Development of Quadrature Detection Surface Coil for Functional Magnetic Resonance Imaging at 3T MRI System

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ABSTRACT

We describe quadrature type surface coil for functional magnetic resonance imaging at 3T MRI system. The coil consisted of two coplanar resonators and was used as both transmitter and receiver. The signal-to-noise ratio (SNR) of the coil was compared with that of a standard birdcage head coil. Visual cortex activation on normal subjects using LED flicker was performed. The SNR of surface coil was found to be better than that of the conventional head coil.

1. INTRODUCTION

We describe quadrature type surface coil for functional magnetic resonance imaging at 3T MRI system. The coil consisted of two coplanar resonators and was used as both transmitter and receiver. The signal-to-noise ratio (SNR) of the coil was compared with that of a standard birdcage head coil. Visual cortex activation on normal subjects using LED flicker was performed. The SNR of surface coil was found to be better than that of the conventional head coil. Functional MRI (fMRI) has widely used to study neurologic function during the past decade. This method for display of human brain activation is based on blood oxygenation level dependent (BOLD) contrast. However, the BOLD signal changes is so small although static magnetic field is high. Therefore the surface coil which has better SNR was used to successful detection of small BOLD signal changes. We have proposed a surface coil which has improved SNR compared with the standard head coil. Usually, a cylindrical head coil provides good homogeneity but less SNR than surface coil. A surface coil has better SNR at the expense of image homogeneity. In this paper, a surface coil of transmit-receive mode offers a better SNR as compared with a head coil.

2. MATERIALS AND METHODS

All experiments were conducted on 3T MRI system (Medinus Co., Ltd. Korea). The performance of a quadrature type surface coil was compared with that of conventional head coil. A acryl cylinder was used as coil holder. The radius of a cylinder is 14cm. The surface coil was constructed on surface of cylinder. The conductive elements placed on the outer surface of the cylinder. To evaluate the coil, multi-test phantom (Nuclear Associates, NY, USA) was used. A spin echo sequence with a TR/TE/flip angle=500/12.4ms/75°was used to measure SNR. Visual activation functional imaging was obtained with volunteers. The LED flicker was used as visual stimulator. Its frequency is about 10Hz. The task block is 5 off, 5 on. This two block is repeated 3 times. The total scan number is 30. The EPI sequence was used to acquire fMRI data. EPI pulse sequence parameters were set at TR/TE=2400ms/35ms, slice thickness=5mm, FOV=240×240mm, and matrix size=64×64. The scan time is 2.5s per image. The fMRI data was processed using SPM99 (Institute of Neurology, University College of London, U.K). The functional maps were overlaid onto T1-weighted images.

3. RESULTS

Signal fall-off of a surface coil was observed as a function of distance from conductors. The SNR values of the surface coil decrease as functions of depth. In the vicinity of the conductors high signal is observed as would be expected. The visual cortex functional mapping is overlaid with T1-weighted images. The activated regions corresponding to the part of the visual cortex are clearly visualized. Individual time course of signal changes showed good correlation with stimulation.

4. CONCLUSION

A BOLD signal changes is only a few of percent. Thus, in functional MRI study, there is a great need for improve SNR of the raw fMRI data. From SNR measurements, the surface coil offers better SNR but it has FOV limitation. However, the coil provided satisfactory fMRI BOLD imaging at depth of 8-10cm from the coil and enough better SNR for superficial imaging. In conclusion, a coil for fMRI studies, which should offer improved SNR and enough FOV coverage, is presented.

REFERENCES

1. Willem JC, Veen VD, Hallander JA, Pohost GM, Human brain activation: perfusion or BOLD effects, in "Proc. 2nd Annual Meeting, SMR, 1994", p623
2. Lin CS, Gold J, Rajan S, A novel multi-segment transmit-receive surface coil for neuro functional MRI, in "Proc. 2nd Annual Meeting, SMR, 1994", p1105
3. Hayes CE, Edelstein WA, Schenck JF, Mueller OM, Eash M, An efficient, homogeneous radio frequency coil for whole body NMR imaging at 1.5T, J. Magn. Reson., 63, 622-626, 1985
4. Ackerman JJH, Grove TH, Wong GG, Gadian DG, Radda GK, Mapping of metabolites in whole animals by 31P NMR using surface coil, Nature(London), 283, 167-170, 1980
5. Roemer PB, Edelstein WA, Hayes CE, Souza SP, Mueller OM, The NMR phased array, Magn. Reson. Med., 16, 192-225, 1990
6. Wright SM, Magin RL, Kelton JR, Array of mutually coupled receiver coil: Theory and application, Magn. Reson. Med., 17, 252-268, 1991
7. Hayes CE, Hattes N, Roemer PB, Volume imaging with MR phased arrays, Magn. Reson. Med., 18, 309-319, 1991