Design of a $^1$H/$^{31}$P RF Switchable Surface Coil for *in vivo* Spectroscopy and Imaging at 11.75 T


**Introduction**

Surface coils (SC) have high localized signal-to-noise ratios (SNR) compared to volume coils. Double resonance coils are desirable especially for *in vivo* experiments, mainly because there is no need to remove and reposition the sample when switching between channels. However, all double resonance coil designs in the literature suffer from losses when compared to their complementary single-tuned configuration. In this work, we present the concept of a switchable SC that can be tuned to at least two frequencies while maintaining the characteristics and performance of the single-tuned SC. An optimized $^1$H and $^{31}$P SC was implemented at 11.75 T to provide a resonant network at 500 and 202.4 MHz, respectively. This coil is being applied to the study of dynamic changes in metabolites and high energy phosphates (HEP) of murine muscle *in vivo*.

**Experimental**

A simple L-type matching network was used to build a surface coil that can be tuned at both $^1$H and $^{31}$P resonance frequencies at 11.75 T (500 MHz and 202 MHz, respectively). The design of the coil was adjusted to accommodate the differences in the muscle sizes so that its field of view covers the ROI. To accommodate the *in vivo* experiments, a mouse apparatus was designed. The apparatus consisted of a removable RF shield (to facilitate animal mounting), a mouse harness, the surface coil and slots in the base to allow the passage of stimulation leads into the chamber. The performance of the SC was evaluated on bench by measuring the quality factor (Q) and by acquiring non-localized $^{31}$P spectra and the $^1$H GRE images of C57 mouse leg *in vivo* at 11.75 T.

**Results and Discussion**

A $^{1}$H/$^{31}$P switchable SC (Fig. 1) was designed and tested successfully at 11.75 T. It is tunable at both resonance frequencies (500 and 202.4 MHz). Q values were found to be 100 and 120 for $^1$H and $^{31}$P channels, respectively. These values were consistent with different sample loads. *In vitro* data (not shown) indicated that the SC had a penetration depth of 4 mm and 3.5 mm for $^1$H and $^{31}$P channels, respectively. Non-localized *in vivo* $^{31}$P spectrum (Fig. 2) was acquired in approximately 1 minute at an SNR of 24. The SC also was used to acquire *in vivo* $^1$H 2D GRE images of a mouse leg at in-plane resolution of 60×60 µm and 98×78 µm for axial and sagittal images, respectively. These images show the sensitivity of the SC for *in vivo* imaging of the soleus and gastrocnemius muscles. $^1$H 3D GRE image with 75-µm isotropic resolution is shown in Fig. 3.

**Conclusions**

We have developed a switchable $^1$H/$^{31}$P SC that can be tuned to phosphorous and proton frequencies for 11.75 T without removal from the magnet. NMR spectroscopy and imaging results indicate that this SC is sensitive for both proton and phosphorus and it can be used to perform anatomical images as well as the acquisition of $^{31}$P and $^1$H spectra during the *in vivo* examination of the mouse skeletal muscle. The application of this coil is not limited to the study of metabolites and HEP in muscle, for example it has been used to quantify the flow *in vitro* using phase contrast MRI technique [1].

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**References**