Echo-Planar Imaging of the Human Brain Using a Three Axis Local Gradient Coil

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Purpose

We describe here our implementation of single shot echo-planar imaging of the human brain using a three axis head gradient coil and a specialized RF coil in an otherwise standard clinical imaging system. The use of a three axis local gradient coil allows us to obtain single shot echo-planar images at 128×128 resolution in any imaging plane, and minimizes the demands on the gradient amplifier system.

Methods

Scanner: General Electric 1.5T Signa.

Gradient Coil: The gradient coil used was designed by gradient descent (1). It is a symmetrical coil with inherently balanced torques that was designed for minimum length in order to avoid interference with the shoulders. It has an inner diameter of 30cm and a length of 37cm. The gradient fields were optimized for a region of interest (ROI) that encompasses the human brain, and imaging of the brain is performed without any geometric correction of the images. The ROI is a cylinder of diameter 18.75cm and length 16.5cm. The residual RMS error in the gradient fields over this ROI and other technical parameters are given in Table 1.

RF Coil: A transmit-receive elliptical quadrature endcap birdcage design was used in order to maximize the filling factor in the limited space of the gradient coil. A copper RF shield was used to isolate the RF fields from the gradient coil.

Pulse Sequences: Single-shot blipped echo-planar using either a spin-echo or gradient recalled echo is used. Chemical shift saturation is employed before the excitation pulse, and multi-slice, and multi-repetition capabilities are supported. Data are collected at the maximum rate of 125kHz or 8μs per IQ pair. A linear phase correction based on a reference image with no gradient in the blip direction is used to minimize the Nyquist ghosts caused by reversing the readout gradient for every echo. Data acquisition times are 40ms for a 64×64 matrix using a full k-space scan, and 80ms for a 128×128 matrix using a partial k-space scan. The minimum field of view using 2G/cm is 16cm.

Results

Figure 1 shows a profile of a 128x128 image of a $CuSO_4$ phantom acquired using a spin-echo EPI sequence. The field of view is 24cm, slice thickness is 5mm, TE is 20ms, and TR is infinite. The measured SNR in this scan is 410, and the signal to ghost ratio is approximately 50. For a scan with identical parameters in the human head, the measured SNR (average of white and gray matter) is 133.

Conclusion

Single shot EPI of the human brain using a three axis local gradient coil in an otherwise standard human scanner can give consistently good image quality and high SNR at resolutions of up to 128×128.

References

1. Wong EC, Jesmanowicz A, Hyde JS. *Magn. Reson. Med.* **21**, 39-48 (1991).

Table 1

Head Gradient Coil Specifications

	X	Y	Z
RMS Error(%)	2.94	2.85	2.46
Gradient(G/cm@100A)	2.03	2.11	2.17
Inductance(mH)	.149	.174	.076

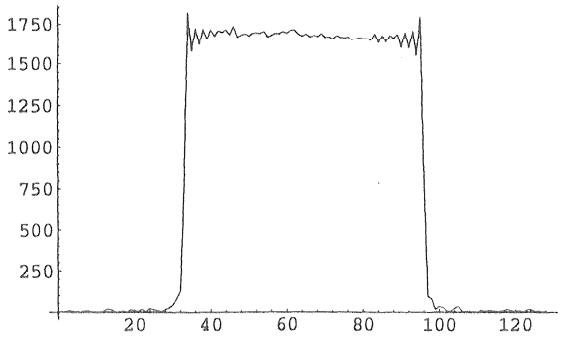

Figure 1 Profile through a 128×128 echo-planar image of a phantom.