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Stem cell therapies in the treatment of Parkinson's disease

Stem Cell Therapies in the Treatment of Parkinson's Disease

Mother cell therapies in the treatment of Parkinson's disease

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SUMMARY

Parkinson's disease is a progressive neurodegenerative disease characterized by the loss of dopaminergic neurons, impairing motor and non-motor functions and significantly impacting the quality of life of patients. This study aimed to investigate the use of stem cells as a therapeutic strategy in Parkinson's disease, analyzing the main cell types employed, their mechanisms of action, efficacy, safety, and limitations.

This is an integrative literature review, conducted through searches in the PubMed, SciELO, and Google databases. The results demonstrated that embryonic stem cells (ESCs), induced pluripotent stem cells (iPSCs), and mesenchymal stem cells (MSCs) have relevant therapeutic potential for the treatment of the disease. ESCs and iPSCs stood out for their ability to differentiate into dopaminergic neurons, favoring neuronal regeneration, while MSCs showed anti-inflammatory and neuroprotective effects.

Potential improvement in both motor and non-motor symptoms of the disease was also observed. However, challenges related to tumorigenesis, immune rejection, genetic instability, and functional integration of transplanted cells were identified. It is concluded that stem cell therapies represent a promising and innovative approach, although further clinical studies are still needed to ensure safety, efficacy, and therapeutic standardization.

Descriptors: Parkinson's Disease, Pluripotent Stem Cells, and Regenerative Medicine

1 INTRODUCTION

Parkinson's disease (PD) is a progressive neurodegenerative disease that affects primarily the motor system, characterized by clinical signs such as resting tremor, rigidity Muscular dysfunction, bradykinesia, postural instability, and gait disturbances. These symptoms have an impact directly impacting the autonomy and quality of life of the affected individuals, thus constituting a This condition is of great clinical and social relevance. Furthermore, the gradual progression of the disease makes it difficult... Early diagnosis and appropriate management require ongoing monitoring and interventions. multidisciplinary (ARMSTRONG; OKUN, 2020; KALIA; LANG, 2022).

In addition to motor manifestations, Parkinson's disease presents a wide range of non-motor symptoms. often underestimated, which have a significant impact on patients' lives. (SCHAPIRA et (al., 2023) Among these, cognitive deficits, memory alterations, and impaired attention stand out. Executive dysfunctions and alterations in spatial orientation, which tend to worsen with progression. of the disease, especially in elderly individuals. In addition, symptoms such as depression, anxiety, Sleep disturbances and fatigue are common, which reinforces the clinical complexity of the disease (BLOEM).

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et al., 2021).

In the epidemiological context, Parkinson's Disease stands out as the second most common disease. The most prevalent neurodegenerative disease in the world, second only to Alzheimer's disease. (GBD, 2023; (ZHU et al., 2024) Recent estimates indicate that more than 11 million people live with A disease worldwide, with a trend of continuous growth due to aging.

The population is increasing due to the rise in life expectancy. The frequency is higher in individuals older than 20 years old. The average age is 60 years and there is a slight predominance of males, highlighting the growing impact of this condition on global public health (WORLD HEALTH ORGANIZATION, 2022).

Regarding treatment, current therapeutic approaches are predominantly symptomatic and are not able to stop or reverse the progression of the disease. Levodopa (L-DOPA remains the gold standard in pharmacological treatment, being effective in improving Motor symptoms (ARMSTRONG; OKUN, 2020). However, its prolonged use is associated complications such as dyskinesias and motor fluctuations. Other therapeutic options include dopamine agonists, monoamine oxidase type B (MAO-B) and catechol-methyltransferase (COMT), in addition to deep brain stimulation in more advanced stages. (BLOEM et al., 2021; SCHAPIRA et al., 2023).

Given the limitations of conventional therapies, regenerative medicine has emerged as a prominent field. as a promising alternative, especially through the use of stem cells.(PESSOA et (al., 2023) These cells have the capacity for self-renewal and differentiation into various types cellular, including dopaminergic neurons, may contribute to tissue regeneration. neural.(MENDES et al., 2024;)In addition, they exhibit neuroprotective effects through secretion of trophic factors, modulation of the inflammatory response, and stimulation of plasticity synaptic, expanding its therapeutic potential (BARKER et al., 2020).

Despite the progress, significant challenges remain, such as the risk of tumorigenesis, immunological rejection, difficulties in functional integration, and ethical issues, especially in The use of embryonic cells (BARKER et al., 2020). The general objective of this study is to... to investigate the use of stem cells as a therapeutic strategy in Parkinson's Disease, encompassing the identification and characterization of the main types of stem cells used in research scientific methods, the evaluation of its effectiveness and safety, and the analysis of associated risks, such as tumorigenesis and immune rejection, and understanding the mechanisms involved in regeneration. Neuronal function and improvement in motor and non-motor symptoms of the disease.

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2 METHODOLOGY

This study consisted of an integrative review. The literature review was...
This study was conducted based on articles from the last 10 years, using a structured search in databases. PubMed, SciELO, and Google Scholar were searched without language restrictions. The search was conducted using of descriptors obtained from the Health Sciences Descriptors (DeCS): “Parkinson Disease”, "Pluripotent Stem Cells" and "Regenerative Medicine," combined with the Boolean operator AND. The following structured searches were performed: “Parkinson Disease AND Pluripotent Stem Cells” and “Parkinson Disease AND Regenerative Medicine”.

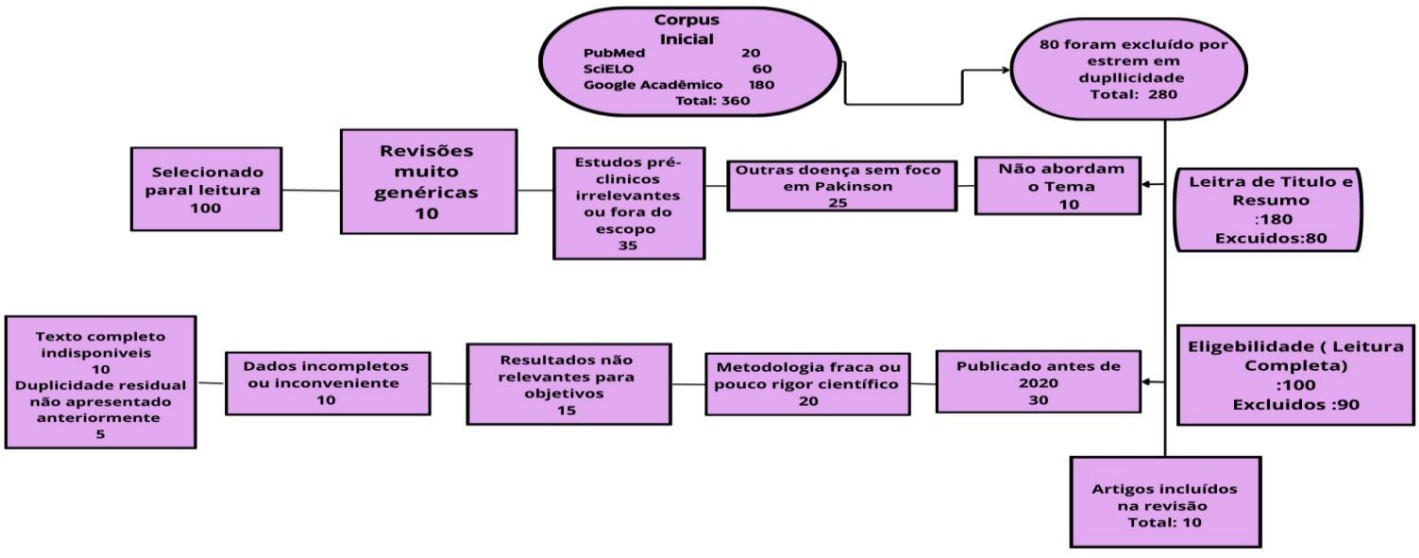
The inclusion criteria adopted were: articles that addressed stem cells in treatment of Parkinson's disease, focusing on the types of embryonic stem cells used, and studies that addressed older populations.

The following were considered exclusion criteria: articles that did not address the Disease of Parkinson's studies did not address the use of stem cells, focusing only on animal models without practical applications. clinical studies did not specify the cell type used, nor did they present results on efficacy or ethical considerations, were duplicates, were outside the scope of the last 5 years, or were unavailable in Full text.

3 RESULT

Based on the research conducted in the databases, 360 were found. studies. After reviewing the titles and applying the inclusion and exclusion criteria, 10 articles were selected. selected to be included in the analysis corpus (Figure 1).

Figure 1. Flowchart for article selection, 2026.



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Among the 10 selected articles, studies on Parkinson's disease were analyzed that...

They addressed clinical, pathophysiological, and therapeutic aspects. The limitations of the [method/method] were highlighted.

Conventional therapies and the potential of stem cells, with neuroprotective and regenerative effects.

Non-motor symptoms and the increasing prevalence of the disease were also discussed.

Details of the studies are presented in Table 1.

Table 1. Characteristics of the selected scientific articles, including titles, authors, year of publication, objectives and results, 2026.

Study Titles	Authors	Years	Objective	Results
Stem cell-based therapies for Parkinson's disease	Barker et al.	2020	Evaluate the use of stem cells in DP	Highlights therapeutic potential and challenges.
Mechanisms of Parkinson's disease	Yang et al.	2020	Investigate pathophysiological mechanisms of PD	It explains processes such as neurodegeneration.
Parkinson's disease	Bloem et al.	2021	Analyze clinical and therapeutic aspects of DP	Comprehensive review of the disease
iPSC-derived neurons in Parkinson's therapy	Takahashi et al.	2021	Evaluate the differentiation of iPSCs in from dopaminergic neurons.	Potential evidence of regenerative need more studies
Tumorigenicity risk of iPSCs in vivo: nip it in the bud	Chaoliang Zhong	2022	To investigate the efficacy and safety of stem cells in Parkinson's disease.	Partial improvement of symptoms, initial safety, and need for further studies.
Mesenchymal stem cells in Parkinson's disease	Li et al.	2022	Investigating the therapeutic effects of MSCs	It demonstrates functional improvement and anti-inflammatory action.

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Stem cell in neurodegenerative diseases.	Pessoa et al.	2023	To assess the role of stem cells in neurodegenerative diseases.	Demonstra effects neuroprotective
Stem cell therapies in the treatment of neurodegenerative diseases	Mendes et al.	2024	To analyze therapeutic advances with stem cells.	It points advances and out challenges.
Global epidemiology of Parkinson's disease	Zhu et al.al.	202 4	To assess the the global epidemiology of Parkinson's disease.	Shows an increase in prevalence.
Stem cell therapy for Parkinson's disease: A new hope for neural regeneration	Yasmin Garkani Mokhtari	2025	Reviewing the diagnosis and treatment of Parkinson's disease.	It discusses current therapies and their limitations.

4. DISCUSSION

The role of stem cells as alternative therapies in the treatment of Parkinson's disease. fulfilling the proposed objective of investigating its efficacy, safety, mechanisms of action and limitations. Overall, the results show that, although conventional therapies are While effective in controlling symptoms, they do not reverse neurodegeneration, which reinforces the... The need for innovative approaches.

In this approach, studies such as those by Barker et al. (2020), Pessoa et al. (2023) and Mokhtari (2025) highlight that stem cells have significant therapeutic potential, primarily due to its ability to differentiate into dopaminergic neurons and to release of neurotrophic factors. These findings contribute to the goal of identifying and to characterize the main cell types used, including induced pluripotent stem cells. (iPSCs), embryonic stem cells (ESCs) and mesenchymal stem cells (MSCs), broadly discussed in the studies by Takahashi et al. (2021) and Li et al. (2022), which highlighted both the potential for regeneration as well as anti-inflammatory effects.

ESCs exhibit high pluripotent potential and a virtually unlimited capacity to adapt. differentiate into various cell types, including dopaminergic neurons. Studies by Barker et al. (2020) point out that ESCs have great potential for direct cell replacement in PD, contributing to the reconstruction of the nigrostriatal pathway. However, its use is still limited by

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Ethical issues related to the use of human embryos, as well as the risk of teratoma formation.
and the need for rigorous control in cell differentiation, which hinders its widespread application.
clinic.

iPSC stem cells, in turn, suggest an innovative and more viable alternative. They are
produced from the reprogramming of adult somatic cells. iPSCs retain characteristics
similar to ESCs, including pluripotency, but with the advantage of enabling therapies
autologous, significantly reducing the risk of immune rejection. As evidenced by
Takahashi et al. (2021) found that these cells can be differentiated into dopaminergic neurons.
functional, which shows promising results for neuronal regeneration. However, studies
such as Zhong's (2022) report, they warn of important risks, especially tumorigenesis, resulting from
due to the genetic instability and high proliferative potential of these cells, as well as for the
The need for safer and more standardized protocols.

MSC stem cells are multipotent and have less capacity for differentiation into...
neurons when compared to ESCs and IPSCs. Their relevant role, mainly due to
their paracrine effects. As pointed out by Li et al. (2022), MSCs act in the modulation of
inflammatory response, in the reduction of oxidative stress and in the release of neurotrophic factors,
promoting an environment conducive to neuronal survival. Pessoa et al. (2023) reinforce that
These cells exert significant neuroprotective effects, contributing to functional improvement.
of patients, even without promoting direct neuronal replacement.

With this, we can analyze that ESCs and iPSCs stem cells, as demonstrated
According to Takahashi et al. (2021), they stand out for their ability to generate dopaminergic neurons.
functional, in addition to the possibility of autologous application, which reduces the risk of rejection.
immunological. MSCs, according to Li et al. (2022), have less differentiation potential.
neuronal, however, they play an important role in modulating the neural microenvironment by
through anti-inflammatory and neuroprotective effects, also highlighted by Pessoa et al.
(2023).

Regarding therapeutic efficacy, the findings indicate that stem cells...
They contribute to the functional improvement of patients, whether through neuronal regeneration or other effects.
neuroprotective. Studies such as those by Pessoa et al. (2023) and Mokhtari (2025) reinforce that these
Cells play a role in releasing neurotrophic factors and protecting remaining neurons.
favoring the improvement of motor symptoms. Furthermore, as discussed by Mendes et al.
(2024), there is also potential impact on non-motor symptoms, expanding the therapeutic reach.
of these approaches.

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Despite the progress, the analysis of the results reveals important limitations regarding safety. of stem cell therapies. Among them, the risk of tumorigenesis stands out, especially associated with induced pluripotent stem cells (iPSCs). According to Zhong (2022), this risk is directly related to the high proliferative capacity and pluripotency potential of these cells, which, when not fully differentiated before transplantation, can give rise to Tumor formations, such as teratomas. This risk is also present in ESCs that share characteristics of pluripotent cells (Barker et al., 2020; Zhong, 2022). Furthermore, the possibility of genetic instability resulting from cellular reprogramming, increasing the genomic instability and contributing to unwanted cellular transformation.

Another critical point concerns the associated risks, including immune rejection in Allogeneic transplants and the presence of undifferentiated cells in the grafts reinforce the The need for rigorous quality control. Furthermore, the functional integration of the cells. The success of transplants is still limited, since it involves not only cell survival, but also... also the formation of adequate synaptic connections in neural tissues (Mendes et al., 2024; Pessoa et al., 2023).

Regarding the mechanisms of action, the studies analyzed demonstrate that the cells-

The brainstem acts through multiple pathways. In addition to substances from dopaminergic neurons, there is also the release of... of neurotrophic factors, with a reduction in oxidative stress, as evidenced by Pessoa et al. (2023). These mechanisms contribute to neuroprotection and to the possible slowing down of disease progression.

Additionally, the analysis of the studies by Bloem et al. (2021) and Zhu et al. (2024) reinforces the The complexity of Parkinson's disease, from both a clinical and epidemiological point of view, highlighting the increased prevalence and presence of both motor and non-motor symptoms. highlights the importance of therapies that not only control symptoms, but also act on... disease progression, as proposed by cell therapies.

Finally, in general, the studies analyzed converge to indicate that therapies with Stem cells represent a promising and innovative approach in the treatment of the disease. Parkinson's. However, more robust clinical studies are still needed for standardization of the protocols, long-term evaluation, and safety assurance, before their widespread application in clinical practice.

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CONCLUSION

This study achieved its objective of investigating the use of stem cells as a strategy.
therapeutic methods in the treatment of Parkinson's disease, enabling the analysis of the main types
The cells used, their mechanisms of action, their therapeutic efficacy, their limitations and
of the associated risks. From the review of the selected studies, it was possible to understand that
Cell therapies represent a promising alternative in the face of the limitations of other treatments.
conventional treatments, which currently only act in the symptomatic control of the disease, without preventing its progression.
neurodegenerative progression.

The results demonstrated that embryonic stem cells (ESCs), the stem cells
Induced pluripotent stem cells (iPSCs) and mesenchymal stem cells (MSCs) have potential
Therapeutically relevant in the context of Parkinson's disease. ESCs and iPSCs stand out for...
high differentiation capacity in dopaminergic neurons, contributing to the
neuronal regeneration and for the possible restoration of functions compromised by degeneration of
Substantia nigra. MSCs, on the other hand, exhibit important neuroprotective and immunomodulatory effects.
acting to reduce inflammation and oxidative stress, as well as promoting the release of factors
neurotrophic factors that promote neuronal survival.

Furthermore, it has been observed that stem cell therapies have positive impacts.
both the motor and non-motor symptoms of the disease, and may
to contribute to improving the quality of life, functional autonomy and well-being of
patients. In this way, the study highlights not only the clinical relevance of these therapies, but
also its potential social impact, considering the progressive increase in the prevalence of

Parkinson's disease as a consequence of population aging. In this context,
Regenerative therapies may, in the future, reduce complications, hospitalizations, and associated costs.
to the prolonged treatment of the disease, promoting important benefits for health systems.
and for society.

Despite the progress observed, significant security challenges remain.
and to the clinical application of these therapies. Among the main risks identified are
tumorigenesis, especially associated with pluripotent cells, immune rejection,
Genetic instability and difficulties in the functional integration of transplanted cells into the tissue.
neural. These factors demonstrate that, although the results are promising, they are still
Rigorous control, standardization, and monitoring protocols are necessary to ensure greater [quality/quality/safety].
safety and therapeutic efficacy.

In this context, the importance of biomedical professionals in the development and application of technology is also highlighted.

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of these innovative therapies. The biomedical professional plays a key role in research in biotechnology, cell biology, genetics and regenerative medicine, working directly in cell culture, molecular analysis, the development of laboratory protocols and in investigating the mechanisms involved in neurodegeneration. Furthermore, the biomedical scientist contributes for scientific production and the advancement of cell therapies, being essential for the integration between Experimental research, diagnosis, and therapeutic innovation focused on neurodegenerative diseases.

In conclusion, stem cell therapies represent an approach... Innovative and promising for the treatment of Parkinson's disease, with the potential to go beyond... Symptomatic control, with prospects for neural regeneration and neuroprotection. However, future Further research is needed to expand knowledge about safety and long-term effectiveness. In the long term, the standardization of therapeutic protocols and the functional integration of cells transplanted. More robust clinical studies may contribute to consolidating the application of these. therapies in clinical practice, promoting relevant scientific advances and new possibilities. therapeutics for patients affected by the disease.

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