Two-channel High-Temperature Superconducting Array for Diffusion Tensor Imaging of Rat Spinal Cord at 7T

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Target Audience

Investigator who shows interests in high-temperature superconducting (HTS) phased array coil to obtain high SNR and large FOV at 7T

Introduction

Signal-to-noise ratio (SNR) is the bottle neck while we are pushing MRI towards high spatial and temporal resolution, especially in the large FOV scanning. Diffusion imaging was hard to apply on spinal cord in clinical due to the time consuming problem and low SNR in high spatial resolution, although it is much valuable to obtain the diffusivity parameter in spinal cord. High temperature superconducting (HTS) coil has been proposed as a promising technique for SNR improvement in MRI with surface or volume coil [1]. However, a volume body HTS coil is not fully demonstrated its capability in the large FOV study, such as the spinal cord due to its reduced SNR gain[2]. Therefore, this study is aiming to implement a two-channel 4cm x 4cm HTS array platform, which is utilizing an 8cm FOV for acquiring diffusion tensor imaging on rat spinal cord at high field like 7T. For the comparison, a copper phased array coil in the same structure was been made.

Materials and Methods

The Dewar was design and implemented in a HTS platform for keeping the phased coil at 77K. It was made of quartz glass, and the vacuum pressure was kept below 10^{-5} torr. The inductive couple mechanism was used for signal picked up [3]. SD rat was sacrificed and the coil was place on the spinal cord (Figure 1). All the images were performed on 7T animal MRI (Bruker, Ettlingen, Germany). The DTI were acquired with six directions, including [+x, +y, 0], [+x, -y, 0], [0, +y, +z], [0, -y, +z], [+x, 0, +z] and [-x, 0, +z]. The imaging parameters were listed as the following: FOV: 8 × 2.5 cm^2, resolution: 312×312 μm^2, slice thickness=2-mm, TR/TE=1500/26.7-ms, b=1000-s/mm^2, and scan time was 56-min. For comparison, the DTI study by copper phased array at 300K in the same setup and same configuration was examined.

Results

Figure 2 shows the 1.9 times SNR gain by using HTS coil array compared to copper coil array at 7T MRI. To evaluate the performance of the HTS array, the reproducibility of DTI was performed. The standard deviation of angle difference of two DTI scans was calculated using the formula:θ= cos-1(|v1· · v2|)sign((v1 × v2) e3) [4]. The result shows the standard deviation(SD) was reduced from 26.7-deg of copper coil to 18.9-deg of HTS coil significantly (Figure 3). In various region of spine, this SD are changed due to different spine structure. In Fig.4, the scatter plot of deviation angle *vs.* FA are shown.

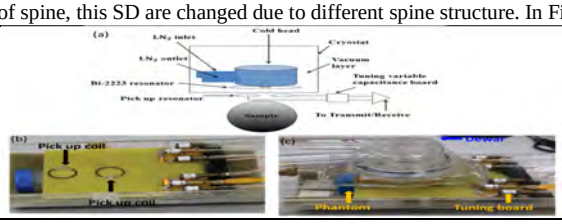

Figure 1. (a) the configuration of HTS platform; (b) the pick up coil; (c) the setup of Dewar and pick up coil.

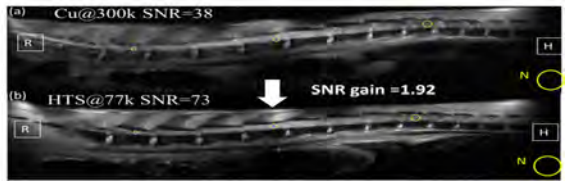

Figure 2. (a)The DWI b-value=0 by two-channel copper phased array coil (b)The DWI b-value=0 by two-channel HTS phased array coil.

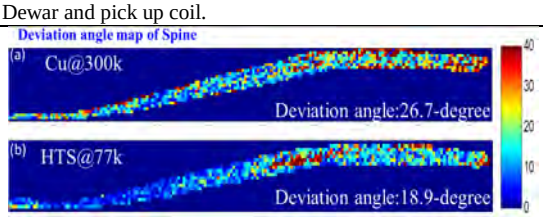

Figure 3. (a)The two-channel copper phased array coil deviation angle is 26.7°(b) The two-channel HTS phased array coil deviation angle is 18.9°.

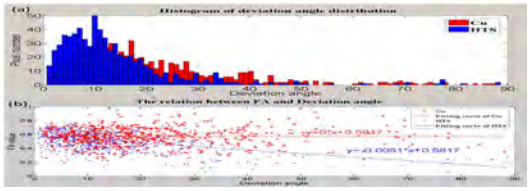

Figure 4. (a)The histogram of the deviation angle distribution (b) The relation between FA and Deviation angle

Conclusions

We have first demonstrated the diffusion spinal cord study by using HTS coil platform, further, SNR could be improved 1.9-folded compared to copper coil at 300K. The reproducibility is improved by showing that deviation angle decrease from 26.7° to 18.9°. Compared to the SNR gain 1.9-2 in our previous 8 cm HTSC spine volume coil at 3T, this study demonstrate the capability using phase array HTS coil to maintain a high SNR and large FOV study for spinal cord at a higher field like 7T. We are aiming to implement a 4 channel HTSC coil or 2 channel thin film phased array coil to achieve even better SNR at the 7T MR system in the near future for high resolution MR imaging.

References

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