

## COMPLEX AND PATIENT-SPECIFIC SCAFFOLDS AND TISSUE ENGINEERING CONSTRUCTS BY EXTRUSION-BASED 3D (BIO)PRINTING

Michael Gelinsky, University Hospital and Medical Faculty of Technische Universität Dresden, Germany  
michael.gelinsky@tu-dresden.de

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Extrusion-based additive manufacturing (“3D plotting”) is a very versatile technology as in principle any pasty material can be utilised. In addition, the printers used for 3D plotting are less complicated and therefore also cheaper in comparison to e.g. laser-based systems. In our lab several suitable biomaterials – biopolymer hydrogels, composites but also a pasty calcium phosphate bone cement (CPC) – have been developed for 3D plotting of scaffolds as well as for biofabrication purposes. Of special interest are alginate/methylcellulose blends with or without laponite (a synthetic clay) as additional component which both allow bioprinting of macroscopic but still open-porous, cell-laden constructs. Beside bioprinting of mammalian cells (human MSC) we could demonstrate successful utilisation of microalgae and plant cells.

By using a multi-channel 3D plotting device (BioScaffolder 3.1 from Gesim, Germany) we could combine two different materials in an alternating fashion within one construct. This also works for the combination of cell-laden biopolymer hydrogel blends and the self-setting calcium phosphate bone cement which provides mechanical stiffness.

Another option for combining two materials is extrusion through a double nozzle system, leading to strands with core/shell morphology (Fig. 1). Especially if stiff, highly concentrated alginate-based hydrogels or CPC are used as shell material mechanically robust and open-porous constructs with tailored properties can be manufactured. By loading shell and core part with different drugs or growth factors dual release systems with adjustable release properties can be realised. Finally, also living cells can be suspended in the soft biopolymer hydrogels, acting as core material in core/shell bioprinting, leading to stable tissue engineering constructs.



Figure 1: Principle of core/shell plotting. (A) Double extrusion nozzle, (B) Core/shell extrusion, (C) 3D Plotting of a core/shell scaffold