Bioactive glasses meet biofabrication: novel approaches for 3D bioprinting

Aldo R. Boccaccini

Institute of Biomaterials, University of Erlangen-Nuremberg, 91058 Erlangen, Germany

Abstract

Bioactive glass (BG) is considered the first man-made material capable to bond strongly to bone [1]. The most well-known applications of BGs are in the dental and orthopedic sectors, for example as bone filling material, small size (not load bearing) prostheses and as coatings on metallic orthopedic and dental implants. BGs started to be considered for tissue engineering (TE) applications about two decades ago, starting with bone repair applications and more recently expanding to soft TE and wound healing. In TE applications, the biochemical reactivity of BGs, in particular the biological interactions at the BG-tissue interface, are exploited. Such bioreactiviy of BGs is manifested in the release of biologically active ions capable of activating specific cellular pathways [2]. For example, numerous biologically active ions can be doped in BGs, which are released in a controlled manner and can induce an angiogenic effect, which is essential to achieve vascularization in TE approaches.

In the first part of the presentation, several examples will be presented showing that suitable concentrations of ionic BG dissolution products (e.g. Cu, Co, B) can increase the secretion of vascular endothelial growth factor (VEGF) from stem cells. Moreover, results of cell culture studies showing the effect of ion concentration from BG dissolution in cell culture medium on cellular responses will be presented indicating a way to design the composition of bioactive glasses to achieve specific biological performance for given applications (bone regeneration, wound healing, muscle repair, etc.).

In the second part of the presentation, applications of particulate BGs, including sol-gel derived mesoporous nanoparticles, in the field of 3D bioprinting (biofabrication) will be discussed [3]. The development of composite hydrogels incorporating BG (nano)particles is being increasingly considered as a convenient approach to exploit BGs in novel 3D bioprinting strategies, for example for the development of bioinks for 3D bioprinting. Examples of such applications will be presented with focus on recent developments in the field of hydrogel-bioactive glass systems as innovative multimaterial bioinks for cell encapsulation and for biofabrication of cell laden 3D scaffolds of increasing complexity [3, 4]. The challenges and opportunities for further research in the field will be discussed.

References

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