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CELL THERAPY IN THE TREATMENT OF DEGENERATIVE DISEASES

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Thaís Guedes[1], Jaques Adriano de Castro Filho[2], Rachel Ann Asencio Bracelis[3], Izabella Dária Zarattini Oliveira[4] and Sarah Araújo do Rosário[5]

ABSTRACT

Cell therapy has emerged as a promising alternative in the treatment of degenerative diseases, with the aim of restoring or replacing damaged cells and improving the function of affected organs. This study reviewed the application of cell therapy in conditions such as neurodegenerative diseases, cardiovascular diseases, and osteoarthritis, based on studies published between 2016 and 2024. The review was carried out in the PubMed, Google Scholar and Scopus databases, using specific descriptors and combining keywords such as "cell therapy", "stem cells", "neurodegenerative diseases", "cardiovascular diseases" and "osteoarthritis". The results indicate that cell therapy has demonstrated significant efficacy, especially in the treatment of diseases such as Parkinson's, Alzheimer's and heart failure, with improvement in clinical outcomes, including the regeneration of damaged tissues, increased motor function and reduced progression of symptoms. In addition, cell therapy has shown benefits in cartilage regeneration in patients with osteoarthritis, providing a less invasive alternative to traditional approaches. However, challenges such as the safety of therapies, the immunogenicity of implanted cells, and variability in patient responses still limit their wide and effective application. This review discusses the main cell therapy approaches, the benefits observed, as well as the obstacles that need to be overcome for this technology to become a viable and safe therapeutic solution in the treatment of degenerative diseases.

Keywords: Cell Therapy. Degenerative Diseases. Cell Regeneration. Neurodegeneration. Cell Therapy in the Treatment of Diseases.

[1] Medical Student
Faculty of Mines - FAMINAS-BH
E-mail: thaisguedesoficial@gmail.com
[2] Graduating in Medicine
Alfredo Nasser University Center - UNIFAN
E-mail: magnusgodoy@gmail.com
[3] Medical Student
Santo Amaro Medical School - UNISA
E-mail: rachel20024001@gmail.com
[4] Medical Student
Faculty of Mines – FAMINAS BH
E-mail: izabellazarattini.med@gmail.com
[5] Medical Student
University of Ribeirão Preto - UNAERP
E-mail: saraharaujorosario@gmail.com

INTRODUCTION

Degenerative diseases, including conditions such as neurodegenerative diseases, cardiovascular diseases, and osteoarthritis, represent one of the greatest public health challenges in the world. With the increase in life expectancy, the prevalence of these diseases has increased considerably, resulting in a great impact on health policies and the quality of life of patients. These conditions, often associated with aging, are among the leading causes of morbidity and mortality in several populations, requiring effective and innovative therapeutic solutions. Traditionally, the treatment of these diseases has been focused on symptomatic management, control of progression, and improvement of quality of life, often without a definitive cure. However, cell therapy emerges as an innovative approach with the potential to not only alleviate symptoms, but also restore lost function, by offering alternatives to regenerate damaged tissues or replace failing cells.

Cell therapy, which involves using living cells such as stem cells to regenerate damaged tissues or restore the function of affected organs and systems, has shown promising advances in regenerative medicine. This approach not only aims to repair the damage caused by degenerative diseases, but also offers the prospect of treating conditions that, until recently, were considered irreversible. With the evolution of cell culture techniques, tissue engineering, and genetic manipulation, cell therapy has become increasingly relevant, demonstrating the potential for a more effective and personalized therapeutic approach.

This study aimed to analyze the advances, efficacy and challenges of cell therapy in the treatment of degenerative diseases, with emphasis on its clinical application, the results obtained so far, the limitations and obstacles to its wide adoption. In addition, it is intended to discuss the future perspectives of this therapy, taking into account the ethical and financial aspects and possible technological innovations that can improve this approach in the treatment of these conditions.

THEORETICAL FRAMEWORK

Cell therapy, especially the use of stem cells, has stood out as a promising approach in the treatment of degenerative diseases. Stem cells are undifferentiated cells that have the remarkable ability to differentiate into several specialized cell types, which makes them essential for the regeneration of damaged tissues and the restoration of lost cellular functions. This property makes them a valuable therapeutic tool in conditions of cellular degeneration, such as neurodegenerative, cardiovascular, and joint diseases. According to

Liu et al. (2020), the plasticity of stem cells allows not only the repair of existing damage, but also the possibility of more efficient functional repair compared to traditional therapies.

In neurodegenerative diseases, such as Parkinson's and Alzheimer's disease, stem cells have shown great therapeutic potential. Studies have shown that the application of stem cells in experimental models and in early clinical trials can improve motor function, reduce neuronal loss, and promote neuroprotection (Vogel et al., 2019). Neural stem cells, for example, have the ability to differentiate into neurons and glial cells, promoting the regeneration of the central nervous system, something that traditional treatments, such as drugs, cannot achieve as effectively. The use of these cells could therefore revolutionize the treatment of diseases such as Parkinson's, Alzheimer's and other degenerative conditions of the central nervous system.

In addition, in heart disease, the use of mesenchymal stem cells has shown positive results, especially in the regeneration of heart muscle after infarctions. Injecting these cells can stimulate the recovery of heart function, promoting the regeneration of damaged tissue and preventing serious complications such as heart failure (Deng et al., 2018). Clinical studies have explored the use of different sources of stem cells, such as those from bone marrow, adipose tissue, and umbilical cord, which have shown promising regenerative capabilities in myocardial infarction models.

In conditions such as osteoarthritis, cell therapy has been successfully applied in the regeneration of damaged cartilage, offering a less invasive alternative compared to conventional treatments such as joint surgeries or joint replacement (Kim et al., 2021). The use of mesenchymal stem cells derived from various sources, such as bone marrow and adipose tissue, has shown the ability to repair cartilage, reduce pain, and improve patient mobility. These treatments not only help with joint regeneration but also prevent joint degeneration from worsening, offering a less traumatic therapeutic option.

However, the use of stem cells presents considerable challenges. Ethical issues related to the use of embryonic stem cells, the risk of immune rejection, the difficulty in controlling cell differentiation precisely, and the potential formation of tumors are some of the main concerns. In addition, the variability in patient response and the lack of standardized protocols for the use of these therapies are significant obstacles to their large-scale application (Jiang et al., 2017). The standardization of treatments, as well as the resolution of technical problems related to the manipulation and differentiation of stem cells, are critical areas that need more research and development.

The lack of a complete understanding of the mechanisms that govern cell differentiation and the integration of stem cells into the body also raises questions about the

safety and efficacy of long-term treatments. Controlling cell proliferation and maintaining regenerative function without the risk of tumor formation are challenges that must be solved before cell therapy becomes a common and accessible clinical practice. Therefore, despite promising advances, the technical, ethical, and biological challenges associated with the use of stem cells need to be overcome for this therapy to be widely adopted in the treatment of degenerative diseases.

METHODOLOGY

An integrative literature review was carried out, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, with the objective of evaluating the efficacy of cell therapy in the treatment of degenerative diseases. The search was conducted in the PubMed, Google Scholar, and Scopus databases, covering articles published between 2016 and 2024. The inclusion criteria were primary research articles that investigated cell therapy in degenerative diseases, including clinical and experimental studies that evaluated the efficacy of these therapies. Articles with small sample sizes, uncontrolled case studies, narrative reviews, and studies that did not specifically focus on cell therapy were excluded. The search was restricted to articles in English, Spanish, and Portuguese to ensure a representative and diverse sample of studies.

For the search, descriptors broadly related to cell therapy and degenerative diseases were used, such as "Cell therapy", "Stem cells", "Mesenchymal stem cells", "Regenerative medicine", "Neurodegenerative diseases", "Parkinson's disease", "Cardiovascular diseases" and "Osteoarthritis", among others. The combination of these terms was made using Boolean operators, such as AND, OR, and NOT, to refine and expand the results, ensuring that the identified articles addressed the topics in an integrated and relevant way.

Data analysis included the extraction of information on the types of cells used, the diseases treated, the clinical outcomes observed (such as improved function and tissue regeneration), and the main challenges encountered in the studies, such as ethical issues and difficulty in controlling cell differentiation. The evaluation of the quality of the studies was based on methodological criteria, such as the study design, the robustness of the results, and the clarity of the presentation of the data. When possible, a meta-analysis was performed to assess the consistency of the results, complemented by a qualitative discussion of the most relevant studies.

RESULTS AND DISCUSSIONS

Cell therapy has emerged as a promising approach in the treatment of degenerative diseases, encompassing neurodegenerative, cardiovascular, and osteoarticular conditions. This review aims to deepen the results and discussions on the efficacy and challenges of cell therapy in these pathologies, with emphasis on recent studies and Brazilian contributions.

NEURODEGENERATIVE DISEASES

Neurodegenerative diseases, such as Parkinson's and Alzheimer's, are characterized by the progressive degeneration of neurons, resulting in cognitive and motor decline. Cell therapy, especially with stem cells, has been investigated as a strategy to replace or repair damaged neurons.

Studies indicate that mesenchymal stem cells (MSCs) have the ability to secrete neurotrophic factors that promote neuronal survival and neurogenesis. For example, Vogel et al. (2019) demonstrated that administering MSCs to animal models of Parkinson's resulted in improved motor function and reduced neuronal loss. However, translating these findings to humans faces challenges, such as the low survival rate of transplanted cells and heterogeneous responses among patients.

In the Brazilian context, Silva et al. (2021) conducted a clinical study involving patients with Parkinson's disease, where neural stem cells were implanted in the brain striatum. The results showed significant improvement in motor function in some patients, although the variability in responses indicates the need for more refined criteria for candidate selection and standardized treatment protocols.

CARDIOVASCULAR DISEASES

Heart failure, often resulting from myocardial infarction, remains a leading cause of morbidity and mortality globally. Cell therapy has been explored as an alternative to promote the regeneration of damaged heart tissue. Deng et al. (2018) reported that injection of MSCs into the infarcted myocardium of animal models led to an improvement in cardiac function and reduction of the necrosis area. These effects are attributed to the ability of MSCs to secrete paracrine factors that stimulate angiogenesis and reduce cell apoptosis. However, the durability of these benefits and the functional integration of the transplanted cells remain open questions.

In Brazil, Ribeiro et al. (2020) conducted a clinical trial with patients with advanced heart failure, in which autologous MSCs were administered intracoronally. After six months

of follow-up, an improvement in the left ventricular ejection fraction and functional capacity of the patients was observed. However, the absence of control groups and the limited sample size highlight the need for more robust studies to confirm these findings.

OSTEOARTHRITIS

Osteoarthritis is a degenerative joint disease characterized by the progressive degradation of cartilage, leading to pain and loss of function. Cell therapy, particularly with MSCs, has been investigated as an approach to regenerate damaged cartilage and relieve symptoms. Kim et al. (2021) conducted a randomized controlled trial in patients with knee osteoarthritis where MSCs were injected intra-articularally. The results showed a significant reduction in pain and improvement in joint function after 12 months, associated with cartilage regeneration observed by magnetic resonance imaging. However, heterogeneity in cell quality and culture protocols may influence clinical outcomes.

In Brazil, Costa et al. (2019) evaluated the efficacy of MSC therapy in patients with knee osteoarthritis refractory to conventional treatment. After intra-articular administration of the cells, patients reported improvement in pain scale and functional capacity. Despite the promising results, the authors highlight the need for studies with larger numbers of participants and long-term follow-up to validate the safety and efficacy of the intervention.

CHALLENGES AND FUTURE PROSPECTS

Despite advances, cell therapy faces significant challenges that limit its broad clinical application. The variability in patient response suggests the need for personalized approaches, considering factors such as age, comorbidities, and specific characteristics of the disease. In addition, the immunogenicity of transplanted cells and the potential risk of tumor formation require close monitoring and development of techniques to minimize these risks.

The standardization of cell isolation, expansion, and administration protocols is crucial to ensure reproducibility and comparability between studies. In Brazil, initiatives such as the creation of stem cell banks and the establishment of specific regulatory guidelines have sought to foster research and safe clinical application of cell therapy. However, issues related to cost and equitable access to treatments remain challenges to be overcome.

CONCLUSION

Cell therapy offers great potential for the treatment of degenerative diseases, with promising results in several areas, including neurodegenerative, cardiovascular, and joint

diseases. While the benefits are evident, challenges such as the safety of therapies, long-term efficacy, and variability in outcomes still limit their large-scale application. Regulation of procedures, development of standardized protocols, and improvement in cell differentiation techniques will be crucial to the advancement of cell therapy. The future of cell therapy promises to revolutionize the treatment of degenerative diseases, becoming a vital tool in regenerative medicine.

However, it is important to recognize some limitations in existing studies on cell therapy. Many of the clinical trials carried out so far have small and variable sample sizes, which makes it difficult to generalize the results to the population on a large scale. In addition, most studies still focus on short-term trials, with little data on the long-term efficacy and safety of cell therapies. The variability in the types of cells used, in the administration protocols, and in the conditions of the patients also contributes to the difficulty in establishing definitive conclusions about the success of these therapies.

To advance cell therapy, future studies should focus on clinical trials with larger and more diverse samples, as well as a more robust assessment of long-term effects. Standardization of treatment protocols, including the choice of the most appropriate cells and the most efficient administration technique, is essential to optimize outcomes. It will also be necessary to explore more deeply the issues related to immunogenicity and cell rejection, seeking alternatives that minimize these risks. The combination of cell therapy with other therapeutic approaches, such as tissue engineering and nanotechnology, may represent a promising prospect for maximizing benefits and overcoming current limitations. In short, the field of cell therapy is still evolving, and more research is needed to consolidate its clinical application in degenerative diseases.

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