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3D-Printing of Bio ceramics for Bone Regeneration Applications

Rainer Gadow
University of Stuttgart, GerAbstract

Bone degradation and fractures represent a significant concern to human health and to the increased population life expectancy. When such defects overcome a certain critical size, body induced autorepair cannot restore lost skeleton functionality. Medical treatment involves bone grafting, a common surgical procedure with more than 2.0 million grafting procedures performed worldwide each year. Autologous bone grafts are currently the golden standard treatment but are associated with donor-site complications, risk of infection and size and shape limitations. Artificial scaffolds with tailored geometry, porosity, architecture and composition present an alternative to autologous grafts and are excellent 3D templates to provide structural support for ingrowth of the newly formed bone. The use of bioceramics like calcium phosphates (Hap,TCP) or bioactive glasses for the regeneration of critical bone defects is intensively researched worldwide. The advantages of additive manufacturing technology make it possible to process these ceramic materials into customized patient-specific implants. In this work the process chain of powder-based inkjet-3D-printing is presented. This includes the production of bioceramic suspensions from bioglass, calcium phosphates and composites and spray dry granulation to obtain flowable granulates. 3D-printing is performed from CAD-modelling to post-processing of the printed structures. Printed components are sintered and characterized with respect to mechanical properties and in vitro biocompatibility. After sintering the scaffolds show high porosity (about 70 %) and high surface roughness (Ra about 25 µm, Rz up to 200 µm) which is beneficial for the colonization of bone cells. In vitro tests using MG-63 stem cells showed an effective growth of cells on the outer and inner surface of the scaffolds and the formation of reinforcing secondary hydroxyapatite crystals.

rainer.gadow@ifkb.uni-stuttgart.de