How biomaterial performance can be programmed and predicted

September 13 2011

(PhysOrg.com) -- Biomaterials, in particular biodegradable materials, are increasingly used in medicine. These materials serve on their own as structural support and replacement, and as platforms for drug release, embedding of cells and tissue engineering. Yet, many materials and devices fail in clinical trials because they do not perform as expected from in vitro experiments. There has not been concise means of predicting in vivo performance from in vitro experiments, hampering the development of new materials and assessment of safety, efficacy and applicability of existing materials.

“In many experimental studies, mice are euthanized to evaluate material fate and erosion. This process uses large number of animals and yet cannot provide sequential time-lapse measures of the same specimen, results in high variability and only a qualitative measure of erosion,” said Dr. Natalie Artzi, a Research Scientist working with Prof. Elazer Edelman in the Biomedical Engineering Center. The key element in the design of erodible materials is the ability to program their in vivo retention time, dictating the need for monitoring their effect in real time. This motivated Dr. Artzi who designed and directed the research to develop means to noninvasively track erosion of devices and predict their therapeutic capacity.

“This paper is exciting on multiple levels as it addresses at once multiple outstanding issues in materials science. The work explains how material function is context dependent and defines how, when and why observations in vitro can predict performance in vivo. These findings can

now set the stage for characterizing material-tissue interactions on a broad scale, optimizing materials design, and developing novel materials for specific tissue, conditions and applications," said Elazer R. Edelman, principal investigator and MIT's Thomas D. and Virginia W. Cabot Professor of Health Sciences and Technology.

In a recent publication in *Nature Materials*, the team led by Dr. Artzi uniquely harnessed, for the first time, fluorescence imaging to follow material mass loss in vivo in a sequential manner. They further use mathematical modeling to predict in vivo erosion of materials from in vitro erosion kinetics. This method can serve as a rapid in vitro tool for screening material candidates and expedite development of medical devices.

The team explored the effect of material shape, composition and environmental conditions dictated by the choice of implantation site, on the erosion profile of natural and synthetic materials. This profile dictates material efficacy and when drugs and cells are embedded in the material, material erosion will dictate drug release and cells efficacy and secretion profile determining the therapeutic outcome.

"We envision that an integrative approach that considers dynamic changes in erodible materials and matches their properties with those of specific tissue type and state, will allow the development of medical devices with tunable and predictable clinical outcomes," said Dr. Natalie Artzi.

The ability to detect and forecast the time course of in vivo erosion is crucial to the design, informed regulatory scrutiny and use of the increasing number of biomedical devices with erosive properties Artzi added.

The team Dr. Artzi directs use these findings and techniques to

characterize and design composite materials that degrade in a programmed manner to enable programmed drug release and controlled cellular function for cardiovascular and cancer applications.

In addition to Artzi and Edelman, co-authors of the paper are Nuria Oliva, Cristina Puron, Sagi Shitreet, Shay Artzi, Adriana bon Ramos, Adam Groothuis, and Gary Sahagian.

Provided by Massachusetts Institute of Technology