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Abstract

Extrusion-based 3D printing of osteoinductive scaffolds with a spongiosa-like structure

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Critical-sized bone defects can result from trauma, inflammation, and tumor resection. Such bone defects, often have irregular shapes, resulting in the need for new technologies to produce suitable implants. 3D printing is an additive manufacturing method to create complex and individualized bone constructs, which can be seeded with autologous cells from the patients. In this study, we established an extrusion-based printing technology to produce osteoinductive scaffolds based on biocompatible polycaprolactone (PCL) combined with calcium phosphate (CA) [1], [2]. The internal structure of the scaffolds resembles a bone-like spongiosa with irregular interconnected pores (diameter: 2mm +/- 0.2 mm SD), whereas the outer shape is a ring with a diameter of 20 mm and a height of 10 mm. The scaffold was printed using the thermoplastic PCL or PCL-CA and a BIO X6 printer. To produce the printing material, PCL was combined with calcium phosphate nano powder (> 150 nm particle size) under heating. After printing, 5 x 10^6 MG63 (osteosarcoma cell line) were seeded on the constructs using a rotating incubator for 24 hours.

This extrusion-based printing process has the ability to create a construct with a bone-like mechanical stability. Mechanical properties are under investigation. In first studies the integrated calcium phosphate shows an influence on the gene expression of the osteogenic differentiation markers (collagen-1, osteocalcin) and the adhesion marker integrin-ß1 in MG63 cells. The MG63 cells attach to the PCL and the PCL CA and proliferate over the investigated time frame (14 days) as indicated by DNA quantification. An increase of the cell density is also visible by confocal laser scanning microscopy, after the cytoskeleton of the cells was stained with Phalloidin TRITC and Hoechst as nuclear counter stain. The actin cytoskeleton visualizes the elongated morphology of the cell, also shown by electron microscopy pictures, which also depicts the material surfaces. The porous PCL ring could serve as an outer matrix for the implant, providing construct stability similar to natural bone.

AUTHOR'S STATEMENT

Authors state no conflict of interest. Informed consent: Informed consent has been obtained from all individuals included in this study. Ethical approval: The research related to human use complies with all the relevant national regulations, institutional policies and was performed in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee.

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