SNR Enhancement by Free Local Resonators for Traveling Wave MRI

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Introduction

Traveling wave MR (1) is a promising technique for imaging large samples using a relatively small, easy-to-build patch antenna, rather than a conventional, large sized body volume coil of which design is technically challenging, particularly at ultrahigh fields. Due to the use of far fields, traveling wave MR suffers from low signal-to-noise ratio (SNR), compared with traditional near field, standing wave technology. Previous studies show that SNR of traveling wave MR can be improved by using a local receive coil connected to the preamplifier and receiver of the MR system (2). In this work, we present a method to enhance imaging SNR for traveling wave MRI by using free local resonators. The local resonators tuned at the Larmor frequency of proton at 7T are free of connection to the MR system and are placed in the region of interest near the imaging sample. MR signals are still excited and received by the antenna as used in traditional traveling wave method. The results of in vivo MR imaging experiment at 7T in rats show that SNR of traveling wave MR using free local resonators is significantly improved over the traditional traveling wave MR method.

Methods and Materials

A microstrip antenna was designed to operate at 298.2MHz, the proton Larmor frequency of our 7T system. In the traveling wave MR imaging experiment, the antenna was placed in the magnet bore, approximately 80cm away from the imaging sample (or the center of the magnet) and used to excite and receive MR signals. A rectangular LC loop resonator with dimensions of 3.8cm x 5 cm was constructed to resonate at 298.2MHz. This LC resonator does not have physical connections to the MR system and can be freely place to any area of interest of a MR sample. The experiment setup is illustrated in Figure 1. With this resonator, local B1 field can be amplified when using traveling wave MR imaging, ultimately resulting in improved SNR. All the imaging experiments were performed on a whole body 7T MR scanner (GE Healthcare, Milwaukee, WI). Its magnetic bore size is large enough to support a cut-off frequency of 286MHz, which enables traveling wave MR experiment at 7T. To simply the experiment, there is no extra RF shielding used in the magnet bore which is believed to be able to form a better behaved waveguide. In vivo traveling wave MR imaging in rats was performed with and without the free local resonator. The imaging results were compared in terms of SNR and field distribution. Gradient echo sequence was used in all imaging acquisitions. The imaging parameters were TR/TE = 250ms/3.3ms, matrix size = 128 x 128, slice thickness = 3mm (with free local resonator), 5mm (without free local resonator) FOV = 8cm x 8cm (with free local resonator), 15cm x 15cm (without free local resonator).

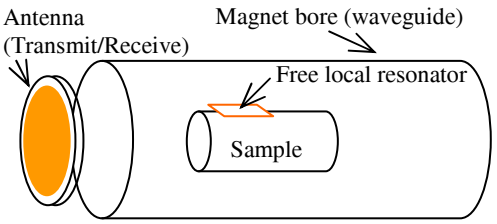

Fig 1 Experiment setup of traveling wave MRI with a free local resonator for SNR enhancement. The free local resonator has no physical connections to MR system, making it convenient to place to any target of interest to enhance SNR in traveling wave MR. The local resonator can be big or small, can be a single loop resonator or a decoupled resonator array to cover larger area.

Results and Discussion

In vivo rat head images acquired using traveling wave MRI with and without free local resonators are shown in Figure 2. Measured highest achievable SNR was 195 for imaging with free local resonator and 20 for imaging without free local resonator, although the later was acquired with favorable acquisition parameters (i.e. thicker slice and larger FOV), This results indicate a nearly 10-fold SNR gain of the proposed method using free local resonators over traditional traveling wave MR. The proposed method of free local resonators provides a simple and convenient approach to increasing MR SNR in traveling wave MR. It might be possible to use a multi-element array, instead of a single local resonator, to further enhance SNR and also possible imaging coverage.

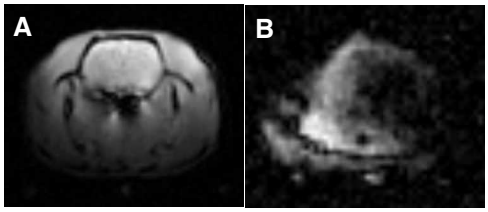

Fig 2 (**A**) In vivo rat head image at 7T using traveling wave MRI with a free local RF resonator. Acquisition parameters: GRE, TR/TE 250ms/3.3ms, thk 3mm, matrix size 128 x 128, FOV 8cm, acquisition time 5.3 min (highest achievable **SNR = 195**). (**B**) Rat brain image at 7T using regular traveling wave MRI. All parameters are same, except FOV 15cm, thk 5mm (highest achievable **SNR =20**). This result demonstrates SNR enhancement capability of free local resonator to traveling wave MRI.

References

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