Journal of Experimental and Basic Medical Sciences 2024;5(1):39-43

Review

Revolutionizing Health Technologies: The Transformative Power of Stem Cells

Tutku Özaydın[1], Kerem Can Tunç[1], Oytun Erbaş[1]

ABSTRACT

People have always sought to live a healthy life, find cures for diseases, and develop new treatments for illnesses throughout their lives. Therefore, various research has been conducted from the past to the present day. Stem cell therapy, an innovative approach according to the treatment methods found, has attracted the attention of researchers with a wide range of treatment options. Stem cells can self-renew, proliferate, differentiate, and contribute to the healing of many diseases with the treatment options they offer. The use of stem cells obtained from many tissues in health technology, and their active role in regenerative medicine applications, excites the scientific community. In this chapter, stem cells, their types, and their application areas in health technology are briefly described.

Keywords: Stem cell, stem cell treatments, health technology, innovation.

Stem cells are the primary source of all cells in our body and are the building blocks of tissue and organs. They can divide extensively, self-renew, and regenerate damaged tissue to restore its previous function. They are undifferentiated cells that can differentiate into specialized cells.[1] The genes found in the cell nucleus control which cell the stem cell will differentiate into. They can turn into different cell types according to the signals coming from these genes, and their differentiation capacity is quite high.[2]

Stem cells are primarily classified into three groups based on their differentiation potential: totipotent, pluripotent, and multipotent. Totipotent stem cells are cells that can form an entire organism.[3]

A totipotent stem cell, such as the zygote, is the first embryonic stem cell (ESC) with the ability to differentiate into all cell types that make up the organism from the start.[2] These cells can differentiate into all cell types that can form the whole organism. Pluripotent and multipotent stem cells observed after the embryonic stage, unlike totipotent stem cells, cannot form a new organism but are reserved in the organism to produce the required cell lines.[4]

[1]ERBAS Institute of Experimental Medicine, Illinois, USA & Gebze, Türkiye

Correspondence: Tutku Özaydın. Institute of Experimental Medicine, 41470 Gebze-Kocaeli, Türkiye

E-mail: tutku.ozaydiin@gmail.com

Cite this article as: Özaydın T, Tunç KC, Erbaş O. Revolutionizing Health Technologies: The Transformative Power of Stem Cells. JEB Med Sci 2024;5(1):39-43.

doi: 10.5606/jebms.2024.1071

Received : October 26, 2023
Accepted : November 5, 2023
Published online : February 26, 2024

In laboratory conditions, these types of stem cells can differentiate into more cell types when provided with the necessary conditions and signals.[3]

There are two main types of stem cells: Embryonic stem cells and adult stem cells (ASCs). Adult stem cells are further divided into hematopoietic stem cells (HSCs) and mesenchymal stem cells (MSCs). Hematopoietic stem cells can differentiate into all blood cell types and can be obtained from bone marrow, cord blood, peripheral blood, and fetal liver. Mesenchymal stem cells are located in the bone marrow stroma and can differentiate into cells such as bone, cartilage, muscle, tendon, ligament, and fat.[5]

STEM CELLS IN HEALTH TECHNOLOGIES

Stem cell therapies in the field of healthcare are applications that use stem cells or stem cell-derived cells for repairing or renewing damaged cells or tissues. Stem cells attract the attention of researchers due to their ease of access, ability to differentiate into many cell types, ability to proliferate, and safe transplantation. Stem cell studies play an important

role in embryonic processes, cellular development, and differentiation mechanisms, drug research, creating various disease models, and developing new treatments in the field of regenerative medicine.[6]

Stem Cells and Drug Discovery

Developing new drugs is costly and time-consuming. The discovery and development of drugs using stem cells have great potential to reduce costs and save time. This potential has made stem cells a valuable resource in pharmaceutical research. Cells for drug research can be obtained from primary tissue, immortalized tumor cells, or genetically modified cells. Human induced pluripotent stem cells (iPSCs) can also be used for drug discovery studies. However, it has been observed that it takes a long time and is costly to obtain completely differentiated cell types using iPSCs, ASCs and ESCs are also among the types of stem cells used for drug discovery. Developing methods, conducting high-throughput drug screening, and evaluating toxicity will make stem cell models more active in drug discovery.[7]

STEM CELL THERAPY FOR DISEASES

Neurological Disorders

Examples of human neurodegenerative disorders include Parkinson's disease (PD), Huntington's disease, Amyotrophic lateral sclerosis, Alzheimer's disease (AD), stroke, or spinal cord injury. These diseases are caused by the loss of neurons and glial cells, which are the supporting cells of the brain and spinal cord. Studies have shown positive results in producing neurons and glial cells from stem cells such as ESCs, MSCs, and neural stem cells (NSCs). Stem cell-based cell therapies for neurodegenerative disorders are still being developed.[8] It is known that there are regenerative stem cells in the central nervous system. These cells contribute to recovery in conditions such as stroke or paralysis, but their limited numbers result in limited effects. Therefore, delivering them externally is considered a suitable option for treatment. Studies using fetal tissue as a source of stem cells have also yielded positive results for some diseases. Additionally, autologous stem cells obtained from the patient's bone marrow are seen as an ideal source, and HSCs are stem cells capable of self-renewal and differentiation into mature blood cells. It has been shown that HSCs can differentiate into neuronal cells under suitable conditions.[9]

Parkinson's disease is one of the most common neurodegenerative disorders where stem cell therapy is being investigated. It affects about 0.3% of the general population. Although current treatments can significantly improve the quality of life for many PD patients, they have not been able to slow down or stop the progression of the disease. Numerous clinical and preclinical studies have shown that ESC and iPSCs have a positive impact on PD treatment.[10]

Stem cells are one of the treatment modalities used for AD therapy. Most of the currently available drugs for AD treatment in the market only reduce the emergence of the disease or slow down its progression. These drugs cannot reverse or cure existing AD in any way. Therefore, there is a need to develop a treatment that can not only stop the progression of the disease but also restore the damaged brain's function and combat the pathogenic process of the disease.[11]

Clinical studies show that stem cells have the potential to be suitable for AD treatment. When considering the early stages of the disease, stem cells are thought to not only halt the progression of the disease but also reverse its symptoms.[12]

Promising studies are ongoing for these new and effective treatments, but several issues need to be resolved before stem cell therapy for neurological disorders can be adopted. Firstly, it is necessary to determine which type of stem cells would be the most suitable source for treatments. A better understanding of the mechanism by which stem cell transplantation would lead to regeneration or functional recovery is also required. Solid progress in stem cell research is crucial for developing stem cell-based treatments for neurological disorders.[8]

Cardiovascular Diseases

Despite the progress in treatments for cardiovascular diseases, developing innovative treatment options is still important. Stem cell therapy emerges as an effective treatment approach in this field. Many studies have shown that stem cell therapy could be a suitable therapeutic approach for the treatment of heart diseases.[13]

Laboratory experiments and recent clinical trials have shown that cell-based therapies can improve heart function and have a positive effect on heart regeneration. In these experiments, it has been demonstrated that cardiac stem cells can differentiate into various cell types found in the heart, including heart muscle cells, and contribute to the formation of new blood vessels in the heart.[14,15]

These new findings suggest that stem cell therapy can prevent and even improve the progression of cardiovascular diseases.[14]

It is very important to elucidate the mechanisms that underlie the beneficial effects of stem cell transplantation in cardiovascular diseases. Based on these beneficial mechanisms, researchers should develop different therapeutic strategies to enhance the power of stem cell repair and shape the future of stem cell therapies. The key issue to be considered is not a uniform therapeutic intervention for all patient groups in these promising therapies, but rather the development of treatments that are appropriate for individual disease parameters. Since cardiovascular diseases are complex disorders, the selection of stem cell type, dosage, and transplantation method should be more personalized.[16]

Skin Wounds and Skin Aging

The skin is composed of three layers, the epidermis, dermis, and hypodermis, and is considered one of the most vital organs in the body due to its protective barrier function against various external factors. A wound or injury is defined as any disruption in the normal tissue structure of the skin that can result in tissue loss. The repair of wounds on the skin is a complex biological process that occurs in all tissues and organs of the human body. The focus of stem cell therapy in wound healing is to enhance the quality of wound healing. Researchers aim to accelerate wound healing, prevent scar formation, and promote earlier wound closure through the use of stem cells. Embryonic stem cells, iPSCs, and ASCs can be used for wound healing and regeneration of injured skin.[17]

Another area where the therapeutic properties of stem cells are used is skin aging. Skin aging, which occurs naturally, is a condition that worsens and accelerates due to factors such as inadequate and improper nutrition, exposure to ultraviolet radiation, and the use of alcohol and tobacco. Mesenchymal stem cells have the potential for regeneration and can be applied to damaged and aged skin, promoting rapid cell proliferation in skin regeneration. In skin rejuvenation, researchers emphasize that MSCs support the production of collagen and elastic fibers and protect the skin from aging caused by ultraviolet radiation.[18]

Ocular Diseases

Stem cell therapies are extensively researched to restore neural circuits or derive endogenous retinal neurons from stem cells for degenerative eye diseases. In these treatments, it has been observed that ESCs, iPSCs, and endogenous retinal stem cells can replace lost photoreceptors and retinal pigment epithelial cells. Additionally, the visual ability of the diseased eye has been restored as a result of these treatments.[19]

The eyes are a unique organ for examining and observing the effects of MSCs, as the external location makes the application of treatment easier and the responses to treatment more understandable. Successful healing of injured retinal ganglion cells was achieved with treatment using MSCs, and MSCs showed the potential for transdifferentiation into cornea epithelium and cornea-specific cell types during the wound healing process.[19,20]

Cancer Treatment

Cancer, characterized by the uncontrolled proliferation of abnormal cells and abnormal recognition by the immune system, is a globally lethal disease and poses a serious threat to human health. The merging of the developing field of stem cells with cancer is generating unprecedented sparks in the development of new treatments for cancer.[21] Currently, numerous stem cell-based therapies are being investigated in preclinical trials, offering great promise for cancer treatment. The differentiation capacity of stem cells is crucial for applied cancer treatment. The stem cells selected for cancer treatment should be selected according to the type, progression, and treatment purpose of the cancer.[22]

Studies have shown that MSCs, in particular, can affect the immune system by helping to support immune function in the face of a threat and can migrate to tumor areas. Due to their ability to harbor tumors, MSCs are considered promising tools for selectively administering anticancer drugs to patients. Transplantation of bone marrow or HSCs is also commonly used in the treatment of lymphoma, leukemia, and multiple myeloma.[23]

Like any newly tested treatment, unwanted situations can also occur during the implementation of stem cell therapies. The biggest challenge in cancer treatment is the development of chemotherapy resistance in a small subpopulation of cancer stem cells (CSCs) and the recurrence and progression of the disease. It is known that the failure to eliminate existing cancers is an important mechanism underlying the resistance of CSCs to current cancer treatments. For this reason, CSCs have become an important focus in current cancer research. Due to their metabolic similarities, the differences between CSCs and normal stem cells need to be investigated and addressed. Developing new effective treatments that can eliminate CSCs without damaging normal cells can reduce the risk of relapse and metastasis.[24]

Diverse Applications of Stem Cells Across Various Fields

Stem cells have been identified in many tissues, including bone marrow, umbilical cord, blood, intestine, skin, muscle, brain, and heart. Comprehensive preclinical and clinical studies have demonstrated the structural and functional regeneration abilities of stem cells in these tissues.[25]

Stem cell research is also being conducted for a vital organ, the liver. There are over 100 types of liver diseases, and liver diseases are a leading cause of death worldwide. Problems in the liver can lead to liver failure and irreversible damage to the liver. Scientists are using stem cells to develop treatments for liver diseases. One example of this is the production of hepatocytes, the main parenchymal cell in the liver, which makes up approximately 70-85% of the liver. Stem cells could be a promising method for reducing the need for liver transplants in the future.[26]

Another field where stem cells are used is Type 1 diabetes, which occurs when insulin hormone is deficient in the body. The required treatment is to prevent β cell loss and rescue endogenous insulin production. Studies are being conducted to derive β cells from iPSCs for the treatment of Type 1 diabetes.[27]

Stem cell therapy is also important in dentistry, gene therapy, muscle-tendon and ligament injuries, spinal cord injuries, anemia, and epilepsy treatment. Research is ongoing in these areas, and promising results are being obtained.[28-31] In particular, ESCs, MSCs, NSCs, and iPSCs have been applied in preclinical animal studies and clinical trials for epilepsy treatment. Stem cell therapy is a promising new therapeutic strategy for epilepsy. The cell therapies being studied can be a viable option for long-term seizure control, especially in drug-resistant epilepsy.[31] Looking at the broad range of applications, it can be seen that stem cells have attracted researchers' attention and have become an important part of health technology.

In conclusion, research and clinical trials have shown that stem cell studies have been given a significant place in healthcare technology. Stem cells have provided hope for patients in many areas such as cancer and AD, drug discovery, neurological and cardiological treatments, skin wounds, and eye diseases. As experience with research and clinical trials increases, the effects of treatments will be clarified and new horizons will be opened in the field of regenerative medicine. Mesenchymal stem cells and iPSCs are particularly expected to be used for the treatment of many health problems in the future. Resolving problems that arise in treatments, determining the appropriate stem cell type to be used, and selecting the appropriate method is of great importance in the development of stem cell technology. It is clear that promising stem cell studies will increase further in the future and will surpass many existing treatments.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Ateş U. Let's Get to Know the Stem Cell, FNG & Science Journal of Medical Transplantation 2016;1:19-28.
2. Çerçi E, Erdost H. Stem Cells, Ataturk University Journal of Veterinary Sciences 2019;14:221-8.
3. Yalçın MB, Bora ES, Erdoğan MA, Çakır A, Erbaş O. The Effect of Adipose-Derived Mesenchymal Stem Cells on Peripheral Nerve Damage in a Rodent Model. J Clin Med. 2023 Oct 9;12:6411.
4. Çoban Z. D, Güran Ş. Use of applications for activation or silencing of a desired gene by gene transfer in stem cells in regenerative medicine, Cumhuriyet Medical Journal 2013;35:138-42.
5. Cannazik O, Polat B. Application Areas in Stem Cells and Veterinary Medicine, Atatürk University Journal of Veterinary Sciences 2014;9:198-205.
6. Çavuşoğlu T, Yılmaz Ö, Uyanıkgil Y, Ateş U, Aktaş E. Ö, Baka M. Stem Cell Studies in Turkey; Current Situation from an Ethical and Legal Perspective 2017;3:95-102.
7. Lou YJ, Liang XG. Embryonic stem cell application in drug discovery. Acta Pharmacol Sin. 2011 Feb;32:152-9.
8. Kim SU, Lee HJ, Kim YB. Neural stem cell-based treatment for neurodegenerative diseases. Neuropathology. 2013 Oct;33:491-504.
9. Şahin F, Saydam G, Omay SB. Stem Cell Plasticity and Stem Cell Therapy in Clinical Practice, Turkish Journal of Hematology-Oncology 2005;15:48-56.
10. Sonntag KC, Song B, Lee N, Jung JH, Cha Y, Leblanc P, et al. Pluripotent stem cell-based therapy for Parkinson's disease: Current status and future prospects. Prog Neurobiol. 2018 Sep;168:1-20.
11. Liew LC, Katsuda T, Gailhouste L, Nakagama H, Ochiya T. Mesenchymal stem cell-derived extracellular vesicles: a glimmer of hope in treating Alzheimer's disease, International Immunology. 2017 Jan;29:11-9.
12. Duncan T, Valenzuela M. Alzheimer's disease, dementia, and stem cell therapy. Stem Cell Research & Therapy. 2017;8:111.
13. Goradel NH, Hour FG, Negahdari B, Malekshahi ZV,

Hashemzehi M, Masoudifar A, et al. Stem Cell Therapy: A New Therapeutic Option for Cardiovascular Diseases. J Cell Biochem. 2018 Jan;119:95-104.

14. Segers, V, Lee, R. Stem-cell therapy for cardiac disease. Nature 2008;451:937-42.
15. Abbott JD, Giordano FJ. Stem cells and cardiovascular disease. J Nucl Cardiol. 2003 Jul-Aug;10:403-12.
16. Müller P, Lemcke H, David R. Stem Cell Therapy in Heart Diseases - Cell Types, Mechanisms and Improvement Strategies. Cell Physiol Bioc hem. 2018;48:2607-55.
17. Dehkordi AN, Babaheydari FM, Çehelgerdi M, Dehkordi SR. Skin tissue engineering: wound healing based on stem-cell-based therapeutic strategies. Stem Cell Res Ther 2019;10:111.
18. Yigitturk G, Erbas O, Karabay Yavasoglu NU, Acikgoz E, Buhur A, Gokhan A, et al. The neuro-restorative effect of adipose-derived mesenchymal stem cell transplantation on a mouse model of diabetic neuropathy. Neurol Res. 2022 Feb;44:156-64.
19. Mead B, Berry M, Logan A, Scott RA, Leadbeater W, Scheven BA. Stem cell treatment of degenerative eye disease. Stem Cell Res. 2015 May;14:243-57.
20. Venkatakrishnan J, Saeed Y, Kao WW. Trends in using mesenchymal stromal/stem cells (MSCs) in treating corneal diseases. Ocul Surf. 2022 Oct;26:255-67.
21. Yin W, Wang J, Jiang L, James Kang Y. Cancer and stem cells. Exp Biol Med (Maywood). 2021 Aug;246:1791-801.
22. Chu DT, Nguyen TT, Tien NLB, Tran DK, Jeong JH, Anh PG, et al. Recent Progress of Stem Cell Therapy in Cancer Treatment: Molecular Mechanisms and Potential Applications. Cells. 2020 Feb 28;9:563.
23. Lan T, Luo M, Wei X. Mesenchymal stem/stromal cells in cancer therapy. J Hematol Oncol. 2021 Nov 17;14:195.
24. Chae YC, Kim JH. Cancer stem cell metabolism: target for cancer therapy. BMB Rep. 2018 Jul;51:319-26.
25. Gurusamy N, Alsayari A, Rajasingh S, Rajasingh J. Adult Stem Cells for Regenerative Therapy. Prog Mol Biol Transl Sci. 2018;160:1-22.
26. Wang J, Sun M, Liu W, Li Y, Li M. Stem Cell-Based Therapies for Liver Diseases: An Overview and Update. Tissue Eng Regen Med. 2019 Feb 21;16:107-18.
27. Loretelli C, Assi E, Seelam AJ, Ben Nasr M, Fiorina P. Cell therapy for type 1 diabetes. Expert Opin Biol Ther. 2020 Aug;20:887-97.
28. Mautner K, Blazuk J. Where do injectable stem cell treatments apply in treatment of muscle, tendon, and ligament injuries? PM R. 2015 Apr;7:33-40.
29. Shao A, Tu S, Lu J, Zhang J. Crosstalk between stem cell and spinal cord injury: pathophysiology and treatment strategies. Stem Cell Res Ther. 2019 Aug 6;10:238.
30. Anurogo D, Yuli Prasetyo Budi N, Thi Ngo MH, Huang YH, Pawitan JA. Cell and Gene Therapy for Anemia: Hematopoietic Stem Cells and Gene Editing. Int J Mol Sci. 2021 Jun 10;22:6275.
31. Chang BL, Chang KH. Stem Cell Therapy in Treating Epilepsy. Front Neurosci. 2022 Jun 27;16:934507.