

7T Body Imaging: First Results

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Objective: To investigate the feasibility of whole body imaging at 7T.

Introduction: Whole body imaging and its clinical applications have been commercially developed for 3T. Body imaging has been demonstrated in research applications to 4T.[1] Major MRI system manufacturers are now supporting 7T whole body MRI systems for human head imaging. Are 7T systems capable of human body imaging as well? The aim of this study is to find out.

Methods: The methods consisted of modeling, hardware development and data measurement.

Modeling: Initial modeling used the Remcom Finite Difference Time Domain method to numerically predict RF field and loss contours in the NLM Visual Human digital atlas. Figure 1 shows such a scale model of an adult male loading a TEM body coil. The electrical dimenions of the coil are: i.d. = 57.5cm, o.d. = 62.5cm, active element length = 33cm, cavity length = 100cm.

Hardware Development: 7T equipment specific to human body imaging is not commercially available. Therefore, an initial effort was made to build the necessary means in house. The MRI system used for the study is a Magnex 7T, 90cm bore magnet with Magnex whole body gradients and shims (i.d.= 63cm). A Varian Inova console was used, together with a custom, 8kW solid state RF power amplifier from Communications Power Corporation (CPC). An actively detuned, 300 MHz, RF body coil of the model dimensions was built together with its PIN detuning circuits and system control interface as shown in Figure 2. The details of this device can be found in the first reference. Specialty 300 MHz receive circuits such as the 4-element stripline dual breast array show in Figure 5 also were developed together with the necessary PIN decoupling circuits and multi-channel, digital receivers.

Measurement: Due to the limited peak power available (approximately 4 kW at the coil) and the significant high frequency load losses predicted, initial measurements employed low tip angle sequences of long pulse widths. For an initial mapping of the RF "landscape" in the body at 300 MHz, coronal, saggital, and transaxial images were acquired with the body coil switched to transmit and receive mode, without the use of additional receiver coils. The common parameters used for acquiring the gradient echo, whole body images of Figure 3 were: 256x256 matrix, 3mm thick slice, 2 ms windowed sinc RF pulse, flip angle = 25 degrees. Specific to the coronal images: TR/TR = 60/4 ms 50x35 cm, NT=4, scan time = 110 sec. The saggital images were acquired by: TR/TE = 50/4 ms, 50x35 cm, NT=2, scan time 55 sec., and the transaxial images required: TR/TE = 50/4 ms 35x35 cm NT=4 Scan time 110 sec. Additionally, the body coil was used as an actively detuned, homogeneous transmitter for breast imaging with the local receiver coils shown in Figure 5. The acquisition parameters for this gradient echo sequence were: 256x128 matrix, 42cm/25cm, 3mm thick slice, 2 ms windowed sinc RF pulse, TR/TE = 50/5 ms, flip angle = 20 degrees, scan time 12 sec.

Results and Discussion: The models predicted significant RF artifacts in at least one sharp line running longitudinally through the body, primarily due to destructive interference of the short (12cm) wavelengths in the high water content tissue dielectrics at 300MHz. Imaging proved these predictions generally correct. See Figure 3. Also shown in the Figure 3 images are what appear to be susceptibility artifacts possibly due to gas pockets in the bowel. Apparent susceptibility artifacts were also noted near the body, between the breasts in female subjects. See Figure 4. B₀ phenomena were not modeled for this investigation.. The RF power (SAR) used to acquire the images was estimated by: Average SAR = 996 W peak power * 0.2789 (sinc Se power ratio) = 277.7 Watts * 2ms/50ms = 11.1 W per slice in each TR. 11.1 * 5 slices = 55.5W, or less that 1.0 W/kg for most adults, well within the FDA guideline for human torso imaging. The observed artifacts and RF power requirements however do not appear to preclude the possibility of useful whole body imaging for at least some applications at 7T. Breast imaging for example is a strong candidate. Scout imaging combined with low gamma spectroscopy of almost any organ or tissue might prove highly successful at 7T. Furthermore, recent work suggests that at least some of the artifacts observed at 7T may be manipulated or removed by RF field shimming for targeting localized regions of interest. [1]

Conclusions: These preliminary results demonstrate that safe and successful whole body imaging at 7T may be feasible.

Reference: Vaughan, Adriany, Snyder, et.al., Efficient High Frequency Body Coil for High Field MRI. MRM 52:851-859 (2004)

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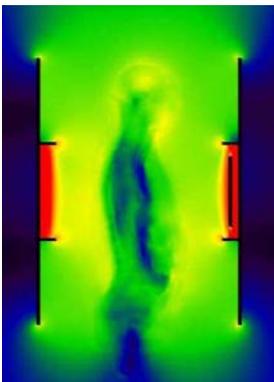


Figure 1. Model Body in Coil



Figure 2. 300 MHz TEM Body Coil

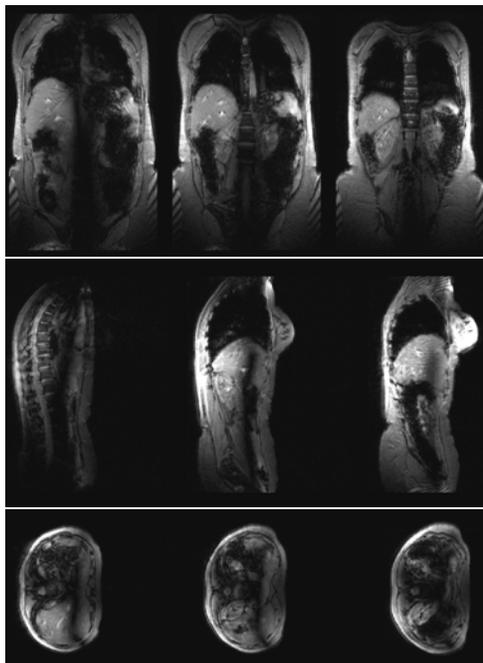


Figure 3. 7T Whole Body Images

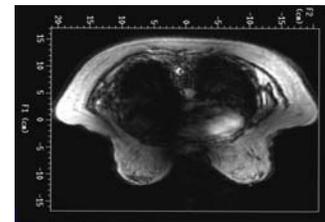


Figure 4. 7T Chest Image (with heart)



Figure 5. 300MHz Breast Array

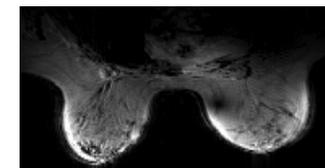


Figure 6. Breast Images from Coil above