Hydrogen peroxide releasing biomaterials for vascularization in bone tissue regeneration

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In the United States, 5-10% of bone fractures result in nonunion. Traditional solutions such as autografts and allografts have significant side effects, including donor site morbidity and disease transmission, respectively. Although new regenerative engineering treatments have been developed, their high cost and limited scalability have prevented their widespread clinical adoption. An additional limitation of bone tissue regeneration is inherent tissue complexity as vascular and neural networks must be regenerated in addition to osteoblasts. The Biomodulatory Materials Engineering Laboratory is working to develop a cheaper and more widely applicable option for large volume bone repair using novel biomaterials. This project focuses specifically on using the simple signaling molecule hydrogen peroxide to induce the differentiation of endothelial cells from mesenchymal stem cells for bone tissue vascularization applications.

First, the therapeutic window for the differentiation of mesenchymal stem cells into endothelial cells using hydrogen peroxide was determined by exposing the cells to various concentrations of hydrogen peroxide for one, three, and seven days. Proliferation and differentiation of the cells was determined for each timepoint using DNA/ATP assays and fluorescent microscopy, respectively. A novel hydrogen-peroxide-releasing biomaterial was then synthesized by modifying glutamic acid with hydrogen peroxide to form a peroxy acid (i.e., perglutamic acid).

Future research will focus on leveraging perglutamic acid as a monomer for various degradable polymers (e.e, polyanhydrides, polyesters, polyamides), for which cell studies can be conducted guided by the already established therapeutic window. The effects of these new biomaterials on off-target cells will also be studied. After biomaterials for osteogenesis, angiogenesis, and neurogenesis have each been synthesized, they can be integrated for large volume bone repair through tissue regeneration.