Reconstruction methods of 8 channel head multi-coil by imitating birdcage coil current distribution

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Synopsis

Homogeneous images were reconstructed with 8 channel head multi-coil by imitating 8 element birdcage coil's current distribution without additional data like homogeneous images acquired by a whole body coil. This technique of imitating another type of larger coil's current distribution is useful especiallyfor multi-coil with many numbers of coils like 8 or more.

Introduction

The number of coils in RF multi-coil is increasing especially since the advent of parallel imaging techniques. (1,2) RF coil configurations are usually optimized from the viewpoint of SNR. However, it is often the case that there is more intensity change caused by the coil's B1 maps in the images reconstructed by the sum-of-square methods (3). Considering transmission from multi coils, the elements located near by each other works at a distance as the one element, the current of which is the same as the sum of the original element's currents. This means that an excitation profile by a larger coil is available if the current and the phase can be controlled to imitate the coil's current distribution. On the other hand, the reciprocal theory tells that the RF signal received by a larger coil is composed from a set of signals received by some (or all) coils in the multi-coil. The element configuration of GE's 8 channel head multi-coil is similar to an 8 element birdcage coil so the homogeneous image by the birdcage coil is expected to be composed from the data received by the 8 channel head muli-coil.

Theory and Simulation

Assume that phases of the signals received by coils are the same with 8 channel head multi-coil. (The phase of a received signal depends on the coil position and the electrical length between the coil's feeding point and the receiver.) Also assume that preamplifier gains are the same with all coils. The current amplitude of the birdcage coil's homogeneous mode is the one-period of sinusoidal pattern along with the end ring. The phase is the same everywhere on the end ring. Thus the current distribution of 8 element birdcage coil is imitated as

$$\mathrm{Im} = \sum_{k=1}^{8} \left(\cos\left(\frac{k}{8}\cdot 2\pi\right)\cdot coil(k) + \cos\left(\frac{k}{8}\cdot 2\pi + \frac{\pi}{2}\right)\cdot coil(k)\cdot \exp\left(i\cdot\frac{\pi}{2}\right)\right) \qquad [1]$$

, where *coil(k)* means the received signal by *k-th* coil, and *i* is the imaginary unit. (Fig.1) B1 maps were calculated based on Biot Savart law with all coils in the model shown in Fig.1. The reconstructed B1 maps were composed with both sum-of-square methods and Eq.[1]. (Fig.2) The simulation result showed that homogeneity improved in the image reconstructed following Eq.[1].

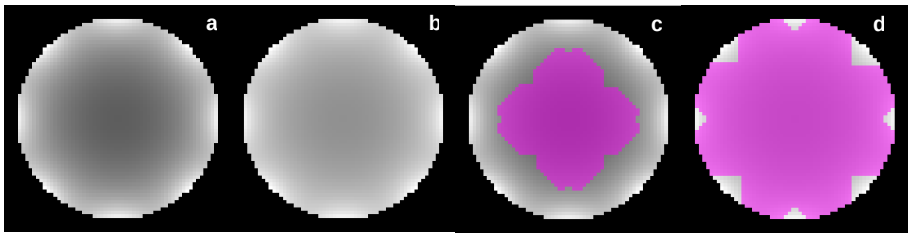

Fig.2 Simulation results; a sum-of-square image (a) and the image reconstructed by imitating the birdcage coil current distribution (b). The pinked area in both (c) and (d) show the homogeneous area which is defined as the area where intensity difference between any adjacent pixels is less than 3%.

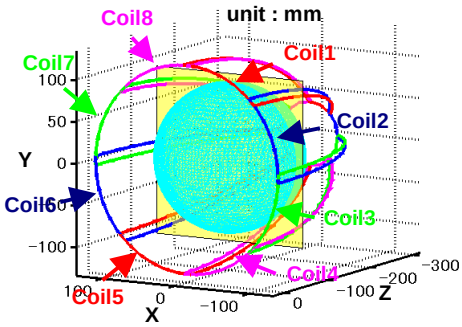

Fig.1 The model of 8 channel head multi-coil on a dome type of coil base. The size of each coil is almost the same as that of GE 8 channel head multi-coil. The current direction on each coil has circularly symmetric around z axis. B0 direction is Z. The blue sphere shows the phantom. The yellow plane is the simulated plane.

Methods and Results

The reconstruction methods of Eq.[1] was applied to the head MRI data acquired by a 1.5T GE Signa Excite system. Preamplifier gains were assumed the same with all coils. The phase of the data from each coil was shifted to be the same and then combined following Eq.[1]. Fig.3 shows the results.

Discussion

This technique can be also available to calculate B1 map of each coil without homogeneous images like images acquired with a whole body coil because homogeneous images is reconstructed from the same data set. This B1 map calculation methods is thought robust against the motion artifact caused by the motion between a multi-coil reference image acquisition and a whole body coil reference image acquisition.

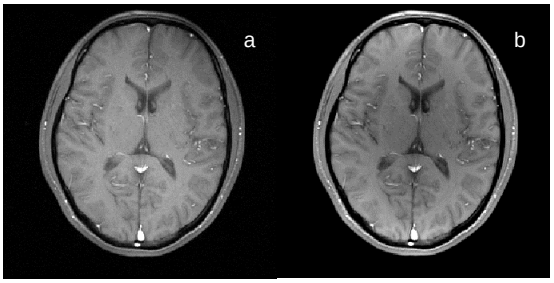

Fig.3 a head image reconstructed by imitating 8 element birdcage coil (a). Sum-of-square image (b) is also shown for comparison.

References

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(3) Hayes CE, et al., Magn Reson Med 1990; 16: 181-191.