A 16 Channel Transceive Surface Loop Array Coil for Parallel Imaging at 7T

W. Liu[1], S. moeller[1], U. Goerke[1], G. Adriany[1], E. Auerbach[1], C. Collins[2], T. Vaughan[1], and K. Ugurbil[1]
[1]Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, MN, United States, [2]radiology, Penn State University, Hershey, PA, United States

INTRODUCTION: A transceive array coil (1) transmits radiofrequency (RF) power and receives MR signal through the multiple independent channels of the same array thus can take advantage of both parallel transmit and receive encoding. In this study, a 16 channel conventional surface loop array (conventional) (2) was compared numerically to a surface coil array with the elements turned 90 degree (perpendicular) array and a conventional surface loop array coil was then constructed and tested for parallel imaging performance.

METHODS: Simulation: A gapped 16 channel conventional loop and a perpendicular transceive array are modeled with the FDTD method (XFDTD, Remcom). The basic coil element consisting of 2 parallel 16cm x 1.3cm copper plates spaced 2 cm apart and connected by wires at the ends, is the same in two coils except the orientation. In the conventional array the axis of the element is perpendicular to the surface of the spherical phantom (3-liter, average brain at 7T) while in the perpendicular array the axis of the element is tangent to the surface of the phantom (Figure 1a&b). The diameter of the coils is 22cm. The individual elements in each array are driven with voltage sources of equal magnitude and incremental phases (22.5°, 45°, 67.5°…) and the transmit RF magnetic field ($B1^+$), receive sensitivity maps ($B1^-$/sqrt(input power)), and intensity of a full relaxed gradient echo image (GRE) was calculated on the central transverse slice with the methods described elsewhere (3). The $B1^+$ field is normalized as if a 90 degree flip angle is produced at the center of the phantom and GRE image intensity for both arrays is scaled to the same arbitrary number. G-factor maps for a reduction factor of 1-4 in both the up-down and the left-right direction are also calculated (4).

Experiment: Sixteen rectangular surface loops (10cm x 2.44cm, gap =2.44cm, conductor width =1.27cm, Fig. 2a&b) were glued onto a 0.64cm thick nylon sheet which was wrapped around into a cylindrical coil (~ 22.3cm diameter). A variable capacitor connected two loops in the middle to decouple the nearest neighbors and cable traps were used to suppress the cable shield currents. The coil was tuned and matched on the bench with a spherical phantom that has similar loading effect as human head and the S12 is within the range of -14.2 to 16.9 dB. Very high resolution T1 (3D Inversion Turbo flash, TI=1.5s, TR=2.53s, TE=3.99ms, voxel size = 0.65 x 0.65 x 0.85 mm, 208 slices, NEX=1) weighted images were acquired with (Grappa, reduction factor=4, acquisition time = 4m48s) (5) or without parallel imaging (acquisition time=16m13s) on a Siemens 7T system 32 channel receive based on TIM technology. Retuning and rematching in the magnet room was not necessary because of the well balanced circuitry. The individual channels were driven with voltages of equal magnitude and incremental phases. Noise correlation matrix was also measured.

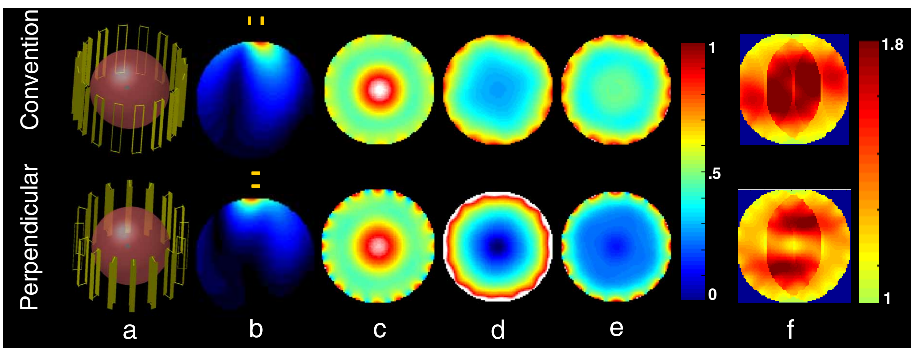
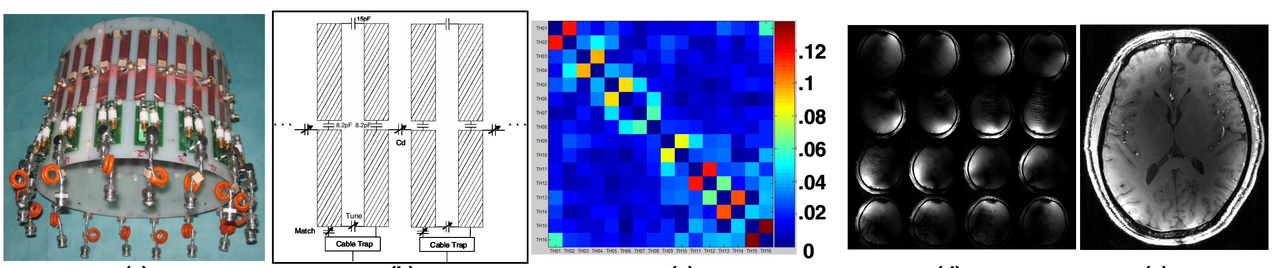


Fig 1. **a**) coil models **b**) $|B1^-|$ from a top element **c**) $|B1^+|$ **d**) sensitivity map **e**)GRE image **f**) g-maps.

Conv./ Perpen.		Reduction in Y			
		1	2	3	4
Red. in X	1	1.16	1.13	1.15	1.05
	2	1.13	1.12	1.13	1.02
	3	1.14	1.13	0.97	0.89
	4	1.05	1.02	0.89	0.71

Table 1. The ratio between the effective parallel imaging encoding, calculated by normalizing sensitivity profile to the g-factor, of the conventional to the perpendicular array at the center half of the brain for different reduction factors.



(a) (b) (c) (d) (e)

RESULTS AND DISCUSSION:

The simulation results are shown in Figure 1. Compared to the perpendicular array, the conventional has a more focused profile and penetrates deeper into the phantom (Fig 1b). The conventional array has higher SNR (Fig 1e) in conventional images, whereas the perpendicular array has lower g-factors. The receive profile normalized by the g-factor is the effective parallel imaging (PI) encoding capability. Table 1 shows the ratio between the effective PI encoding of the conventional to the perpendicular array. The ratio is taken over a central ROI of ½ the size of the object. For small to moderate reduction factors the conventional coil exhibits better SNR in the center while the perpendicular array has better SNR at the periphery.

Experimental setting and results for the conventional surface loop array are shown in Figure 2. In the experiment, noise correlation (Fig 2c) between any two channels is less than 14%. The T1 weighted image from individual channels in Figure 2d shows good isolation between channels. With distinguished B1 profiles and good isolation between individual channels, this coil is also ready for parallel transmit encoding.

REFERENCES: 1) Adriany G et al. MRM 53:434-445 (2005); 2) Roemer P et al. MRM 16:192-225 (1990); 3) Collins C et al. MRM 45:692-699 (2001); 4) Pruessmann K et al. MRM 42:952–962 (1999) 5) Griswold M et al. MRM 47:1202–1210 (2002);

ACKNOWLEDGEMENT: BTRR P41 008079, NIH R01-EB000895; NIH R01-CA009420