PhD Open Days

Construction and modeling of electroconductive scaffolds and bioreactor devices for osteochondral tissue engineering

Doctoral Program in Bioengineering | Pedro Marcelino (pmama@tecnico.ulisboa.pt)

Motivation and Background

Due to illnesses or trauma, the osteochondral tissue deteriorates leading to the development of osteochondral tissue diseases (e.g., osteoarthritis).

Current clinical therapies for osteochondral defects have failed to provide fully satisfactory outcomes, leading to the emergence of innovative tissue engineering alternatives.

Current state-of-the-art constructs do not reproduce the complex hierarchical structure of the native tissue in its entirety.

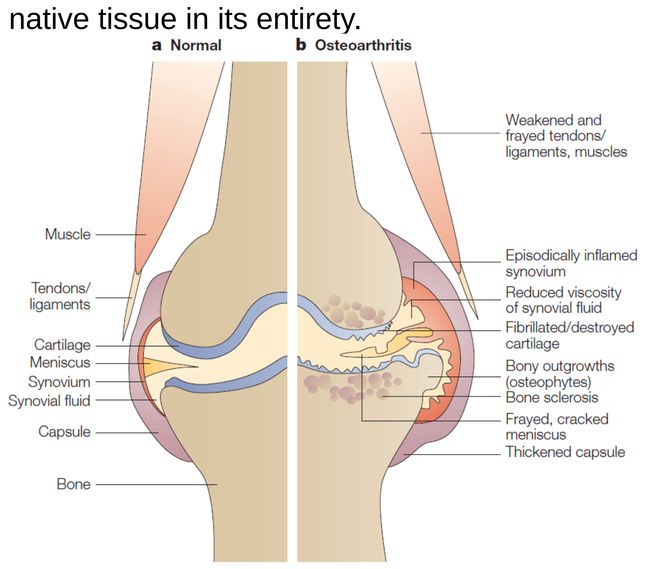


Figure 1: Schematic representation of normal and osteoarthritic osteochondral tissue

- This project aims to create a tissue engineering platform for the design and manufacture of osteochondral tissue substitutes supported by a bioreactor device capable of providing multimodal stimulation to cell seeded scaffolds.
- We hypothesize that replicating the native environment in terms of electrical, mechanical and fluid dynamics conditions will allow the generation of mechanically competent osteochondral tissue constructs with improved functionality.

Outcomes

Design of curved scaffolds and simulation of their mechanical behavior under compressive stress

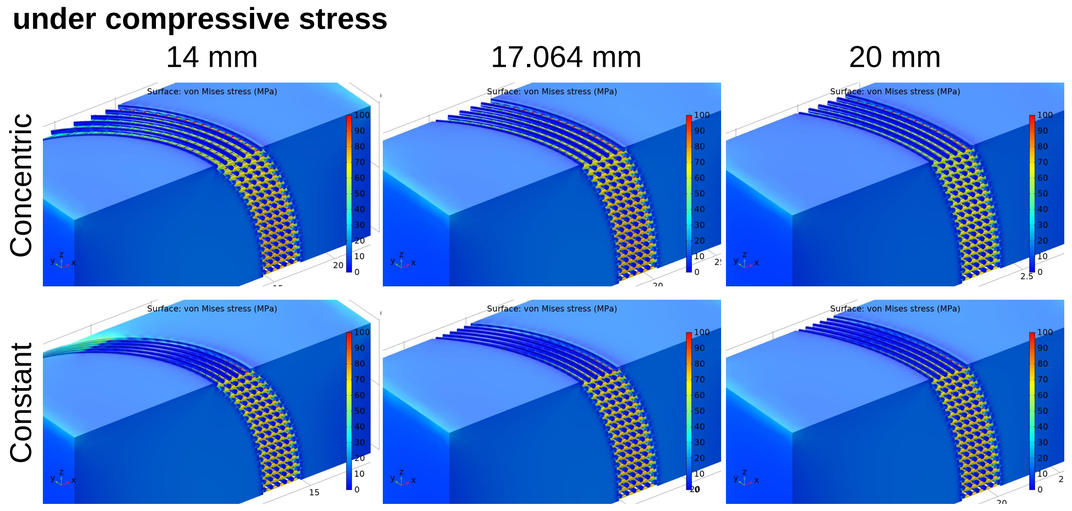


Figure 2: Finite Element Analysis simulation of the von Mises stress in the compression of the scaffolds, placed between adjoining solid blocks. The model predicts which regions will sustain greater stress under compression

Design and manufacture of pore gradient scaffolds

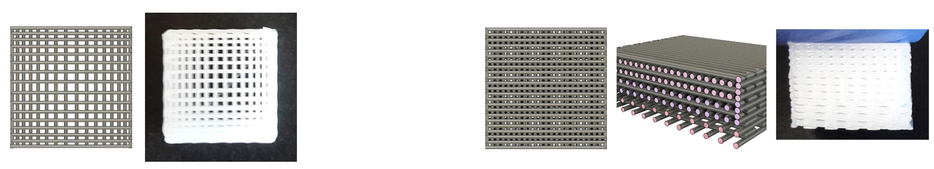


Figure 3: CAD models and fused filament fabrication 3D prints of scaffolds displaying a pore gradient: linear variation in pore size from the center to the edges (left); assemblage of three regions with different porosities (right)

Construction of device capable of printing composites

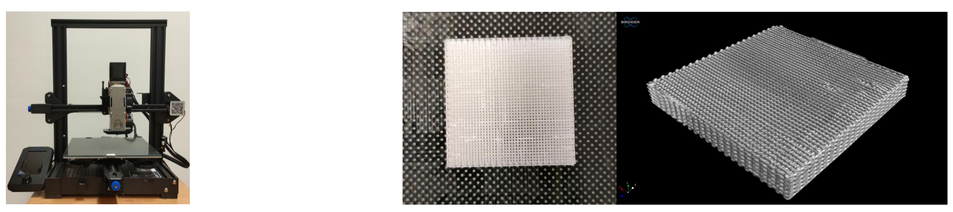


Figure 4: Constructed screw 3D printer device (left); 3D printed scaffold in TPU and µ-computer tomography reconstruction (right)

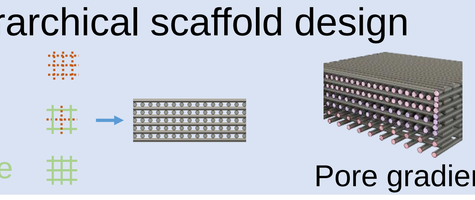
Aim of the project

1 - Create digital twin models to guide the development of scaffolds and devices

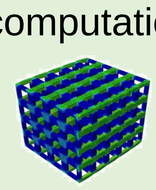
2 - Design and fabrication of a multigradient scaffold

Extrusion system

Hierarchical scaffold design

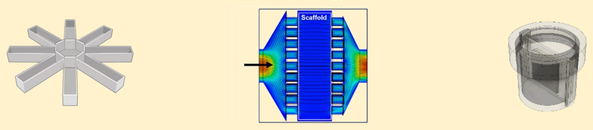


Scaffold computational model

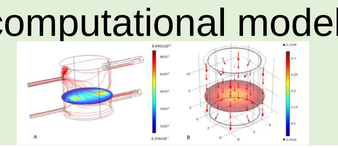


3 - 3D printing of a bioreactor system

Multimodal bioreactor design and manufacturing

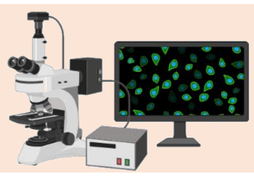


Bioreactor computational model



4 - Experimental biological validation

In vitro



In vivo

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