HTS volume coil enhanced SNR in Wideband mice whole body screening

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Abstract

With a nearly 2-fold SNR increase using the world's first high temperature superconducting (HTS) animal volume coil, the W=3 accelerated Wideband high-resolution mice whole body scan serves as an example of good balance between image quality and temporal/spatial resolution. The experiment was conducted with copper and $Bi_2Sr_2Ca_2Cu_3O_x$ (Bi-2223) volume coils to show the difference.

Introduction

Animal models have always been reasonable analogies for human research. By planting/inducing various diseases, studies can be conducted on rodents to give a closer understanding of what will happen to human. However, with the increase of spatial resolution, the loss in SNR of animal MR imaging needs more averaging or higher fields to compensate. Other than moving to high-field systems, another solution is to use high temperature superconducting materials as radiofrequency coils [1,2]. By decreasing thermal heat, the SNR can be increased several folds depending on coil dimension and main field strength. As for spatial/temporal resolution, Wideband MRI is a technology that enables multiple images to be acquired in one single excitation, reducing the total scan time for whole body screening [3]. Here we present a whole new method combining wideband method with a HTS saddle coil. Whole mice body images were acquired with a W=3 Wideband MR imaging sequence. Utilizing the advantages of these two technologies, we are able to take fast high resolution whole body imaging without compromising SNR.

Materials and Methods

The mice whole body scans were performed on a Bruker 3T BioSpec MRI system with S112 mini gradient with a maximum gradient strength of 200mT/m. two sets of Images taken with 1. a copper volume coil at room temperature (300k) and 2. a HTS volume coil soaked in liquid nitrogen (77k) to maintain its state of superconductivity. The volume coil has the dimension of 5 cm width and 8 cm length was implemented. The two coils have identical size and shapes, both placed at the same position in the animal holder for a fair comparison, MR signals were acquired via inductive coupled pick-up coils. The hardware setup is illustrated below in Fig. 1. The total coverage of the mice was 57.6mm, W=3 Wideband MR imaging was used with TR/TE = 100/7.3 ms, effective slice thickness = 0.33 mm, FOV = 3 x 2.8 cm, Matrix size = 160 x 128, spatial resolution=0.187mmx0.218mm

Results

Since the two sets of images share the same spatial resolution, the structures and contrast are fairly the same. However, images taken with HTS@77k volume coil have less background noise. The average SNR gain from measured data HTS coils compared to copper coils is 1.98, shown in Fig.2 which is mainly contributed from the loss of noise, while there is almost no increase in signal intensity.

Fig. 1 (left) see-through picture of HTS volume coil, and (right) sagittal view of the coil. Each components are labeled as followed: (1) dewar (2)pick up coil (3)mice (4)HTS saddle coil (5) LN2 intake & exit.

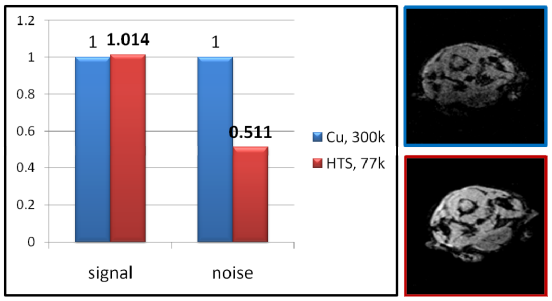

Fig. 2 Signal/noise comparison acquired by different coil settings (left). One of the images was also displayed at the right.

Conclusions

Using the world's first HTS animal volume coil, we have shown its capability to boost SNR in animal studies. Unlike surface coils, the HTS volume coil can easily cover the entire length of the mice, making studies of large coverage easier. Furthermore, SNR gain of HTS volume coils cannot be simply derived with equations that was used to predict surface coil gains and might need numerical analysis tools for a more precise calculation. As for experiment settings, the HTS volume coil along with the vacuum chamber encapsulates the whole subject, meaning that heat insulation might be a more challenging topic. After 30 minutes of experiment, the behind of the mice is slight frozen for it was placed at the position with less air circulation.

Encouraged by this experiment, we will continue to improve the design of HTC coils as well as holders to fully utilize its advantages in MR imaging.

References

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