Towards ^{13}C NMR spectroscopy of human muscle at 7T using broadband ^{1}H decoupling

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Introduction Multi-nuclear MR spectroscopy at high magnetic field (7T and above) is a promising tool for investigating cerebral metabolism with optimal sensitivity affording a wide range of applications in medical research. In particular, ^{13}C MRS is a unique modality that specifically enables the measurement of tissue Glycogen [1]. The main difficulty while implementing ^{13}C MRS in human scanners at high field is the need for decoupling of the single-bond ^{13}C-^{1}H hetero-nuclear J coupling while respecting the IEC guidelines for SAR. In this study we present a successful implementation of in vivo ^{13}C MRS at 7T in human calf muscle, including the in vivo detection of Glycogen together with an experimental evaluation of an existing decoupling technique Waltz16 [3], exploring its feasibility in humans at 7T and comparing it to continuous-wave (CW) decoupling.

Methods All experiments were performed on a 7 Tesla MR human scanner (Siemens Medical Solutions, Erlangen, Germany). A dual-tuned RF ^{13}C-^{1}H surface coil was built, consisting on a combination of quadrature ^{1}H coil (9cm diameter both loops) and linear ^{13}C coil (6cm diameter) [2]. Both ^{1}H and ^{13}C coils were matched to 50Ω by a parallel circuit, giving more stability under different loading and avoiding unwanted sparks through the loop capacitors. A bazooka balun was inserted in the ^{1}H and ^{13}C coaxial cables, to reduce currents flowing on the shield of the cable. We measured the bandwidth of Waltz16 in an acetate phantom by applying the decoupling sequence at a range of offset frequencies. The in vivo measurement was carried out with a healthy volunteer who gave informed consent according to the procedure approved by the local ethics committee. A pulse-acquire sequence with adiabatic half passage excitation (2050μs) was implemented together with ^{1}H decoupling using Waltz16 [3] and CW. Both Waltz16 and CW were applied in vitro and in vivo (20% of the acquisition time i.e. 102ms, vector size 2048, BW 2kHz, 2650ms TR and 256 averages). First and second order shim were adjusted using FASTMAP with VOI 50x40x60 mm^3.

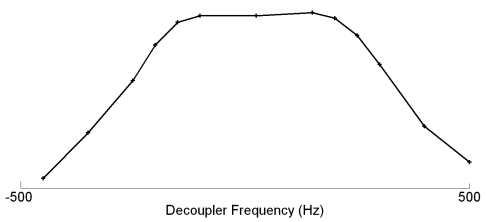

Figure 1: Decoupling bandwidth for Waltz16

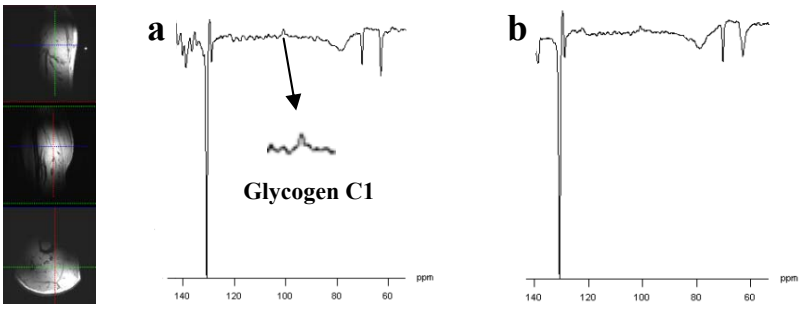

Figure 2: ^{13}C natural abundance signal of glycogen in human calf obtained by pulse-acquire with a) Waltz16 and b) CW decoupling (TR 2650ms, acquisition time 102ms, decoupling time 20ms, 256 averages and vector size 2048).

Results and Discussion Waltz16 was evaluated by plotting the acetate peak height against decoupling offset frequency, resulting in a bandwidth of approximatly 700Hz (Figure1). The validation in vivo showed natural abundance glycogen C1 detected using both CW and Waltz16 as illustrated in Figure2, where in particular Waltz16 also provided enhancement of Glyceryl. We conclude that is feasible to apply Waltz16 scheme at 7T to achieve broadband ^{1}H decoupling in vivo in human muscle within the ICE guidelines and this will allow further extention of this technique for ^{13}C MRS measurement such as in human brain.

References [1] M.J.Avison PNAS 1988. [2] G. Adriany et al 1997. [3] A.J.Shaka et al, Magn Reson 1983.

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