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CURING DISEASE IN SPACE FOR EARTH: DEVELOPMENTS IN REGENERATIVE MEDICINE RESEARCH DURING SPACEFLIGHT ENABLE BIOMANUFACTURING OF STEM CELLS FOR THERAPIES

Abstract

Purpose: Over the last two decades, there have been tremendous advancements in stem cell biology research and innovations in space technologies, coupled with increasing interest from the International Space Station (ISS) to use microgravity for research and product development with potential benefits on Earth. Stem cells have properties which make them suitable to use for regenerative applications due to their unlimited self-renewal and ability to differentiate into other cell types. Many opportunities exist in investigating stem cell behavior in space relevant to regenerative medicine applications including disease modeling, stem cell-derived products, biofabrication, three-dimensional (3D) organoid formation and developing cellular therapies, all of which pose potential benefits for use on Earth. Therefore, the aim of our research project is to better understand all the evidence available about stem cell research conducted in space aboard the ISS to inform regenerative medicine applications. We discuss the advantages which microgravity provides stem cells by allowing a more natural 3D state for their expansion which closely resembles growth of cells in the human body. We also identify the limitations and gaps which exist in our knowledge, scientific methods and funding capabilities of turning in-space stem cell therapies a reality for patients. Also, stem cells grown in space for research and subsequent therapies must follow the best practices currently in place including those outlined by the International Stem Cell Initiative (ICSI) and International Society for Stem Cell Research (ISSCR). Nonetheless, major developments and discoveries have occurred in the past decade alone which can propel this unique branch of regenerative medicine further. Conclusion: Our work provides a roadmap of the developments which have occurred in recent years on the growth of safe, viable and effective stem cells in space for potential use on Earth within regenerative medicine practices, including future directions. We also discuss the potential opportunities available for commercialization of these in-space stem cells and associated challenges and solutions. Investigating stem cells in space for potential use in cellular therapies on Earth is highly relevant in today's world where novel approaches are constantly required to help advance the medical field forwards. Incorporating microgravity into projects of a translational nature may lead to benefits towards patients on Earth to address important developmental and aging disorders, injuries, and diseases across different organ systems. The results of our work provide information fundamental to stem cell biology while broadening the perspective about regenerative medicine innovation in space.