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DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

3D and 4D printing of stimuli-responsive and functionally graded biomaterials for osteochondral defects regeneration

Since cartilage and subchondral bone have different biological properties, the therapy of osteochondral defects remains a great challenge. The osteochondral interface is difficult to regenerate due to its poor regenerative capacity and complex stratified architecture. The osteochondral unit is one of a kind tissue that contains bone, cartilage, and transitional layers with gradated mechanical and biological properties. Fabrication of new implants that guides osteochondral tissue regeneration and possesses properties and functions which gradually change in accordance with injured tissue is still a major issue. Additive manufacturing, especially 3D printing has gained a lot of interest in the past decades as a fabrication technology platform for implants. This technology involves depositing materials precisely layer-by-layer manner using computer-aid controls, and thus resulting in 3D geometry with desired spatial arrangement. However, currently produced 3D printed implants are unable to mimic native tissue closely, especially biological properties of osteochondral tissue. Moreover, nowadays the implants need to attain a predefined shape to enable delivery to the application site by minimally invasive intervention. 4D printing, allows to produce implants that meet the above requirements. 4D printing is a combination of 3D printing and the fourth dimension, which is time. Smart materials together with a smart design are crucial in this technology. 4D printing requires materials, able to expand, flexure and/or deform in response to a particular stimulus. Smart polymeric materials, capable of changing shape under the influence of various external stimuli are so-called “shape memory polymers”.

In the current proposal, we would like to combine the advantages of shape memory polymers (i.e. smart materials that have the ability to return after deformation to their original shape induced by an external stimulus like temperature, electrical field etc.) and other stimuli-responsive materials (enabling faster tissue regeneration) in order to develop smart filaments for 3D printing. The filaments produced will be used to develop gradient implants showing a gradient of biological and mechanical properties identical to that found in natural osteochondral tissue and in addition will have the ability to return to its original shape after deformation.

We would like to create a novel functionally graded scaffold for osteochondral reconstruction, that not only possess adequate biocompatibility, biodegradability, porosity, mechanical and biological properties but also are able to self-transform, in form or function, when are exposed to a predetermined stimulus.

The main objectives of this project are to develop the osteochondral, graded, stimuli-responsive and smart scaffolds using 4D printing method and gain the basic knowledge of how these stimuli responsive scaffolds behave over time when triggered by external stimuli and after interaction with cells.