Michael Gelinsky

Biography

Michael Gelinsky is professor and head of the Centre for Translational Bone, Joint and Soft Tissue Research at the University Hospital and Faculty of Medicine of Dresden University of Technology, Germany. He is a chemist by training and expert in biomaterials, tissue engineering and 3D printing/bioprinting. In 2020 be became "Fellow Biomaterials Science and Engineering", from 2021 until 2025 he was the president of the German Society for Biomaterials and was admitted as Honorary Fellow by the Society for Biomaterials and Artificial Organs India in 2024. Since beginning of this year he received the honour of a Distinguished Professor of Tohoku University in Sendai, Japan as a second affiliation.

3D Printing and bioprinting solutions for regeneration of bone and osteochondral defects

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INTRODUCTION: Although bone tissue in general has a quite high capacity for regeneration and can heal without scar formation, thanks to the life-long remodelling processes, some bone defects are not healing spontaneous and need support by biomaterials or even cell-containing, tissue engineered constructs. In contrast, osteochondral lesions – i.e. deep lesions of articular cartilage in which the underlying, subchondral bone is affected, too – do not heal spontaneously due to the limited regenerative capacity of the non-vascularised cartilage layer. We have developed a number of biomaterials based on calcium phosphate cements (CPC) and mesoporous bioactive glasses (MBG) that can be extrusion-printed to either form cell-free implants or, in combination with bioinks, cell-laden tissue constructs. The presentation will give an overview about recent developments, their advantages and limitations.

METHODS: As base-material a clinically approved, α-tricalcium phosphate-based CPC setting to hydroxyapatite has been utilised in which the solid precursor mixture is suspended in an oily liquid – which can be applied in microextrusion 3D printing [1]. To increase porosity and degradadibility and for advancing the opportunities of functionalisation with bioactive metal ions, drugs or growth factors, the CPC was combined with particulate MBG [2]. For bioprinting of bone-like constructs, such biomaterial inks were co-printed with cell-laden, alginate-based bioinks of different compositions in which either human osteoblasts or mesenchymal stroma cells were embedded [3]. For bioprinting of osteochondral constructs, the method of core/shell extrusion has been utilised with chondrocytes or osteoblasts in the respective shell compartments and either TGF-β3 or BMP-2, immobilised in specific, Laponite-containing biomaterial inks as the core compartments [4]. All constructs were thoroughly characterised *in vitro* and selected materials were also tested in small or large animal models.

RESULTS: The pasty CPC could be extruded through nozzles with a diameter of 200 µm or larger. Combinations of CPC and MBG were still printable and the setting was not negatively affected by this modification. E.g. Sr^{2+} ions could be included both in the CPC and MBG phase, leading to different release kinetics. CPC-MBG composites possessed higher microporosity and were degraded faster *in vivo*. Bioprinting of bone-like constructs by alternating deposition of CPC and bioink strands could be achieved and high cell viability was observed. Blending of the base bioink components alginate and methylcellulose with either human blood plasma or egg white increased cell viability significantly and supported cell spreading in and on the bioink strands. In the aforementioned strategy for local growth factor (GF) release from core/shell bioprinted osteochondral constructs it could be demonstrated that the release kinetics of the GF could be adjusted in a wide range by the inclusion of the nanoclay material Laponite. The respective desired cell differentiation was supported but no negative side effects on the other cell type were observed.

DISCUSSION & CONCLUSIONS: Composites consisting of CPC and MBG offer a versatile toolbox for different applications in the field of bone regeneration. It could be demonstrated that addition of MBG improved several properties, especially the functionalisation with different factors. CPC can be co-printed with cell-laden bioinks, leading to bone-like tissue models. Layered arrangements of bioinks allow the fabrication of osteochondral constructs.

ACKNOWLEDGEMENTS: Several team members contributed to the respective studies that have been supported by different funding sources; both will be mentioned in the presentation.

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