IMPLANTED MAGNETIC RESONANCE COIL SYSTEM FOR IN VIVO IMAGING AND SPECTROSCOPY OF A BIOARTIFICIAL PANCREAS

N. Volland (UF, Biomedical Engineering), I. Constantinidis (UF, Medicine) and T. H. Mareci (UF, Biochemistry and Molecular Biology)

Introduction

The development of a bioartificial pancreas is one possibility being explored to alleviating the stress of treatment on diabetes patients and restoring independent partial blood glucose control. Therefore monitoring such a macroconstruct non-invasively is a key to understanding functionality and enhancing performance in vivo. Nuclear magnetic resonance (MR) imaging and spectroscopy shows great promise for non-invasive monitoring of a bioartificial pancreas in vivo and has been applied using surface coils at 4.7 T [1]. However sensitivity of these measurements at 4.7 T severely limits the utility of MR with surface coils. To overcome these limitations, we have taken the first successful step toward developing a non-invasive MR method for in vivo monitoring of a bioartificial pancreas macroconstruct using implantable coils at 11.1T.

Experimental

We developed an implanted coil system [2] consisting of an internal (implantable) coil inductively coupled to an external coil [3] (see Fig. 1), for MR imaging and spectroscopy on an 11.1 Tesla, 40-cm clear horizontal bore magnet. The 1.2-cm-diameter 2-turn internal coil will surround the cells in the bioartificial pancreas macroconstruct [1] with the coil directly implanted inside the macroconstruct. The coil system functions as both transmitter and receiver at 470 MHz but in this coupled setting, two configurations are possible: either the current co-rotates in the same direction in both coils or current counter-rotates in the opposite direction. These two configurations, along with a simple surface coil configuration (SC configuration) were simulated, constructed, tested, and optimized on the bench. Then MR images were acquired using a water sample. The signal-to-noise ratio (SNR) was calculated from the images for each configuration (co-rotating, counter-rotating, and SC), at the implanted coil position to allow the determination of the configuration with the highest sensitivity.

Results and Discussion

The results for each configuration of implanted coil were compared with the SC configuration as a reference. The co-rotating configuration gives an average SNR gain of 3.81 over the SC configuration; whereas the counter-rotating configuration gives an average SNR gain of only 2.64 over the SC configuration. Consequently the co-rotating configuration has a better SNR gain than the counter-rotating configuration by a factor of 1.72.

Conclusions

Both theoretically and experimentally, implanted coils demonstrate a SNR improvement of a factor of 2-to-4 over single surface coil configurations at the location of the implanted coil (macroconstruct location) and the co-rotating configuration gives a factor of 1.5-to-2 gain in SNR over the counter-rotating configuration. Also we have successfully used the co-rotating coil system to measure localized spectroscopy using phantoms. Since the co-rotating configuration gives the highest sensitivity, this configuration will be developed further as a non-invasive method for monitoring a bioartificial pancreas in vivo.

Acknowledgements

MRI data were obtained at the Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) facility in the McKnight Brain Institute of the University of Florida and supported through the NHMFL and by NIH grants DK056980 (IC), DK047858 (IC), NS42075 (THM), and RR16105 (THM).

References