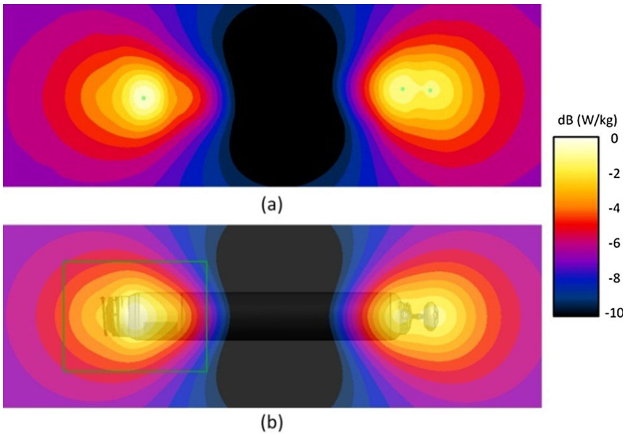

Fig. 2 SAR **a** measurement and **b** simulation

Results: The peak SAR hot spots occur near the LP electrodes. The combined numerical and experimental uncertainty was 22 % using methods of ISO/TS10974 [5]. The linear regression indicates that 99 % of the 884 data points are within the ±22 % uncertainty bound. For an input impedance of $R = 7.4\ \Omega$ and $C = 508$ pF (mean measurement values based on four Nanostim devices), the induced voltage was found to be 0.36 V and 0.58 V (at 95 percentile tolerance interval) per 1 kV/m peak tangential incident electric field in 0.47 and 1.2 S/m saline, respectively (Fig. 3).

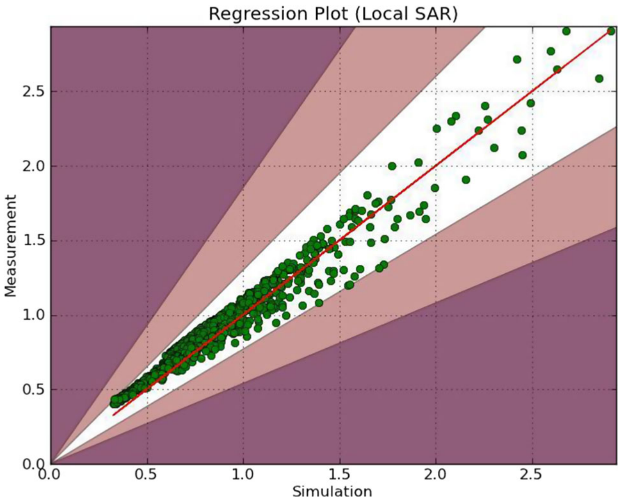

Fig. 3 Linear regression. *Shaded regions* represent 68 % and 95 % tolerance intervals with a combined uncertainty of 22 %

Discussion/Conclusion: The conventional method to determine the induced voltage is to add electronics inside the pacemaker which allow a voltage measurement while exposed to RF. This is no longer required; instead SAR measurements are used to validate the induced voltage. The worst-case induced voltage per 1 kV/m peak tangential incident electric field was 0.58 V. The induced voltage level for in vivo fields can now derived and utilized in the RF injection test per ISO/TS10974.

References:

[1] SEMCAD-X V14.8 Electromagnetic and Thermal Simulation Platform SPEAG.
[2] Dosimetry Assessment System DASY52 NEO, SPEAG.
[3] Elliptical Implant Test Phantom (ELIT) for 1.5 Tesla RF Safety Evaluations, ZMT.
[4] Medical Implant Test System (MITS) for 1.5 Tesla RF Safety Evaluation, ZMT.
[5] ISO/TS 10974:2012 Assessment of the safety of magnetic resonance imaging for patients with an active implantable medical device.

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Evaluation of RF heating surrounding a heart valve implant at 64 MHz (1.5 T MRI system)

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Purpose/Introduction: The presence of electrically conductive implants worn by patients during magnetic resonance imaging (MRI) scans may induce temperature increase in the surrounding tissue near the implants due to electromagnetic (EM) interactions at specific frequencies within the radio frequency (RF) range. A novel heart valve implant provided by [1] has been studied as part of the developing process with respect to RF heating in a MRI environment. In order to predict such coupling effects several factors have to be considered including electrical, physical, and geometrical properties of the implant parts and the surrounding tissue as well as magnetic field strengths and exposure times.
Subjects and Methods: RF heating of the patient's tissue due to the presence of the heart valve implant was predicted conforming to the ASTM F2182 standard [2] using a 3D-FDTD full-wave simulation platform (SEMCAD X v.14.8, SPEAG) as shown in Fig. 1. Several orientations and positions of the implant have been processed during RF exposure from a validated generic RF birdcage coil at 64 MHz (i.e. for a 1.5 T MRI system) to specify the worst configuration/orientation of the implant inside the body while locating the spots with the highest risk for maximum temperature rise. Measurements of the actual temperature rise were performed at the in-house test bench.

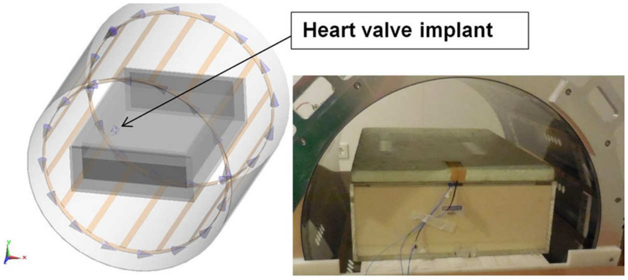

Fig. 1 Test setup: (left) simulation model; (right) measurement setup.

Results: The worst-case result of the electromagnetic simulation (20 mm distance from both the gel surface and the inner wall of the ASTM phantom) is depicted in Fig. 2 for 64 MHz, indicating a 30 W/kg averaged SAR over 1 g mass in the surrounding tissue. The temperature probes located at the hot spot were immersed together with the implant into the saline gel ($\varepsilon_r = 81$, $\sigma = 0.46$ S/m). Finally a 1.4 °C temperature rise has been registered at the probe located in the apparent hot spot.

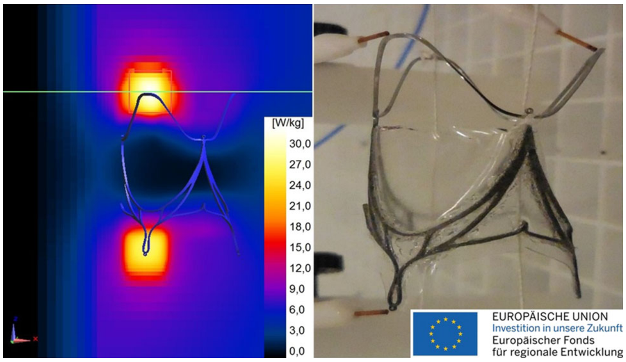

Fig. 2 1g average SAR distribution: red box shows the hot spot with the maximum SAR of 30 W/kg (left); proper location of the temperature probes in the metrological measurement (right).

Discussion/Conclusion: Different orientations of the heart valve implant with respect to the polarization of the local E-field significantly affect the level of the power input to the implant from the RF birdcage coil. The current setup registered a maximum of 1.4 °C temperature rise after 900 s exposure in the surrounding tissue of the implant, which is not located at the sharpest edge of the implant profile as expected in most cases.

References:

[1] "Institute of Applied Medical Engineering, Helmholtz Institute", http//www.hia.rwth-aachen.de (accessed: 2015-04-23).
[2] ASTM F2182-11a: "Standard Test Method for Measurement of Radio Frequency Induced Heating On or Near Passive Implants During Magnetic Resonance Imaging".

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Fast design of 2D spatially selective RF pulses for parallel transmit at ultra-high fields

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Purpose/Introduction: Ultra-high field MRI can improve human brain studies of structure and function due to increased SNR and CNR and therefore higher spatial resolution. However, severe field inhomogeneities and thus high relaxivity demand short RF pulses that execute robustly, while performing advanced tasks, for example, 2D spatial selection for reduced FOV imaging. Pulses played on parallel transmit (pTx) coils have increased degrees of freedom to assist with, yet the pulses need demanding computational facilities. The purpose of the abstract is to present a reliable and fast algorithm for designing 2D spatially selective RF pulses tolerating ultra-high field complications such as B_0/B_1 field inhomogeneities.

Subjects and Methods: A monotonic convergent (MC) algorithm [2, 3] is often compared to a typical gradient-ascent algorithm as in Ref. [1]. However, the output from such a gradient-based algorithm depends on the initial guess and the gradient accuracy. The MC algorithm lacks these disadvantages and has shorter computation times due to a faster progress [2]. Its tolerance to experimental imperfections was demonstrated with a clinical 3T system [4]. In the present work, we extend the MC algorithm to pTx and show in vivo results acquired with a 7T system (70 mT/m and 200 T/m/s), and an 8-channel pTx head coil (Nova Medical). We used a spin echo sequence, exchanging the excitation pulse with a 90° 2DRF pulse. Total forward power supplied to the coil was limited to 8 W. Full FOV sequence: TR/TE = 250/18.7 ms, isotropic 2 mm^3 resolution. Reduced FOV: TR/TE = 250/19.9 ms, resolutions $0.6 \times 0.6 \times 2\ \mathrm{mm}^3$ and $0.6 \times 0.6 \times 0.6\ \mathrm{mm}^3$. The excitation was performed during a spiral k-space trajectory [5]. B_0 maps were acquired with a dual gradine echo sequence while DREAM [6] with transmit channels phase encoding [7] was used for B_1 mapping.

Results: The volunteer gave informed signed consent prior to the measurements. Figure 1 presents the full and reduced FOV results from optimization without (uncompensated) and with (compensated) field maps.

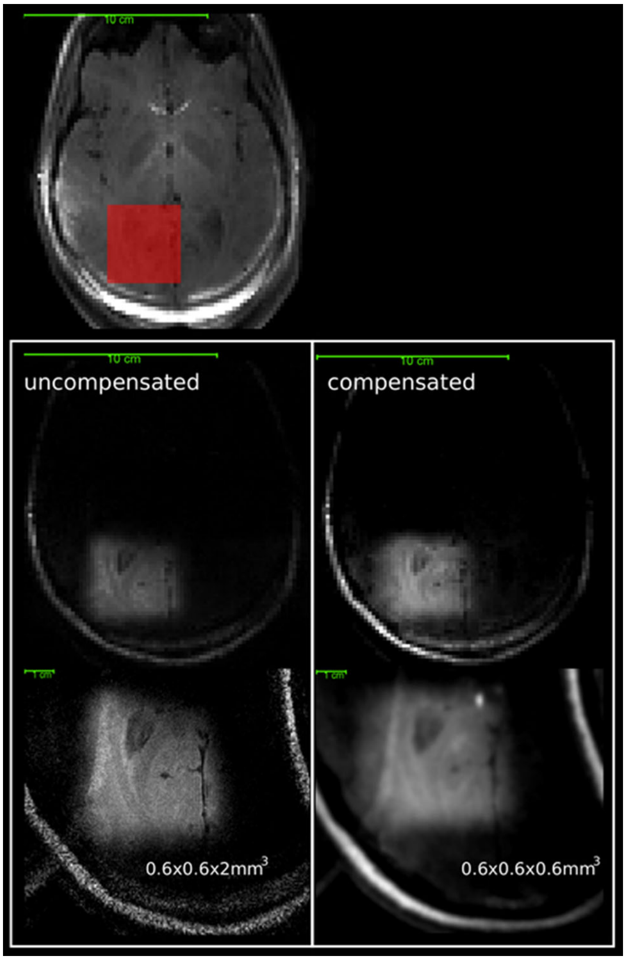

Fig. 1 Results with 2DRF pulses, demonstrating inhomogeneity robustness of uncompensated pulses and high resolution images with compensated pulses (anisotropic diffusion filter was applied for a better visual perception)