Application of 3D-Bioprinting and Electromagnetic Field for the Development of Bioartificial Bone from Stem Cell-Laden Bioink Incorporating Sepiolite and Eggshell

Elcin, Tan (School: Ted Ankara College Foundation Private High School)

Methods of regenerative medicine have the potential to overcome the limitations of conventional medicine in treating complex bone defects. In this project, to address these limitations, the regenerative approach of bone tissue engineering was embraced with 3D-bioprinting and low frequency-pulsed electromagnetic field (LF-PEMF) technologies by developing a bioartificial draft tissue construct capable of osteogenic differentiation and reflective of suitable properties for prospective in vivo studies. For that purpose, an optimized composite bioink formulation comprised of gelatin methacrylate, sepiolite and eggshell was suspended with mesenchymal stem cells and extruded through a 3D-bioprinter to generate cellular 3D-structures in designed forms. These 3D-bioprints were then cultured up to 20 days under LF-PEMF-exposed and unexposed conditions, while specific parameters were evaluated. The release of a model protein from the constructs was also investigated. The results obtained from biochemical, histochemical, and immunohistochemical evaluations indicated the in vitro osteogenic differentiation of 3D-bioprinted constructs in both LF-PEMF-exposed and unexposed groups. However, the LF-PEMF-exposed group demonstrated a higher level of osteogenesis. Besides, the prints with the proposed bioink showed a sustained release of the model protein. Overall, the experimental design and the proposed bone construct supported the osteogenic differentiation of mesenchymal stem cells. While also addressing the limitations of the studied field and providing an alternative tissue-specific bioink model using LF-PEMF, the study gathered evidence for in vivo studies and contributed to the vision for a regenerative and personalized treatment modality that can cope with complex bone defects.

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