Short dipole array for enhanced B1 efficiency/sensitivity at the expense of SAR

Alexander J.E. Raaijmakers[1], Arcan Erturk[2], Greg Metzger[2], Cornelis A.T. van den Berg[1], and Gregor Adriany[2]
[1]*Imaging Division, UMC Utrecht, Utrecht, Utrecht, Netherlands,* [2]*Center for Magnetic Resonance Research, Minneapolis, Minnesota, United States*

Target audience: Researchers interested in the use of dipole antennas as surface array elements for UHF body imaging

Purpose: Body imaging at UHF requires the use of surface transmit/receive arrays to achieve sufficient transmit efficiency and SNR. Recently, dipole antennas have emerged as high-performance surface coil array elements. Various designs have been presented where often a trade-off needs to be made between high efficiency/sensitivity and low SAR levels. However, not all imaging applications are limited by SAR levels. We therefore explore an adapted, basic dipole antenna design that is optimized for high B_1 sensitivity/efficiency while accepting increased SAR levels. A recent study shows that this results in a dipole antenna length of 20 cm [1].

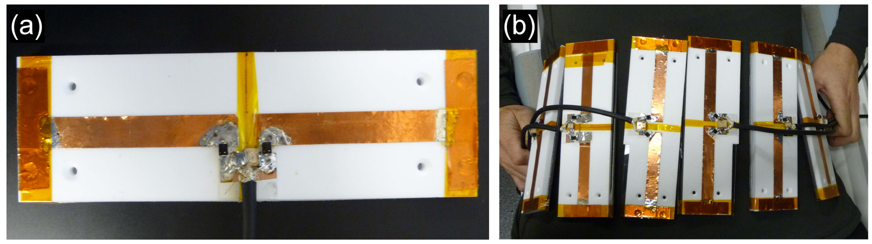

Figure 1: Single short dipole antenna (a) and short dipole antenna array mounted on a volunteer (b)

Methods: Coil array elements are made from Teflon slabs (190 x 60 x 6 mm) that are mounted on equally large PMMA spacers of 4 mm thickness. T-shaped antenna legs were made from 12.5 mm wide copper tape. For matching , two series inductors (39 nH) and a parallel capacitor (6.8 pF) were used (figure 1a). An array of 10 elements has been constructed and positioned around the pelvis (figure 1b). SAR safety assessment has been derived from a numerical simulation (Semcad X, ZMT, Zurich) on the human model Duke [2] with 8 elements. The array is tested on a Magnetom 7T scanner (Siemens, Erlangen, Germany), equipped with 16x1 kW amplifiers (only 10 channels are used). A 35 year old male volunteer (written informed consent) was scanned subsequently with our short dipole antenna array and a 10 channel fractionated dipole array [3] (MR Coils B.V., Drunen, The Netherlands). Each array was characterized by a SNR measurement over the prostate: gradient echo sequence with TR/TE=10s/3.1ms, flip-angle=90°, 2.7x1.4x3mm^3, followed by a noise scan from which normalized SNR maps were acquired [4]. In addition, an AFI-based flip angle measurement was performed [5] and T2w TSE images were acquired (TR/TE=6000/72ms, 0.7x0.7x3mm^3, 13 slices).

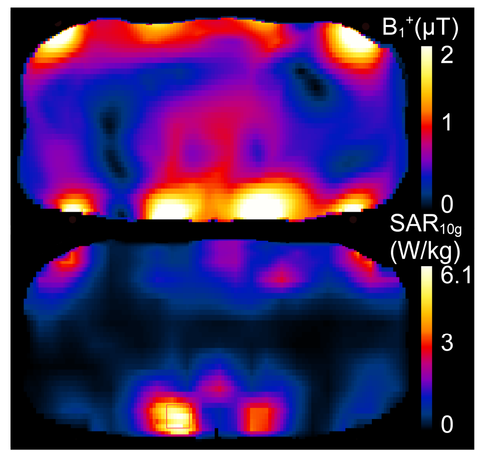

Figure 2: Numerical simulation results for 8-element short dipole array

	Frac. Dipole	Short dipole
SNR (prostate)	6.29	6.96 (+10%)
B1+ (FA in prostate)	37.9	46.5 (+23%)
SARmax (8x1W)	3.2	6.1
B1+/√SARmax	21.2	18.8

Table 1: Performance characteristics for short dipole array and frac. dipole array

Results: Simulation results show that the SAR_{10g} level for 8x1W input power is 6.1 W/kg (figure 2) which is much larger than the value for the fractionated dipole array (3.2 W/kg for 8x1W). Flip angle measurements show 22% improved performance as indicated in table 1. As a result, the $B_1^+/\sqrt{SAR_{max}}$ ratio is 11.3% smaller for the short dipole array. The SNR comparison shows the opposite: 10% more for the short dipole array. T2w images are presented in figure 3. Clearly, good quality images can be acquired with the new dipole antenna array.

Conclusion: A short dipole antenna array can increase the B1 efficiency/SNR in comparison to the existing fractionated dipole array but at the expense of larger SAR levels.

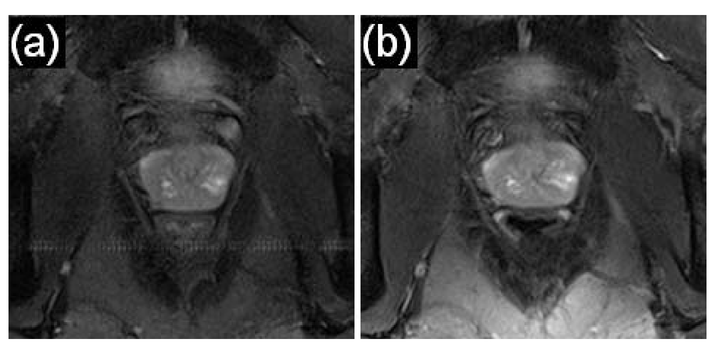

Figure 3: T2w images (a) Fractionated dipole (b) Short dipole

References: [1] Raaijmakers et al. ISMRM 22nd Annual Meeting 2014 #4887 [2] Christ et al. PMB 55 N23 2010 [3] Raaijmakers et al. ISMRM 21st Annual Meeting 2013 #4382 [4] Edelstein (1986) MRM 3:604-618. [5] Yarnykh (2007) MRM 57:192-200.