Performance Prediction and Tissue Ingrowth Evaluation of 3D Plotted Osteochondral Scaffolds

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The use of porous scaffolds in tissue engineering holds promise since they have the potential of providing temporary mechanical support while facilitating tissue ingrowth by allowing the inclusion of seeded cells. The goal of this work is to improve the design of osteochondral scaffolds by analysing the effect of scaffold architecture on its biomechanical performance under physiological loads.

PLLA scaffolds, featuring a gradient in pore size (200-400 microns) and porosity (50% to 85%) through the thickness, were obtained using a 3D plotting technique. The polymer, dissolved in a solvent, was dispensed into a plotting medium to build a 3D interconnected geometry.

The layer at 85% porosity showed similar mechanical properties to that of typical cartilage under unconfined compression test. The tissue ingrowth studies for these constructs are currently underway. A modelling software was used to predict the biomechanical performance of scaffolds surrounded by native osteochondral tissues. Different mechanical properties were assigned to different layers of cartilage-bone tissues to account for the variations in properties through the thickness. The comparison of simulation results under compressive loads demonstrated that the stress field inside scaffolds and that of cartilage are similar.

The performance prediction is coupled with the kinetic models of scaffold degradation and tissue growth allowing the prediction of construct biomechanical performance during its structural evolution. The optimization of biomechanical performance is currently underway to design scaffolds with desired biphasic properties (modulus and permeability) as to mimic the stiffness of native osteochondral tissues while providing the maximum porosity to promote tissue ingrowth.