Harsh Jain
Mathematical Biosciences Institute, Ohio State University
e-mail: hjain@mbi.osu.edu
Helen Byrne
University of Nottingham
Nicanor Moldovan
Biomedical Engineering, Ohio State University

Mathematical Validation of a Novel Implantable Oxygen Sensor

Non-vascularized tissue engineering constructs and other solid implants with biomedical applications, such as encapsulated live cells or glucose sensors, need oxygen (O2) for proper functioning. To better understand the availability of O2 to implants, a novel sensor has been developed by researchers at the Ohio State University, that can non-invasively record, after implantation in mice, the signal provided by local pO2. This has subsequently been used to study the process of neovascularization and foreign body reaction in response to an implanted device. Briefly, bone marrow progenitor cells embedded in a Matrigel plug were implanted next to the sensor, or gel alone used as control, and weekly O2 readings noted. In order to explain these readings, we have developed a partial differential equation model of the experimental system. The model anticipates that pO2 in implant follows a parabolic pattern, the descending side of the curve being indicative of the response to normalization of metabolic demands of tissue which requires a lower pO2. The model is sensitive to angiogenic stimulation, predicting a rapid raise in pO2 and a slower reduction of the signal. These results can thus be used to predict the various stages of foreign body reaction that occurs in response to the implants, and the effect stem-cell therapy has on this. A 2D illustration of this is also simulated.