

Novel RF coil array designs to improve SNR in dorsal areas of the brain

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Introduction: The conventional RF coil arrays developed for head imaging usually have poorer sensitivity to the dorsal areas of the brain because the coil elements wrap around the head such that they are more sensitive to anterior, posterior, left and right areas of the brain (Fig.1(a)). To partially overcome this problem, manufacturers usually build coils on dome-shaped frames and curve the elements toward the top of the head. But the curved ends have poor sensitivity to the transverse magnetization; thus they have little contribution to the received MR signal [1]. An end cap design was

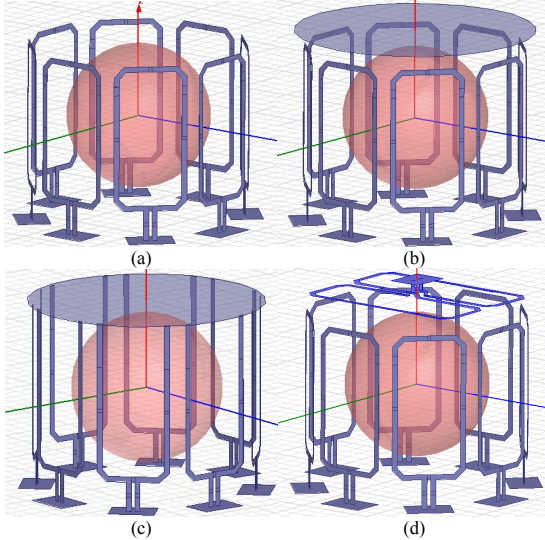


Figure 1. Different RF array coil configurations: (a) 8 loops, (b) 8 loops & end cap, (c) 8 loops & connected end cap, (d) 8 loops & Fo8 on top.

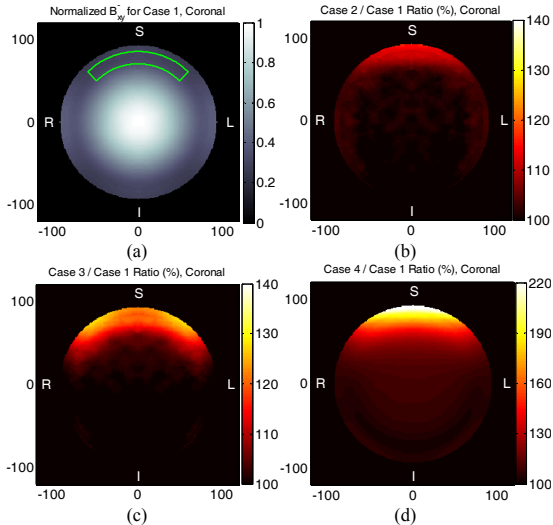


Figure 2. (a) The normalized sensitivity in central coronal slice for the 1st case. (b-d) The percentage SNR improvement for the 2nd, 3rd, and 4th designs with respect to the 1st case.

Table 1. SNR Improvement for coils

Case	in ROI	in Slice
2 nd case	8.3%	2.0%
3 rd case	18.6%	3.1%
4 th case	64.6%	18.3%

its limited performance. Fo8 sensitivity in the coronal and sagittal directions will not be identical, while end cap yields more uniform sensitivity. Two orthogonally placed Fo8 coils can be used to improve uniformity, but this may complicate the coil decoupling needs.

References: [1] Liang ZP *et al.*, P. of MRI, IEEE P, 2000. [2] Hanes CE *et al.*, 5th ISMRM, 39-40, 1986. [3] Alfonsetti M *et al.*, Meas., 43, 1266-76, 2010. [4] Gabriel S *et al.*, PMB., 41, 2251-69, 1996.

previously proposed for birdcage coils [2] that enhanced field uniformity in superior regions of the brain but it has not been used in phased array coils. Alternatively, transverse field RF coils (Figure-of-8, Fo8) might improve SNR in dorsal regions. Fo8 coils are typically combined with the loop coils on flat coil geometries such as spine (CTL) coils but they are not typically used in head coils [3]. Since the Fo8 coil is sensitive to the magnetization that is parallel to its plane, it is ideal for placing over the top of the head. In this study, two different end cap designs and a Fo8 element placed on top of the head were investigated using simulations in order to improve SNR in sensorimotor and parietal areas.

Methods: Full wave electromagnetic modeling (HFSS, ANSYS Inc., Canonsburg, PA, US) was used to study and compare the performances of a conventional coil array design and three novel configurations:

1. Eight rectangular loop elements were placed on a cylindrical surface. A spherical phantom with two compartments was used to mimic the human head (Fig.1(a)). The electrical properties of the inner compartment were selected as the weighted sum of white matter, gray matter and CSF values at $f_0=127.73\text{MHz}$ ($r:8.5\text{cm}$, $\sigma:0.57\text{S/m}$, loss $\tan:1.19$, $\epsilon:63.4\epsilon_0$) [4]. For the outer layer, weighted sum of skull's and scalp's properties were used ($r:9.3\text{cm}$, $\sigma:0.57\text{S/m}$, loss $\tan:0.97$, $\epsilon:35.8\epsilon_0$). Individual coil elements were modeled with conductor segments made up of copper foils (width:6.35mm, thickness:0.04mm). Four capacitors of equal values were placed equidistant from each other for tuning. The matching circuit was also implemented in the model.
2. An end cap was placed transaxially 11cm away from the center of the sphere. The coil conductors did not have any connection to the end cap through conductors or any circuit elements. The rest of the parameters were the same with the 1st case (Fig.1(b)).
3. This design was similar to the 2nd case with the end cap; but the coil conductors were terminated at the end cap and three tuning capacitors were used (the end segment and its capacitor was removed to connect the coil to end cap) (Fig.1(c)).
4. The same model as in the 1st case was used and a Fo8 element was placed transaxially 11cm away from the center of the sphere (Fig.1(d)). Tuning was implemented with eight capacitors since the total length of wire was longer than the loop element. Its orientation was selected such that its receive sensitivity was maximum in the coronal slice that cut through the center of the spherical phantom.

All elements were matched to 50Ω at f_0 . Then the combined receive sensitivity map of RF coil elements was calculated in the central coronal slice for each of the four designs. We then calculated the amount of SNR improvement in a selected region of interest (ROI) that hypothetically covers the sensorimotor areas (green ROI in Fig.2(a)). To calculate the percentage SNR improvement, the sensitivity map of each design was divided by the sensitivity of the conventional design (the 1st case) and multiplied by 100.

Results: The normalized sensitivity in the central coronal slice for the 1st design is given in Fig.2(a). The percentage improvement for the 2nd, 3rd, and 4th designs with respect to the 1st design are shown in Fig.2(b), (c) and (d), respectively. The sensitivity profiles along the z direction are shown in Fig.3 for each design. The average SNR improvement inside the ROI and the overall slice are given in Table 1.

Conclusions: The two end cap designs improved the SNR in the ROI by 8% and 18% for the unconnected and connected cases, respectively. The Fo8 element had superior improvement by 65%. However, decoupling of Fo8 would be done with low impedance preamplifiers, which might degrade the overall performance because of

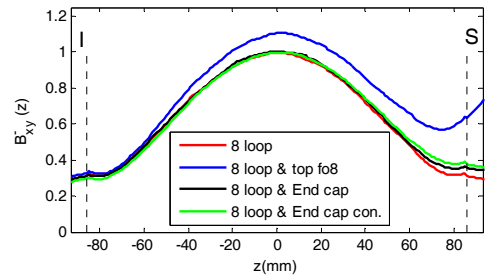


Figure 3. Sensitivity profiles for four coil designs. The end cap or Fo8 is on the right.