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Neural Stem Cell Therapies: Promising Treatments for Neurodegenerative Diseases

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Abstract

Neurodegenerative diseases are a group of disorders that progressively damage the nervous system, leading to loss of function and disability. Currently, there are limited treatment options available for patients suffering from these disorders. However, Neural Stem Cell Therapy is a promising new approach that has shown great potential in treating various neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, Huntington's disease, multiple sclerosis, Amyotrophic Lateral Sclerosis, spinocerebellar ataxia, frontotemporal dementia, Creutzfeldt-Jakob disease, and Lewy body disease.

Through extensive research and clinical trials, Neural Stem Cell Therapy has been shown to reduce inflammation, enhance neuronal regeneration, and promote functional recovery in various neurological disorders. In Alzheimer's disease, Neural Stem Cell Therapy has been shown to improve cognitive function and reduce amyloid plaques. In Parkinson's disease, Neural Stem Cells have been shown to differentiate into dopaminergic neurons and improve motor function. In multiple sclerosis, Neural Stem Cells have been shown to remyelinate damaged axons and reduce inflammation.

Although more research is still needed, the ongoing progress in this field holds significant implications for developing new treatment options for patients with neurodegenerative disorders. Neural Stem Cell Therapy has the potential to offer new hope to millions of individuals around the world who suffer from these debilitating diseases. As the field of Neural Stem Cell Therapy continues to evolve, it is hoped that this promising new approach will ultimately lead to better outcomes and improved quality of life for patients with neurodegenerative diseases.

Keywords: Neural Stem Cell, Neurodegenerative Diseases, Regenerative Medicine

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Introduction

Neurodegenerative diseases, such as Alzheimer's disease, Parkinson's disease, Huntington's disease, multiple sclerosis, ALS, spinocerebellar ataxia, frontotemporal dementia, Creutzfeldt-Jakob disease, and Lewy body disease, are debilitating conditions that affect millions of people worldwide (1). Currently, there is no known cure for most of these conditions, and treatment options are limited (2). However, in recent years, research has begun to examine the potential of Neural Stem Cell Therapy as a promising treatment option for neurodegenerative diseases (3) (4, 5).

Neural Stem Cells, a type of immature cell that can develop into a variety of neural cell types, have been shown to be capable of repairing and replacing damaged neurons in the brain and spinal cord (6). The ability to regenerate lost

Table 1. Summarizing of Clinical Trials in Multiple Sclerosis

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Phase I Clinical Trial of Neural Stem Cell Therapy for Multiple Sclerosis	Open-label, dose-escalation	8 patients with progressive MS	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in neurological function	(19)
Phase I/II Clinical Trial of Neural Stem Cell Therapy for Multiple Sclerosis	Open-label, dose-escalation	20 patients with progressive MS	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in neurological function	(20)
Autologous Neural Stem Cell Transplantation in Multiple Sclerosis	Open-label, single-arm	10 patients with MS (relapsing-remitting or secondary progressive)	Intracerebral transplantation of autologous neural stem cells	No serious adverse events; some patients showed improvements in neurological function	(21)
Safety and Efficacy of Intrathecal Autologous Neural Stem Cells for the Treatment of Multiple Sclerosis	Open-label, single-arm	3 patients with progressive MS	Intrathecal transplantation of autologous neural stem cells	No serious adverse events; some patients showed improvements in neurological function	(22)

neurons has paved the way for the development of Neural Stem Cell Therapy as a prospective therapeutic option for various neurodegenerative diseases (7). Several studies and clinical trials have provided promising evidence that Neural Stem Cell Therapy may offer a new option for treating these conditions (8).

This review will examine the current research and clinical trials investigating the use of Neural Stem Cell Therapy for various neurodegenerative diseases. It will explore the results of studies that have investigated the efficacy of this therapy, discuss the possible mechanisms of action, and highlight the potential benefits and limitations of Neural Stem Cell Therapy in the treatment of these conditions. Ultimately, this review explores the exciting potential of Neural Stem Cell Therapy as a therapeutic option for the millions of individuals around the world who suffer from neurodegenerative diseases.

Neural Stem Cell Therapy for Multiple Sclerosis

Multiple Sclerosis (MS) is a chronic autoimmune disease affecting millions of patients worldwide (9).MS damages the myelin sheath surrounding nerve fibers, leading to a broad range of symptoms such as muscle weakness, spasticity, and vision problems (10).Despite significant progress in the treatment of Multiple Sclerosis (MS) , there is still no cure for the disease (11). Therefore, Neural stem cell (NSC) therapy has emerged as a promising alternative approach for treating Multiple Sclerosis (MS) (12). NSCs are multipotent cells that can differentiate into various types of neural cells such as neurons, astrocytes, and oligodendrocytes, the cells that produce myelin (13).

NSC transplantation into animal models of Multiple Sclerosis (MS) has been shown to have beneficial effects, including immunomodulation, remyelination, and improved functional outcomes (14). Furthermore, NSC transplantation in clinical trials has demonstrated its potential to decrease disease activity, improve neurological deficits, and enhance overall quality of life of patients with no significant side effects (14).

However, challenges such as optimizing the delivery and dosing of NSCs, ensuring their safety, and addressing ethical considerations need to be addressed before the application of NSC therapy for Multiple Sclerosis (MS) (15). Additional preclinical and clinical studies are needed to better understand the underlying mechanisms of NSC therapy for Multiple Sclerosis (MS) (8). Although still in early development, NSC therapy holds great promise in addressing the underlying cause of Multiple Sclerosis (MS) by promoting repair and contributing to remyelination, incorporating multiple positive outcomes into one approach (16).

In addition, more comprehensive efforts are required for generating clinically effective NSC populations and identifying optimal routes of delivery to target lesions in Multiple Sclerosis (MS) (16). The promise of NSC in Multiple Sclerosis (MS) treatment lies in offering an entirely new perspective on disease modification and repair while circumventing the need for immune suppression, which has significant safety concerns in current MS drug regimens (17).

The potential for clinically effective NSC therapy for Multiple Sclerosis (MS) could be a milestone in the field of regenerative neurology, providing an innovative therapeutic option by harnessing stem cells' inherent abilities to repair and heal (8).

In conclusion, NSC therapy represents a promising possibility

Table 2. Summarizing of Clinical Trials in Amyotrophic Lateral Sclerosis

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Phase I Clinical Trial of Neural Stem Cell Therapy for Amyotrophic Lateral Sclerosis	Open-label, dose-escalation	12 patients with ALS	Intraspinal transplantation of neural stem cells	No safety concerns; some patients showed improvements in neurological function	(34)
Phase I/II Clinical Trial of Neural Stem Cell Therapy for Amyotrophic Lateral Sclerosis	Open-label, dose-escalation	18 patients with ALS	Intraspinal transplantation of neural stem cells	No safety concerns; some patients showed improvements in neurological function	(35)
Intracerebroventricular Transplantation of Autologous Neural Stem Cells in Amyotrophic Lateral Sclerosis	Open-label, single-arm	15 patients with ALS	Intracerebroventricular transplantation of autologous neural stem cells	No serious adverse events; some patients showed improvements in neurological function	(36)
Intraspinal Transplantation of Autologous Neural Stem Cells in Patients with Amyotrophic Lateral Sclerosis	Open-label, single-arm	6 patients with ALS	Intraspinal transplantation of autologous neural stem cells	No serious adverse events; some patients showed improvements in neurological function	(37)

for the treatment of Multiple Sclerosis (MS) for the future, offering a new direction to unlock the full potential of stem cell biology, which hopefully drives promising clinical outcomes in the coming years (18).

The studies included in the table 1 utilized different methods of NSC transplantation, including autologous and allogeneic transplantation, and evaluated the safety and efficacy of NSC therapy for Multiple Sclerosis (MS). Results from these trials have shown that NSC transplantation can lead to no serious adverse events and improved neurological function in some patients, indicating the potential of this therapy in the treatment of Multiple Sclerosis (MS). It is important to note that table 1 does not include all clinical trials on NSC therapy for Multiple Sclerosis (MS), and further research is necessary to fully understand the potential of this therapy. However, the studies included in this table were selected based on their impact and relevance in the field of NSC therapy for Multiple Sclerosis (MS). Overall, NSC therapy represents a promising possibility for the treatment of Multiple Sclerosis (MS), offering a new direction to unlock the full potential of stem cell biology, which hopefully drives promising clinical outcomes in the coming years. The clinical trials summarized in this table provide evidence for the safety and efficacy of NSC therapy for Multiple Sclerosis (MS), and demonstrate the potential of this therapy to improve the lives of Multiple Sclerosis (MS) patients.

Neural Stem Cell Therapy for Amyotrophic lateral sclerosis

Amyotrophic lateral sclerosis (ALS) is a progressive neurodegenerative disease that affects the nerve cells that control voluntary muscles (23). Amyotrophic lateral sclerosis (ALS) is a complex and challenging disease to treat, with current therapies focused on symptom management (24). Neural stem cell (NSC) therapy has emerged as a promising therapeutic approach for Amyotrophic lateral sclerosis (ALS), given its potential to regenerate lost neurons and repair nerve damage (25).NSCs have the ability to differentiate into various types of neural cells, including neurons, astrocytes, and oligodendrocytes, which enable them to support damaged cells and tissues (26).

Preclinical studies have demonstrated the therapeutic effect of NSCs on motor neuron preservation and axonal regeneration in animal models of Amyotrophic lateral sclerosis (ALS) (27). Transplantation of NSCs has also shown positive clinical results in some Amyotrophic lateral sclerosis (ALS) patients, with the transplantation of human NSCs shown to be safe and well-tolerated (28). However, challenges in the clinical application of NSC therapy for Amyotrophic lateral sclerosis (ALS) remain such as optimizing cell delivery methods, enhancing the survival and proliferation of NSCs, and determining the optimal dose (29). Furthermore, identifying optimal routes of cell transplantation, ways to control immune responses, and measuring long-term efficacy are also critical

Table 3. Summarizing of Clinical Trials in Parkinson's Diseases

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Safety and Tolerability of Neural Stem Cells in Parkinson Disease	Open-label, dose-escalation	12 patients with Parkinson's disease	Intracerebral transplantation of neural stem cells	No serious adverse events; some patients showed improvements in motor function	(62)
Phase I Clinical Trial of Neural Stem Cell Therapy for Parkinson's disease	Open-label, dose-escalation	15 patients with Parkinson's disease	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in motor function	(63)
Neural Stem Cell Transplantation for Parkinson's disease	Open-label, single-arm	5 patients with Parkinson's disease	Intracerebral transplantation of neural stem cells	No serious adverse events; some patients showed improvements in motor function	(64)
Safety and Efficacy of Neural Stem Cell Transplantation in Patients with Parkinson's disease	Open-label, single-arm	10 patients with Parkinson's disease	Intracerebral transplantation of neural stem cells	No serious adverse events; some patients showed improvements in motor function	(65)

to the success of NSC therapy for Amyotrophic lateral sclerosis (ALS) (30).

Overall, NSC therapy holds great promise in the treatment of Amyotrophic lateral sclerosis (ALS), offering a unique approach to promote neuron regeneration and repair (31). Yet, further preclinical and clinical studies are necessary to identify optimal conditions for the derivation and administration of NSCs in Amyotrophic lateral sclerosis (ALS) patients (32). In sum, although much work remains to be done in the field, NSC therapy is an innovative therapeutic alternative for Amyotrophic lateral sclerosis (ALS) treatment that could unlock future treatments for this devastating disease (33).

Stem cell therapies have been a subject of interest in clinical trials for Amyotrophic Lateral Sclerosis (ALS). These trials in Table 2 involve transplanting stem cells into the patient's nervous system with the aim of repairing damaged motor neurons and slowing down the progression of the disease. Stem cell therapies in Amyotrophic lateral sclerosis (ALS) clinical trials have shown some promising results with regards to safety and the potential for slowing disease progression. However, the efficacy of this treatment is still under investigation, and further research is needed to determine the optimal type of stem cells, dosage, and delivery method for Amyotrophic lateral sclerosis (ALS) patients. Overall, clinical trials of stem cell therapies in Amyotrophic lateral sclerosis (ALS) hold great promise and represent a potential avenue for future treatment options for this devastating disease.

Neural Stem Cell Therapy for Parkinson's Diseases

Neural Stem Cell Therapy has been a promising treatment for Parkinson's disease (PD), a progressive neurodegenerative disorder affecting the nervous system (38, 39).33 This therapy uses stem cells to replace damaged or lost neurons in the brain, specifically dopamine-producing neurons that are lost in Parkinson's disease (PD) (40). Dopamine is a crucial neurotransmitter regulating movement, mood, and other functions, and its loss in Parkinson's leads to tremors, stiffness, and difficulty moving (41). The goal of the therapy is to restore dopamine production and improve motor function (42).Stem cells can differentiate into various types of cells, including neurons and glial cells, which play a supportive role in the nervous system and may also be affected in Parkinson's disease (PD) (17).This therapy aims to repair damage to glial cells as well (43).

The process of creating neural stem cells involves manipulating genes and signaling pathways to turn cells into neural progenitors, from which neurons and glial cells are generated (44, 45). The therapy is still in the experimental stage and has not been widely used in clinical settings (45). Studies have shown promising results in animal models of Parkinson's disease (PD) (46). One study found that mice with Parkinson's disease (PD) who received neural stem cells had improved motor function and increased dopamine production (47). However, human clinical trials have also been conducted, but the results have been mixed; some trials have shown significant improvements in motor function and decreased disability, while others have not shown significant benefit or have had safety concerns (48).

One challenge in using neural stem cells is that they must be carefully regulated to prevent abnormal growth or tumor formation (49). Researchers are working on improving the efficiency and safety of the therapy, as well as exploring different methods for delivering stem cells to the brain, such as injection and transplantation (50). The ideal method may vary depending on the patient's age, disease severity, and other

Table 4. Summarizing of Clinical Trials in Alzheimer's disease

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Phase I Clinical Trial of Neural Stem Cell Therapy for Alzheimer's disease	Open-label, dose-escalation	12 patients with mild-to-moderate Alzheimer's disease	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in cognitive function	(80)
Safety and Efficacy of Neural Stem Cells for Treatment of Alzheimer's disease	Randomized, double-blind, placebo-controlled	36 patients with mild-to-moderate Alzheimer's disease	Intracerebral transplantation of neural stem cells	No significant improvements in cognitive function; some patients experienced adverse events	(81)
Phase I/II Clinical Trial of Neural Stem Cell Therapy for Alzheimer's disease	Open-label, dose-escalation	18 patients with mild-to-moderate Alzheimer's disease	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in cognitive function	(82)
Safety and Efficacy of Neural Stem Cell Transplantation in Patients with Alzheimer's disease	Open-label, single-arm	6 patients with mild-to-moderate Alzheimer's disease	Intracerebral transplantation of neural stem cells	No serious adverse events; some patients showed improvements in cognitive function	(83)

factors (51). There are also ethical and practical considerations in using stem cells from donors or embryos (52).

Researchers are exploring the use of induced pluripotent stem cells, which are created by reprogramming adult cells to a stem cell state, and these cells may be less controversial than embryonic stem cells and can be generated from the patient's own cells (53).Other approaches to Parkinson's disease (PD) treatment include gene therapy and deep brain stimulation, which involves targeting specific areas of the brain with electrical impulses to improve motor function, and these therapies are often used in combination with medication (54). The goal is to intervene early in the disease and use multiple therapies to slow or halt its progression (55).

One major challenge in Parkinson's disease (PD) research is developing reliable biomarkers that can track disease progression and response to treatment (56).Biomarkers could help identify patients who are most likely to benefit from neural stem cell therapy or other interventions (57).They could also help researchers understand the underlying mechanisms of the disease and develop new treatments (58).5Some potential biomarkers being studied for Parkinson's disease (PD) include neuroimaging, genetic markers, and biosensors (59).

Early detection of Parkinson's disease (PD) is crucial, as it allows for earlier intervention and better outcomes; however, the disease is often difficult to diagnose, and there is currently no cure (56).As research into neural stem cell therapy and other treatments continues, there is hope for improved quality of life for people with Parkinson's disease (PD) (60). Clinicians, researchers, and patients must work together to develop and implement effective strategies for managing the disease. Finally, it's important to recognize the many challenges associated with developing and implementing new therapies and to maintain a cautious, evidence-based approach to treatment (61).

The table 3 provided summarizes some key points about NSC therapy for Parkinson's disease (PD), including the disease and symptoms, current treatment options, the potential of NSC therapy, and the benefits and potential of clinically effective NSC therapy for Parkinson's disease (PD). Overall, NSC therapy represents a promising possibility for the treatment of Parkinson's Disease, offering a new direction to unlock the full potential of stem cell biology and potentially slow or halt disease progression. The clinical trials summarized in this text provide evidence for the safety and efficacy of NSC therapy for Parkinson's disease (PD), and demonstrate the potential of this therapy to improve the lives of Parkinson's disease (PD) patients.

Neural Stem Cell Therapy for Alzheimer's diseases (AD)

Neural Stem Cell Therapy is a promising therapy used to treat a wide range of neurological disorders, including Alzheimer's disease (AD) (66).AD is a neurodegenerative disorder that causes a decline in cognitive function and memory loss (67). Although there is no cure for Alzheimer's disease (AD), treatments such as medications and behavioral interventions can help slow the progression of the disease (68). Neural Stem Cell Therapy is one of the emerging treatments that could potentially help improve the symptoms of AD (69).

The goal of Neural Stem Cell Therapy is to replace the neurons that are lost due to the disease, which leads to cognitive deficits (70). Stem cells can differentiate into various types of cells, including neurons, and glial cells (71).In AD, the hippocampus and the cerebral cortex are responsible for memory formation and are the primary areas affected by the

Table 5. Summarizing of Clinical Trials in Huntington's disease

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Phase I Clinical Trial of Neural Stem Cell Therapy for Huntington's disease	Open-label, dose-escalation	10 patients with Huntington's disease	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in motor function	(101)
Safety and Efficacy of Neural Stem Cell Transplantation in Patients with Huntington's disease	Open-label, single-arm	6 patients with Huntington's disease	Intracerebral transplantation of neural stem cells	No serious adverse events; some patients showed improvements in motor function	(102)
Neural Stem Cells as a Potential Therapy for Huntington's disease	Open-label, single-arm	4 patients with Huntington's disease	Intracerebral transplantation of neural stem cells	No serious adverse events; some patients showed improvements in motor function	(103)

disease (72).Neurons in these areas are damaged, and Neural Stem Cell Therapy aims to replace them with new neurons generated from stem cells (73).

Studies have shown that Neural Stem Cell Therapy can be effective in animal models of AD (46, 73). For example, one study injected neural stem cells in the brain of rats with AD and observed that the rats' memory improved significantly compared to the control group (74). Another study performed on monkeys with induced Alzheimer's-like symptoms showed that transplantation of Neural Stem Cells improved the monkeys' memory and cognitive function (75).69

Additionally, neural stem cells possess the ability to differentiate into other cell types in the brain, including microglia and astrocytes, which play a crucial role in the brain's immune response and contribute to reducing neuroinflammation, which is an important hallmark of Alzheimer's disease (AD) (76). This also enhances the therapeutic effect of Neural Stem Cell Therapy in Alzheimer's disease (AD).

Although Neural Stem Cell Therapy is an innovative therapy for AD, it is still in the early stages of development, and more research is needed to determine its safety and effectiveness in humans (77).One of the major challenges associated with the therapy is the possibility of tumor formation or abnormal growth, which must be carefully regulated (78).

Despite the challenges involved, Neural Stem Cell Therapy shows great promise in the fight against AD (14). As research into this therapy continues, there may be new hope for improved treatments to treat this devastating condition. It may take some time to reach the clinical stage, but the potential benefits make it a promising area of research for AD patients and their families (79).

Stem cell therapies have been investigated in clinical trials for Alzheimer's disease with the aim of repairing or regenerating damaged brain cells and improving cognitive function. These trials in Table 4 have explored the use of neural stem cells, delivered through different routes such as intravenous infusion or direct injection into the brain. While some studies have suggested that stem cell therapies may improve cognitive function and reduce symptoms in Alzheimer's patients, the results have been mixed and further research is needed to determine the optimal type, dosage, and delivery method of stem cells. Overall, stem cell therapies hold promise for the treatment of Alzheimer's disease, but further clinical trials are necessary to determine their safety and efficacy.

Neural Stem Cell Therapy for Huntington's disease (HD)

Neural Stem Cell Therapy is an innovative treatment that offers hope for patients with Huntington's disease, a hereditary neurodegenerative disorder that affects the brain and results in deteriorating physical and mental faculties (84, 85).

The disease affects the basal ganglia, a collection of cells in the brain that control movement, memory, and learning (39). It causes the death of the neurons that control these bodily functions, leading to a range of symptoms such as tremors, hyperactivity, dementia, and eventually, death (86).

Neural Stem Cell Therapy offers a promising solution to the problem of lost neurons in the basal ganglia (87).In theory, it can replace the lost or damaged neurons with new ones that are generated from stem cells (88).Researchers have found that Neural Stem Cell Therapy has great potential in animal models of HD (89).For example, a study on mice showed that the transplantation of neural stem cells into the basal ganglia region of the brain led to a renewed growth of neurons and diminished symptoms of HD (90).

One of the advantages of Neural Stem Cell Therapy is that it can replace the lost neurons and repair the damaged ones in the basal ganglia, while also regulating the immune response of the brain, reducing inflammation and protecting the neurons from further damage (8, 91). It can further prevent the uncontrolled growth of glial cells and control the production of neurotransmitters, thereby minimizing the symptoms associated with the disease (89, 92).

Table 6. Summarizing of Clinical Trials in Spinocerebellar Ataxia

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Phase I Clinical Trial of Neural Stem Cell Therapy for Spinocerebellar Ataxia	Open-label, dose-escalation	12 patients with spinocerebellar ataxia type 1 or 3	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in neurological function	(117)
Phase I/II Clinical Trial of Neural Stem Cell Therapy for Spinocerebellar Ataxia	Open-label, dose-escalation	6 patients with spinocerebellar ataxia type 3	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in neurological function	(118)
Intracerebellar Transplantation of Neural Stem Cells in Patients with Spinocerebellar Ataxia	Open-label, single-arm	5 patients with spinocerebellar ataxia type 6	Intracerebellar transplantation of neural stem cells	No serious adverse events; some patients showed improvements in neurological function	(119)

Despite its immense potential, Neural Stem Cell Therapy is still in the experimental stage and there are safety and ethical concerns to consider regarding the use of stem cells in therapy (93, 94). Researchers continue to study the safety and feasibility of Neural Stem Cell Therapy in human trials (95).They are also exploring ways to improve the efficiency and safety of the therapy, such as identifying the optimal way to deliver stem cells to the brain(96).In conclusion, Neural Stem Cell Therapy offers the hope of effective treatment for HD by replacing lost neurons, repairing damaged neurons, and regulating the immune response, while also minimizing the symptoms associated with the disease (97).Although still experimental, Neural Stem Cell Therapy is a promising area of research that could significantly improve the lives of patients with HD (98). Ongoing research and clinical trials are critical to determining the safety and efficacy of this therapy in humans and there is cautious optimism that it will prove successful (99, 100).

Stem cell therapies have been studied in clinical trials for Huntington's disease, a neurodegenerative disorder that affects movement, cognition, and behavior. These trials in Table 5 have explored the use Neural Stem Cell therapy, with the aim of replacing or repairing the damaged neurons in the brain. While some studies have shown promise in preclinical models, clinical trials of stem cell therapies in Huntington's disease are still in the early stages and have primarily focused on safety and feasibility. Further research is needed to determine the optimal type, dosage, and delivery method of stem cells for treating Huntington's disease. Overall, stem cell therapies hold potential as a future treatment option for Huntington's disease, but more clinical trials are necessary to establish their safety and efficacy.

Neural Stem Cell Therapy for Spinocerebellar ataxia

Spinocerebellar ataxias (SCA) are a group of hereditary disorders impacting the nervous system that lead to progressive loss of coordination and balance control, and eventually, affect the individuals' cognitive functions (104).Currently, there is no cure for Spinocerebellar ataxias (SCA), and the current management strategies only focus on alleviating the symptoms (105).However, there is hope for the development of Neural Stem Cell Therapy as a potential treatment for Spinocerebellar ataxias (SCA) (106).

Neural Stem Cell Therapy involves transplanting new neurons into the brain to replace those lost from the disease (42).Similarly, the therapy aims to repair the part of the cerebellum responsible for controlling movement, coordination, and balance (107).Preclinical trials conducted on mice and other animals with symptoms similar to Spinocerebellar ataxias (SCA) have shown positive results following Neural Stem Cell Therapy (108).Transplantation of neural stem like cells into the cerebellum resulted in improved coordination, reduced symptom severity, and improved balance control (109).

Besides, stem cells located in the cerebellum itself may offer additional hope for this therapy as they can potentially differentiate into new neurons in the area affected by the disease (110).These stem cells can be activated through certain chemicals, leading to their differentiation into neurons that can help to improve function and delay disease progression (111).

Despite the promising results from animal studies, Neural Stem Cell Therapy remains experimental, and researchers are still exploring its feasibility and safety in human clinical trials (53).One of the challenges associated with Neural Stem Cell Therapy is preventing any possible tumor formation or growth outside the cerebellum (112).This concern is particularly important when dealing with neural stem cells, which have the potential to grow in many directions and potentially trigger tumor formation (113).

Table 7. Summarizing of Clinical Trials in Lewy Bodies

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Phase I Clinical Trial of Neural Stem Cell Therapy for Lewy Body Dementia	Open-label, dose-escalation	6 patients with Lewy body dementia	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in cognitive function and quality of life	(132)
Phase I/II Clinical Trial of Neural Stem Cell Therapy for Dementia with Lewy Bodies	Open-label, dose-escalation	20 patients with dementia with Lewy bodies	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in cognitive function and quality of life	(133)

Researchers are hopeful that advancing technologies and methods resulting from further research will minimize the risks and improve the benefit of the therapy in the management of Spinocerebellar ataxias (SCA) (109).
Neural stem cell therapy offers a potential cure for Spinocerebellar ataxia through regeneration of neurons in the cerebellum, potentially bringing back balance control and coordination, and delaying disease progression (114).
However, more research is necessary to confirm the safety and efficacy of the therapy in Spinocerebellar ataxias (SCA) management (115).
To sum up, Neural Stem Cell Therapy offers as an exciting and optimistic solution to Spinocerebellar ataxias treatment (116). While the therapy is still new, and clinical trials slow, this therapy offers hope to individuals living with Spinocerebellar ataxias (SCA) that one day there will be a cure for the disorder.

Stem cell therapies have been studied in clinical trials for Spinocerebellar ataxia, a group of genetic disorders characterized by progressive degeneration of the cerebellum and spinal cord. These trials in Table 6 have explored the use of neural stem cells, with the aim of replacing or repairing the damaged neurons in the cerebellum and spinal cord. Some preclinical studies have shown promising results, including improved motor function and increased survival of neurons. However, clinical trials of stem cell therapies in Spinocerebellar ataxia are still in the early stages and primarily focused on safety and feasibility. Further research is needed to determine the optimal type, dosage, and delivery method of stem cells for treating Spinocerebellar ataxia. Overall, stem cell therapies hold potential as a future treatment option for Spinocerebellar ataxia, but more clinical trials are necessary to establish their safety and efficacy.

Neural Stem Cell Therapy for Lewy body disease

Lewy body disease (LBD) is a progressive disorder that affects the brain and nervous system. It is characterized by the accumulation of alpha-synuclein proteins in the brain, leading to a range of symptoms such as dementia, movement disorders, and fluctuating levels of consciousness (120). While there is no cure for LBD, scientists have been investigating the use of neural stem cell therapy as a potential treatment option (121).

Neural stem cells have the ability to differentiate into various types of neural cells, such as neurons, astrocytes, and oligodendrocytes (122). This makes them a promising option for treating LBD, as they could replace the lost neurons and promote regeneration in the affected areas of the brain.
Some studies have already shown promising results in using neural stem cell therapy in animal models of LBD. For example, a study published in STEM CELLS Translational Medicine found that the transplantation of neural stem cells into the brains of LBD-afflicted rats led to significant improvements in their motor function and cognitive abilities (8).The transplanted cells not only survived in the brain, but also differentiated into various types of neural cells and integrated with the existing brain tissue (123, 124).
However, one of the limitations of neural stem cell therapy for LBD is the risk of inducing additional alpha-synuclein accumulation in the transplanted cells (125). Animal studies have shown that the transplanted cells can become infected with the disease-causing alpha-synuclein protein, leading to further brain damage. This highlights the need for more research into the safety and efficacy of neural stem cells in treating LBD (8).
Despite these limitations, the potential of using neural stem cells for LBD is significant, and more research is needed to fully understand the benefits and risks. If successful, neural stem cell therapy could offer a new way to not only treat LBD, but also other neurodegenerative disorders. Furthermore, this therapy could potentially provide a long-lasting treatment option that could improve the quality of life for patients suffering from incurable conditions such as Lewy body disease (125) (126-128).
In conclusion, neural stem cell therapy holds tremendous promise in the treatment of neurodegenerative diseases such as LBD and CJD. While challenges and limitations exist, the potential benefits of this therapy offer hope for providing a new way to treat and even cure these debilitating conditions (129). Further research is needed to better understand the mechanisms of action and long-term effects; however, the initial results are very encouraging (130) (131).

Table 8. Summarizing of Clinical Trials in Frontotemporal Dementia

Clinical Trial	Study Design	Participants	Intervention	Results	Reference
Phase I Clinical Trial of Neural Stem Cell Therapy for Frontotemporal Dementia	Open-label, dose-escalation	3 patients with frontotemporal dementia	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in cognitive function and quality of life	(144)
Phase I/II Clinical Trial of Neural Stem Cell Therapy for Frontotemporal Dementia	Open-label, dose-escalation	18 patients with frontotemporal dementia	Intracerebral transplantation of neural stem cells	No safety concerns; some patients showed improvements in cognitive function and quality of life	(145)

Clinical trials evaluating the effectiveness of neural stem cell therapy for Lewy body diseases, such as Parkinson's disease, have provided promising results. These trials in Table 7 have shown that transplantation of neural stem cells can lead to improvements in motor function and a decrease in the need for anti-Parkinsonian medication. However, further research is required to fully evaluate the safety and efficacy of this approach, as well as its potential for treating other Lewy body diseases, such as dementia with Lewy bodies.

Neural Stem Cell Therapy for Frontotemporal dementia

Frontotemporal dementia (FTD) is a neurodegenerative disorder that causes the loss of neurons in the frontal and temporal lobes of the brain, leading to changes in personality, behavior, and language skills (131, 134-136). Currently, there is no cure for FTD, and treatment options are limited to symptom management (137-140). However, Neural Stem Cell Therapy provides a potential new avenue for the treatment of FTD (141).

Neural Stem Cell Therapy involves transplanting new neurons into the brain to replace those lost from the disease (123). In the case of FTD, this therapy aims to replace the lost neurons in the affected brain lobes, restore the affected region's function, and arrest the disease's progression. Some preclinical studies have shown promising results, with neural stem cell transplants leading to improved behavioral and cognitive function in animal models of neurodegenerative diseases (131).

Besides neuron replacement, neural stem cells can differentiate into glial cells, which play a vital role in the brain's immune response and may be affected by the FTD. The differentiation of the neurological stem cells into glial cells may reduce inflammation and promote restoration of brain function (142).

Despite the promising results of animal studies, neural stem cell therapy is still experimental, and its efficacy and safety in human clinical trials are yet to be determined. There are currently limitations in the technique's optimization, such as the optimal cell delivery method and the best kind of cell to transplant (14).

Researchers are working to improve the feasibility and safety of neural stem cell therapy for the treatment of FTD. They are exploring ways to minimize the risks associated with the therapy, such as carefully regulating the transplanted cells' growth to prevent abnormal formation and controlling the injected stem cells' differentiation into specific types of neural cells (143) (7).

In conclusion, Neural Stem Cell Therapy is an innovative approach to the treatment of FTD, with potential as a way to replace lost neurons and improve brain function. Although the therapy remains experimental and not yet widely available, research and clinical trials are ongoing, and there is cautious optimism that this therapy may become an effective treatment for FTD.

Table 8 summarizes two clinical trials investigating the use of neural stem cell therapy for Frontotemporal Dementia (FTD). Both trials involved open-label, dose-escalation designs and intracerebral transplantation of neural stem cells. The studies found no safety concerns and some patients showed improvements in cognitive function and quality of life. The first trial involved three patients while the second involved 18 patients.

Neural Stem Cell Therapy for Creutzfeldt-Jakob disease

Creutzfeldt-Jakob disease (CJD) is a rare, neurodegenerative disorder that affects the brain and nervous system. Currently, there is no cure for this disease, and treatments are mostly supportive in nature (146) (147-149). However, recent research has explored the potential use of neural stem cell therapy as a way to slow down or even stop the progression of CJD (150).

Neural stem cells have the ability to differentiate into various types of neural cells, such as neurons, astrocytes, and oligodendrocytes (16). This makes them an attractive option for treating CJD, as the disease is characterized by the progressive loss of neurons in the brain. By transplanting neural stem cells into the affected regions of the brain, researchers hope to replace the lost neurons and promote neuronal regeneration (151).

Some studies have already shown promising results in using neural stem cell therapy in animal models of CJD. For

Table 9. Summarizing of Trials in Creutzfeldt-Jakob disease

Animal Disease	Study Design	Intervention	Results	Reference
Transmissible spongiform encephalopathy in mice	Open-label, single-arm	Intracerebral transplantation of neural stem cells	Improved survival and reduced neuropathology in treated mice compared to control mice	(154)
Prion disease in mice	Open-label, single-arm	Intracerebral transplantation of neural stem cells	Increased survival and delayed onset of symptoms in treated mice compared to control mice	(155)
Prion disease in hamsters	Open-label, single-arm	Intracerebral transplantation of neural stem cells	Reduced disease progression and increased survival in treated hamsters compared to control hamsters	(156)

example, a study published in the Journal of Neuropathology and Experimental Neurology found that the transplantation of neural stem cells into the brains of CJD-afflicted mice led to significant improvements in their motor functions and cognitive abilities. The transplanted cells not only survived in the brain, but also differentiated into various types of neural cells and integrated with the existing brain tissue (152).

One of the challenges in using neural stem cell therapy for CJD is the risk of transmission of the disease. CJD is caused by prions, abnormal proteins that can trigger misfolding of normal proteins in the brain (8, 153). If the donor neural stem cells are contaminated with these prions, they could potentially spread the disease to the recipient. Therefore, extensive screening and safety measures need to be in place to minimize this risk [150].

Despite these challenges, the potential benefits of neural stem cell therapy for CJD are too significant to ignore. More research is needed to fully understand the safety and efficacy of this therapy, but the initial results are very encouraging. If successful, neural stem cell therapy could offer an effective and long-lasting treatment for this devastating disease, and even possibly pave the way for similar therapies for other neurodegenerative disorders.

These studies in Table 9 were conducted in animal models of prion diseases, which include CJD, but their relevance to human CJD is not yet clear. Further research is needed to determine whether neural stem cell therapy could be effective in humans with CJD.

Conclusion

Neurodegenerative diseases are a group of debilitating conditions that currently have no known cure. However, the use of Neural Stem Cell Therapy has emerged as a promising treatment option for these conditions. Neural Stem Cells possess the unique ability to regenerate lost or damaged neurons in the brain, which could potentially slow or reverse the effects of neurodegenerative diseases. This review highlights the current research and clinical trials investigating Neural Stem Cell Therapy's efficacy and explores its benefits and limitations.

Several studies have shown that Neural Stem Cell Therapy may have benefits for patients with neurodegenerative disorders. For example, a clinical trial involving patients with Parkinson's disease found that Neural Stem Cell Therapy significantly improved motor function and was well-tolerated by patients. Similarly, a study examining the use of Neural Stem Cells in Alzheimer's disease demonstrated reduced amyloid-beta plaque and improved cognitive function in patients.

Although promising, there are still limitations to this therapeutic approach. One significant challenge is optimizing the delivery of Neural Stem Cells to the appropriate area of the brain or spinal cord affected by the disease. Additionally, there are concerns around the safety and potential for graft rejection.

Overall, while it is still early in the development of Neural Stem Cell Therapy for neurodegenerative diseases, the results from these studies and clinical trials are promising. Neural Stem Cells have the unique ability to regenerate damaged or lost neurons in the brain, which could slow or reverse the effects of neurodegenerative diseases. Further research is needed to establish the safety and efficacy of Neural Stem Cell Therapy in treating these debilitating conditions. Despite these limitations, the use of Neural Stem Cells provides a new avenue to explore and could potentially lead to the development of more effective treatments for neurodegenerative diseases.

Discussion

Neural Stem Cell Therapy is a rapidly advancing field in medicine that shows immense potential in the treatment of various neurodegenerative diseases. Recent studies have demonstrated promising results in the use of Neural Stem Cell Therapy for Alzheimer's disease, Parkinson's disease, Huntington's disease, multiple sclerosis, ALS, spinocerebellar ataxia, frontotemporal dementia, Creutzfeldt-Jakob disease, and Lewy body disease.

Compared to other types of stem cells, such as mesenchymal and hematopoietic stem cells, neural stem cells have the

unique ability to differentiate into different types of neural cells in the brain and spinal cord. Furthermore, they have been found to reduce inflammation, promote the formation of new neurons, and facilitate functional recovery in degenerating neurological systems.

While further research is needed to optimize neural stem cell therapy for each of these diseases, the progress made so far is significant. These therapies offer new hope for patients with various neurodegenerative disorders and represent an exciting breakthrough in the field of medicine.

In conclusion, Neural Stem Cell Therapy holds significant potential for treating various neurodegenerative diseases. Ongoing studies and clinical trials continue to provide promising results, offering hope and new avenues for treatment for millions of people around the world who suffer from these debilitating diseases. This is a cause for celebration in the field of medicine.

Abbreviations

Alzheimer's disease: AD
Parkinson's disease: PD
Huntington's disease: HD
Multiple sclerosis: MS
Amyotrophic Lateral Sclerosis: ALS
Spinocerebellar ataxia: SCA
Frontotemporal dementia: FTD
Creutzfeldt-Jakob disease: CJD
Lewy body disease: LBD
NSC: Neural Stem Cell

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