BIOLOGICAL EVALUATION OF BONE-LIKE SCAFFOLDS IN SIMULATED MICROGRAVITY

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Introduction

Bone mass loss is a well-known consequence to microgravity exposure which implies an alteration of bone homeostasis, a decrease in bone mineral density, an increase in fracture risk, and a premature osteoporotic phenotype [1]. The modifications induced by weightlessness show similarities with known hallmarks of aged bone and it is becoming widely accepted that microgravity induces bone phenotypic changes comparable to those of bone-related disorders experienced on Earth [1]. In this regard, space could be considered an accelerated model to investigate the mechanisms that play a key role in skeletal affections, with the aim to refine existing therapeutic protocols and develop new countermeasures [2].

An experimental strategy to further elucidate the results collected so far and to provide innovative models for space research is highly recommended, especially if referred to long-term space missions (e.g. Moon, Mars) [3]. In this work, an innovative 3D biomimetic platform composed of engineered bone-like scaffolds [4], osteoblastic cell model [5], and a bioreactor capable of simulating microgravity is proposed to analyze the scaffold-cell interaction.

Methods

Three CAD models were designed (Meshmixer, v.2018, Autodesk, San Rafael, CA, USA) with different degrees of porosity to resemble the physio-pathological morphology of human trabecular bone (Table 1). Bone-like scaffolds were then 3D printed employing the fused deposition modeling (FDM) technique processing a polylactic acid (PLA) filament, an approved FDA material, and characterized by means of micro-computed tomography (micro-CT). Human osteosarcoma (SAOS-2) cells were seeded on the scaffolds to evaluate the biological response in simulated microgravity, investigating the metabolic activity and the inflammatory response. Microgravity was simulated by means of a rotary cell culture system (RCCS; Synthecon, Inc., Houston, TX, USA).

Results

The micro-CT analysis showed that 3D printed scaffolds resemble the physio-pathological microarchitecture of human trabecular bone from different anatomic sites. The biological assays confirmed the bioactivity and biocompatibility of the tested scaffolds, without inflammatory response, where the most porous model showed the best cell-scaffold interaction (Figure 1).

	S1	S2	S3
Design	53.8%	72.9%	83%
micro-CT	44.7%	62.3%	80.5%

Table 1: Comparison of designed and micro-CT evaluated scaffold porosity

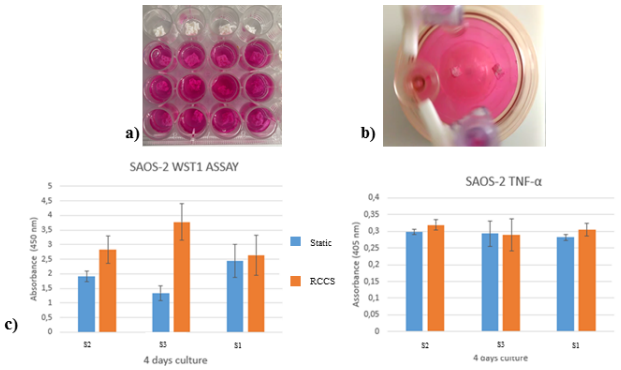

Figure 1: a) Static cell culture; b) RCCS bioreactor with seeded scaffolds; c) results of metabolic activity (left panel) and ELISA biological assay (right panel).

Discussion

The results demonstrated that cell response is directly related to scaffold morphology, being enhanced if dealing with the most porous one. Moreover, simulated microgravity further supported cell adhesion, viability and proliferation. These findings suggest that biomimetic scaffolds and microgravity culture conditions deserve a detailed investigation as an instructive approach to assess cell osteoactivity.

References

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