Micromaterials for reinforcing living implants for application in wound healing and regenerative medicine

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Abstract

Hydrogel-based biomaterials have been developed and reinforced with micromaterials to alleviate anoxic stress, stimulate vascularization, and improve the engraftment of cellularized implants[1-4]. However, the effects of self-oxygenation materials on different aspects of regenerative medicine such as healing of the myocardium after myocardial infarction (MI) or stem cell fate in cellularized hydrogels have not yet been studied.

In my talk, I will shine some light on oxygenating biomaterials that were mixed with different tissue-adhesive hydrogels for two different applications: 1.) Better tissue regeneration in MI and 2.) Stem cell fate commitment for regenerative medicine such as bone regeneration (**Figure 1**). Calcium peroxide as the source of oxygen was encapsulated in polycaprolactone to produce oxygenating microparticles with prolonged oxygen release profiles[1]. These oxygen-generating microparticles were incorporated into bioadhesive silk-alginate or gelatin methacryloyl (GelMA) based hydrogels with or without mesenchymal stem cells (MSCs), for MI and osteochondral differentiation, respectively. For MI, these hydrogels were conjugated with stromal cell derived factor (SDF) to orchestrate chemotaxis and angiogenesis and generate oxygen via oxygenating microparticles (OMPs) to alleviate the cytotoxic anoxic environment. Silk fibroin (SF) was explored to endow elasticity and resilience to the injectable hydrogel. Additionally, tyramine (TA) was conjugated to alginate (TA-Alg) and SF, producing a mechanically robust and tissue adhesive hybrid hydrogel (TSF) that encourages tissue adhesion and enhances the injectability of the hydrogels.

For stem cell fate commitment for bone tissue engineering applications, oxygen-generating microparticles were incorporated into GelMA hydrogels in the presence/absence of osteoinductive silicate nanoparticles (SNPs). A comparative study revealed the osteogenic fate of hMSCs in the designed hydrogels under normoxic (the gold standard for in vitro cultures) and anoxic (common in large bone defects; <0.1% oxygen) conditions.

References

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Figures

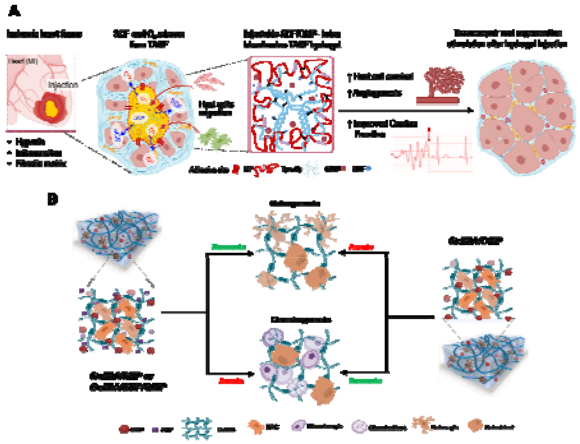

Figure 1. A). Schematics showing for myocardial infarction (MI) healing process by oxygenating and cardioprotective tissue adhesive tyramine conjugated alginate and silk fibroin (TSF) hydrogels encapsulated with oxygen releasing microparticles (OMPs) and conjugated stromal differentiation factor (SDF) applied at the ischemic site and the corresponding vessel regeneration and improved contractile function due to host cells migration and then their survival and maturation at the injured area. B). Depiction of the effect of OMP, SNP, and OMP+SNP on the differentiation fate of hMSCs toward osteogenesis or chondrogenesis under normoxia and anoxia, respectively.