Co-axial 3D bioprinting for Biomimetic Multifibre Skeletal Muscle-based Bioactuators

Judith Fuentes[1]
Rafael Mestre[1], Maria Guix[1], Ibtissam Ghailan[1], Samuel Sánchez[1,2]

[1] Institute for Bioengineering of Catalonia (IBEC), The Barcelona Institute of Science and Technology, 08028, Barcelona, Spain
[2] Institució Catalana de Recerca i Estudis Avancats (ICREA), Barcelona, Spain

jfuentes@ibecbarcelona.eu

Abstract

Recent advances in three-dimensional (3D) bioprinting and tissue engineering have opened new possibilities in the fabrication of bioengineered muscle models able to mimic the complex hierarchical organization and functional properties from the native tissues [1]. The combination of skeletal muscle tissue and artificial elements has led to a wide variety of innovative solutions to create bio-hybrid robotic systems and bioactuators [2] that offer the opportunity to study processes of interest in the biomedical field, such as muscle development and regeneration. However, one key problem in tissue engineering is the poor oxygen and nutrients supply in the inner regions of the printed scaffold, leading to a reduced cell viability.

In our work, we explored co-axial 3D bioprinting [3] as a novel strategy towards overcoming the nutrient diffusion problem by creating individual, non-fused fibers with defined thickness. Therefore, we aim to develop a 3D bioengineered skeletal muscle bioactuator with biomimetic design in terms of structure and functionality. In comparison with conventional 3D-bioprinting, where a single syringe containing the cell-laden bioink is used, in co-axial 3D-bioprinting an outer layer of sacrificial material (pluronic acid in this study) allows a physical confinement on the inner layer (i.e bioink), obtaining thin independent printed fibers that can be hierarchically organized (Figure 1). Such technique is generally implemented in the fabrication of vascular systems [4]. The use of bioprinting techniques allow the fabrication of bioengineered muscle-based actuators that present highly aligned myotubes with contractile capabilities. However, the formation of thinner and individual fibers obtained by co-axial 3D-printing resulted in an enhanced diffusion of nutrients during the muscle maturation process, improving cell differentiation and obtaining stronger bioactuators which present an increased force output in comparison with the actuators fabricated by using conventional printing.

After exploring the potential of 3D bioprinting for fabricating 3D bioengineered skeletal muscle bioactuators, our interests are currently focused on exploiting the regenerative capabilities of muscle tissue to integrate self-healing properties to living actuators [5] and create more biomimetic in vitro muscle models for biomedical applications.

References

[1] Mestre, R., Patiño, T., Barceló, X., Anand, S. Pérez-Jiménez, A., Sánchez, A. Adv. Mater. Technol. (2019). [4, 1800631].
[2] Guix, M., Mestre, R. Patiño, T., De Corato, M., Fuentes, J., Zarpellon, G., Sánchez, S. Sci. Robot. (2021). [6, eabe7577].
[3] Patent #EP203825971 filled, “Printing system for obtaining biological fibers”.
[4] Millik, S. C., Dostie, A. M., Karis, D. G., Smith, P. T., McKenna, M., Chan, N., Curtis, C. D., Nance, E., Theberge, A. B., & Nelson, A. Biofabrication. (2019). [11(4), 045009].
[5] Raman, R., Grant, L., Seo, Y., Cvetkovic, C., Gapinske, M., Palasz, A., Dabbous, H., Kong, H., Perez Pinera, P., Bashir, R. (2017). Adv. Healthc. Mater. Millik, S. C., Dostie, A. M., Karis, D. G., Smith, P. T., McKenna, M., Chan, N., Curtis, C. D., Nance, E., Theberge, A. B., & Nelson, A. Biofabrication. (2019). [11(4), 045009].

Figures

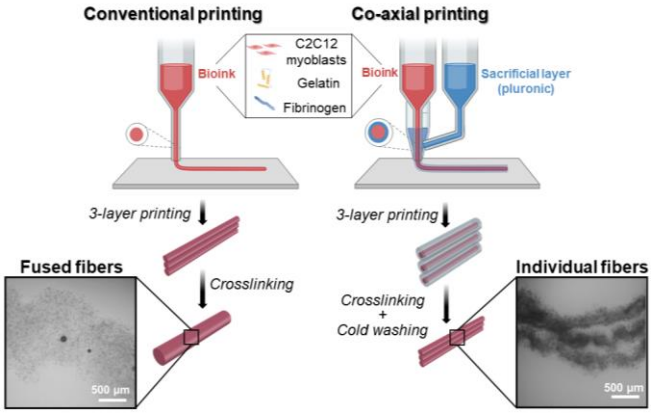

Figure 1. Schematic of the two 3D bioprinting techniques used: conventional printing and co-axial printing.