Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2023, Vol. 5, No 1, Suppl. 1, Article ID 802, 1 Page

Infinite Science Publishing

Abstract

Endothelial monolayer formation on melt electro-written scaffolds under dynamic conditions to mimic *tunica interna*

S. Loewner[1*], S. Heene[1], F. Cholewa[2], H. Heymann[2], H. Blume[2] and C. Blume[1]

[1] *Institute of Technical Chemistry, Leibniz University Hannover, Hannover, Germany*
[2] *Institute of Microelectronic Systems, Leibniz University Hannover, Hannover, Germany*
[*] *Corresponding author, email: loewner@iftc.uni-hannover.de*

The lack of transplantable tissue and organs as well as the limitations of synthetic implants highlight the need for tissue-engineered constructs to obtain safe, long-lasting, and limitless tissue replacements [1]. Scaffolds for cardiovascular applications, such as tissue engineered vascular grafts (TEVG), are thus highly required. For TEVGs, tubular scaffolds should support the formation of confluent endothelial layers in particular under dynamic conditions to prevent thrombosis and maintain hemostasis [2]. For that purpose, a porous and highly diffusible scaffold structure is necessary to allow optimal cell adhesion as well as oxygen and nutrient exchange with the surrounding tissue. Here, we present a 3D-printed scaffold made by a combination of fused deposition modeling (FDM) and melt electro writing (MEW). MEW is a novel 3D printing technique that enables precise micro- to nanoscale fiber deposition by utilizing a strong electrostatic field [3]. Biodegradable polycaprolactone (PCL) was fabricated in to porous scaffolds to enable monolayer formation and alignment of human umbilical endothelial cells (HUVECs). HUVECs were dynamically cultured in ibidi flow slides on PCL scaffolds and cultivated under a shear stress of up to 10 dyn cm^{-2}, equivalent to wall-near shear stress level in arterial vessels. Pore size and coating with human fibrin were optimized to enable confluent endothelial layers on the printed scaffold structures. Cell orientation and shape analysis showed a characteristic alignment and elongation of the tested HUVECs in the direction of flow after dynamic cultivation. In contrast, melt electro-spun scaffolds with chaotic and random fiber deposition were not sufficient to form gap-less cell layers. Thus, the new MEW/FDM scaffold fabrication approach with controllable and replicable printing properties appears most suitable for TEVGs as a template for the innermost vascular wall layer, the *tunica intima*.

AUTHOR'S STATEMENT

Conflict of interest: Authors state no conflict of interest. Animal models: Not applicable. Informed consent: Not applicable. Ethical approval: In this work, no primary cells or human study conception were necessary. An ethical vote thus is not applicable. Acknowledgments: We thank Caroline Mueller for intense technical support, and Dr. Rebecca Jonczyk for many helpful discussions and suggestions concerning the cell culture experiments. Furthermore, we thank Prof. Cornelia Lee-Thedieck (Institute for Cell Biology and Biophysics, Leibniz University Hannover) and her working group.

Research funding: This work has been carried out within the framework of the SMART BIOTECS alliance between the Technische Universitaet Braunschweig and the Leibniz Universitaet Hannover. This initiative is supported by the Ministry of Economy and Culture (MWK) of Lower Saxony, Germany.

REFERENCES

[1] Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet 2016; 388: 1459–1544 [PMID: 27733281 DOI: 10.1016/S0140-6736(16)31012-1]
[2] Sankaran, Krishna Kumar, et al. "Nanoarchitecture of scaffolds and endothelial cells in engineering small diameter vascular grafts." Biotechnology Journal 10.1 (2015): 96-108.
[3] Loewner, Sebastian, et al. "Recent advances in melt electro writing for tissue engineering for 3D printing of microporous scaffolds for tissue engineering." Frontiers in Bioengineering and Biotechnology 10 (2022): 896719.

DOI: 10.18416/AMMM.2023.2309802