Hybrid monopole/loop coil array for human head parallel MR imaging at 7T

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INTRODUCTION The monopole (1, 2) and loop have orthogonal radiofrequency (RF) fields and thus are intrinsically decoupled if they are laid out appropriately. Thus the hybrid monopole/loop array concept, which could combine the advantages of both loop and monopole, might be possible for MR imaging. In this study, this concept was realized by designing and implementing a head coil array containing 4 hybrid monopole/loop blocks at 7T. Bench tests and *in vivo* MR images of this hybrid array were obtained to demonstrate its feasibility and performance in ultrahigh field MRI.

MATERIALS & METHODS A hybrid monopole/loop array containing 4 independent blocks was designed and constructed for human head imaging at 7T (Fig. 1). Each block consists of a monopole channel and a loop channel. The monopole crossed the center of the loop to ensure that the two have orthogonal RF fields and thus are intrinsically electromagnetic decoupled. The 4 monopoles (length 25 cm) and 4 loops (dimension 9 cm×9 cm) were equally spaced along the circumference of an acyclic tube (OD: 25 cm). All channels were used for both transmission and reception. Scattering (S-) parameters of the hybrid coil array loaded with human head were measured with an Agilent network analyzer. GRE images of a healthy human head using the 8-ch hybrid coil array were obtained. The sequence parameters are: FA=25^0, TR/TE=100/10 ms, FOV=200×200 mm^2, matrix=256×256, thickness=2 mm, NEX=1. To demonstrate the benefits of the proposed technique, SNR and g-factor results of the hybrid array were compared with those from monopole-only channels and loop-only channels. All imaging data were acquired on a 7T whole-body MRI scanner (Siemens Healthcare, Erlangen, Germany). In the experiment, scans were conducted two times using 4 loop channels and 4 monopole channels separately.

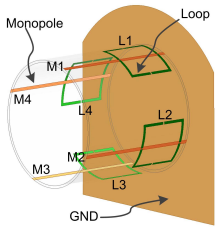

Figure 1 Diagram of the hybrid monopole/loop array.

RESULTS Fig. 2 shows the loaded S-parameter matrix of the 8-ch hybrid array. Average isolation between a loop and a monopole from the same block is -20.1 dB, which verifies their intrinsic decoupling performance. The isolation between loops and monopoles from neighboring blocks is -13.4~-15.2 dB. The average Q_{unload}/Q_{load} of loop channels and monopole channels are 124/34 and 9.4/3.1, respectively. Fig. 3 shows the combined images in different axial planes from all loop channels, all monopole channels and their combination. Loop channels have high signal intensities at the periphery, but these intensities decrease fast with depth. On the contrary, the intensities of images from monopole channels had higher signal intensity at central area. These results indicated that combination of the loop channels and monopole channels, i.e., the hybrid coil array, could provide high signal sensitivities at both the peripheral and central areas. Local SNR (SI/SD×0.655) at the four peripheral areas and the central area of human brain were calculated and marked in red color in Fig. 3. Compared with the loop-only array, the hybrid array had overall SNR gains of 24%~26% and central SNR gains of 89%~108% for different slices. G-factor maps with R of 2, 3, and 4 were calculated using the images from loop channels, monopole channels and all channels (Fig. 4). Average g-factors were also calculated and marked in white color in Fig. 4. At the high accelerate factor of 4, the average g-factor using monopole channels, loop channels and all channels were 1.52, 1.65 and 1.23, respectively.

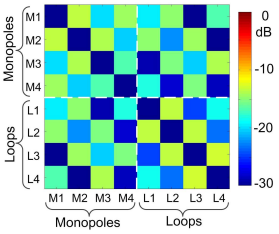

Figure 2 S-parameter matrix of the 8-ch hybrid monopole/ loop array loaded with a healthy human head.

DISCUSSIONS & CONCLUSION When the monopole was placed across the center of the loop, the two coils have orthogonal RF fields and thus were instinct EM decoupled. Based on this characteristic, we proposed and designed a hybrid monopole/loop coil array at 7T. As expected, the coupling between the monopole and loop in the same block was better than -19 dB at 300 MHz, indicating their instinct decoupling performance. Compared with the monopole-only and loop-only arrays, the proposed hybrid array exhibits higher SNR gain and better parallel imaging performance. Beside these benefits, the hybrid array promises additional degrees of freedom for the RF shimming or parallel transmission (pTx) due to increased independent transmit elements (3,4), which could be advantageous to provide more homogeneous transmit field. Due to the limitation of our RF interface, monopoles and loops of the hybrid array were driven separately for imaging acquisition in this study, but they can be used simultaneously given that the coupling among any two channels was low. Although the hybrid monopole/loop array in this study only contains 4 blocks, the number of block could extended to 8 or even more if appropriate decoupling scheme, e.g. magnetic wall decoupling, is applied to ensure sufficient decoupling between adjacent blocks.

REFERENCES [1] S. M. Hong et al. Magn Reson Med, 2014;71:1944-1952. [2] G. Chen, et al. ISMRM, 2014: 4809. [3] J. Paska1, et al. ISMRM, 2008: 149. [4] K. Lakshmanan, et al. ISMRM, 2014: 397.

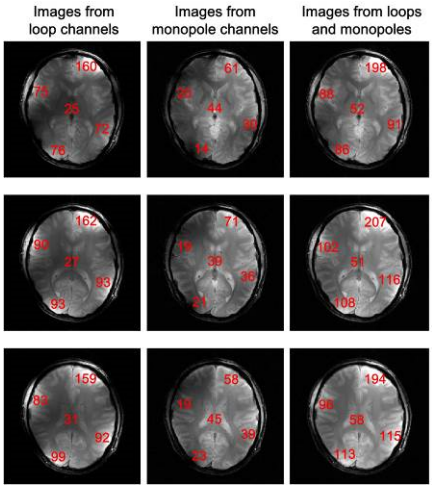

Figure 3 Combined axial images from all loop channels (left column), all monopole channels (middle column) and their combination (right column). These images were combined with RSOS method and shown in the same signal intensity scale. Local SNR at peripheral and central areas of the brain were marked in red color in these images.

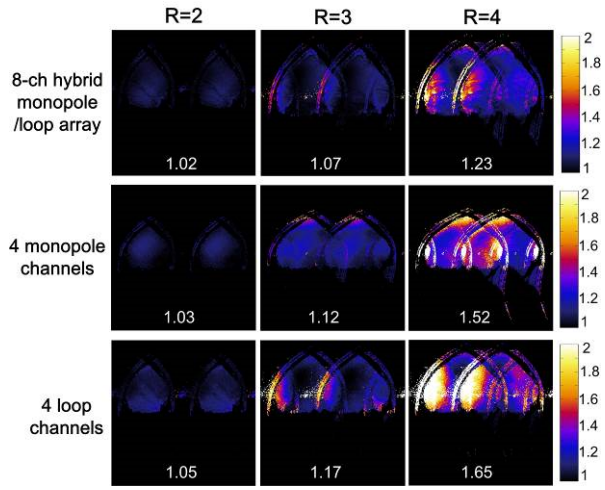

Figure 4 G-factor maps (R=2, 3 and 4) calculated using the images from loop channels, monopole channels and all channels in the sagittal plane. Average g-factors are marked in white color in the g-factor maps.