Numerical Assessment of MRI-Induced Temperature Change for a Head Coil at 7.0 Tesla

Maíra M. Garcia*, Harki Tanaka*, Tiago R. de Oliveira*
*Universidade Federal do ABC, São Bernardo do Campo, Brasil
e-mail: tiago.ribeiro@ufabc.edu.br

Introduction: Patient safety should be the primary concern in any MR procedure [1]. During a regular imaging acquisition, some of the transmitted radiofrequency (RF) power can be dissipated as heat within the patient's tissue. The management and limits of local and global power deposition in human subjects (based on specific absorption rate, SAR) is the leading constraint to the application of ultra-high field MRI [2]. At high magnetic fields, field distribution becomes an issue and assessing the safety conditions require more elaborate strategies than for low-field systems. The calculation of local SAR demands a detailed knowledge of the electric field distribution during the RF excitation. Numerical electromagnetic and thermal simulations are currently the best practical way to evaluate the local information on electric field distributions as well as tissue temperature [3]. Here, we are reporting the recent efforts of our group in numerically quantifying the SAR deposition of a head coil and its overall reliability of RF dosimetry, with an emphasis on the thermal response.

Methods: We first evaluated the numerical calculations of SAR and temperature for the human head phantom in a volume coil for MRI. The electromagnetic field (EM) distributions in the human head were calculated at 64 MHz, 128 MHz, and 297.2 MHz to allow a proper comparison. The head model had a resolution of 3 mm in each dimension. We converted this voxel-based model into a surface-based one so that it could be imported into the electromagnetic finite-element simulation software. The thermal simulation was based on bio-heat transfer model and approaches for taking into account the physiological response of the human body.

Electric Field **SAR** **Temperature**

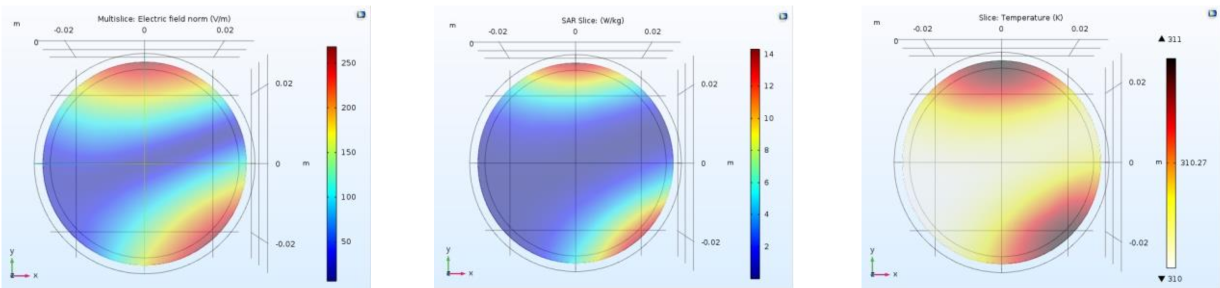

Figure 1. The cross-section of the center coil for Electric field distribution, SAR distribution, and Temperature at 297.2 MHz.

Results: The numerical results indicate that for all cases studied the SAR was not higher than the regulatory limits (showing that existing restrictions on local SAR still, can be used). As the field pattern changes with the frequency, so do the temperature distribution and the ratio of maximum local SAR. The temperature in the borders could rise by more than 1ºC in 297.2 MHz.

Conclusion: Our numerical calculations indicated a nonuniformity in the electric field distribution in 297.2 MHz, and both SAR and temperature distributions are also nonuniform. The temperature distribution correlates well with SAR distributions and the temperature inside the human head did not exceed 39ºC (311 K).

References: [1] Deniz, C.M., et al. "Radiofrequency energy deposition and radiofrequency power requirements in parallel transmission with increasing distance from the coil to the sample." *Magnetic resonance in medicine* 75, no. 1 (2016): 423-432.

[2] Shellock, Frank G. "Radiofrequency energy-induced heating during MR procedures: a review." *Journal of Magnetic Resonance Imaging* 12, no. 1 (2000): 30-36.

[3] Winter, Lukas, et.al. "Design and evaluation of a hybrid radiofrequency applicator for magnetic resonance imaging and RF-induced hyperthermia: electromagnetic field simulations up to 14.0 Tesla and proof-of-concept at 7.0 Tesla." *PloS one* 8, no. 4 (2013): e61661.