Evaluation of SAR and B1 for a transceive pelvic phased-array coil at 3T using FDTD simulations

H-W. Kim[1], J. Caserta[2], D. M. Peterson[3], J. R. Fitzsimmons[1,3]

[1]Radiology, University of Florida, Gainesville, FL, United States, [2]Analog Devices, Winston Salem, NC, United States, [3]McKnight Brain Institute, University of Florida, Gainesville, FL, United States

Abstract: The finite difference time domain (FDTD) method is used to predict local 1g average SAR values in a transceive pelvic phased-array coil (TPPA). Three different quadrature drives are compared to a linear drive.

Introduction: Average SAR values are calculated by measuring the total power delivered to the coil divided by the patient mass. However, it is not possible to measure local SAR values non-invasively. In this study, the finite difference time domain method has been proposed to determine SAR distributions, including local 1g average values, and B_1 profiles. The effects of the phase of TPPA were also examined for simulating SAR and B_1 field.

Methods: A 3T TPPA for imaging the prostate [1] was modeled using the XFDTD software package (Remcom Inc., State College, PA). A 5 mm resolution was used to match the human body model [2]. To model actual array placement, arms and abdominal tissues were removed from the model. The simulation space is 150x150x180 cells. The four-element array was modeled with 0.5-cm wide thin copper plates. Each array element is 12.5cm x 18.5cm, and the array is organized into two pairs – one in front and the other behind the patient Capacitors were used to tune the array to 128MHz. **Figure 1** shows the location of the four voltage sources used. For linear operation, all sources had 0^o offset. For the different quad simulations the drives were: (QD1) 0^o, 90^o, 0^o, 90^o; (QD2) 0^o, 90^o, 90^o, 0^o; (QD3) 0^o, 90^o, 180^o, 270^o. $|B_1^+|$ [3] was measured in the prostate, and scale factors were determined to scale from the simulated B_1^+ value to the B_1^+ needed to generate 90^o and 180^o 1-ms rectangular pulses ($|B_1^+| = 6\square T$) [2,4]. A 1-ms rectangular pulse was chosen because its properties are identical to the 6-ms sinc pulse used in actual scans. The SAR for a sequence was then determined using the number of 90^o and 180^o pulses, number of slices and the TR used.

Results and Discussion: $|B_1^+|$ measured in the prostate is $0.024\square T$, giving a scale factor of 250. **Table 1** gives simulated, pulse scaled and sequence scaled SAR information. The 5x increase in SAR from the gradient-echo to the spin-echo sequence illustrates the strong dependence on sequence selection. However, the ratio of peak 1g average to whole-body average remains constant. During a scan, while monitoring whole-body average SAR, local 1g average could be estimated using this ratio. **Figure 1** shows simulated axial SAR distribution. This shows maximum absorption in the skin and muscle, due to the strength of the field in the skin and the conductivity of the muscle. **Figures 2a-d** shows simulated $|B_1^+|$ in a spherical phantom for the four drive configurations. **Figures 2e,f** are images obtained from the same phantom and correspond to QD2 and QD3. The simulations and phantom images illustrate the need for proper phase settings for the array. The SAR values and B_1 field at various phased control of TPPA which adopted surface coil concept was well evaluated by using FDTD simulation.

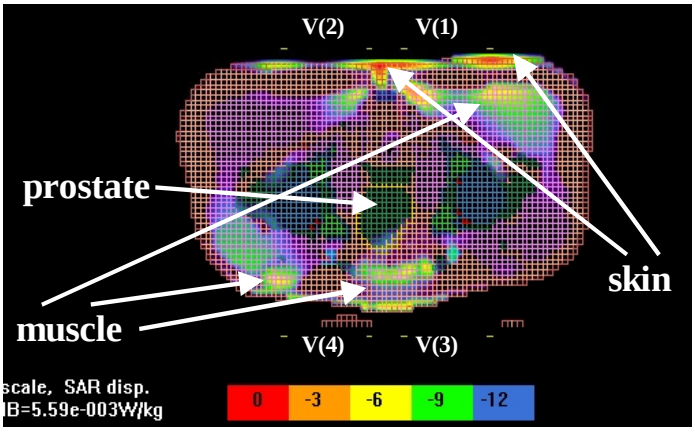
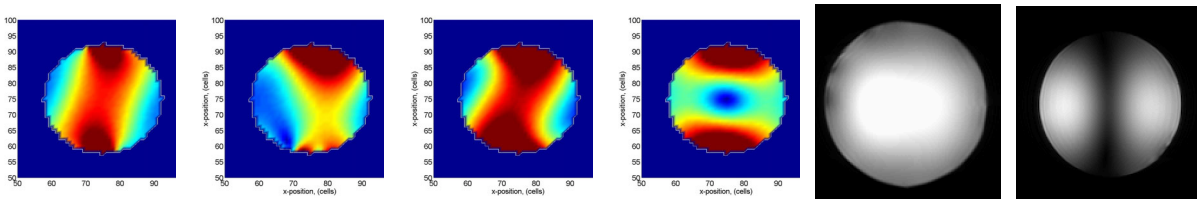


Figure 1: Axial SAR distribution

	90^o	180^o	GRE	SE	FSE
# of 90° pulses			1	1	1
# of 180° pulses			0	1	12
# of slices			3	3	3
TR [ms]			600.	600.	6000.
τ [ms]			1.0	1.0	1.0
Max SAR (W/kg)	368.8	1475.0	**1.8**	**9.2**	**9.0**
Max 1g SAR (W/kg)	318.8	1275.0	**1.6**	**8.0**	**7.8**
Max 10g SAR (W/kg)	150.0	600.0	**0.8**	**3.8**	**3.7**
Average SAR (W/kg)	5.2	20.8	**0.0**	**0.1**	**0.1**
Total Power (W)	397.5	1590.0	**2.0**	**9.9**	**9.7**

Table 1. Simulated SAR values



(2a) Linear (2b) QD1 (2c) QD2 (2d) QD3 (2e) QD2 scan (2f) QD3 scan

Figure 2 Simulation and scanned phantom images

References:

[1] HW Kim, D Buckley, D Peterson, et al., Invest Radio l38:443 (2003)
[2] CM Collins, MB Smith *MRM* 45:684-691, 692-699 (2001)
[3] DI Hoult, *Concepts in MR* 12(4):173-187 (2000)
[4] CM Collins, S Li, MB Smith, *MRM* 40:847-856 (1998)