MARGO: MAxillofacial bone Regeneration by 3D-printed laser-activated Graphene Oxide scaffolds

Main area: Soft graphene-based materials for tissue engineering
Keywords: Bone regeneration, 3D printing, antibacterial, graphene oxid
Duration: 36 months
Total project funding: € 450.000

Abstract

Reconstruction of maxillofacial defects, with the efficient restoration of tissue morphology, mechanical properties, vascularization, and innervation, is a critical medical challenge, particularly in aging patients. The jaws, with dentoalveolar joints, are crucial sites, in which regeneration is hardly achieved with available approaches, often requiring patient-tailored scaffolds that allow new bone growth and avoid graft retraction. Modern advances in tissue engineering are creating 3D printable scaffolds supporting the growth of bone mesenchymal stromal cells that cope with bone regeneration under suitable environmental stimuli. From computer-aided design (CAD) model obtained by medical imaging of patients, 3D printing technologies allow to accurately replicate the volumetric architecture of defects and improve surgical outcomes. This results in enhanced durability, aesthetics and low inflammatory complications. To ensure the success and widespread application of 3D printed bone scaffolds, biomaterials should be engineered to achieve desired functional, mechanical and supportive properties. However, biomaterials used for 3D printing have yet to be implemented to better control stem cell proliferation and differentiation into bone lineages. The MARGO project aims at constructing implants for stem cells driving on laser-activated 3D-printed CAD-based scaffolds. For this purpose, MARGO will use a Graphene Oxide (GO)-based biomaterial. GO is one of the most valuable graphene-related materials (GRMs) with promising results in bone regeneration and antibacterial activity. GO is a low-cost material, can be embedded in 3D printable polymers and has adjustable mechanical properties. Our strategy is based on the reconstruction of maxillofacial defects by CAD technology, 3D printing and laser modification of scaffold surfaces to enhance mammalian cell growth and finely tuned bone regeneration. Indeed, laser-printing of GO surfaces causes a local photo-thermal chemical reduction by removal of oxygen functionalities and allows the formation of nano-wrinkles along with precise geometric patterns. These reduced GO patterns increase stem cell adhesion and orientation and induce differentiation.

The pillars of MARGO are:
1) Scalable and patient-tailored designs by 3D printing;
2) Exploitation and driving of innate reparative capacity of mesenchymal stromal cells grown on laser reduced GO;
3) Direct control of bone formation, antibacterial action, and vascularization via laser activation.

Our breakthrough technology allows precise mimicking of damaged bone and controllable deposition of extracellular matrix components together with high yield in terms of cell growth and differentiation and efficient antibacterial action. The strong synergy emanating from the consortium partners' interdisciplinarity and the pioneering MARGO technology have a manifest connection with the FLAGSHIP topics "Osteoinductivity and immunization capacity of GRMs" and "Soft graphene-based materials for tissue engineering".

Consortium

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