Estimation of Temperature Increase for Passive Implants undergoing MRI Procedure

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Metallic implants tend to heat up during Magnetic Resonance Imaging (MRI) procedures. The standard way to assess the RF-induced heating is to perform computational and experimental phantom studies. Two optical temperature sensor probes (one for the implant and other for the phantom gel) record high precision temperature data during the MRI procedure. We use the data from the phantom temperature sensor as the base to determine the increase in temperature in the implant. The sensor is usually placed in the vicinity where highest increase in temperature is predicted.

This paper discusses an alternative to run the test for a shorter period and use the data to estimate the final temperature using sophisticated curve fitting techniques and custom curve equations. The temperature rise curve follows the equation described by the theory of Pennes Bioheat Equation (PBE). The custom equation discussed in this paper is the sum of an exponential term and damping term (inverse power term) which gives it the shape of a temperature curve. The equation has three variables; hence three temperature samples which best describe the curve from each experiment. For every set of samples, the algorithm calculates discrete variables which make the custom equation unique.

This function is induced to reduce the duration of measurement by predicting the final temperature. As a result, thermal data measured for 6 mins is enough to predict the temperature achieved by the implant had the MR procedure continued for its entire duration. The estimation for implants with relatively higher temperature rise such as larger than 2 °C is more accurate which has an error around 0.1%. For devices with small temperature change has relatively higher error of around 1%.