# Human Head Imaging at 11 Tesla

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**Introduction:** One of the biggest concerns with high field human MRI is the wave behavior resulting from the dielectric properties of tissues at high frequencies in large samples. In this study, images were obtained of a human head at 11.1 T for the very first time. This was accomplished in a freshly dissected and unfixed human head, using a large quadrature volume coil as well as a square surface coil. Wave behavior was significant in the volume coil as expected (1). However, a novel method of independently imaging different regions of the head with the surface coil in order to construct a composite image yielded remarkably homogenous images at this very high field strength. Although experiments at such a high field strength in a human head *in vivo* will likely not be possible for years, these images indicate the continued potential of proton MRI above current clinical field strengths.

**Methods and Results:** A freshly excised human head was obtained from ScienceCare Anatomical, Inc. (Phoenix, AZ). Vessels in the head were ligated to prevent fluid loss. To verify the anatomical regularity of the excised head, images were collected on a 3-T Siemens Allegra system; these data demonstrated normal looking, homogeneous images. All other experiments were performed on an 11.1 T, 40-cm Magnex magnet with a Bruker Biospec console. An 8 element ReCav coil (1) with a diameter of 20.5 cm operating at 470.74 MHz was used for all volume coil experiments. A head was selected that would just fit into the ReCav coil. Sample loading for this arrangement was significant because the sample was pressed tightly against the coil elements. This loading resulted in relatively poor matching, but the power was adequate to provide ample RF penetration for low flip angle acquisitions. A gradient-echo image (TE/TR = 4.5/3000 ms, bandwidth = 123 kHz, FOV = 18 cm, slice thickness = 4 mm) acquired in the ReCav coil is shown in Figure 1.

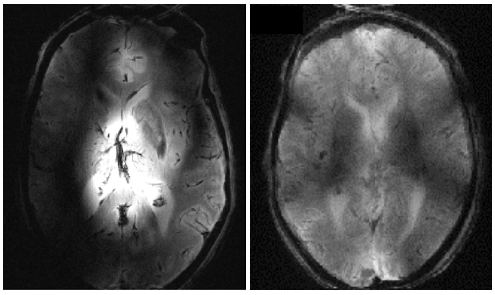

**Figure 1** *Left*: 11-T gradient echo image acquired with 20.5-cm volume coil. *Right*: 11-T Composite image created with surface coil at 8 different locations.

In the absence of array coil or parallel imaging technology on this magnet at present, a single 12.5-cm square surface coil was placed on the outer wall of a 20.5-cm diameter tube and rotated to eight equidistantly-spaced locations about the head. Gradient echo images (TE/TR = 4.5/560 ms, bandwidth = 123 kHz, FOV = 18.5 cm, slice thickness = 4 mm) acquired from all eight locations (Fig. 2) were later combined through summation of magnitude to yield a single image with little apparent RF nonuniformity (Fig. 1, top right) compared to the image acquired with the volume coil.

**Discussion:** These results demonstrate the first MR images of a human head at 11 T. As expected, the volume coil displays significant wave behavior. This wave behavior causes distortions apparent in the inhomogeneous signal amplitude (Fig. 1, top left). As demonstrated by surface coil experiments, pulsing different coils during different TRs may be an effective way to avoid RF interference (2, 3). Even with crude image addition, the image homogeneity of a composite image acquired with individualized sampling is outstanding compared to that acquired with a volume coil. These experiments provide a very favorable vision of the future of high field human imaging despite the known problems of RF wave behavior.

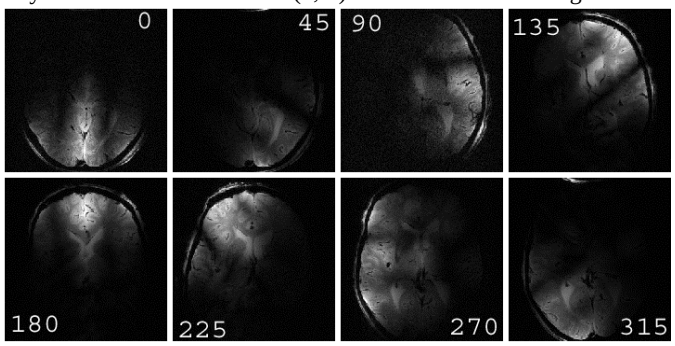


**Figure 2** Eight individual images acquired with a surface coil at different locations with respect to the head. Images summed to create Fig 1. top right.

**References:**

1) BL Beck *et al.*, Magn. Reson. Med., 51, p. 1103, 2004.
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