



COAXIAL: WIDTH-CONTROLLED 3D BIOPRINTING OF THIN AND HOMOGENEOUS BIOMIMETIC FIBRES



CHALLENGE

Skeletal muscles have a high structural complexity. They are made up of 3D myofibers that are axially aligned, grouped into bundles and connected to the vascular and neural network, and to the bones via tendons. Because of this complexity, most research on skeletal muscle tissue has been carried out in a 2D environment and without measuring contraction forces.

One of the challenges is to provide a fabrication method that:

- Allows the thickness of the bioprinted constructs to be carefully controlled in the micrometre range.
- Produces individual fibres that are not fused together, improving the biomimicry of the organisational structure of, for example, skeletal muscle tissue, and increasing cell viability in the inner parts of the constructs due to enriched nutrient and oxygen diffusion.
- Universal enough to incorporate different types of hydrogels and different cross-linking strategies.



MARKET

Muscles are subject to ageing, traumatic injury or myopathies. Skeletal muscles are therefore highly relevant to several industries such as cosmetics (market size USD 507.8 billion in 2018, expected USD 758.4 in 2025) because sustained contractions of facial muscles cause wrinkles; biomedicine diseases such as muscle dystrophies are very heterogeneous and generally understudied; and tissue engineering and regenerative medicine (market size USD 9.9 billion in 2019, expected USD 28.9 in 2026), because implants such as muscle grafts could help heal people with severe muscle damage.

In addition, because of the universality of our method, derived compositions for different tissues could be designed and delivered using the same method.

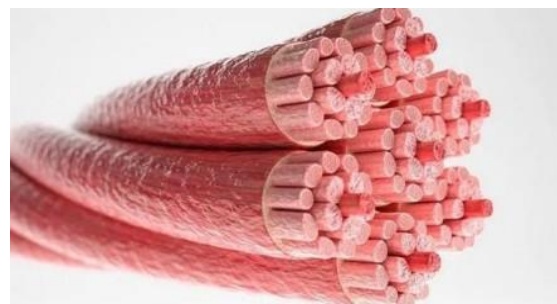


ASSET

IBEC researchers have developed a universal 3D bioprinting system for the production of thin, homogeneous and width-controlled free-form individual fibres that can be used with a range of cell-laden hydrogels. The method inventively separates the fixation process of the 3D-printed fibre structure from the cross-linking step of the hydrogel polymer.

In particular, our method enables the fabrication of multi-layered tissue constructs with high versatility in terms of hydrogel composition and cross-linking processes. In addition, this method does not rely on the use of sodium alginate, as most coaxial approaches do, which is not well tolerated by certain tissues such as skeletal muscle.

As a proof of concept for the application of our 3D bioprinted skeletal muscle tissue, we have developed a force measurement platform that allows us to study the contractile dynamics when stimulated, for example by the application of electrical pulses or the addition of drugs.



Team

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Stage of Development

TRL 4

- Full validation for skeletal muscle tissue (fibre morphology versus printing parameters, cell proliferation and differentiation), demonstrating improved cell differentiation and greater force outputs.
- Testing for specific bioink formulations and drug applications.
- Characterisation of different protocols to obtain high quality fibres with a wide combination of materials.

Exploitation Plan

Service agreements and/or licensing with technical co-development.

Intellectual Property Status

- Patent filed in July 2020.
- Current Status: national phases (EP, US).
- Patent owners: IBEC and ICREA.

ASSET VALUE

- Good replication of highly structured skeletal muscle tissue:
 - Individual fibres are printed with a controlled width.
 - No significant fusion of adjacent fibres.
- System is versatile, allowing bioprinting with a wide range of cell-laden hydrogels (even without support baths).
- The solution is based on coaxial nozzles that can be used with different 3D printing systems.

USES

- 3D bioprinting kit (coaxial extrusion nozzle, bioink, protocol), specifically designed for, but not limited to, muscle application.
- Platform for drug discovery and development in non-clinical animal testing.
- Tissues for regenerative medicine.