REDUCTION OF WAVE EFFECTS AT HIGH FIELD USING SERIAL EXCITATION

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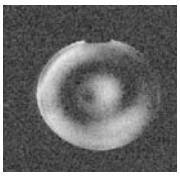
Introduction

The promise of improved sensitivity at higher field strengths has been compromised by field focusing and wave behavior within the sample when imaging large objects within traditional quadrature volume coils, becoming very severe in ex vivo brains, fresh beef, and large cylindrical phantoms at 11.1Tesla [1]. The relatively short wavelengths make it virtually impossible to produce an external source of spin excitation that has sufficient uniformity to obtain a relatively uniform image of the biological sample. These results demand a new perspective be taken in volume coil imaging, which involves novel coil, pulse sequence, and processing algorithms. In this work, we have investigated making spatial and time dependent images to generate a uniform MR image. As a proof of concept, a CRC (counter rotating current) coil was rotated radially around a large cylindrical phantom to acquire independent images. The images were then summed to produce a fairly homogeneous image, which had no significant signal voids.

Methods

A CRC coil was chosen over a single loop because of the improved B1 homogeneity at depth. The coil was placed on an acrylic cylinder of 15.3 cm (6") outer diameter. The outer loop had a diameter of 9 cm and the inner loop 6 cm. The inner loop was displaced vertically 0.5 cm. The CRC was simulated with XFDTD, a finite difference time domain electromagnetic field simulator by Remcom. Spin echo imaging was performed on an 11.1 Tesla, 40 cm Magnex clear bore magnet with a Bruker Biospec console. The CRC coil was first placed at the top of the cylinder and then rotated radially around the cylinder, in 45º increments, each time acquiring an image. This approach produces **W**ave **I**ndependence through **S**erial **E**xcitation (WISE™).

Image with traditional volume coil showing signal voids



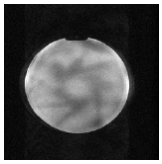


Image using 8 rotations using the CRC coil, reducing the signal voids

Results

The left hand figure above shows a conventional image and the subsequent void. The FDTD simulation of the excitation field indicated good penetration and fairly homogeneous B1 at depth. The right hand figure above shows the summation of eight axial images from the eight, 45° rotations of the CRC around the tissue equivalent phantom. No significant signal voids are present.

Conclusion

The summed images of the time and spatial dependent CRC rotations around the sample produce a much more homogeneous image than that acquired by the traditional quadrature volume coil. There are no significant signal voids. The sum of eight is more homogeneous than the sum of four (not shown), with the trend indicating that more elements will produce an even more homogeneous image. While it is understood that there are significant developments that need to occur to make this approach practical, we feel we have shown that the concept of spatial and time dependent imaging results in uniform MR images previously impossible. The work has been submitted to the ISMRM (1).

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References

1. Beck et al., Magn Reson Med, 51: 1103-1107 (2004).
2. Duensing at al, submitted, ISMRM, Miami (2005).