Poster session 8: New Biomaterials for biofabrication

P8.1

Hydrogels made of recombinant spider silk proteins used as new bioink

Kristin Schacht, Tomasz Jungst, Jürgen Groll, Thomas Scheibel
Universität Bayreuth Lehrstuhl Biomaterialien, Bayreuth, Germany

3D bioprinting is a rapidly expanding field which combines additive manufacturing techniques with tissue engineering design principles and incorporates the simultaneous handling of biomaterials and cells. One of the critical barriers to translate current laboratory-level research to the clinic is the development of process-compatible materials i.e. bioink which fit the definition of biofabrication. Recombinant spider silk proteins are non-immunogenic cytocompatible spider silk fibers have superior mechanical strength and elasticity but the proteins can be fabricated into various types of scaffolds [1 2]. We used hydrogels made of these proteins as bioink in a 3D printing process by a robotic dispensing technique [3]. In particular the suitability of the hydrogels to encapsulate cells was evaluated and the cell viability and printability was investigated. It was shown that fibroblasts were able to adhere and proliferate with high vitality over at least one week in 3D printed spider silk scaffolds [3]. Additionally the recombinant spider silk proteins maintained a high shape-fidelity post-printing. Therefore the employed spider silk materials are a highly attractive novel bioink for biofabrication.

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References:

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P8.3

Multiscale modeling for implantable dental prosthesis – implication to biofabrication

Wei Li, Junning Chen, Michael Swain, Qing Li
The University of Sydney, Sydney, Australia

Solid titanium and its alloys have been the most prevalent materials for dental and orthopedic implants due to their advantageous mechanical and biocompatible properties. Nevertheless there still is a range of biomechanics and biomaterials issues with titanium implants such as delayed osseointegration and limited shear-load bearing capacity in clinic. In order to tackle these problems various physical and chemical treatment technologies have been developed to modify surface morphology of such implantable Dental Prostheses [1]. Fully Porous Coating (FPC) is one of such approaches where beads or particles are sintered to bond onto a solid core of implants under specific conditions. Such a process forms a layer of porous structure on the surface of the implant whose morphology relies on the bead size volume fraction and pattern of distribution. It is claimed that these porous coatings may promote a more favorable osseointegrative micro-environment to facilitate a high level of bone-implant interaction and allow better anchorage of bone-forming cells from the surrounding tissues onto the implant surface [1]. As a result a higher degree of shear loading can be transferred from implant to bone thereby promoting functional osseointegration and biomechanical binding between bone and implant [2].
Given the critical role that porous surface could play to enhance osseointegration a major interest remains in how to optimize morphological parameters. This study aimed to address this issue through a new multiscale modeling and design framework for optimizing the surface morphology to enhance bone - implant interface stability and osseointegration in a biofabrication context. Three different measurements in the micro model are used as design criteria to assess osseointegration outcomes: (1) the density; (2) bone-implant-contact (BIC) ratio and (3) Tresca stress (maximum shear) [1 2]. To achieve these osseointegrative criteria multiobjective optimization is formulated with respect to the design variables of particle size volume fraction and patterns. The optimized surface morphology and the subsequent additive fabrication will allow creating a better microenvironment for cell attachment differentiation and proliferation. While cells are seeded in a passive way during implantation in vivo the biofabricated surface topography enables to better engage cellular activities in both biomechanical and biochemical aspects thereby generating better short and long term clinical outcomes.

References:
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P8.4

Tuneable osteoinductive material for fused deposition modelling

Pedro Costa, Ana Puga, Luis Díaz-Gomez, Angel Concheiro, Dirk Busch, Carmen Alvarez-Lorenzo
University Medical Center Utrecht, Utrecht, Netherlands

Aim: The adoption of additive manufacturing in tissue engineering and regenerative medicine (TERM) strategies greatly relies on the development of novel 3D printable materials with advanced properties. The aim of this work was to develop a material for bone TERM applications with tunable bioerosion rate and dexamethasone release profile which can be further employed in fused deposition modelling (the most common and accessible 3D printing technology in the market).
Methods: Homogeneous polycaprolactone (PCL):poloxamine (PLX) powder blends (100:0 90:10 and 80:20 wt.%) were prepared by turbula mixing. Powder dexamethasone was added to part of the replicates. Blends were converted into filament form through a melt-based processing methodology. Resulting filaments were fed into a Fused Deposition Modelling-based 3D printer to produce 3D porous scaffolds. Scaffolds composed of the various blends were analyzed and compared regarding porosity as well as degradation rate for 3 months. Dexamethasone release profile was assessed by immersing scaffolds into fixed volumes of PBS spectrophotometrically analyzed periodically. Scaffold's osteoinductivity was assessed in vitro by seeding human mesenchymal stem cells (hMSCs) and analyzing ALP activity DNA content morphology and viability by confocal microscopy after 7 14 and 21 days of culture.
Results: Various PCL:PLX ratio blends were successfully converted into filament form and 3D printed as 3D porous scaffolds of homogeneous and reproducible architecture. As expected higher PLX concentrations resulted in greater weight loss due to the greater erosion rate of PLX. Higher concentrations of PLX also resulted in lower sub-micrometric porosity since PLX filled the pores formed by PCL. The dexamethasone release profiles resulted from a balance between porosity and degradation rate. 80:20 samples possessed greater degradation rate but lower porosity while 100:0 samples possessed greater porosity but slower degradation rate. As a result 90:10 samples were the ones with greater drug release given a combination of sufficient porosity and degradation rate. When tested in vitro this resulted in greater overall ALP activity for 90:10 samples followed by 100:0 and 80:20 samples. Cellular proliferation was observed in all blends although cellular content was overall higher in 100:0 samples given that PLX is known to decrease initial cellular attachment.
Conclusions: This work shows that fused deposition modelling can be utilized to manufacture 3D scaffolds composed of various PCL/PLX blend formulations possessing blend ratio-specific erosion rates dexamethasone release profiles and in vitro osteogenic activities. Such material therefore enables to specifically address different regenerative requirements found in various tissue defects.