INDUCTIVELY COUPLED RF COILS FOR TISSUE ENGINEERING

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Introduction

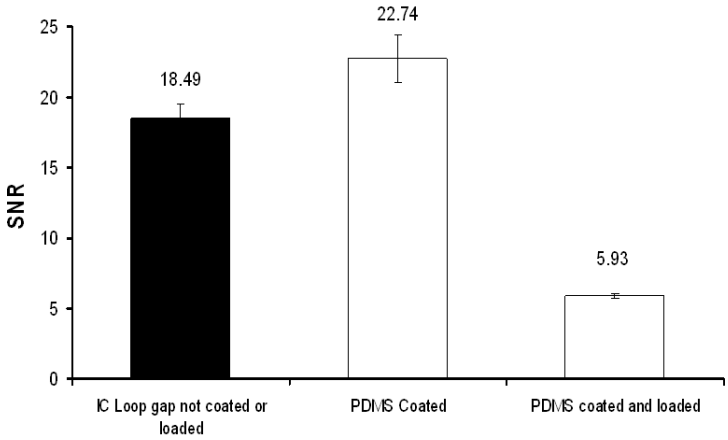
The development and implantation of a tissue engineered pancreatic construct (i.e. bioartificial pancreas) is explored as a possible alternative to islet transplantation to obtain more physiologic blood glucose regulation in patients with type 1 diabetes. Monitoring such a construct non-invasively in vivo is a key to understanding its functionality and possibly predict its failure. Nuclear magnetic resonance (MR) techniques such as imaging and spectroscopy have been utilized in vitro [1] for this purpose, but in vivo [2] studies lack the sensitivity to monitor a construct capable of restoring and maintaining normoglycemia in diabetic animals. To overcome this lack of sensitivity, we are developing an inductively couple RF probe that will be implanted within the tissue substitute and tune to resonance frequencies at 11.1T.

Materials and Methods

The RF system consists of an internal (implantable) coil inductively coupled to an external coil. One of the key issues with the use of inductively coupled coils is the coating of the coil to eliminate its contact with conductive biological fluids or tissues. To test the effect of coating on signal detection, the internal coil was coated with PDMS, a silicon based material that has been used extensively in tissue engineering and it considered to be biocompatible. All NMR measurements were performed at 11.1T horizontal magnet with a clear bore of 40 cm. The instrument is equipped with a Bruker console and two sets of gradients: (i) an 11 G/cm actively-shielded gradient set with an inner diameter bore of 25 cm; and (ii) a 22 G/cm actively-shielded gradient set with an inner diameter bore of 12 cm. The console has multinuclear capability, two broadband 1kW transmit channels, and phased array capability.

Results

Our results show that use of PDMS to coat the internal coil does not affect the SNR when compared to non-coated coils. The biggest effect in the inductively coupled coil sensitivity is when the coil is loaded. Nonetheless, an inductively coupled coil at 11.1T was 5.93x more sensitive that our initial surface coil experiments conducted at 4.7T [1,2]. The figure on the left is a bar graph illustrating the effects of coating with PDMS.



Conclusions

Our data show that by switching to an 11.1T instrument and using inductively coupled coils we can improve our NMR sensitivity by at least 6x. Although under in vivo conditions the maximum improvement in SNR may be lower due to dielectric losses despite the PDMS coating, we anticipate that the improvement in SNR will enable us to lower the cell density within our construct as well as permit the acquisition of NMR spectra from biologically relevant nuclei, such as ^{31}P.

Acknowledgements

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References

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2. Stabler, C.L., Long, R.C., Jr., Constantinidis, I., and Sambanis, A., Cell Transplantation, 14;139-149, 2005.