ADVANCES IN THE DEVELOPMENT OF NEW BIOACTIVE MATERIALS FOR TISSUE ENGINEERING

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Over the past few years bone tissue engineering (BTE) has undergone considerable progress demonstrating great potential for the reconstruction of damaged bone in comparison with conventional therapies. In this context, the used biomaterials in regenerative medicine should be able to support and promote the growth and repair of natural tissues. Bioactive glasses (BGs) have a great potential for bone tissue engineering application based on their osteoconductive and osteoinductive characteristics. This presentation is focused on cell behaviour on BGs with varying particle size (from nm to µm) and sample geometry (including dense discs, patterned surfaces, nanoparticles and highly porous scaffolds). As it is well known, BGs can bond to host bone and stimulate bone cells toward osteogenesis. Silicate BGs, e.g. 45S5 Bioglass®, exhibit positive characteristics for bone engineering applications considering that reactions on the material surface induce the release of critical concentrations of soluble Si, Ca, P and Na ions, which can lead to upregulation of different genes in osteoblastic cells, which in turn promote rapid bone formation. Bioactive glass (type 45S5) nanoparticles (nBG) with a mean particle size in the range 20-60 nm have been compared with µ-sized BG particles in relation to in vitro bioreactivity in simulated body fluid and in their response to osteoblast-like cells. Here, nanoscaled 45S5 bioactive glass particles can be considered a highly promising material for bone tissue engineering, providing very fast kinetics for bone-like hydroxyapatite formation (mineralisation) without any toxic effects on osteoblast cells. Initial cell attachment studies were carried out also on dense (polished) sintered Bioglass® samples and on micro-patterned surfaces. Osteoblast-like MG-63 cells and mesenchymal stem cells (MSC) seeded on micro-patterned bioactive glass surfaces showed different behaviour with MSC exhibiting a better initial attachment than MG-63 cells. Challenges in constructing bone scaffolds are the realisation of an interconnecting porosity, a high total porosity, and the optimisation of pore sizes for bone ingrowth, so that vascularisation is still possible. To obtain porous samples with trabecular architecture analogous to those of the cancellous bone, current research focuses on Bioglass® based glass-ceramic scaffold fabrication by the well-known foam replication method. The regenerative repair of damaged bone tissue requires also reparative cells. The differentiation of osteoblasts from stem cells is one of the first cell lineages that were identified from mesenchymal stem cells. They are also able to secrete cytokines and growth factors that are capable of establishing a regenerative microenvironment. Our examinations revealed good results in vitro for cell seeding efficacy, cell attachment, cell viability, proliferation and cell penetration onto 3D-scaffolds. Preliminary in vivo investigations have revealed also the angiogenic potential of bioactive glass both in particulate form and as 3D scaffolds confirming the high potential of bioactive glasses for bone regeneration strategies at different scales. Recent advances in nanotechnology, sintering, patterning as well as fabrication techniques for scaffolds, based on bioactive glasses, offer new opportunities to develop these advanced biomaterials for the next generation of implantable devices and bone tissue scaffolds with desired tissue-implant interaction.