A z-gradient coil for 3D SENSE imaging at 7 Tesla

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Introduction:

It is known that RF coil geometry significantly affects the reduction factors for parallel imaging. While several techniques have been incorporated to increase the reduction factors in the transverse plane [1-3], little has been accomplished to accelerate SENSE imaging in the z-direction (superior/inferior): Hardy et al.[3] employed multiple channels in the z-direction while Seeber [4] incorporated triangular shaped coils to vary the RF field of both transceiver and receive only coils. However, with both of these solutions, a portion of the coil(s) still generates a magnetic field in the z direction, which does not contribute to the received NMR signal. To alleviate this, a 16-channel stripline TEM coil was built such that the magnitude of transverse magnetic field is a gradient along the z-axis. This spatially varying RF profile allows for SENSE reduction in all three dimensions; without creating a magnetic field component in the z-direction.

Methods

A 16-channel stripline TEM coil, see figure 1, (25cm id by 16cm length) was constructed to produce homogeneous head images at 7T. All elements were equally spaced on a Teflon dielectric and independently tuned and matched to proton's Larmor frequency at 7T, such that all elements could be driven (transmit and receive) in concert. Nearest neighbor elements were capacitively decoupled.

For each element, the Teflon dielectric was tapered in either the superior or inferior direction creating a spatially varying shunt capacitance. To keep constant impedance, the conductor width to dielectric thickness ratio was held constant. By changing the distributed shunt capacitance and current density over the length the coil, a transverse magnetic field gradient on each coil element is created.

Figure 1: The constructed z-gradient TEM coil

Results

Figure 2 shows FLASH images (TE/TR 5ms/18ms) in the coronal and sagittal plane. The FOV for the coronal image was 20 cm by 36cm while the sagittal's FOV was 26.5cm by 36cm; both images have a slice thickness of 4mm. The large FOV in the z-direction is necessary to prevent foldover artifacts from the neck and shoulders.

The reduced FOV image had a 4-fold reduction factor in the z-direction, with an effective aliasing of 2. Due to the undersampling of k-space, the SNR of the reconstructed images was at least reduced by a factor of 2. The mean g-factors for five slices in the coronal and sagittal planes are shown in table 1a. The reduction factor in the z-direction doesn't affect the SENSE performance in the transverse plane, the mean and maximum g-factors are computed for a tight FOV in table 1b.

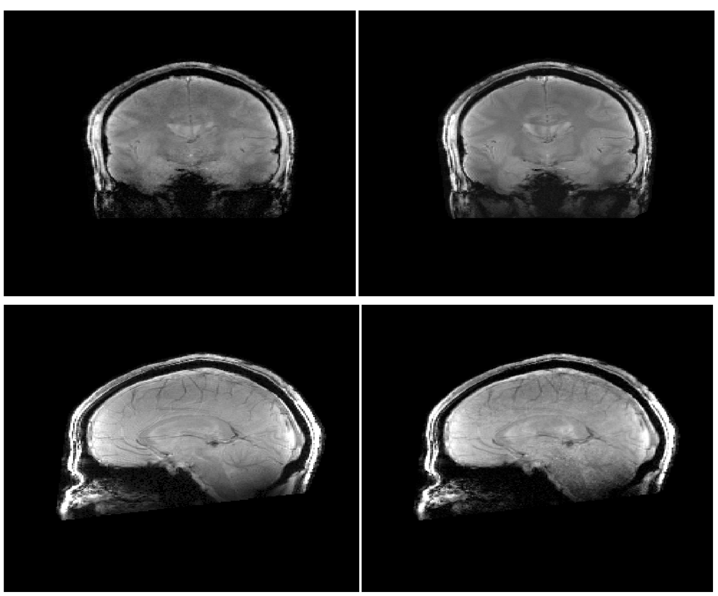

Figure 2: the reconstructed (left) and full FOV (right) images of the coronal and sagittal planes. The reconstructed images have an effective aliasing factor of 2.

Mean g-factors	
Coronal	Sagittal
1.36	1.38
1.33	1.25
1.78	1.78
1.27	1.11
1.82	1.38

Mean & Max g-factors		x-direction			
		R=1	R=2	R=3	R=4
y-direction	R=1	1.00 1.00	1.01 1.05	1.07 1.22	1.19 1.53
	R=2	1.01 1.05	1.02 1.09	1.10 1.29	1.26 1.68
	R=3	1.12 1.34	1.14 1.38	1.41 1.97	2.25 5.38
	R=4	1.47 2.07	1.53 2.18	2.44 4.89	4.70 12.19

Table 1a: The mean g-factors for both the coronal and sagittal planes with a wide FOV

Table 1b: The mean and maximum g-factors for several reductions factors in the axial plane with a tight FOV.

Discussion

This novel coil creates a spatially varying transverse magnetic field that increases SENSE performance by admitting k-space subencoding in the z-direction without adversely inhibiting the coil's performance in the axial plane. This is also the first coil that allows SENSE encoding in the z-direction with current elements that don't create a magnetic field in the z-direction.

Acknowledgments

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