Novel hybrid biomimetic macroporous composites with tuned biodegradability, improved osteointegration and anticancer properties for bone tissue regeneration (HyBioComBone)

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INTRODUCTION: The treatment of large bone defects (LBDs) represents a major challenge in clinical orthopedics. Patients with LBDs caused by trauma, infections, or tissue resections due to cancer, often undergo multiple surgeries with long recovery times leading to deteriorated life quality and increased healthcare costs. The project HyBioComBone aims to develop novel biomimetic macroporous composites with multifunctional properties for bone repair, regeneration, and cancer treatment.

EXPERIMENTAL: The composites will be designed by combining the interpenetrating network (IPN) hydrogels, inorganic nanostructured bioglasses (BAG), and multi-ion doped calcium phosphates (CaP). Optimized composites will be further developed in three directions: a) as carriers for the extracellular vesicles (EVs) derived from adipose-derived stem cells (ADSCs); b) for loading and controlled delivery of commercial and newly synthesized antiproliferative drugs, and c) for loading and controlled delivery of antibiotics.

RESULTS AND DISCUSSION: Biocompatible, bioresorbable, macroporous IPN hydrogels based on synthetic and natural polymers will be obtained. The network parameters of hydrogels will be tuned to obtain a broad range of materials with different biodegradability, mechanical and viscoelastic properties. Scaffolds, microgels, and 3D-printed hydrogels will be developed. Multi-ion doped bioactive inorganic particles (mesoporous BAG nanoparticles, rod-like HAp nanoparticles with morphology similar to the biological apatite, and highly bioactive calcinated CaP spherical microparticles) will be combined with the polymer matrix to improve bioactivity, provide therapeutic ions release and tune mechanical properties. The composites of desired properties will be loaded with commercially available antibiotics, to fight infection, and chemotherapy drug, for treatment of different types of cancer, but also with newly synthesized anticancer drugs. The encapsulation of ADSC-derived EVs in the composites with controlled biodegradation would enable the gradual release of EVs to the surrounding tissue and provide improved osteointegration and bone tissue regeneration.

CONCLUSIONS: New macroporous bioactive composites with adequate mechanical properties, biocompatibility, and tuned biodegradability for hard tissue restoration, coupled with either drugs for the prevention of osteosarcoma recurrence and/or osteomyelitis, or with adipose-derived EVs for the regeneration of large bone defects, will be developed through the project HyBioComBone.

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