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PII: S1090-7807(17)30303-8
DOI: https://doi.org/10.1016/j.jmr.2017.12.011
Reference: YJMRE 6213

To appear in: *Journal of Magnetic Resonance*

Received Date: 28 September 2017
Revised Date: 8 December 2017
Accepted Date: 13 December 2017

B_1-control Receive Array Coil (B-RAC) for Reducing B_1^+ Inhomogeneity in Abdominal Imaging at 3T-MRI

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***Abstract*— B_1^+ inhomogeneity in the human body increases as the nuclear magnetic resonance (NMR) frequency increases. Various methods have thus been developed to reduce B_1^+ inhomogeneity, such as a dielectric pad, a coupling coil, parallel transmit, and radio-frequency (RF) shimming. However, B_1^+ inhomogeneity still remains in some cases of abdominal imaging.**

In this study, we developed a B_1-control receive array coil (B-RAC). Unlike the conventional receive array coil, B-RAC reduces B_1^+ inhomogeneity by using additional PIN diodes to generate the inductive loop during the RF transmit period. The inductive loop can generate dense and sparse regions of the magnetic flux, which can be used to compensate for B_1^+ inhomogeneity. First, B-RAC is modeled in the numerical simulation, and the spatial distributions of B_1^+ in a phantom and a human model were analyzed. Next, we fabricated a 12-channel B-RAC and measured receive sensitivity and B_1^+ maps in a 3T-MRI experiment.

It was demonstrated that B-RAC can reduce B_1^+ inhomogeneity in the phantom and human model without increasing the maximum local specific absorption rate (SAR) in the body. B-RAC was also found to have almost the same the receive sensitivity as the conventional receive coil. Using RF shimming combined with B-RAC was revealed to more effectively reduce B_1^+ inhomogeneity than using only RF shimming.

Therefore, B-RAC can reduce B_1^+ inhomogeneity while maintaining the receive sensitivity.

***Keywords*—Magnetic Resonance Imaging (MRI), B_1^+ inhomogeneity, RF shimming, B_1-control receive array coil, local SAR**

1. Introduction

B_1^+ inhomogeneity in the human body increases as the nuclear magnetic resonance (NMR) frequency increases, causing image shading and less fat suppression. Various methods have thus been developed to reduce B_1^+ inhomogeneity, such as a dielectric pad [1,2], a coupling coil [3-9], parallel transmit [10-14], and radio-frequency (RF) shimming [15-20].

The dielectric pad that has high permittivity is put on the patient's body to reduce the inhomogeneity in the body. However, the pad is heavy (several kg), so it may strain the patient physically.

The coupling coil has around 10% higher resonance frequency than the transmit RF coil and can increase B_1^+ near the coil. However, the coupling coil is placed between the human body and the RF receive coil and so increases the distance between them. Consequently, the sensitivity of the RF receive coil may be decreased below that when the coupling coil is not used. Furthermore, the total weight of a double-layer structure (the layer of the receive coil and the coupling coil) exceeds that of the conventional receive coil.

In parallel transmit, the RF pulse is irradiated by using a multi transmit RF coil, and the gradient magnetic field is simultaneously controlled for the B_1^+ homogenization. The parallel transmit can control the spatial distribution of B_1^+ precisely. However, the duration time of RF pulse of the parallel transmit is longer than that of the conventional RF transmit, so the available sequences are limited in clinical use.

In RF shimming, the amplitude and phase of a RF pulse from each channel is controlled in order to reduce B_1^+ inhomogeneity. RF shimming is applied to various parts of the body and improves the image quality by reducing B_1^+ inhomogeneity. Two-channel RF shimming is widely used especially in commercial magnetic resonance imaging (MRI) systems. However, B_1^+ inhomogeneity remains in some cases of abdominal imaging, for example, around the periphery of the abdomen in a large body.

To reduce B_1^+ inhomogeneity in the periphery of the abdomen, the B_1^+ inhomogeneity in the periphery needs to be controlled. The coupling coil can control the B_1^+ inhomogeneity near the coil, so the B_1^+ inhomogeneity can be reduced by placing the coupling coil around the abdomen. However, the coupling coil decreases the sensitivity and increases the total weight as mentioned before. On the other hand, the receive array can be placed around the abdomen and consists of loop coils like the coupling coil does. Therefore, the B_1^+ inhomogeneity in the periphery of the abdomen can be reduced without the coupling coil if the function for reducing the B_1^+ inhomogeneity of coupling coil is added to the receive array coil. Wiggins et al. [5] showed that the receive coil elements can be used as the coupling coil and that B_1^+ for the

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