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Comprehensive research progress in stem cell therapy

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Abstract. Stem cell therapy is increasingly recognized as an innovative and transformative approach in the field of medicine, with the potential to address tissue damage and manage intricate medical conditions. The utilization of induced pluripotent stem cells (iPSCs) presents a potential avenue for cardiac regeneration in the context of cardiovascular ailments, such as myocardial infarctions. Liver regeneration techniques utilizing mesenchymal stem cells (MSCs) are being offered as potential solutions for end-stage liver failure. Furthermore, stem cell therapy is regarded as a promising intervention for neurodegenerative disorders and ocular conditions, with disease-specific induced pluripotent stem cells (iPSCs) emerging as a frontrunner in prospective therapeutic approaches. The objective of this study is to investigate the advancements made in stem cell therapy research for the diseases mentioned above. It will involve a comprehensive analysis of the mechanisms and principles underlying stem cell treatment in these areas, as well as an examination of the factors that impede the progress of stem cell therapy. Additionally, this paper will offer insights into potential future directions for development in this field.

Keywords: Stem Cell Therapy, Mesenchymal Stem Cells, Pluripotent Stem Cells.

1. Introduction

Numerous research papers in the field of medicine have thus far suggested that cell therapy has considerable promise as an efficacious treatment modality capable of substituting and restoring impaired tissues [1]. Recent studies have demonstrated that stem cells have the potential to effectively address certain complex medical conditions that pose challenges for conventional pharmaceutical and medical interventions. This promising development holds considerable advantages for prospective patients in the future. Stem cell therapy is currently exhibiting its potential in diverse domains, with significant investments being made in this realm and a multitude of state-of-the-art clinical trials underway. The field of stem cell research and therapy is continuously advancing, showcasing its ever-growing promise. At present, stem cells have been utilized in diverse domains of medical practice, including the management of in vivo organ ailments as well as neurodegenerative conditions [2]. Presented below are several illustrations of stem cell therapy.

Cardiovascular disease is the leading cause of death worldwide, with myocardial infarction being one of the primary problems. After a heart attack, the heart undergoes a series of adverse remodeling processes, leading to damage to the heart's structure and function, eventually leading to heart failure [1]. Because adult cardiomyocytes cannot proliferate, adult mammalian hearts have limited regenerative

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capacity and are unable to repair the cardiac damage that occurs post-myocardial infarction. Therefore, stem cell therapy is considered a promising treatment strategy for repairing damaged heart tissue. Although early adult stem cell therapies had limited success, pluripotent stem cells, particularly induced pluripotent stem cells (iPSCs), are regarded as an infinite source of cardiomyocytes, offering new possibilities for cardiac regeneration [3].

The liver is a vital organ for sustaining life, responsible for bile production, nutrient metabolism, toxin removal, blood purification, and immune response. There are many types of liver diseases, including hepatic schistosomiasis, hepatitis, alcoholic liver disease, fatty liver disease, genetic disorders, and cirrhosis, which may lead to liver failure and irreversible liver damage. End-stage liver disease is gradually becoming a leading cause of death worldwide, with many potential treatment options, including medications, artificial liver, and endoscopic and vascular interventions for portal hypertension. However, these treatments can only alleviate clinical symptoms to a certain extent. The reversal of liver function is challenging due to the reduction in the quantity of hepatic cells. At present, orthotopic liver transplantation stands as the sole efficacious intervention for end-stage liver disease. However, the limited availability of liver organ donors, the necessity for prolonged administration of immunosuppressive medicine to mitigate post-transplant rejection, and the substantial financial burden associated with therapy and medication impose constraints on its widespread implementation. The utilization of primary hepatocyte transplantation as a viable substitute for liver transplantation is constrained by the scarcity of donor cells and their low capacity for in vitro growth [4]. Fortunately, recent advancements in the field of regenerative medicine and stem cell research have led to notable strides in the treatment of liver illnesses through the utilization of pluripotent mesenchymal stem cells (MSCs). The utilization of autologous mesenchymal stem cells (MSCs) offers a potential solution for mitigating postoperative symptoms, including immunological rejection, as well as reducing the detrimental effects and extended recovery time associated with extensive surgical procedures. Additionally, this approach can help alleviate the financial burden of increased hospital medical bills [5].

Neurodegenerative diseases, such as Alzheimer's, Huntington's, Parkinson's, Amyotrophic lateral sclerosis, and spinal muscular atrophy, gradually degenerate or kill brain or spinal cord neurons. Stem cell therapy is a promising treatment for several disorders despite their complex pathogenic processes. Induced pluripotent stem cells (iPSCs) are more promising than hematopoietic stem cell transplantation, which can alleviate some illness symptoms. Stem cell treatment inhibits inflammation and releases neurotrophic factors, offering promise for neurodegenerative illnesses [6]. This paper provides a comprehensive analysis of the potential and development prospects of stem cell therapy in the treatment of heart, liver, neurological, and eye diseases. The article begins by discussing how stem cell-based therapies in cardiac regenerative medicine have shown potential for cardiac repair and regeneration, but have had limited success in human clinical trials. It then explores key issues in the treatment of liver diseases, such as the homing ability of mesenchymal stem cells (MSCs), standardization of treatment, and the economic viability of formulations. The research also elaborates on how stem cells promote the development, maintenance, and repair of neural cells by secreting neurotrophic factors and highlights their successful application in patients with amyotrophic lateral sclerosis (ALS). Lastly, the article emphasizes the potential therapeutic effects of exosomes on eye tissues and the innovations brought about by bioengineering and nanotechnology. This article provides valuable insights into the prospects and limitations of stem cell therapy in clinical applications, laying the groundwork for further research and application.

2. Discussion

2.1. Stem cell therapy for heart disease

The use of iPSC-derived cardiomyocytes still faces the issue of immaturity. Although long-term culture can improve maturity, it is still challenging to fully mimic adult cardiomyocytes. Current solutions include chemical therapy, electromechanical stimulation, and biomimetic scaffold cultivation. Electrical

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stimulation of hydrogel cardiomyocytes can improve maturity and function. Some research use gelatin matrices and periodic stretching to improve cardiomyocyte function and survival. Although progress has been achieved, in vitro PSC cardiomyocytes that resemble adults are still difficult to generate. Remaining undifferentiated PSCs are prone to tumor growth following transplantation. PSCs produce a diverse range of cardiac subtypes, including ventricular, atrial, nodal, and Purkinje cardiomyocytes. Hence, the acquisition of extensively purified cardiomyocytes is crucial for the effective implementation of pluripotent stem cell (PSC)-derived cardiac treatment. At present, the directed differentiation of human pluripotent stem cells (PSCs) into distinct cardiac subtypes may be achieved with a high degree of accuracy using transcription factors and growth factors. Moreover, the utilization of surface markers, such as signal regulatory protein alpha (SIRPA), has been demonstrated to enable the isolation of cardiomyocytes from human sources with a high degree of efficiency, reaching up to 98% purity, by the technique of fluorescence-activated cell sorting (FACS). In subsequent periods, the identification of crucial factors influencing cell maturation and the application of 3D printing technology have the potential to yield additional progress in the field of cardiomyocyte research and clinical therapy [3].

The human leukocyte antigen (HLA) system, which encodes MHC proteins, is crucial to post-transplant immunological responses. To avoid rejection, MHC-matched allogeneic transplantation seems promising. In non-human primates, MHC-matched iPSC-CMs allogeneic transplantation can partially re-muscularize infarcted heart muscle and survive long-term without malignancies. However, the survival of allogeneic cells requires the use of toxic immunosuppressive drugs. A new strategy has emerged, using genetic engineering to modify low immunogenicity hPSCs, enhancing their ability to escape immune detection, but further research is needed to prove that these cells can enter patients' bodies and improve their myocardial conditions. Moreover, targeted delivery of stem cells to damaged cardiomyocytes is currently a significant challenge. One approach is to use bispecific antibody technology to modify human hematopoietic stem cells (CD34+), which can significantly increase the delivery efficiency to damaged cardiac tissue. Another approach is to enhance the homing ability of stem cells by adjusting the expression of chemokines [3].

2.2. Stem Cell Therapy for Liver Disease

In this part, the paper will discuss the advancements in liver treatment research with different types of stem cells:

ESC. Research findings indicate that the utilization of human embryonic stem cells (ESCs) has demonstrated efficacy in the regeneration of impaired liver tissue inside a mouse experimental model. Hepatocytes possess the ability to undergo differentiation in order to substitute liver cells and supply the essential nutritional elements required for the process of liver regeneration. Evidence from Europe suggests that human embryonic stem cells (ESCs) have the potential to undergo differentiation into liver cells and effectively sustain liver function when used to treat acute liver failure produced by mouse arginase in mice. Nevertheless, the generation of mature and completely functional liver cells in clinical settings continues to pose a considerable difficulty. In a study conducted by Wang M et al., it was demonstrated that the utilization of polyethyleneimine-modified silica nanoparticles in a continuous growth factor release system may effectively stimulate the differentiation of mouse embryonic stem cells into hepatocyte-like cells (HLCs). This approach resulted in the generation of a substantial quantity of fully functional liver cells in an in vitro setting [7]. Following transplantation into mice, the HLCs have the ability to undergo differentiation into liver cells and effectively regenerate impaired cardiac tissue [4].

iPSC. Human-induced pluripotent stem cells (iPSCs) are considered a potential source for the treatment of end-stage liver diseases. Research has reported the process of differentiating human iPSCs into liver cells, successfully differentiating iPSCs into liver cell-like cells (HLCs) within 25 days that are nearly homogeneous with ESC-derived cells. However, it is still unclear whether these liver cells can treat damaged or diseased liver tissues. Related studies have shown that vascularized and functional human livers generated from human iPSCs through in vitro liver bud transplantation can play a role, even in drug-induced fatal liver failure cases. Moreover, liver cells at different differentiation stages

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from human iPSCs have shown liver regeneration ability in mouse liver cirrhosis cases. However, the immunogenicity of iPSCs remains controversial. Some studies have reported that abnormal gene expression in cells from iPSCs may induce an immune response, so it is recommended to evaluate the immunogenicity of iPSCs before clinical application. On the other hand, there is little evidence that iPSCs cause immune rejection. These two different conclusions may be due to the use of different iPSC lines. Overall, although iPSCs are promising in regenerative medicine, their potential risks need to be fully considered and thoroughly evaluated before therapeutic applications [4].

MSC. The differentiation of mesenchymal stem cells into hepatocyte-like cells shows potential for the regeneration of liver tissue. According to Yuan, MQ, and colleagues, their study observed that rats with liver fibrosis/cirrhosis induced by CCl4 exhibited alterations in human albumin, ∝-fetoprotein, and other markers following the administration of umbilical cord-derived mesenchymal stem cells. These findings provide evidence that the transplanted mesenchymal stem cells underwent a sequential differentiation process, initially transforming into immature liver cells and subsequently maturing into liver-like cells. This differentiation process was found to be dynamic in nature [5]. Fibrosis and liver failure are caused by immune regulatory imbalances. Recent study has shown that mesenchymal stem cells (MSCs) can influence immune responses through cell-to-cell contact or paracrine regulation. MSCs stimulate anti-inflammatory M2 macrophages and inhibit pro-inflammatory M1 macrophages. In adaptive immunity, MSCs can reduce T-cell activation and inhibit T-cell proliferation by blocking the G0/G1 phase of the cell cycle. In chronic liver injury, the damaged liver secretes pro-fibrotic factors, leading to hepatic stellate cell (HSC) activation and proliferation, eventually transforming into myofibroblasts that synthesize the extracellular matrix (ECM). MSCs can exert anti-fibrotic effects through paracrine signaling. Specifically, MSCs can secrete various soluble molecules, inhibit HSC activation and collagen protein formation, and degrade ECM. MSCs have the ability to modulate signaling pathways, hence exerting a regulatory effect on ECM deposition and liver fibrosis. Mesenchymal stem cells possess a homing mechanism and exhibit the ability to serve as a sanctuary for regions of injured tissue, a crucial requirement for their potential application in systemic therapeutic interventions. Exogenous MSCs transplanted into the body are captured by the target tissue's circulatory system and migrate via vascular endothelial cells. Damaged ischemic tissues attract MSCs, allowing them to preferentially cure the damage [5].

2.3. Stem Cell Therapy for Neurodegenerative Diseases

The study conducted by Ahani-Nahayati, M. et al. demonstrates the successful differentiation of human pluripotent stem cells (hPSCs) into midbrain dopaminergic (DA) neurons, with the aim of utilizing these cells for the treatment of Parkinson's disease (PD). The findings of this study demonstrate that the utilization of the floor plate marker CORIN for cell sorting enables the efficient acquisition of DA neuronal progenitor cells. These cells have the ability to persist and undergo differentiation into midbrain dopamine (DA) neurons. Furthermore, it has been observed that neural stem cells (NSCs) produced from human induced pluripotent stem cells (iPSCs) has the ability to endure, migrate, and undergo differentiation into neurons, including dopamine (DA) neurons, within the rat brain. This phenomenon has been found to enhance the performance of rats without the occurrence of tumor formation [6].

Mouse iPSCs can differentiate into glial cells, reducing Aβ plaque deposition in transgenic 5XFAD Alzheimer's disease (AD) mice, improving cognitive deficits in cases. Furthermore, transplantation of iPSCs into the brain ventricles of Huntington's disease (HD) models can promote metabolic recovery in the lesioned striatum. Transplanted iPSCs can successfully differentiate into GABAergic neurons, showing significant therapeutic effects. Meanwhile, implanting human iPSC-derived neural progenitor cells into the spinal cord of rodent models of amyotrophic lateral sclerosis (ALS) allows these cells to survive and differentiate into cells with neuronal phenotypes. iPSC-derived NSCs in ALS mouse models can migrate and integrate into the central nervous system and improve neuromuscular activity and motor unit pathology without forming teratomas, increasing survival rates [6].

In addition, Ahani-Nahayati, M. et al. suggest that mesenchymal stem cells (MSCs) are promising in the field of treating neurodegenerative diseases because they possess self-renewal, multipotency,

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availability, and low ethical concerns. For example, in treating AD, systemic administration of human umbilical cord mesenchymal stem cells (hUC-MSCs) can improve cognitive function in rodent models with AD, which is associated with increased hippocampal neurogenesis and upregulation of synaptic plasticity proteins. MSCs can also be cultured in vitro into DA neurons, and when transplanted into PD rodent models, they can stimulate functional recovery. After non-invasive intranasal administration into the brain of PD models, MSCs can reduce inflammatory cytokine levels, reduce DA neuron death, reduce DA neuron degeneration, and thereby restore function. For HD, transplanted MSCs can survive in the striatum of experimental models and promote the proliferation and differentiation of neuronal cells. Transplanted hBM-MSCs may also interact with host cells and increase the levels of factors such as laminin, VWF, SDF-1, and CXCR4. In addition, survival and differentiation of BM-MSCs in the striatum may restore motor function through upregulation of NGF, BDNF, GDNF, and CNTF. For ALS, intraventricular injection of UC-MSCs can significantly protect motor neurons in the lumbar spinal cord of transplant models, reduce pro-inflammatory cytokine levels, and upregulate anti-inflammatory cytokines and IGF-1 levels. Ahani-Nahayati et al. presented clinical trial illustrations that showcase the practicability, comparative safety, and efficacy of mesenchymal stem cell (MSC) transplantation using cerebrospinal fluid and intravenous administration routes. Additionally, they investigated the safety and tolerability of MSC-neurotrophic factor (MSC-NTF) transplantation [6].

2.4. Stem Cell Therapy for Ocular Diseases

The retina, lens, and cornea develop together to produce the human eye. Diseases or injuries that impact these tissues can cause blindness. Due to the significance of vision to quality of life, scientific research is focused on treating ocular illnesses via tissue transplantation, laser therapy, gene therapy, and cell therapy. The eye is a preferred stem cell transplantation target due to its high disease burden and simplicity of access. iPSCs can be generated from somatic cells through cellular genetic reprogramming and can produce retinal progenitor cells in in vitro models. Using patient-derived iPSCs can reduce the need for immune protection after transplantation. However, the genomic instability of iPSCs is a problem that may induce teratomas. The present emphasis lies on hPSCs, specifically iPSCs, which have demonstrated significant advancements in the field of retinal pigment epithelium (RPE) and photoreceptor replacement for age-related macular degeneration (AMD) [2]. In the subsequent discussion, we will examine the advancements made in the field of stem cell therapy pertaining to several ocular regions.

Ocular Surface, Cornea, and Limbus. Stem cell therapy has brought new hope for the treatment of ocular surface diseases, especially in the treatment of LSCD. Studies on various stem cell types and treatment methods have made significant progress. The methods for preparing corneal epithelial cells from human-induced pluripotent stem cells (hiPSCs)/embryonic stem cells (ESCs) have been verified in both two-dimensional and three-dimensional culture systems. As with cultured limbal epithelial transplantation, bone marrow mesenchymal stem cells (BM-MSCs) can safely repair the corneal epithelium following limbal stem cell shortage (LSCD). MSCs may boost graft survival and regulate the immune system. Seeded umbilical cord mesenchymal stem cells (UC-MSCs) produce stratified epithelial layers on artificial matrices. This method is considered an alternative way to bypass the limited supply of corneal tissue in bilateral LSCD patients. Current research is exploring new applications of stem cell therapy, such as using MSC-derived exosomes [2].

Corneal Stroma and Endothelium. Stem cell therapy may treat corneal diseases and damage. Adult, human-induced pluripotent, embryonic, bone marrow mesenchymal, and ocular surface stem cells are all sources of stem cells. Current research focuses on the following areas. First, the utilization of corneal surface stem cells (LSCs) is a potential therapeutic approach for addressing corneal epithelial damage associated with various corneal surface illnesses. Both autologous and allogeneic transplantation of hematopoietic stem cells (HSCs) have demonstrated excellent outcomes. In instances where local stem cell populations are insufficient, alternative sources of stem cells may be taken into consideration. The second one is corneal stroma diseases. Corneal stromal stem cells and periodontal ligament stem cells can be used to treat corneal stromal diseases, such as corneal scars, opacity, and cloudiness. Corneal

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endothelial diseases: Since corneal endothelial cells (CECs) have limited regenerative ability, stem cell therapy may be a potential treatment for corneal endothelial diseases. These treatments have made progress in animal models, but further clinical research is needed to validate the effectiveness and safety of stem cell therapy [2].

Trabecular Meshwork , Lens and Retina. Glaucoma treatment is being investigated using induced pluripotent stem cells (iPSCs). Research suggests that trabecular meshwork-like cells produced from patients' skin fibroblasts may be the best way to replenish trabecular meshwork cells. Others, such mesenchymal stem cells (MSCs), are being tested to restore trabecular meshwork tissue. Adipose and bone marrow mesenchymal stem cells developed into trabecular meshwork cells in animal models with promising findings [2]. Researchers have successfully isolated lens epithelial stem/progenitor cells (LECs), which continuously self-renew and protect against external damage. Studies have shown that lens regeneration can be achieved by retaining LECs through a new minimally invasive surgical procedure, increasing the transparency of the visual axis and reducing the incidence of complications. In addition, some researchers have successfully created mini lenses through iPSC differentiation, offering more possibilities for future cataract treatment [2].

Stem cells can be used for cell replacement therapy to supplement damaged retinal cells. Both ESCs and iPSCs have been shown to be able to differentiate into RPE or photoreceptor cells, serving as potential sources for replacing lost retinal cells. At the same time, stem cells can also exert paracrine effects, secreting nutrients to support and protect existing retinal cells [2].

3. Limitations and Challenges of Stem Cell Therapy

Stem cell therapy is considered an important approach for the treatment of many diseases in the future, especially in cases where organ transplantation can be avoided. The issue of immune tolerance of transplanted cells has been addressed by using autologous cells [6]. Despite the numerous advantages and promising outcomes associated with stem cell therapy, there is a significant gap in our comprehension of this field, particularly in relation to potential adverse consequences. One of the most significant concerns in the field pertains to the tumorigenic potential of transplanted stem cells. Nevertheless, recent advancements in genetic research and cell reprogramming technology have partially mitigated this risk [5]. However, the field of stem cell transplantation continues to encounter numerous formidable hurdles and obstacles, notably the substantial issue of effectively implanting viable cells within the recipient's organism. Researchers are trying to improve treatment outcomes by pre-treating host tissues or stem cell cultures, encapsulating stem cells in biomaterials, or expanding stem cell cultures, among other methods. However, due to the lack of cost-effective technology, such stem cell treatments are inevitably expensive, and making stem cell therapy affordable for the average person remains a long-term challenge [5]. Solutions are currently being sought, such as removing one's tissues (e.g., adipose stem cells) during other surgeries and preserving them, which could be a way to reduce costs [2]. Additionally, stem cell therapy may lead to some unknown side effects. Allogeneic cell transplantation may result in immune rejection, and although MSCs have been shown not to cause immune rejection, more clinical trial data are needed to confirm this. After transplantation, cells may not differentiate as expected into the desired cell types, or may differentiate into unwanted cell types [5]. Moreover, the use and collection of certain cell types (such as embryonic stem cells, umbilical cord mesenchymal stem cells, and neural stem cells) still have significant ethical controversies, further limiting the application of stem cells in clinical trials [6]. In conclusion, stem cell therapy holds great potential in the field of ophthalmology, but many challenges and obstacles still need to be overcome.

4. Future and Prospects

4.1. Cardiac stem cell therapy research prospects

Cardiac regenerative medicine is a promising field, and current cardiac regeneration research mainly focuses on using stem cells and cell-derived products for treatment, altering the inflammatory microenvironment of the heart, stimulating cell proliferation and differentiation, and promoting tissue

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remodeling. The utilization of stem cell-based therapeutics has demonstrated promise in the realm of heart repair and regeneration in animal models. However, the translation of these findings into successful outcomes in human clinical trials has been constrained [1]. In future cardiac regenerative medicine, some questions are critical. For example, cell choice; currently, MSCs are given more attention in cardiac therapy because they can regulate immune responses and restore homeostasis in the body and avoid some ethical discussions, but the standard and deeper mechanism of MSCs still need to be studied. In addition, in situ cardiac reprogramming is a promising method for generating cardiomyocytes in a patient's heart. Directly converting fibroblasts into cardiomyocytes in the adult heart, inhibiting fibrosis, and promoting myocardial regeneration is a very effective therapy that requires extensive research in the future. Tools for monitoring the heart in patients are also essential, as transplanted stem cells in the heart need strict monitoring to ensure they do not turn into tumors. Issues such as drug delivery and stem cell transplantation need to be addressed, and the development of cardiac regenerative medicine requires in-depth research and clinical validation, combining multiple strategies and technologies to achieve greater efficacy [3].

4.2. Liver stem cell therapy research prospects

Liver disease is a global problem, and the incidence of liver disease is rising year by year. MSCs are still very promising for treating liver disease, but the effects of MSCs on liver disease are influenced by various factors, the most important of which is the homing ability of MSCs. In order to enhance the homing capacity of mesenchymal stem cells (MSCs), scientists have implemented a range of strategies. These strategies encompass the selection of alternative transplantation routes, the optimization of MSC growing conditions, the modification of MSCs themselves or the target tissues, among others. Nevertheless, the precise mechanism underlying the homing of mesenchymal stem cells (MSCs) remains elusive and necessitates additional investigation. Furthermore, it is imperative to establish standardized protocols for the administration of mesenchymal stem cell (MSC) therapy. Presently, clinical trials involving MSCs exhibit varying outcomes due to inconsistencies in their origins, doses, routes of administration, and timing of injections. In conclusion, the exorbitant cost associated with MSC preparations poses a constraint on their clinical utilization, hence necessitating further investigation into more cost-effective formulations [5].

4.3. Neurodegenerative disease stem cell therapy research prospects

Stem cell therapy has great potential in the treatment of neurodegenerative diseases. Stem cells can provide neurotrophic support for remaining cells by secreting factors such as BDNF, GDNF, and NGF, preventing the production or accumulation of toxic factors and promoting the development, maintenance, and repair of nerve cells, which is a very important function. Different stem cells, such as iPSCs, have not been particularly successful in clinical treatment of neurodegenerative diseases, but ALS patients have shown very good results after autologous stem cell transplantation. Mesenchymal stem cells (MSCs) have also shown therapeutic potential in in vitro and in vivo animal models, but clinical treatment effects are not ideal. In the future, researchers need to address various issues to achieve the full application of stem cells in clinical trials, such as optimizing stem cell culture environments, selecting appropriate stimulating compounds, discovering innovative methods to support transplant cell homing, and optimizing cell delivery doses and routes [6].

4.4. Eye stem cell therapy research prospects

The current state of research on stem cell therapy for eye disorders is characterized by its nascent stage. However, preliminary evidence suggests that this therapeutic approach holds considerable potential to revolutionize the management of ocular conditions. Subsequent investigations may place greater emphasis on exploring the prospective therapeutic implications of exosomes, which are cellular vesicles generated by mesenchymal stem cells (MSCs), specifically targeting ocular tissue. Furthermore, it is imperative to acknowledge the advancements introduced by the fields of bioengineering and nanotechnology in this context. The prevailing research trajectory involves the utilization of 3D

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bioengineering technology for the cultivation of fundamental components of the ocular system, as well as the substitution of tissues and organs via targeted delivery systems. By employing bioengineering techniques and implementing enhanced cultivation procedures, the integration of stem cells into recipient sites can be significantly enhanced, resulting in reduced culture times and diminished requirements for tissue harvest [2].

5. Conclusion

The paper presents a thorough examination of the prospective applications and future prospects of stem cell therapy in the treatment of cardiovascular, hepatic, neurological, and ophthalmic disorders. This study provides a comprehensive examination of the application of stem cell therapy in various medical conditions such as heart, liver, neurological, and eye illnesses. The discussion mostly centers around the selection of appropriate stem cell types, the pathways via which transplantation occurs, the technological constraints associated with cell transplantation, and potential avenues for future research. The paper primarily focuses on the evaluation of stem cell-based therapies within the realm of cardiac regenerative medicine. It highlights the promising outcomes observed in animal models, demonstrating the potential of these therapies for repair and regeneration. However, the research also underscores the comparatively restricted achievements witnessed in human clinical trials. This paper focuses on several important aspects within the field of liver disease research, including the migratory potential of mesenchymal stem cells (MSCs), the need for treatment uniformity, and the evaluation of formulation cost-effectiveness. For neurodegenerative diseases, the article mentions how stem cells promote the development, maintenance, and repair of nerve cells by secreting neurotrophic factors, and describes the success of stem cell therapy in ALS patients. Finally, in the treatment of eye diseases, the article explores the potential therapeutic effects of exosomes on eye tissue, as well as the innovations brought about by bioengineering and nanotechnology.

This paper provides an in-depth exploration of the application of stem cell therapy in the treatment of various diseases, offering a comprehensive overview of the use of stem cell therapy. This is significant for understanding the prospects and limitations of stem cell therapy in clinical applications. Faced with exciting potential and significant challenges, the analysis and discussion in this paper lay a solid foundation for further research and application. We look forward to stem cell therapy serving clinical treatment more effectively, bringing more hope and better lives to patients.

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