Stripline/TEM Transceiver Array for 7T Body Imaging

C. J. Snyder[1], L. DelaBarre[1], P-F. Van de Moortele[1], A. L. Snyder[1], C. Akgun[1], J. Tian[1], G. Metzger[1], K. Ugurbil[1,2], and J. T. Vaughan[1]

[1]Center for Magnetic Resonance Research, University of Minnsota, Minneapolis, MN, United States, [2]Hochfeld-Magnetresonanz-Zentrum, Max Plank Institut für Biologische Kybernetic, Tübingen, Germany

Introduction: Due to the higher intrinsic SNR and benefits associated with parallel imaging at high field, body imaging at 7T holds many rewards. However, the shortened wavelengths in the human body and destructive interference patterns at high fields (1) make 7T body imaging difficult. Fortunately though, preliminary results have shown the feasibility of 7T body imaging (2,3). Additionally, recent experiments and simulations (4-7) of the head have shown transceiver arrays can provide relatively homogeneous B_1 fields at 7T. A flexible eight-channel transceiver TEM array was built to investigate the feasibility of homogeneous body imaging at 7T.

Methods: All imaging experiments were performed on a 7T (ω_0=297 MHz), 90cm bore magnet (Mangex Scientific, UK) equipped with Siemens console and whole body gradients. A single 8kW RF amplifier (CPC, Brentwood, NY) was used; the RF power was subsequently spilt with an equal-amplitude, equal-phase eight-way power splitter (Werlatone, Brewster, NY). Eight high-power phase shifters, (ATM, Patchogue, NY) and incremental cable lengths were used to adjust the transmit phase.

An eight-channel flexible TEM transceiver array (fig. 1a) was built according to stripline transmission line principles (8,9). The physical geometry of the individual coil elements was 15.3 cm in length with 1.27 cm inner conductor and a 5.0cm outer conductor. A 1.9cm thick PTFE dielectric, with a low loss tangent and a permittivity of 2.08, separated the inner and outer conductor. Two identical PTFE plates (22.7cm by 35.6 cm) were used to secure and house four coil elements—this provided a four-channel anterior and four-channel posterior array. The plates were 0.3cm thick providing a flexible former allowing both arrays to be contoured to individual subjects. A 4.3 cm air gap separated each coil element. Each element was individually tuned to the proton Larmor frequency at 7 tesla; capacitive decoupling provided greater than 18dB isolation between nearest-neighbor elements.

B_1 shimming, as described in (10), was employed to optimize the transmit phase for each element on the array.

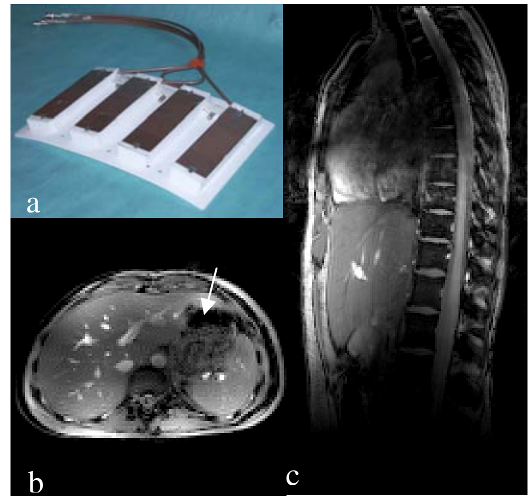


Figure 1: (a) the anterior 4-channel array. GRE images of the liver in the (b) axial and (c) sagittal planes. The white arrow in (b) points to a region of signal loss due to gas in the stomach or bowels and not to destructive interference of multiple channels.

Results: Figures 1b,c show the homogeneity and coverage of the surface array when shimmed. Axial images of the liver (fig 1b) were acquired with a GRE sequence (TR/TE= 100ms/3.6ms) with a resolution of 2.3mm x 2.3mm x 5.0mm. Sagittal images (fig 1c) were acquired using GRE sequence (TR/TE=150ms/4.1ms) and a resolution of 1.5mm x 1.5mm x 3.0 mm. To reduce artifacts, both sequences were acquired during 1 breath hold. The surface array provided a homogeneous RF field over a large field of view.

A major application of this new array is cardiac imaging at 7T (fig. 2). Short axis images (fig 2a) were acquired with a breath-held, EKG-retrogated FLASH cine sequence (TR/TE=45ms/3.1ms) with an image resolution of 1.7mm x 1.7mm x 5.5mm. Four chamber images (fig 2b) were acquired with a breath-held, EKG-retrogated FLASH cine sequence (TR/TE=30ms/3.1ms) with an image resolution of 2.0mm x 2.0mm x 5.5mm. Forty time point images were acquired over 12 heartbeats for both the short and four chamber axis cines. The contrast and resolution allowed for easy identification of the left atrium (LA), left ventricle (LV), right atrium (RA), right ventricle (RV), mitral valve (MV), tricuspid valve (TV) and the descending aorta (AR).

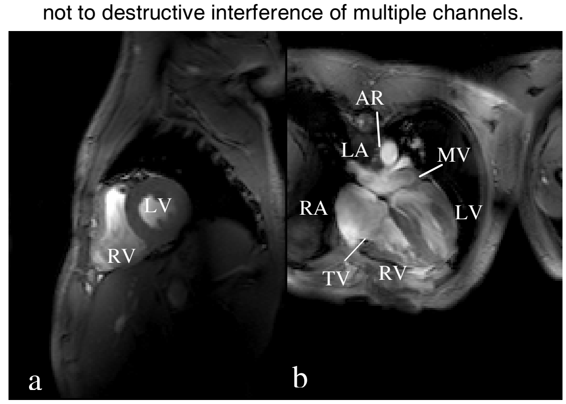
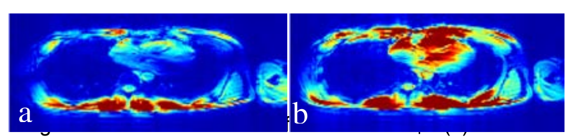


Figure 2: (a) Short axis and (b) four chamber axis FLASH cines images of the heart during systole

The axial slice in figure 3 shows the significance of B_1^+ shimming. Figure 3a shows the fraction of available B_1^+ when all elements have equal transmit phase; significant destructive interference is seen in the posterior of the heart. Figure 3b shows the computed optimization.



shimming and (b) computed optimization.

Conclusions: A flexible stripline/TEM surface array for body imaging at 7T has been demonstrated. The large, approximately homogeneous B_1 field of this array makes it suitable for volume body imaging, however the ability to contour the array to individual subjects and control the individual element's transmit phases (B_1 shimming) also make this array highly sensitive over localized regions of the body. In addition to liver and cardiac imaging, this array is being used for prostate and uterus imaging. Successful body imaging at 7T is feasible.

References: [1] Van de Moortele P-F et al. MRM 2005; 54(6): 1503-1518 [2] Vaughan JT et al. Proc. of the 14th meeting of ISMRM 2006, 213 [3] Ibrahim T et al. Proc. of the 13th meeting of ISMRM 2005, 820 [4] Snyder et al. Proc. of the 14th meeting of ISMRM 2006, 421 [5] Mao W et al. MRM 2006; 556:918-922 [6] Ibrahim T IEEE transactions of Medical Imaging 2006; 25(10): 1341-1347 [7] Li BK et al. Proc. of 27th meeting of the Engineering in Medicine and Biology, IEEE, 2005 [8] Vaughan JT, US Patent 6,633,161 (2003) [9] Vaughan JT et al. MRM 1994;32;206-218 [10] Van de Moortele et al. International Symposium on Biomedical MRI and Spectroscopy at Very High Fields 2006.

Acknowledgements: This work was graciously funded by: BTRR-P41 RR008079; NIH R01-EB000895; NIH R01-CA0094200