A form-fitted 3 channel ^{31}P, two channel ^{1}H transceive coil for calf muscle studies at 7 T

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Introduction ^{31}P spectroscopy is used for studies on metabolic response of muscle to exercise and recovery. Increased coil sensitivity is a critical factor for this technique, as the resulting SNR increase can be traded in for higher temporal resolution, or (better) spatial localization of the signal. Higher SNR enables time resolved and localized single voxel spectroscopy, providing higher specificity as compared to nonlocalized techniques [1]. Also chemical shift imaging (CSI) could be performed with higher spatial resolution. RF coils with increased sensitive volume enable studies also in deeper lying muscles. We show first results with an RF coil providing both increased sensitivity and an enlarged sensitive volume, as compared to commonly available single surface coils. Together with the higher transverse magnetization available at 7 Tesla, this will enable measurements of muscle metabolism in the human calf with improved accuracy.

Materials and Methods The coil consists of three overlap-decoupled rectangular elements for ^{31}P and a two-element array for ^{1}H, decoupled by a shared conductor. The coil housing consists of a 14 cm inner diameter half cylinder made from acrylic glass, form-fitted to an average human calf. All coil elements act as transceivers, the required power splitters, transmit-receive switches and low-noise preamplifiers are housed in a separate interface box.

Coil performance in terms of $B_1^+/\sqrt{(\text{local peak } SAR_{10g})}$ was optimized by determining the appropriate phase relations between channels [2] by 3D EM simulation (XFdtd, Remcom, State College, USA). 10 g averaged SAR was obtained employing a fast convolution based algorithm [3]. The scattering parameter matrix was measured on the network analyzer (E5061B, Agilent, Santa Clara, USA). MR measurements were performed on a 7 T scanner (Siemens, Erlangen, Germany) using the proposed calf coil and the standard 10 cm ^{31}P/^{1}H loop coil used in previous studies (Rapid Biomedical, Rimpar, Germany) for comparison.

The right calf of a healthy volunteer (male, 20 years) was investigated. ^{1}H images and ^{31}P CSI data were acquired using identical protocols with both coils. Images were acquired with a 2D GRE sequence with 0.2 x 0.2 mm² in plane resolution, slice thickness 3 mm, TR/TE = 12/5.6 ms, TA = 2 min 46 s. The parameters for the 2D FID CSI sequence were: nominal voxel size = 1 x 1 cm², slice thickness 4 cm, TR = 5 s, Gaussian pulse, flip angle adjusted for maximal overall signal. Metabolic maps for PCr from CSI data were processed with jMRUI [4] and quantified using AMARES.

Results All five coil elements were matched to < -20 dB, isolation between ^{1}H channels was -40 dB, the overlapping ^{31}P channels were decoupled by <-10 dB. Fig. 2 shows high resolution ^{1}H images in vivo. The extended FOV and increased homogeneity for the form-fitted 2 channel array can clearly be seen. Metabolic maps for PCr are displayed in Fig. 3. A 2.4-fold SNR increase has been shown in localized spectra of the medial gastrocnemius muscle [5].

Discussion We developed a dedicated calf coil for investigations of muscle metabolism at 7 T. The extended field of view and signal-to-noise obtained by increasing the number of channels for transmit and receive, together with the form-fitted shape of the coil array enable spectroscopy studies with improved temporal and/or spatial resolution, as well as investigation of other muscles than gastrocnemius.

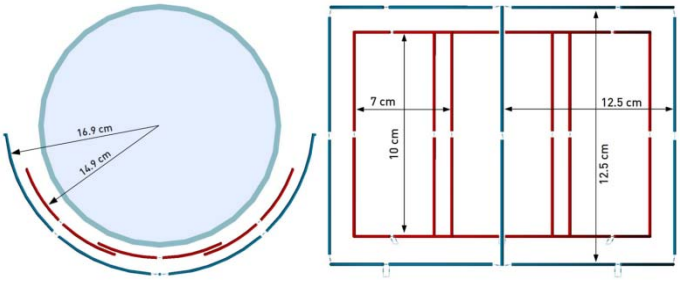

Fig. 1: *Shape, size and arrangement of the coil elements. Two ^{1}H channels (blue) and three ^{31}P channels (red)*

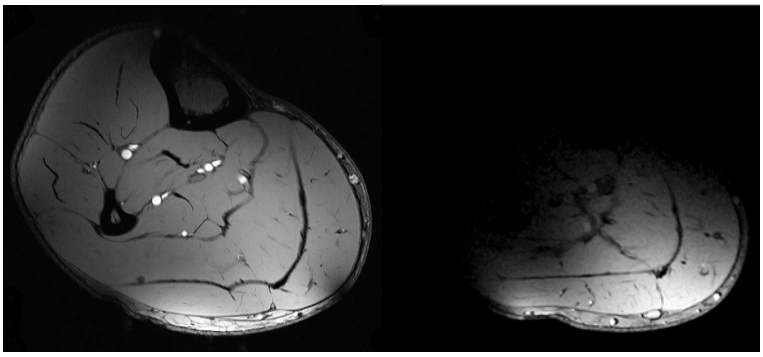

Fig. 2: *0.2 mm in plane resolution transversal images of the calf. Left: 2 channel ^{1}H calf coil. Right: single loop ^{1}H coil.*

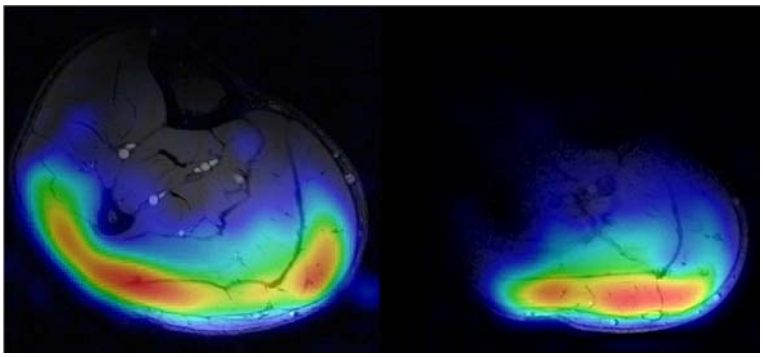

Fig. 3: *Metabolic maps for PCr signal, scaled to maximum value within each map. Please note that this is not a direct SNR comparison. Left: 3 channel ^{31}P calf coil. Right: single loop ^{31}P coil.*

References [1] Meyerspeer et al., *MRM*, 2012 (epub ahead of print), DOI:10.1002/mrm.24205, [2] Kuehne et al., *Proc. ISMRM 2012*, #2735, [3] Goluch et al., submitted to *ISMRM 2013*, #5044, [4] Stefan et al., Meas. Sci. Technol., 2009, [5] Meyerspeer et al., submitted to *ISMRM 2013*, #5170

Acknowledgements This work was funded by the Austrian BMWFJ, FFG Project Nr. 832107