Spatial Localization Using Actively-Shielded Head-Only Asymmetrical Radial Gradient Coil

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Purpose: The purpose of this paper is to propose a head-only radial gradient coil for spatially localized brain MRI/MRS. Although the SHOT(Selection with High-Order gradienT) is useful for spatial localization since it can provide 3-D selection with just two RF pulses thus reducing the selection artifact and increasing the signal to noise ratio (SNR), its application has been limited to small-bore animal systems due to the limitation in the gradient strength. In this paper, we have designed and implemented a head-only actively shielded radial gradient coil with enough strength for the application to the localized MRI and MRS of the human brain.

Materials and Method: The radial gradient coil for brain MRI/MRS is composed of a 35-cm-diameter primary layer and a 45-cm-diameter shield layer. Its current distribution has been optimized to have the minimum power by using the target-field approach. It is asymmetrical to insert the head. To make a radial gradient in the x-y plane, target fields proportional to the square of the radial position are specified with respective to the radial positions of r = 0, 2, 6 cm. The length of the coil is 70 cm and its loop-current elements are defined with 0.5 cm interval. Three-mm-diameter copper wire was used and stabilized by epoxy. The radial gradient intensity of the designed coil was 0.7 G/cm^2/100Amp. A spin echo pulse sequence can be devised to use SHOT, and spatially selective MRS pulse sequences can be devised easily by removing the read gradient.

Results: The field distribution from the radial gradient coil on the x-y plane is checked by simulation as well as experiments and the result shows almost-ideal radial field change. The shielding efficiency has also been checked by both simulation and experiment. After combining the primary and shield layers, the residual field on the magnet conducting layer was less than 3% of the original peak field. We also compared the calculated inductance with directly measured inductance of the radial gradient coil. The calculated inductance was 268.4 uH which is close to the measured inductance of 272uH (less than 1.32% error). Axial volunteer images with a radial selection show the utility of the proposed localization method. A number of volume-localized MRI experiments have been performed by using the constructed coil set. Medisons Magnum 1.0T has been used for MR experiments.

Conclusion: The constructed radial-gradient coil seems to be useful for spatial localization for both MRI and MRS.

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