RF-heating testing in 64 MHz RF-laboratory system and 1.5 Tesla MRI – A comparative evaluation

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INTRODUCTION

Radio frequency induced heating is one of the most important risks in MRI scanning of medical implants. To avoid those risks, medical implants must be tested according to ASTM F2182 in a magnet resonant environment. RF laboratory workbench systems are presented as an alternative for these clinical systems. We are presenting a comparison between the results of RF-heating measurements in a 1.5 Tesla Philips Intera MRI system and in a 64 MHz RF laboratory system (Zurich Medtech AG).

METHODS

The measurements were done with a titanium rod as test object. This object was placed in an acrylic glass phantom at a worst case position. The inner dimensions of the phantom are: 65 cm x 42 cm. As simulation fluid, we used a gel which was mixed according to ASTM F2182-11a. The gel was filled in the phantom onto a height of 9 cm. 3 temperature probes have been placed at the implant where the RF heating is expected to be the greatest (determined in a computer simulation). One temperature probe has been used as a reference probe to verify that the same RF exposure has been used during all test runs positioned at the contra-lateral side of the phantom from the test object position. Temperature measurements were done with a fiber optic thermometer (FOTEMP4, OPTOCON, Dresden, Germany) which had a resolution of 0.1°C and a probe accuracy of ±0.1°C close to point of calibration = 23°C.

The following settings have been done for the tests in the MRI: sequence = TSE, TSE factor = 17, TE = 60 ms, TR = 6061 ms, flip angle = 90°, refocusing angle = 180°, SAR-mode = high, gradient mode = maximum, NSA = 3, TSE echo spacing = 6.7 ms, shot duration = 113 ms, bandwidth/pixel = 390.6 Hz, WFS [pixel] = 0.556, SAR (software displayed) = "<2.0" W/kg and PNS = 44 %. Whereas these configurations have been done at the medical implant test system: Band = 64 MHz/1.5 T, PRR = 154.32 Hz, pulse type = sinc 1pi, duty cycle = 12.04 %, frequency = 63.62 MHz, power level = 60.7 dBm, E-field level = 1.3 V/m and target = "Pk Power". The calorimetrically determined whole phantom SAR has been 2.3 W/kg in both measurements.

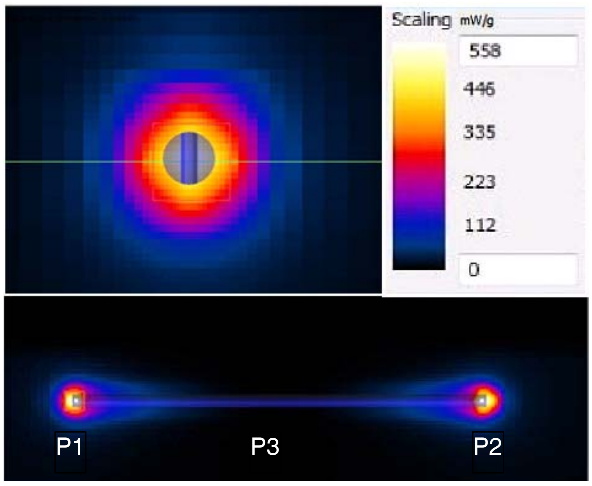

Fig. 1: Distribution of SAR around the titanium rod, P1 to P3: Positioning of temperature probes

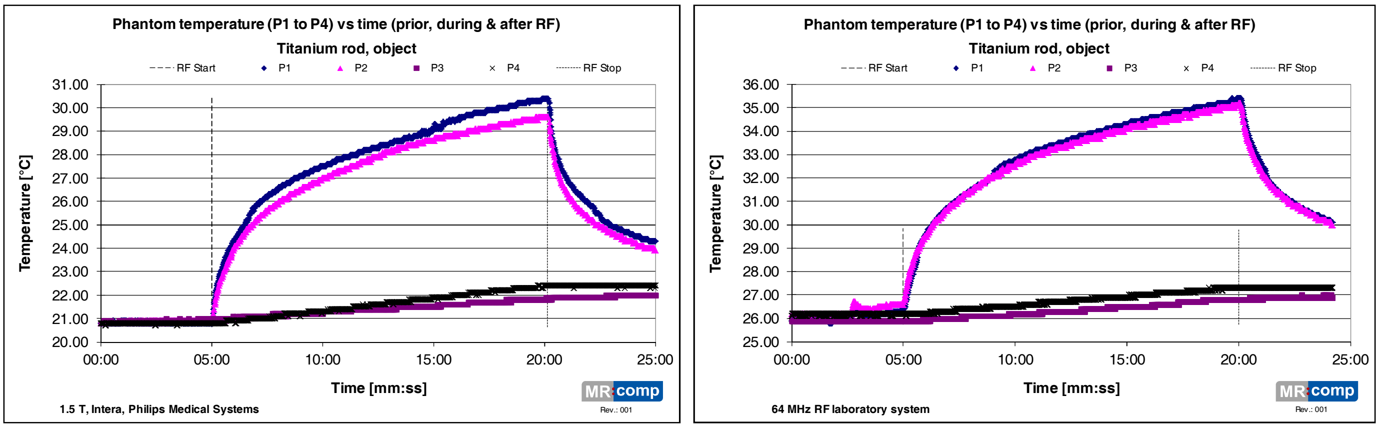

Fig. 2: RF-induced heating in 1.5 T MR (left) and 64 MHz laboratory system (right)

Measurements were done by applying the RF sequences with the described settings over a duration of 15 minutes. In the first run of each system the test object was positioned at the phantom as described above. The second run was a control test with the same settings and positions of the probes as before, but without the test object. Fig. 2 shows the results of both test runs with test object in the two different systems. An increasing temperature at the titanium rod was visible over the RF-application time. The difference of temperature between the test run with object and the related control test run was maximal 9.6°C at the cranial side of the titanium rod in the MRI. At the medical implant test system these difference has a maximum of 9.1°C at the cranial object end. In both cases, the probe 1 and probe 2, which were located at the ends of the test object, detected a greater temperature increase compared with/to the other two probes. The results show that the temperature increase in the middle part of the titanium rod was nearly the same as those of the reference probe. This confirmed the forecast calculations of the numerical study, which is shown in fig. 1.

DISCUSSION & CONCLUSION

Overall good conformity of both test methods is detectable as result. These finding leads to the conclusion that the RF laboratory system used for the presented measurements is suitable to replace the required MR system in ASTM F2182.