Large field-of-view in vivo imaging using traveling waves on a whole body 7 tesla scanner

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Introduction. The use of traveling waves for high field MRI has recently been suggested (1,2) as a promising method for obtaining large field-of-view images, with the additional advantage that the transmitter/receiver is placed a considerable distance from the sample allowing flexible access and experimental setup. At Larmor frequencies of 300 MHz and above, the cutoff frequency of the inside bore of a commercial MRI scanner allows a wave corresponding to the TE11 mode of a waveguide to pass along the bore with relatively little attenuation. Here, we evaluate initial in vivo results imaging the brain using such traveling waves on a commercial 7T system (Philips Achieva). In this case the dielectric loading of the human body is sufficient to reduce the cutoff frequency to below the Larmor frequency.

Methods. A number of different antennas were designed for operation at 298.1 MHz, including a patch antenna, crossed dipole and single dipole. Standard impedance matching schemes for antennas were employed to reduce the VSWR below 1.5:1. For parallel imaging applications, a Nova Medical 16-channel phased array coil was used. Electromagnetic simulations were performed using CST Microwave Studio. All experiments were performed on a Philips Achieva 7 tesla human scanner with an RF shield of inner diameter 58 cm. Since the patient bed contains an aluminum sheet, the bed was removed before scanning.

Results. Figure 1(a) shows the variation in $B_{1,x}$ as a function of distance along the body using electromagnetic simulations for the patch antenna, magnet bore and human body (simplified model). The peak intensity is found in the head, with a relatively deep null at the level of the shoulders, probably caused by a strong dielectric mismatch (the shoulders are also in an area of high loss, being close to the RF shield). The exact distribution of the $B_{1,x}$ along the bore of the axis (z-direction) is highly dependent upon the dimensions of the body (both axial and lateral), as well as any loading used for "dielectrically matching". Figure 1(b) shows the $B_{1,x}$ component produced by the TE11 mode of the waveguide in the centre of the head, with the expected central brightening. Figure 1(c) shows initial results from a three-dimensional, low flip-angle gradient echo sequence using the antenna as both transmit and receive with no dielectric matching. Although there are areas of low signal intensity within the brain, as seen with conventional transmit/receive systems, the axial penetration of the RF is limited only by the linearity of the gradients (~55 cm) and produces considerable signal from the chest wall. Figure 1(d) shows phantom results using the antenna as the transmitter, and the phased array as the receiver. This results in an increase in the MR signal-to-noise and also allows parallel imaging to be performed.

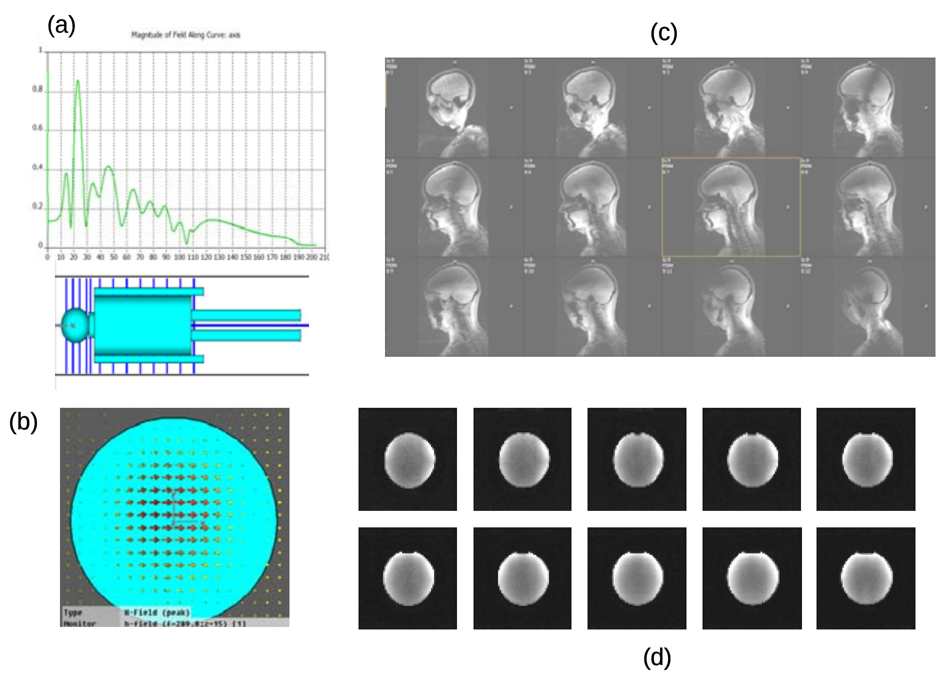

Figure 1. (a) Simulation studies showing the variation in the transverse B-field component as a function of distance from the patch antenna which is placed 50 cm away from the head at the entrance to the bore of the magnet. (b) Transverse B-field component through the centre of the head. (c) Images of the head obtained from a low flip-angle (10^o) gradient echo sequence using the antenna in both transmit and receive mode. (d). Images of an oil phantom with the antenna used to transmit and a 16-channel phased array receive coil. No intensity correction has been used on the images.

Discussion. Initial results using a patch antenna indicate that large field-of-view is possible using this technique, although obtaining maximum S/N for different samples will require significantly different loading strategies, and power limitations are likely to result in low flip-angle excitations. Since the TE11 dominant mode, and this is characterized by a strong electric field in the center of the waveguide, it will be important to assess the SAR performance of the traveling wave approach.

References. 1. D.Bruner et al. ISMRM, 2008, p 434. 2. C.A.T.van der Berg, ISMRM Workshop High Field, Asilomar, 2007.