Biofabrication of Patient-Specific Cardiac Patches for Heart Failure

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Cardiovascular disease remains a primary cause of death globally. Following the onset of myocardial infarction, blood flow to the ventricular myocardium is disrupted leading to cell death and fibrosis. Irreversible damage to the myocardium is responsible for heart failure, a life-threatening condition with decreased cardiac function. The gold-standard treatment for patients with end-stage heart failure is a heart transplant. The procedure has several complications and limitations, including a limited number of organ donors and the transplant recipient need for life-long immune suppression. Biofabricating viable and functional cardiac tissues provides new hope for heart failure patients.

3D bioprinting enables deposition of stem cells embedded in hydrogels into a 3D design resulting in novel biofabricated tissues.[1] Our team has developed a novel approach for creating personalised cardiac patches. The cardiac patch design is modelled on patient cardiac CT and MRI scans and 3D bioprinted with patient's own stem cells in the form of cardiac spheroids.[2] The data from cardiac imaging are analysed to determine the epicardial contours of the ventricular wall, and the scarring in the infarcted regions. The personalised approach ensures that the shape and the size of the patch conforms to the patient anatomy, and that areas for depositing cardiac spheroids are specified to match the fibrotic regions in the myocardium. The use of patient-derived stem cells removes the reliance on organ donation and the transplant recipient need for life-long immune suppression. The finalised cardiac patch 3D designs are converted to a format suitable for 3D bioprinting.

A hydrogel composition of 4% alginate and 8% gelatin was shown in our previous study to provide an ideal environment for cell viability and function, and ensure optimal patch durability.[3] To date, cardiac patch designs based on patient cardiac imaging have been 3D bioprinted in our lab using a CELLINK BIOX 6 bioprinter. The bioprinter allows for independent deposition of multiple biomaterials in one print, making the method ideal for accurate placement of cardiac spheroids. To establish an optimal 3D bioprinting method co-axial and support-free 3D bioprinting techniques are tested for biofabrication of the cardiac patches.

In our recent preclinical study we demonstrated that cardiac patches improve cardiac function following transplantation.[4] The patient-specific design and 3D bioprinting of the cardiac patches by our team is advancing the treatment towards clinical studies. Future steps include developing an anatomical *in vitro* model for testing the cardiac patch performance.

References:

[1] Matthews, N.; et al. 3D Bioprinting for Cardiovascular Applications. In: *3D Printing and Bioprinting for Pharmaceutical and Medical Applications*. CRC Press; 2023.

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[4] Roche, C.D.; et al. *Bioprinting* **30**, e00263.