A Fully Tested Head Coil for 7T Compatible with a Dome Gradient Set

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Introduction A novel eight-element multi-transmit proton head coil (the dome coil) has been developed for use at 7T. The dome coil was designed with the intention of reducing SAR in the shoulders as well as being suitable for use in hemispherical gradients [1]. The dome coil was constructed and used to image phantoms and biological structures. It has also been simulated extensively to ascertain its SAR characteristics. Example images, B_1 maps and SAR data are all presented here.

Methods The geometry of the dome coil is shown in figure 1. Eight curved transmission elements (point a in figure 1) are arranged radially to create a hemispherical shape. The radius of curvature of the elements is 155 mm. A hemispherical screen of radius 175 mm (b) is placed behind the transmission elements. The screen is formed from three layers, one of copper, one of dielectric then another copper layer. This layered structure inhibits eddy currents in the screen. Slits in the screen (c) between each element help to isolate the elements from each other. Variable capacitors (d) placed at either end of each element tune the elements to 298 MHz and match them to 50Ω. Each element is approximately a ¼ wavelength long and is driven 3 cm from the end of the strip (e). The coaxial cables used to drive each element are fed into the coil from the rear (f) and are soldered directly onto the screen to reduce stray inductances and capacitances. SAR and B_1 simulations were performed using XFDTD (Remcom Ltd., PA, USA). The HUGO body model was inserted into the coil and the coil elements were then all driven by 298 MHz sinusoidal signals, with each element being 45^o out of phase with its neighbours. A second simulation was performed using an eight-element birdcage of similar dimensions to provide a comparison. Both simulations were scaled so that each coil created a 0.7μT B_1 field in the centre transverse slice of the head, in order to make their results directly comparable. The coil was taken to a shielded 7T/68 cm MR scanner (Siemens Medical Solutions, Erlangen, Germany) with a head gradient insert (41 cm, 80mT/m maximum gradient strength) in order to obtain image data. B_1 maps were acquired using the Sa2RAGE sequence [2] and images were taken using a GRE sequence (TR = 8.6 ms, TE = 4 ms, resolution 1.1x1x7 mm). The images were taken with the elements driven in a calibrated circularly polarized mode.

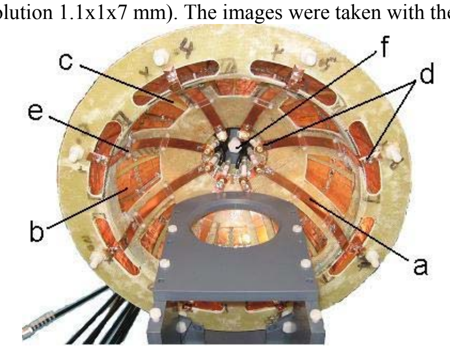

Figure 1 – The dome coil with a phantom holder in place. a) elements, b) screen, c) slits in screen, d) tuning and matching capacitors, e) driving points, f) driving coaxial cables

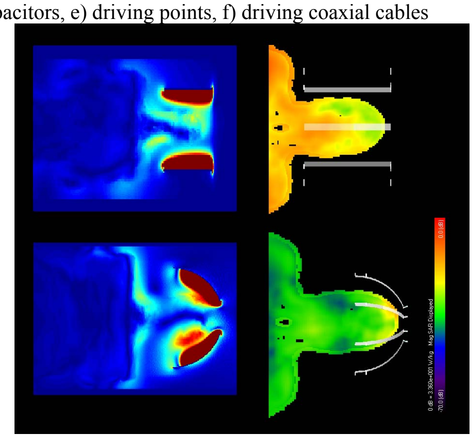

Figure 2 – B_1 generated by the birdcage (top left) and dome (bottom left). Local SAR generated by the birdcage (top right) and dome (bottom right).

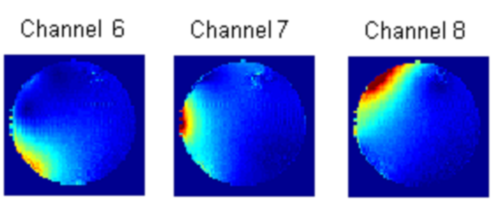

Figure 3 – Typical B_1 maps from three of the elements.

Results Figure 2 shows the results from the B_1 and SAR simulations. The maximum local (10g averaged) SAR produced in the head was 5.64 Wkg^{-1} for the birdcage and 0.96 Wkg^{-1} for the dome. The local SAR in the shoulder was 3.32 Wkg^{-1} from the birdcage and 0.30 Wkg^{-1} from the dome. The dome only generates B_1 in the top half of the head, which helps to reduce the SAR but still allows full brain coverage. The local SAR produced by the dome is also lower, particularly in the neck and shoulder areas. Figure 3 contains typical B_1 maps obtained from the eight elements. From these images it is evident that it is possible to construct the elements so that they do not couple to their neighbours and produce B_1 in the centre of the coil. Figure 4 shows two images of a pineapple taken by the dome coil (note that these images were reconstructed from only five elements as three of the elements were not performing well at the time of the coil testing). The SNR of the sagittal image is 245 while the SNR of the transverse image is 92. Using the same scanning parameters to image a phantom with a volume head coil on a Phillips Achieva 7T system resulted in SNR values of 103 and 78 respectively. Although the results are not directly comparable due to the difference in imaging system, they do demonstrate that the dome coil achieved SNR values comparable to a conventional coil.

Conclusion The dome coil has been successfully constructed and tested; it achieves its goal of producing less SAR in the shoulders, and can be fitted within the dome shaped gradients. The SAR of the dome coil is lower than the SAR produced by a comparable birdcage coil. B_1 maps have been produced and from these it has been determined that it is possible to tune and match each element while decoupling them from their neighbours. Finally, the dome coil has been used to image a pineapple and has produced images with SNR values comparable to a conventional coil.

References [1] Dan Green, James Leggett, and Richard Bowtell, *Hemispherical Gradient Coils for Magnetic Resonance Imaging*, Magnetic Resonance in Medicine 54:656-668 (2005). [2] F. Eggenschwiler, A. Magill, R. Gruetter and J. P. Marques, *Sa2RAGE – A new sequence for rapid 3D B_1^+-mapping with a wide sensitivity range*, Proc. Intl. Soc. Mag. Reson. Med. 18 (2010)

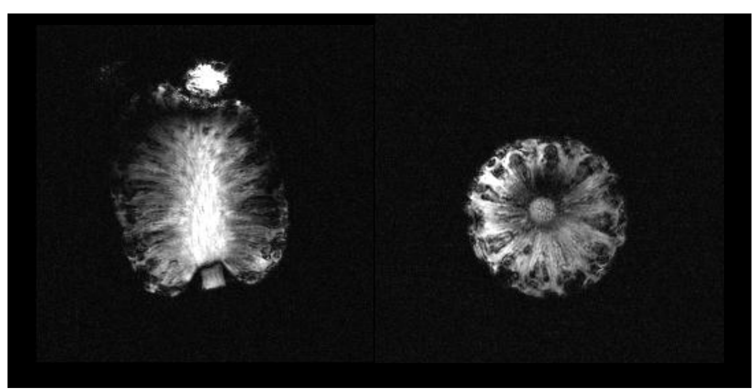

Figure 4 – Sagittal (left) and transverse (right) images of a pineapple reconstructed from five elements.