

Investigating the Potential of Stem Cell Therapy in Treating Neurodegenerative Diseases

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Abstract: *Stem cell therapy is an extensively researched topic these days as it can potentially improve certain neurodegenerative diseases like Parkinson's disease and Alzheimer's disease by its mechanism of tissue repairment and the production of new cells. Stem cells are also being used to treat other diseases like cancer, arthritis, etc, and are showing good results. Stem cell therapy has its set of limitations as its effectiveness may decline concerning the age of the patient, as well as their functioning can be disrupted if there is any sort of blockage in the pathway of these cells.*

Keywords: Stem cell therapy, mesenchymal stem cells, embryonic stem cells, neural stem cells, Alzheimer's disease, Parkinson's disease, osteoarthritis, liver failure.

1. Introduction to stem cells and their properties

Stem cells are a type of cells that have the ability to differentiate into specific cell types. There are two main types:

- Pluripotent stem cells - They have the ability to differentiate into any cell type. The pluripotent stem cells are present in the embryo for a very short period before giving rise to various other cell types including the three germ layers.
- These cells are also known as "embryonic stem cells" because they are extracted from the embryo as the inner cell mass of the embryo contains 10 - 15% of these cells which can be isolated for later use.
- Multipotent stem cells - They are restricted to a specific cell type that they can differentiate into. The multipotent cells have various sub - types some will differentiate into a particular germline and others in a type of tissue.
- These cells are a viable option for clinical use. They are extracted from developing embryos during the gastrulation period. These cells have the flexibility to differentiate into all the cell types of their particular germ layer. They are known to have the highest differentiating potential.
- Neural stem cells - They can be extracted from the fetal or adult central nervous system by dissecting some specific regions of the brain. These cells can further differentiate into oligodendrocytes (responsible for producing myelin sheaths for the nerve cells), neurons, and astrocytes (perform functions including metabolic, synaptic, neuroprotective, structural, and homeostatic).

Overview of neurodegenerative diseases (Alzheimer's, Parkinson's, etc.)

1) Alzheimer's disease

This is a brain disorder that affects the memory and eventually the ability to perform daily tasks. This disorder is usually observed among people in later life. The effect of this disease is divided into stages in the start there is an abnormal buildup of protein in the brain in the form of amyloid plaques and tangles. In the initial stages, the hippocampus and the entorhinal cortex located in the temporal lobe of the brain are damaged which are the main parts involved in the formation of memories.

There is loss in the connections between the neurons of the brain as well as the stop in the functioning of them which eventually leads to the death of these neurons. Some symptoms of this disorder are memory loss, difficulty in finding words, vision issues, etc.

The cause of this disease is influenced by multiple genes in combination with lifestyle and environmental factors. People suffering from Down syndrome are much more prone to getting this disease as they have an extra chromosome 21, which contains the APP gene which can produce an excessive amount of amyloid precursor protein which in turn can cause the formation of plaques in the brain.

2) Parkinson's disease

This is a movement disorder of the nervous system. The neurons of the brain with time weaken and eventually die, which causes issues in walking, talking, or carrying out simple tasks. People suffering from these issues can have other diseases as well, not just Parkinson's disease.

The main symptoms of this disease are - tremors, rigidity, bradykinesia (the slowing down of automatic and spontaneous movement), and postural instability. Certain other problems that may accompany this disease are - depression, speech changes, sleep issues, dementia, and problems with swallowing and chewing.

The risk factors of this disease include - age, heredity, exposure to certain chemicals or pesticides, and biological sex (it is seen to affect more men than women).

2. Mechanisms of stem cell therapy in treating neurodegeneration

Neurogenesis is the process of formation of new neurons in the brain that occurs throughout the human life span. Daily, 9000 - 10000 new cells are made in the hippocampus out of which 90% of the cells have the potential to differentiate into neurons. This is observed to mainly occur at two locations - The subventricular zone (a region on the outside of each lateral ventricle wall) and the subgranular zone. The neurons made in these regions migrate to their set destinations, simultaneously the precursors travel to their destination to carry out processes like - proliferation, cell death or survival, and differentiation.

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1) About the Parkinson's disease

Currently, available therapies target the symptoms of this disease and are not a cure for the illness. During this disease the neurons responsible for producing dopamine start to degenerate (dopaminergic neurons). When stem cell therapy is used for this particular disease the aim is to produce the dopaminergic neurons, which is made possible by the differentiation of stem cells into dopaminergic neurons.

It has also been found that the fibroblasts from the PD patients can be reprogrammed to differentiate into the dopaminergic neurons.

2) About the Alzheimer's disease

Alzheimer's is one of the most common forms of dementia and most of the people suffering from this speak treatment at the advanced stage of Alzheimer's. The approach used is to save the preexisting cells and replace the lost neurons. The recent groundbreaking approach for Alzheimer's patients has been the introduction of mesenchymal stem cells which are injected through an intravenous injection.

The mesenchymal stem cells are known for their ability to repair inflammation. Some benefits of using stem cell therapy in the treatment of Alzheimer's disease include enhanced memory functions, neuronal regeneration, and overall recovery improvement.

3) Ethical and safety challenges

Taking into consideration the Embryonic stem cells derived from the inner cellular mass of an embryo and have the ability to differentiate into all three germ layers (endoderm, ectoderm, and mesoderm) the ethical dilemma arises if it is right to destroy a human embryo at an early stage for the extraction of these cells. The major question is also that is it correct to destroy a human embryo to cure illnesses. Except for the ethical concerns, there are safety concerns as well - the ESCs have the ability to benefit us but also can reverse and prove to be harmful.

If undifferentiated ESCs are transplanted then they might form teratomas and tumors that contain all three germ layers. The only way to avoid this is to differentiate the ESCs in a suitable place and then before infection screen them to check the presence of any undifferentiated ESCs.

Limitations of stem cell therapy

Stem cell therapy gives hope for improvement through the production of new cells, but is not a cure for diseases. The main idea of stem cells is to repair the damaged tissues for an improvement in functioning.

Another limitation is that the number of stem cells in the bone marrow is low which will lead to less number of cells being transfused.

There might be obstruction in the pathway of the stem cells like a blocked artery which can negatively impact their functioning in the repairment of the damaged tissue resulting in slow, or no improvement.

Quality of the stem cells is also vital as observed that the stem cells are produced more efficiently in the bone marrow of the young people as compared to the older people.

Use of stem cell therapy in other diseases**a) Liver failure**

The liver is an essential part of our body and there are several diseases associated with this organ that can affect its functioning. Liver failure is one of the most serious liver diseases which is caused due to dysfunctions in the liver or other factors. Some clinical trials have shown that with the help of stem cell therapy regeneration and recovery are possible. The stem cells need to be transfused several times (the correct dosage is not defined yet). It has also been observed that the use of mesenchymal stem cells in particular has shown improvement in bilirubin levels and albumin levels.

b) Arthritis

This is a condition wherein the person suffers from inflammation of joints which causes pain and also difficulty in mobility.

Stem cell therapy for arthritis has proven to be effective for Osteoarthritis which is the breaking down of the cartilage between the bones over time, usually occurs in old age. Stem cell therapy is seen to be a good alternative and to be less invasive than joint replacement surgeries etc. Cartilage repair, enhancement of bone regeneration, and reduction in bone lesions are all seen in patients using stem cell therapy. Overall, it can be concluded that if first - line treatments like reduction in weight and shifting to a better lifestyle prove ineffective stem cell therapy could be considered as an alternative.

3. Conclusion

It can be concluded that stem cell therapy offers an enormous hope for improvement in neurodegenerative diseases and with more research and development a lot more can be achieved. Stem cell therapy with more findings can offer a less invasive method of treatment for other diseases as well apart from neurodegenerative diseases (an alternative to surgery) like for diseases like arthritis, liver failure, and even cancer.

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