8-element QD Domed Head Array Coil Using Inductive Decouplers

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Introduction A wraparound head multiple RF coil seems appropriate for use in functional MRI because of its relatively high sensitivity on the cortical area [1,2]. Yet in fMRI experiments it is important that the RF coil have space in which physiological monitors and physiological stimulation apparatus can be installed so that the object's physiological condition can be controlled precisely. So, we considered head multiple coils having a diameter as large as conventional RF receiving coils would be useful for clinical fMRI.

We present a newly developed 1.5 T 8-element QD domed head array coil, that uses inductive decouplers to eliminate mutual coupling. The array coil, which has the same size and head clearance as a conventional head RF coil, has more than 1.7 times greater sensitivity on the cortical area than does a conventional head RF coil.

Method The multiple RF coil consists of eight rectangular element coils arranged to surround a cylinder (Fig. 1). The multiple RF coil's sensitivity vs. the cylinder diameter and the coil's length were calculated under an object-loaded condition by using the moment method combined with the impedance method [3]. A head-neck-shoulder biological object has modeled by an impedance network. The calculated y-direction sensitivity profile of an element coil arranged beside the occiput is shown in Fig. 2. The center sensitivity (y=0) of the element coil changes very little with the cylinder diameter and the coil's longitudinal size (0.7 A/m/(W $^{0.5}$)). The sensitivity at the object's surface (y=-90) for element coils of type 1 arranged on an ellipsoid cylinder with a long axis diameter (y) of 240 mm and a short axis diameter (x) of 200 mm (2.9-3.5 A/m/(W $^{0.5}$)) was 2.3-2.7 times higher than the sensitivity of a QD birdcage resonator (1.275 A/m/(W $^{0.5}$))with a diameter of 280 mm and a length of 300 mm. The sensitivity at the object's surface for element coils of type 2 arranged on a circular cylinder with a diameter of 286 mm (2.3-2.6 A/m/(W $^{0.5}$)) was 1.8-2.0 times higher than that of the birdcage resonator.

We fabricated an array coil of type 2 with a length of 250 mm. The top part of the cylinder and the surrounding coils was domed to improve sensitivity. The mutual coupling between coils that did not overlap each other was not eliminated by the low impedance method alone because of higher Q-factor of the surface coils. We eliminated the residual mutual coupling by using a mutual decoupler until -16 dB, which seemed sufficiently small to remove noise correlation [4]. The mutual decoupler consists of two small 8-shaped series resonant coils that were strongly mutually coupled with each other. Signals from the surface coils were combined to with four signals by using the QD method after the phase match. Then each QD image was combined by using a pixel-by-pixel weighting function, and shading was corrected.

Experimental results Figure 3 shows the phantom images obtained using the fabricated multiple RF coil. The partial images of the surface coils are different from each other, which signifies independent operation of the surface coil. Figure 4 shows the head image that was obtained by using the multiple RF coil, which has 1.7 times greater sensitivity on the cortical area than dose a conventional head QD coil. The multiple RF coil's measured S/N at the center head was the same as the conventional head QD coil's. This array coil can also operate with a 4-channel linear detection circuit to improve sensitivity more on the cortical area though the FOV is limited by half. This degree of flexibility in operation is helpful in fMRI experiments.

Conclusions The feasibility of an 8-element QD domed head array coil using inductive decouplers was evaluated. Isolation between element coils was eliminated by using the inductive decoupler. The fabricated multiple RF coil has 1.7 times higher sensitivity on the cortical area than dose a conventional QD head coil.

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References [1] H. A. Stark and E. M. Haacke, 4th ISMRM, 1412, 1996. [2] C. Leussler, 4th ISMRM, 249, 1996. [3] H. Ochi et al., 11th SMRM, 4021, 1992. [4] T. Takahashi et al., 4th ISMRM, 1418, 1996.

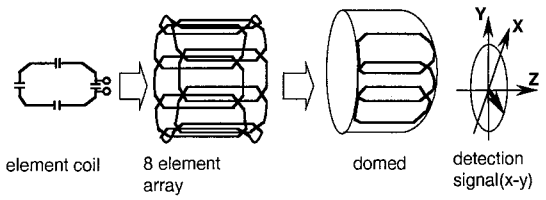

Fig. 1 Schematic view of multiple RF coil

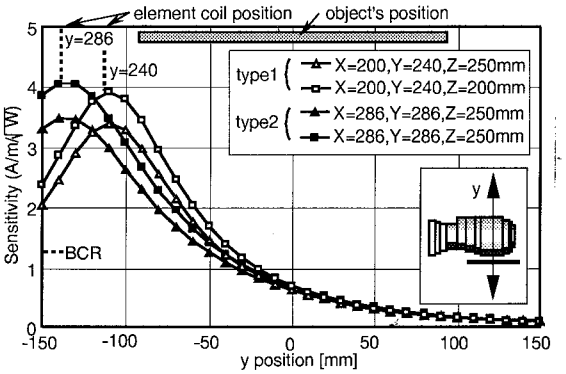

Fig.2 Sensitivity profile of element coils (Calculated)

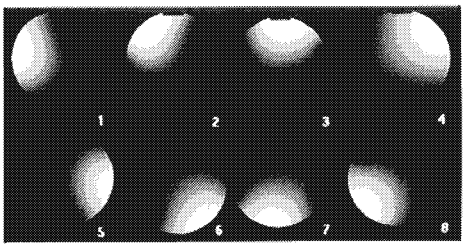

Fig.3 Phantom images (trans)

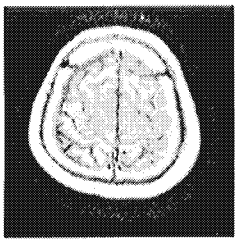

Fig.4 Head image (trans)