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TISSUE ENGINEERING ON THE EARTH AND IN SPACE

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At present the issue of organ donation is rather acute. One of the ways to overcome this challenge is tissue engineering. Here an attempt is made to provide an insight into the biotechnical achievements of modern scientists in tissue engineering.

Traditional tissue engineering (TE) strategies are based on using biocompatible scaffolds for seeding cells; this concept was initially proposed by Langer and Vacanti [5]. According to this concept, «scaffold» could be defined as a «temporal and removable support,» which makes it different from nonbiodegradable permanent implants and prostheses. Thus, the biodegradable scaffolds are considered as the most critical and essential element of TE technology framework that enables biofabrication of three-dimensional (3D) organ constructs and development of TE industry [1].

Apart from traditional scaffold-based tissue engineering, the novel «scaffold-free» approach, which does not require structural biomaterials, is being under investigation. Scaffold-free TE implies temporary supporting platforms that enable cell (or tissue spheroids) self-assembly or self-organization, proliferation, differentiation, and extracellular matrix (ECM) production. Some of them involve the use of different carrying temporal and removable support ranging from removable metallic needles or removable agarose hydrogel. At the same time, there are several strategies based on the living material self-assembly guided by field forces such as magnetic force, acoustic force, electrostatic force, and microgravity [4]. In particular, TE implies principles of magnetic levitation first demonstrated by Geim's group [6] on living objects and then successfully used in chemistry, material science, and biochemistry. This approach uses magnetic levitation to guide the self-assembly of diamagnetic objects (cells or tissue spheroids) into 3D constructs in a paramagnetic fluid medium in the magnetic field gradient generated by strong magnets. In previous study, scientists [2] carried out the successful scaffold-free, label-free, and nozzle-free magnetic levitational bioassembly of tissue-engineered construct using chondrospheres as building blocks. This approach has been implemented in space.

The choice of cartilage bioassembly in space experiments is determined, in particular, by a growing interest in the evaluation of effects of microgravity on human intervertebral discs and articular cartilages in the case of long-term spaceflights. So far, there have been performed just two studies on biofabrication of cartilage in space [4]. This is because space experiments are extremely expensive and time-consuming. In their seminal study, Freed [7] grew bovine articular chondrocytes on polyglycolic acid scaffolds in rotating bioreactors for 3 months on Earth. After that, cartilaginous constructs were cultured aboard the Mir Space Station or on Earth for 4 months. In contrast, Stamenković [8] grew porcine chondrocytes into cylindrical chambers under microgravity conditions on the International Space Station (ISS), under simulated microgravity conditions on a random positioning machine and normal gravity for 16 days [3].

Both experiments are revolutionary in their own way and have made a breakthrough in tissue engineering both on the Earth and in space.

References

1. Chan B.P., Leong K.W. Scaffolding in tissue engineering: general approaches and tissue-specific considerations // US National Library of Medicine. 2008.
2. Pina S., Ribeiro V.P., Marques C.F., Maia F.R., Silva T.H., Reis R.L., Oliveira J.M. Scaffolding Strategies for Tissue Engineering and Regenerative Medicine Applications // US National Library of Medicine. 2019.
3. Rosenzweig D.H., Chicatun F., Nazhat S.N., Quinn T.M. Cartilaginous constructs using primary chondrocytes from continuous expansion culture seeded in dense collagen gels // National Library of Medicine. 2013.
4. Parfenov V.A., Khesuani Y.D., Petrov S.V., Karalkin P.A. Magnetic levitational bioassembly of 3D tissue construct in space // Science Advances. 2020.
5. Langer R., Vacanti J. Tissue engineering // Science. 1993.
6. Berry M.V., Geim A.K. Of flying frogs and levitrons // European Journal of Physics. 1997.
7. Freed L.E., Langer R., Martin I., Pellis N.R., Vunjak-Novakovic G. Tissue engineering of cartilage in space // Proceedings of the National Academy of Sciences. 1997.
8. Stamenković V., Keller G., Nesic D., Cogoli A., Grogan S.P. Neocartilage formation in 1 g, simulated, and microgravity environments: Implications for tissue engineering // Tissue Engineering. Part A. 2010.