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CELLULAR RESPONSE IN THREE- DIMENSIONAL (3D) MICROENVIRONMENTS/CONSTRUCTS UNDER MICROGRAVITY

Abstract

The world is facing a significant increase in ageing population and as such tissue engineering and regenerative medicine development is critical to ensure the healthcare and well-being of humanity now and into the future. However, before we can reach the ultimate goal of tissue/organ replacement, fundamental understanding into the underlying mechanisms of cellular regeneration and homeostasis must first be elucidated to allow control and development of personalized tissue engineering. The microgravity environment enables a scaffold free and nozzle free technique to form cellular constructs.

Most importantly, cells have been shown to remain viable in the microgravity environment. Several cellular processes are affected by exposure to microgravity, including growth, differentiation, migration and cell-cell interactions. The way these processes are affected differs per cell type and have been observed by identifying alterations in gene expression. It has been shown that stem cells can preserve their stemness in microgravity, while differentiation into a specific cell type also improves under the right conditions. These results indicate the relevance of continued research into the altered cellular processes in microgravity.

Moreover, in microgravity cells are triggered to form spheroids with increased yield, greater size and improved viability compared to control samples on earth. The consequently formed spheroids could have a multitude of earthly and in-orbit applications. For instance, spheroids can be useful models in cancer research by simulating tumor growth, metastasis and testing drug efficacy. Also, stem cell spheroids can be used to produce differentiated cells with increased yield. Although much has to be discovered about the mechanisms of spheroid formation, different gene and protein targets have been identified that influence spheroid formation. This implies the possibility to control spheroid formation in G or even trigger spheroid formation without the need of G exposure.

The microgravity environment creates the unique opportunity of growing cells without the need of a scaffold. Studies show promising results for the formation of constructs for cartilage, blood vessel, thyroid and bone tissue. Several tissues have not yet been investigated extensively. These first steps into the realm of microgravity tissue engineering are promising and could improve health on earth by bringing us a step closer to the in vitro creation of tissues and organs for applications in transplantations, drug and product safety testing and personalized medicine. Future research should focus on the formation of larger constructs in microgravity and the acclimatization of the cellular constructs from microgravity to earths gravity.