Development of micropatterned surfaces of poly(butylene succinate) by micromolding for guided tissue engineering

Daniela F. Coutinho a,b, Manuela E. Gomes a,b, Nuno M. Neves a,b, Rui L. Reis a,b,*

a 3B's Research Group – Biomaterials, Biodegradables and Biomimetics, Department of Polymer Engineering, University of Minho, Headquarters of the European Institute of Excellence on Tissue Engineering and Regenerative Medicine, AvePark, Taipas, 4806-909 Guimarães, Portugal
b ICVS/3B's – PT Government Associate Laboratory, Braga/Guimarães, Portugal

ABSTRACT

Native tissues present complex architectures at the micro- and nanoscale that dictate their biological function. Several microfabrication techniques have been employed for engineering polymeric surfaces that could replicate in vitro these micro- and nanofeatures. In this study, biomimetic surfaces of poly(butylene succinate) (PBS) were engineered by a micromolding technique. After the optimization of the system parameters, 20 surfaces with different combinations of groove and ridge sizes were developed and characterized by scanning electron microscopy (SEM). The influence of the engineered microfeatures over the viability and attachment of human adipose derived adult stem cells (hASCs) was evaluated. hASCs cultured onto the engineered surfaces were demonstrated to remain viable for all tested patterns. SEM and immunostaining showed adequate attachment and spreading of the stem cells for all the patterned groove/ridge combinations. This study indicated that it is possible to engineer micropatterned surfaces of PBS and that the developed structures could have great potential for tissue engineering where cell alignment is an essential requisite.

© 2012 Acta Materialia Inc. Published by Elsevier Ltd. All rights reserved.

1. Introduction

One of the major motivations for the increasing effort spent on designing and developing micro- and nanostructured surfaces and materials for tissue engineering strategies is that natural tissues and the associated extracellular matrices (ECMs) are composed of micro- and nanoscaled elements [1,2]. In fact, when an implant first contacts the host environment, a layer of proteins immediately covers the surface of the implant [3]. The adsorptive behavior of these proteins is highly dependent on the surface properties, including its micro- and nanostructure [4,5], as well as on the material chemistry [6,7]. This surface-specific adjustment can result in the presentation of different regions of the proteins to cells, ultimately determining the success of the implant.

The micro- and nanoscale biological elements present in the ECM arrange themselves in specific architectures, essential for normal tissue function. An outstanding example is the organization of fibroblasts and cardiomyocytes in native myocardial tissue. These cells align themselves and assemble in parallel arrays in a way that is critical to obtain the electrical and mechanical properties of the heart [8]. Similarly, collagen fibers in the bone are aligned structures that provide bone with the tensile strength necessary to ensure the functionality of the tissue [9]. Thus, while developing engineered tissues it is of major importance to replicate the native microarchitecture, namely the controlled cellular alignment, and therefore to modulate in vitro the tissue function.

Several microfabrication techniques allow replication of the microarchitecture of tissues, modulating in vitro the cell shape, function or differentiation. Specifically, several different methods have been reported for cellular alignment, namely micropatterning of molecules [10], fabricating fibrous scaffolds by electrospinning [11–13] or engineering microchannels using soft-lithography methodologies [14,15]. Substrates with micropatterned adhesive proteins provide tight control over the cell attachment process. However, these patterned surfaces consist of a two-dimensional (2-D) substrate to culture cells. Three-dimensional (3-D) structures with multiple opportunities for cell attachment have been developed using various technologies, including electrospinning [11–13]. It has been reported that cells are able to align along the fibers within the 3-D network [12]. In order to more precisely control the overall orientation of cells, microchannels have been fabricated using micromolding or photolithography methods. Cardiac organoids have been formed within microengineered channels as a result of the alignment of cardiomyocytes [14].