SciMedCentral

JSM Biotechnology & Biomedical Engineering

Editorial

The Potential of Tailored Biomaterials to Radically Change Medical Implants

Megan C. Frost[1,2*]

[1]*Department of Biomedical Engineering, Michigan Technological University, USA*
[2]*Department of Material Science and Engineering, Michigan Technological University, USA*

Corresponding author
Megan C. Frost, Department of Biomedical Engineering and Material science and Engineering, Michigan Technological University, USA, Tel: 906-487-3350; Email: mcfrost@mtu.edu

Submitted: 31 August 2013

Accepted: 31 August 2013

Published: 02 September 2013

Efforts to treat human disease have long involved the use of natural and synthetic materials contacting blood and tissues. Despite the intentions of restoring function, the materials universally inspire a biological response. This biological response is necessary for normal wound healing to occur. Problems arise when the biological response causes the medical intervention to fail (e.g., artificial vascular graft re-occludes from thrombosis and/or neointimal hyperplasia or subcutaneous glucose sensor becomes encapsulated with collagen). Tremendous research progress has been made over the last several decades in designing and fabricating materials that mimic natural physiological structures, allowing biological response to be controlled and tuned. Additionally, we have a much more detailed understanding of steps involved in the body's dynamic response to foreign materials. Materials development and biological understanding of the physiological response have both contributed to huge advances in ways we think about treating diseases and design medical devices.

Work has attempted to change the chemical and physical properties of materials used for implanted device. An review by Wisniewski and Reichert [1] describes approaches that have been investigated to modify the surface properties of implantable sensors, but the underlying principles involved and reasons for the specific modifications apply to a wide range of implanted devices. Approaches include use of hydrogels to improve hydrophilicity of surfaces, thereby decreasing protein adsorption and reducing biofouling, modification that incorporates phospholipids on materials to mimic the surface properties of cells, thin Nafion coatings to allow ion diffusion and reduce protein adsorption, and the use of modified natural materials such as cellulose with diols and glycols have shown to reduce compliment activation. A wide range of biomimetic hydrogels that contain additives and different crosslinking agents have allowed porosity to be tuned and controlled [2,3].

Topography is another aspect of materials design that has been shown to governor biological response. Controlling surface roughness impacts protein adsorption, cellular integration and encapsulation. Controlled surface texture has been shown to direct cell growth. For example, highly aligned electrospun fiber that controlled fiber diameter and density have been shown to direct neuron outgrowth and growth and proliferation of lymphatic endothelial cells [4,5]. Controlling the stiffness of tissue scaffolds has been shown to alter cellular responses such as cell-matrix adhesion, size of focal adhesion, motility of cells, differentiation, proliferation and viability [6].

Many drug releasing composite systems have been developed that release one or more active agents that mediate biological response in the physiological environment. Norton et al. [7] developed a hydrogel system based on 2-hydroxyethyl methacrylate that released both the anti-inflammatory agent, dexamethasone (DX), and/or the angiogenic agent, vascular endothelial growth factor (VEGF). The idea is that the inflammatory response can be limited while angiogenesis is stimulated. These types of approaches are attempting to combine more optimized materials properties with specific drug release to manipulate the biological response in a manner that more closely resembles normal physiological conditions and behavior.

A very promising active agent for controlled release from implants is nitric oxide (NO). NO is a free radical gas that is toxic in high doses and is a known environmental contaminant. In the 80's, NO was identified to be the elusive endothelial derived relaxing factor and is now known to be a potent signaling molecule involved in many normal and pathological processes and is released endogenously by many different cells [8]. NO is a potent anti-thrombotic agent [9] and plays a role in mediating the inflammatory response in subcutaneous tissue [10]. NO is an important signaling molecule in shifting inflammation from acute stages to potentially helping in enhancing wound healing. If NO can be released from the surfaces of implanted devices at the appropriate levels and with good temporal control, evidence suggests that NO may radically reduce the biological response [11]. Work in our laboratory and elsewhere has focused on the developing polymeric system that contain NO donors in an attempt to harness the potential of controlled NO release to significantly control biological response to devices fabricated from or coated with these NO-donating polymer systems. By combining the ever-increasing knowledge of details involved in biological response to foreign materials and the ability to release

NO and other biologically active agents, the potential exists to create composite systems that will mimic normal physiological conditions.

By including the critically important variable of temporal control over the release of active agents in systems that can respond to the dynamic physiological conditions present *in vivo*, medical devices have the potential to very elegantly restore appropriate physiological function to damaged and diseased tissue. It is imperative to be mindful of tailoring biomaterials to the site of implantation, the specific medical condition that is under treatment and the ultimate wound healing state that will resolve the condition. The possibility of combining passive materials that by and large have the needed biocompatibility and active release agents that further mediate the biological response to the device opens up an exciting array of potential combined therapeutic active release agents and base materials that address issues of biological response thus making medical interventions vastly more effective.

REFERENCES

1. Wisniewski N, Reichert M. Methods for reducing biosensor membrane biofouling. Colloids Surf B Biointerfaces. 2000; 18: 197-219.
2. Kros A, Gerritsen M, Sprakel VSI, Sommerdijk NAJM, Jansen JA, Nolte RJM. Silica-based hybrid materials as biocompatible coatings for glucose sensors. Sens Actuators B: chemical. 2001; 81: 68-75.
3. Ju YM, Yu B, West L, Moussy Y, Moussy F. J Biomed Mater Res. 2009; 92A: 650.
4. Wang HB, Mullins ME, Cregg JM, McCarthy CW, Gilbert RJ. Varying the diameter of aligned electrospun fibers alters neurite outgrowth and Schwann cell migration. Acta Biomater. 2010; 6: 2970-2978.
5. Bouta EM, McCarthy CW, Keim A, Wang HB, Gilbert RJ, Goldman J. Biomaterial guides for lymphatic endothelial cell alignment and migration. Acta Biomater. 2011; 7: 1104-1113.
6. Drexler JW, Powell HM. Regulation of electrospun scaffold stiffness via coaxial core diameter. Acta Biomater. 2011; 7: 1133-1139.
7. Norton LW, Koschwanez HE, Wisniewski NA, Klitzman B, Reichert WM. Vascular endothelial growth factor and dexamethasone release from nonfouling sensor coatings affect the foreign body response. J Biomed Mater Res A. 2007; 81: 858-869.
8. Moncada S. Nitric oxide in the vasculature: physiology and pathophysiology. Ann N Y Acad Sci. 1997; 811: 60-67.
9. Radomski MW, Palmer RM, Moncada S. The role of nitric oxide and cGMP in platelet adhesion to vascular endothelium. Biochem Biophys Res Commun. 1987; 148: 1482-1489.
10. Nichols SP, Koh A, Brown NL, Rose MB, Sun B, Slomberg DL, et al. The effect of nitric oxide surface flux on the foreign body response to subcutaneous implants. Biomaterials. 2012; 33: 6305-6312.
11. Wu Y, Meyerhoff ME. Nitric oxide-releasing/generating polymers for the development of implantable chemical sensors with enhanced biocompatibility. Talanta. 2008; 75: 642-650.

Cite this article

Frost MC (2013) The Potential of Tailored Biomaterials to Radically Change Medical Implants. JSM Biotechnol Bioeng 1(2): 1011.