.4	195.7	65.2	71.8
load	44.8	48.7	24.8	16.7

Table.1 The Q values from measurement and simulation.

The SNRs were calculated by the NEMA method, using successive axial SE images. The SE sequence parameters were TR/TE=1000/14, BW=15.63kHz, slice thickness=3mm, FOV=24cmx24cm, resolution=256x256, and 1NEX.

Table.2 shows the results. With the NiCl phantom the 15cm coil had about twice higher SNR than that of the 23cm coil, even though the SNRs with the silicon phantom were comparable.

	silicon phantom	NiCL phantom	human head model
coil	measured	measured	simulated
15cm long	249.23	772.75	33.31
23cm long	263.30	399.26	30.67

Table.2 Measured and simulated relative SNR values

Fig.1 shows the measured B1 uniformity with axial images for both phantoms. The B1 uniformities of axial images are almost the same with the NiCl phantom even though there is a clear difference with the silicon phantom. Fig.2 shows volunteer images with axial and coronal planes. 23cm coil had a little bit longer B1 distribution in S-I direction. However, 15cm coil also had enough coverage in S-I direction for brain study.

RF power necessary for excitation was measured under the assumption that signal in the center of the NiCl phantom is maximized. Table.3 shows that the 15cm long coil needs 10% less power than the 23cm coil.

coil	measured	simulation
15cm long	235	0.9
23cm long	260	1.06

Table.3 RF power in relative units.

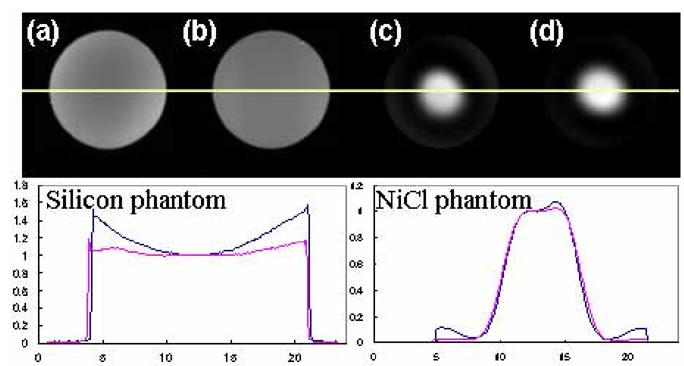

Fig.1 B1 Uniformity demonstrated with axial images of the silicon phantom using the 15cm coil (a), and the 23cm coil (b); and with axial images of the NiCl phantom using the 15cm coil (c), and the 23cm coil (d). Pink and blue lines in the graphs show B1 intensity along yellow lines in the 15cm coil's and 23cm coil's images respectively. The B1 intensity was normalized with B1 intensity at phantom center.

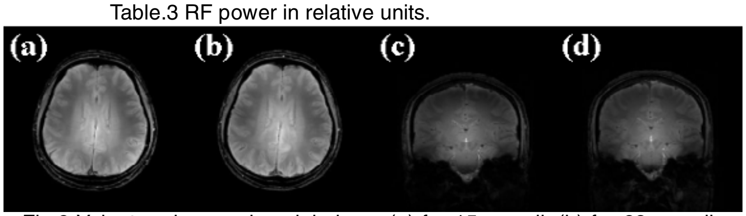

Fig.2 Volunteer images in axial plane; (a) for 15cm coil, (b) for 23cm coil, and coronal plane; (c) for 15cm coil, (d) for 23cm coil.

Conclusion

For 7T head imaging, the efficiency of high-pass birdcage coils can be improved by making their axial length much shorter than would be typical for low field imaging, without adversely affecting the B1 homogeneity for brain study. The FDTD simulations also support the same relative tendencies.

Reference (1) McKinnon & Boskamp, Proceedings of ISMRM 2004, p485 (2) Taflove & Hagness, "Computation Electrodynamics", 2nd Ed. (2000) (3) Gabriel, www.brooks.af.mil/AFRL/HED/hedr/reports/dielectric

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