# High-resolution MRI of Implanted Skin Chambers with Integrated Coils

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## Introduction

Skin chambers are surgically implanted under the skin of an animal to study the interaction of different cell types with the host tissue. Before implantation tumor cells are grown in the interior of the chambers on a collagen separation layer. After several weeks mutual infiltration of the separation layer is observed both from the animal's stroma cells as well as the tumor cells. In this micro-environment the development of stroma and neovasculature and the homing of progenitor cells can be studied with high precision in longitudinal studies.
MRI is ideally suited for repetitive imaging of the skin chamber's interior. For the animal studies both a high spatial resolution as well as a short measurement time is required, which can be difficult to achieve with rf coils of the same size as the animal. To increase the local SNR, recently, inductively coupled local rf coils were integrated into the chambers. In this work we report on two different coils designs for the skin chamber and on first results in a mouse model.

## Materials and Methods

Inductively coupled coils were integrated into a commercially available skin chamber system for small animals (30268, Silicon Culture, Renner GmbH, Dannstadt, Germany). The chambers consist of an outer cap, a base ring and an inner ring (Fig. 1) which was replaced by a PEEK coil former. A solenoid coil of a miniature coaxial cable (PicoCoax, AXON Cables, PCX42K10 AK, 50 Ω, Ø = 0.34 mm) was wound onto the coil former. Two different coil designs were used: (1) A self-resonant coil where the inner conductor of one end was soldered to the outer braiding of the other to form a self-resonant structure, and (2) a conventional coil design tuned with an additional chip capacitor. Coils were manufactured both for $B_0$ = 1.5 T (i.e., 63.7 MHz) as well as for $B_0$ = 3 T.
The coils were characterized by measuring the loaded and unloaded $Q$ factors. The $B_1$ amplification during rf excitation was assessed with a FLASH pulse sequence (TR = 141 ms, TE = 5 ms) where the flip angle α was varied between 1° and 90°. At each location inside and outside the coil the Ernst angles were determined, and their ratio (i.e., the $B_1$ amplification) was mapped.
The coils were implanted into nude mice, and, in one mouse, the chamber was previously loaded with high-grade malignant human squamous carcinoma cells (HaCaT-ras A5RT3) on collagen. Two weeks after implantation, when the wounds were healed, the animals were imaged up to three times over a time span of 6 weeks in a 1.5 T / 3 T (Symphony / Tim Trio, Siemens, Erlangen, Germany) whole body MR system. For signal reception, a small loop coil (1.5 T) / head coil (3 T) were used. High resolution images of the coil interior were acquired with a 3D FLASH sequence after administration of an intravascular contrast agent to visualize the neovasculature induced by the tumor cells. For imaging the following parameters were used: TR = 24 ms, TE = 8.6 ms, BW = 110 Hz/pixel, α = 60°, matrix = 256×512, 88 partitions, FOV= 25×50 mm², TA = 13 min 51 s.

## Results and Discussion

Both self resonant and conventional rf coils showed a $B_1$ amplification at the center of the coil of 8 to 10, which was in good agreement with the $Q$ measurements. Over time, body liquids penetrating some coils caused a resonance frequency shift, which could be reduced by careful sealing. With sealed coils, high-resolution post-contrast data sets of the chamber interior could be acquired at 1.5 T and 3 T in less than 15 min with 100 µm isotropic resolution (Fig. 2), which are in excellent agreement with histology. Signal from structures outside the coils was effectively suppressed by the decreased flip angle outside the coil. In this context, small angiogenic vessels with less than 100 µm in diameter could be visualized. Inductively coupled rf coils are an excellent tool for longitudinal studies in skin chambers.

*Fig 1: (top) RF coil, PEEK coil former, base ring and cap of a skin chamber. (bottom) skin chamber after implantation into a nude mouse.*

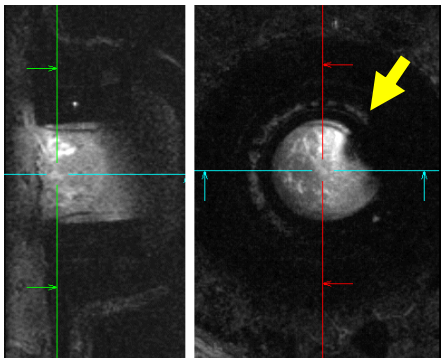

*Fig 2: Lateral (left) and frontal (right) cross section of the implanted skin chamber with a conventional 3T rf coil. The 3D FLASH data (100 µm isotropic resolution) were acquired after injection of an intravascular contrast agent showing the vasculature. A small susceptibility artifact is visible (arrow) close to the chip capacitor.*

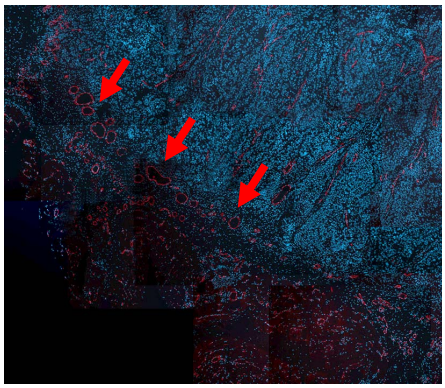

*Fig 3: DAPI and CD31 staining of a tissue sample demonstrating the new blood vessels (red, arrows) induced by the tumor cells (blue).*

## References

[1] Umathum R, et al. Proc Intl Soc Mag Reson Med 15 (2007) 3268

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