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Advanced methods for design, fabrication and characterization of tissue engineered constructs

ABSTRACT

The aim of the presentation is to show few examples how numerical modeling, biofabrication and advance characterization methods could help in development of different scaffolds for regeneration of cartilage, bone, and nerve tissues. Using numerical approach it is possible to preclinical predict mechanical properties, degradation profile of the tissue engineered constructs as well as chance of new tissue formation in the 3D porous structures. For instance, computational model could be used to simulate process of scaffold degradation taking into account effect of the environmental conditions, the frequency of medium replacement, and the geometry of the scaffold components. Moreover, the influence of internal architecture and stiffness of the 3D constructs on the bone tissue formation could be evaluated.Biofabrication methods such as 3D printing, bioprinting or electrospinning are particularly promising methods for production of custom-designed scaffolds with patients-specific geometry, controlled internal architecture, and case-specific composition. For instance, Fused Deposition Modeling (FDM) could be applied to fabricate PCL-based scaffolds with required mechanical properties and degradation profiles tuned to different treatment strategies of bone tissue regeneration. An extrusion-based bioprinting technique is very useful to develop, layer-by-layer, a 3D construct consisting of different cell types and biomaterials. Finally, electrospinning allows for obtaining artificial grafts mimicking the nanotopography and composition of extracellular matrix (ECM) of native tissue, which might assist in regeneration of tissue defects. For instance, the nanofibrous scaffolds composed of P(LLA-CL), collagen I and collagen III with aligned fiber orientations mimic closely the extracellular matrix of nerve and have great potential as a tissue engineering construct for accelerated regeneration of this tissue.Nowadays, 3D and 4D imaging techniques combined with advanced image analysis could be used to characterize novel biomaterials and scaffolds for tissue regeneration. 3D imaging technique which combines X-ray absorption microtomography (uCT) and X-ray diffraction microtomography (XRD-CT) was used by us to examine the in vitro degradation process of polycaprolactone–based composites. The conventional uCT method was applied to examine the in vitro tissue ingrowth into biodegradable scaffolds. The combination of microfocus X-ray computed tomography and in-situ mechanical loading allowed us to quantify the scaffolds morphology prior and during loading, to verify the mechanical properties, to analyze fracture behavior, and to estimate the internal local deformation distributions.

BIO

2004 – present	Senior Researcher, PI – WUT Professor, Division of Materials Design, Faculty of Materials Science and Engineering, Warsaw University of Technology, Poland
2000 – 2004	PostDoc: Biomaterial Laboratory, Faculty of Aerospace Engineering, Delft University of Technology, The Netherlands *New Biomaterials for shoulder joint endoprothesis*
1996 – 2000	PhD student, Warsaw University of Technology, Faculty of Power and Aeronautical Engineering, Poland
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