MRI of the human torso at 7 Tesla using dual quadrature patch antennas.

A. Webb[1], and N. Smith[1]
[1]Radiology, Leiden University Medical Center, Leiden, Netherlands

Introduction. Imaging the human torso at high field (7 tesla and above) presents considerable challenges in terms of RF coil design. The relatively short wavelength of electromagnetic radiation within the body can lead to areas of severe signal drop-out due to destructive interference. By using transmit arrays with control over the magnitude and phase of the driving signal to each element of the array, these destructive phase effects can be partially overcome and a homogeneous transmit field achieved [1-4]. However, such array technology is not yet widely available. Here we use a novel arrangement of two quadrature patch antennas placed above and below the subject in order to produce relatively homogeneous signal intensity throughout the body: such an arrangement can be used on any commercial system.

Methods. All experiments were performed on a Philips Achieva 7T whole-body system, which has a measured output of 1 kW per quadrature channel. Two circular patch antennas were constructed according to standard design criteria [5], which have been summarized by Zhang et al. [6]. The copper circles (50 µm thick) were 35 cm in diameter, and are mounted on a 40 cm square of acrylic with thicknes 3 cm [7]. The position of the quadrature feed points were calculated [5,6] in order to match the unloaded antenna to 50 Ω: an additional lumped-element matching network was added for impedance matching with a human load. The quadrature transmit/receive lines from the spectrometer were split equally and connected to the relevant ports of the two patch antennas. A foam spacer of ~3 cm thickness was placed between the subject and each antenna. Network analyzer plots gave S_{11} measurements of < -20 dB for each port, and S_{21} isolation measurements for each antenna of < -20 dB. Images were acquired using rapid low tip-angle gradient-echo sequences (TR/TE/FA 20 ms/3.4 ms/10^o, slice thickness 3 mm, 8slices, data matrix 268 x 180, in-plane resolution 1.5 x 1.5 mm, 4 signal averages).

Results and Discussion. Figure 1 shows a series of images acquired through the torso of a female volunteer, with patch antennas placed symmetrically above and below the subject. Due to the thick acrylic sheet, the coils cannot be formed around the body, and this leads to some areas of lower intensity at the periphery. Since no respiratory or cardiac gating was used, images also show some small motion artifacts.

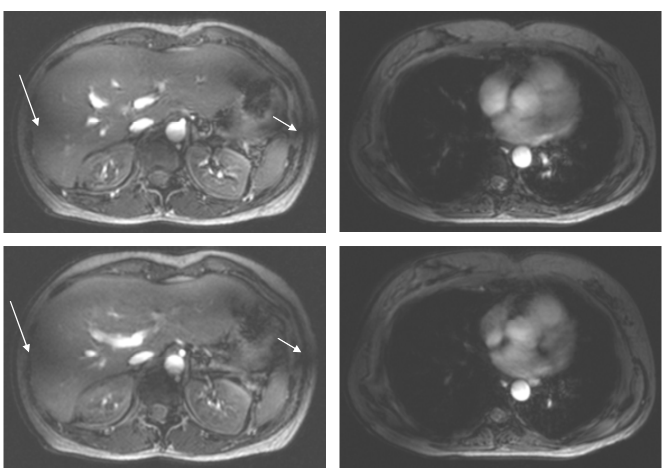

Figure 1. Low tip angle gradient echo images acquired using the dual patch antenna configuration of the liver (left) and through the heart (right). Small areas of low signal intensity can be seen (white arrows) in the periphery of the torso, but overall the signal intensity within the liver and kidneys is homogeneous.

Conclusions. Relatively homogeneous images can be acquired through the human torso using a simple two-coil patch antenna arrangement. Further improvements involve incorporating high dielectric constant materials which will allow more compact and flexible designs to be constructed, which can then be more closely formed to the human body.

References

[1] J.T.Vaughan et al. Magn.Reson.Med. 61, 244, 2009. [2] C.J.Snyder et al. Magn.Reson.Med. 61, 517, 2009. [3] S.Maderwald et al. Proc ISMRM, p821, 2009. [4] G.J.Metzger et al. Magn.Reson.Med. 59, 396, 2008. [5] C.Balanis, Antenna Theory: analysis and design, 3rd Edition, Wiley, 2005. [6] B.Zhang et al. Proc ISMRM, p4746, 2009. [7] D.Brunner et al. Nature, 457, 994, 2009.