RF Coil and Positioning Setup for IMCL Spectroscopy on the Mouse Calf

Dominik Berthel[1], Michael Neumaier[2], Titus Lanz[1], Thomas Kaulisch[2], and Detlef Stiller[2]
[1]*Rapid Biomedical GmbH, Rimpar, Germany,* [2]*In-Vivo Imaging Unit, Boehringer Ingelheim Pharma GmbH & Co. KG, Biberach, Germany*

INTRODUCTION

Over the last years ^{1}H-MR spectroscopy (^{1}HMRS) of in vivo tibialis muscle became significantly important as a non-invasive method for the examination of intra-myocellular lipids (IMCL) regarded as a translational biomarker for insulin sensitivity. The orientation of the muscle fibers along the main magnetic field (B0) is very important to preserve fully evaluable MR spectra [1,2]. For qualified in vivo ^{1}HMRS experiments of the mouse muscle a coil setup with an easy and defined positioning system is required [3]. We present a setup which offers this reproducible positioning of the mouse leg while offering a high Rx sensitivity by an optimised two channel RF coil.

MATERIALS & METHODS

All the components for the positioning setup are separate modules, which are fixed to an animal cradle system (inner diameter 65 mm, thickness 1.5 mm). Whereas the mouse body is positioned on an anatomical bed (Fig.1b), the mouse foot will be held tightly by an adjustable multi-point shot (Fig.1d). For further fixation, the setup is equipped with a bite bar which is integrated into an adjustable anesthesia mask (Fig.1a), the position can be adapted for all spatial directions (x,y,z). The combined use of the bite bar, the animal bed and the multi-point shot leads to a reproducible positioning of the fixed mouse calf muscle (Fig. 2). The mouse ankle is locked by allocating the red lever (Fig.3) to avoid leaping out and reduce movements of the mouse leg. The base of the multi-point shot is displaceable in x- and z-direction to adjust the extension of the leg and position it in parallel to the B0-Field. All modules of the positioning setup can be replaced individually.

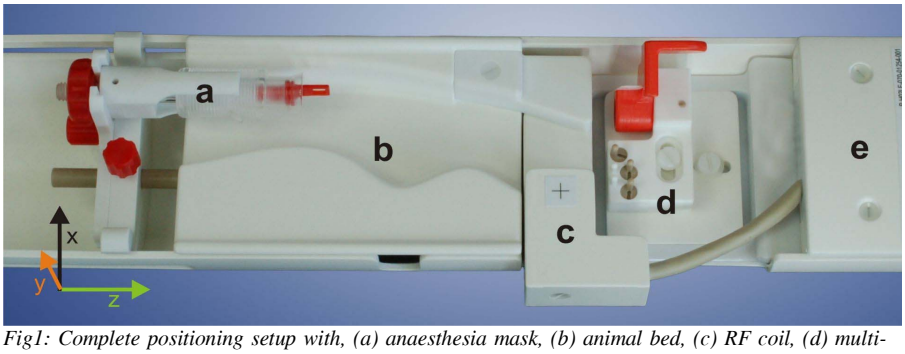

Fig1: Complete positioning setup with, (a) anaesthesia mask, (b) animal bed, (c) RF coil, (d) multi-point-shot for fixation of the mouse leg, (e) interface box, preamp.

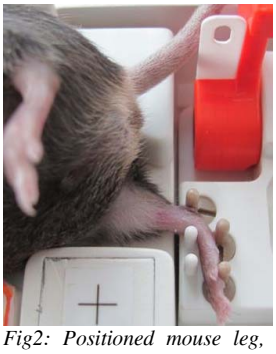

Fig2: Positioned mouse leg, RF coil not centered

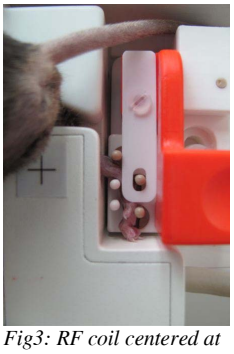

Fig3: RF coil centered at the positioned and fixed

Coil Design

The receive (Rx) coil (Fig.5) is installed around an elliptical (8 x 11 mm^2) shaped housing (Fig.4) which can be displaced in x-direction. The coil can be placed over the ROI of the fixed and centered mouse calf, nearly without moving and deforming the object. The coil housing slid at a profile which has an interlock at the exact measurement position (ISO-centre x-position). The coil which is wounded at the elliptical aperture is a two-channel receive only coil with a loop-butterfly design. The S21-isolation between the two coil elements is better than -20 dB. The integrated low noise preamplifiers are located at the interface box (Fig.1e). The optimized coil design provides nearly homogenous MR-imaging of the mouse calf / tibialis muscle and a high sensitivity for MRS.

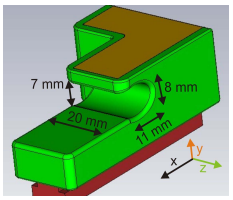

Fig.4 Coil housing with aperture dimension

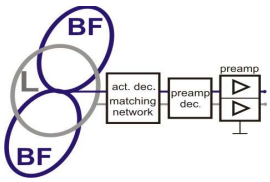

Fig. 5: Coil principle loop(L)-butterfly (BF)-design and block diagram

RESULTS

Positioning of the anesthetized mouse and fixing the lower leg using the multi-point-shot takes about 1 minute. A Gradient-Echo-Pilot-scan was used to place the voxel of interest (VOI) within the tibialis muscle for MR spectroscopy (PRESS). The complete positioning adjustment procedure takes less than 5 minutes. The images (Fig.6) of a mouse calf were acquired on a Pharmascan 7Tesla with Avance III-Interface (Bruker-BioSpin, Ettlingen, Germany) using a FLASH-sequence (coronar - TR=350 ms, TE=4.1 ms, 256x192) / transversal - TR=120 ms, TE=4.0 ms, 192x192). Fig 7. shows a typical single-voxel IMCL spectrum, acquired with a PRESS-Sequence (TR=1300 ms, TE=20 ms, ACC=756) by using a prototype Helmholtz RF coil [3]. Due to the positioning setup, it is possible to position the VOI into the magnetic iso-centre. This improves the shimming procedure and shortens the adjustment procedure time.

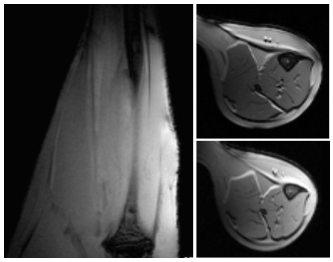

Fig. 6: MR-FLASH-Images mouse calf (transversal / coronar)

DISCUSSION

By the use of this presented RF coil and positioning setup, incorrect voxel-positions will be avoided and so a high throughput of IMCL-studies can be achieved. A further optimization of the complete setup would lead to reduction of positioning time and so shorter measurement time. In the future a throughput of more than two studies per hour is possible. With a larger scaling the complete setup can also be used for IMCL-studies on rats.

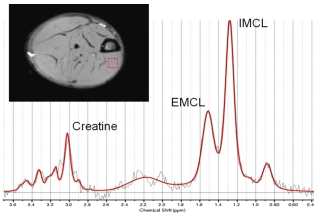

Fig. 7: Single-voxel spectrum

REFERENCES

[1] Boesch C. et al. NMR Biomed 2006; 19(7):968-988,
[2] Boesch C. et al. J Magn. Reson. Imaging 2007; 25(2):321-338
[3] Neumaier M, et al. Magnetic Resonace in Medicine 62:1036-1041 (2009)