Zig-zag ^{13}C surface coil at 7T for high-sensitivity subcutaneous lipid MRS

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Introduction

The metabolic implications of lipid accumulation may depend on the composition of the fat itself. For example, it is well known that diets high in saturated fat are unhealthy, while omega-3 rich foods are beneficial. An excess in some minor lipid-derived metabolites, such as arachidonic acid and *trans* fats, can lead to increased risk of diabetes, heart disease and inflammation. Analytical high-resolution spectroscopy has been used, for many years, to accurately quantify food lipid composition. It relies on high magnetic fields for chemical shift dispersion, good shimming for metabolite separation, and proton decoupling for spectral simplification. In order to obtain non-localized signals from subcutaneous fat only, while not suffering the low coverage and increased noise levels of a very small surface coil, here we report on the design of a zigzag carbon-13 surface coil (1) with coverage designed to obtain high-resolution spectra exclusively from the subcutaneous lipids at 7T.

Methods

The *in vivo* human protocol was approved by the local IRB. A single channel surface coil was build using 1mm thick copper wire on a Teflon substrate. The dimensions of the coil are shown on figure 1. The spacing between the opposing current elements was chosen to be 5 mm so that to limit the field penetration to the average thickness of subcutaneous fat of 7-8 mm. The coil was tuned using a single variable capacitor and impedance matched to 50 Ohms. In order to obtain the majority of the signal from a volume ~5 mm deep in tissue, the spacing between successive meanders was the same dimension. Since the coil is small and only sees lipid the RF field is not significantly different from that at low field calculated using the Biot-Savart law. A proton trap was also inserted in the coil to filter out unwanted noise during decoupling. A separate dual-channel partial volume proton calf coil was used for localization, shimming, and decoupling. To investigate the depth of coverage, a 1D CSI was performed across the FOV of a phantom filled with grapeseed oil. Proton-decoupled spectra were acquired with non-localized 13C FID acquisition, with BW 13 kHz, 8k samples, 32 averages, WALTZ-16 decoupling with B1 18uT applied for the first 20% of the acquisition time, and a 1.5 s long train of NOE pulses with B1 of 10uT and 5% duty cycle. *In vivo* human spectra were obtained with NOE only since the use of the large proton coil for decoupling would exceed the allowed SAR.

Results

Figures 1B, C show the 1D penetration profile of the coil. As predicted, there is a sharp fall off of the excitation field, with signal intensity decreasing 50% 7 mm away from the coil surface. This is a much sharper decline as compared to a surface coil having the same overall dimensions (20x25 mm). Figures 2A, B show the high sensitivity achievable with 6 minutes of acquisition, without and with decoupling, respectively. The complex multiplet structure is seen to cleanly collapse to singlets upon decoupling. Fig. 2C shows coupled *in vivo* human lipid spectrum. Work is currently underway on a smaller proton coil to enable proton decoupling *in vivo* within the SAR limits. In conclusion, high sensitivity spectra can be obtained from the subcutaneous lipids exclusively when using a zigzag ^{13}C coil at 7T.

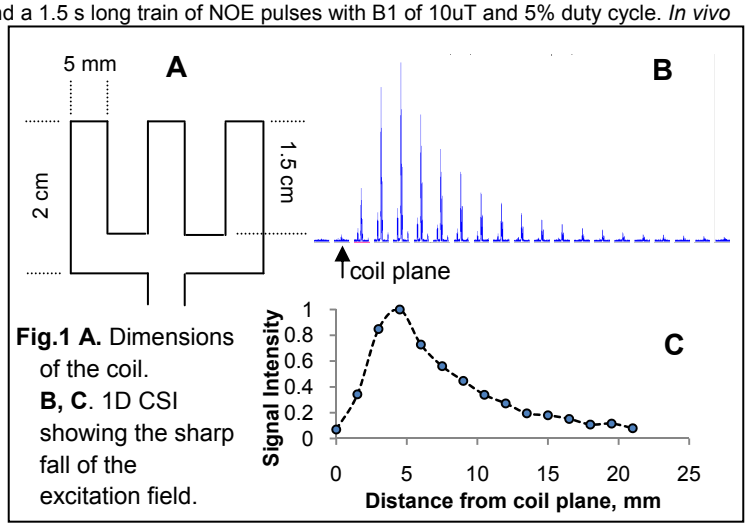

Fig.1 A. Dimensions of the coil. **B, C**. 1D CSI showing the sharp fall of the excitation field.

Reference

1. T. Nakada, et al. 31P NMR spectroscopy of the stomach by zig-zag coil, M RM 5 449 (1987)

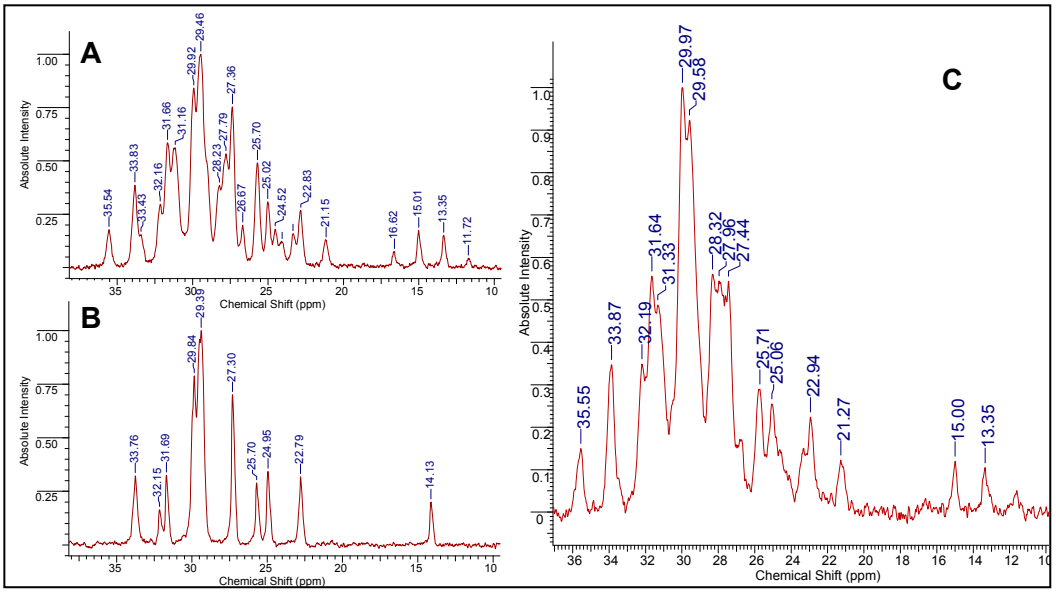

Fig.2.

A. Coupled spectra of grapeseed oil phantom showing high sensitivity of the coil.

B. Spectra simplification is achieved with the successful application of proton decoupling. No appreciable sidebands can be detected.

C. In vivo human lipid spectrum of the fingerprint region.