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Neural stem cells, Redefining Therapy

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Neurodegenerative disorders might get a permanent cure with the help of rapid progress in the neuron replacement therapy.

In the early 1990s, researchers revealed that the embryonic nerve cells injected into brain can migrate throughout the organ, grow into healthy replacement cells, and help to reverse brain damage thus leading to treatments for multiple sclerosis and other devastating diseases of the central nervous system. In the embryo, brain cells are thought to develop from unspecialized cells called neural stem cells(NSC). Considering NSCs ability to differentiate into a wide range of cell types, researchers are trying to use them to replace brain cells that are damaged by injury or disease.

Research and development

Researchers from the Harvard Stem Cell Institute(HSCI) and Columbia University took the development further by demonstrating that the pluripotent stem cells derived from a patient with amyotrophic lateral sclerosis(ALS) can be differentiated into motor neurons, the brain cells that are destroyed by ALS, the fatal neurodegenerative disease, also known as Lou Gehrig’s disease. The researchers believe that if they can figure out how a person’s motor neurons die, they can able to figure out the ways to save that person. Scientists believe that stem cells are the valuable tools to understand the disease process and create mini-representations of disease or assays for the purpose of drug screening. This could further help to examine cellular and molecular defects in motor neurons and glial cells derived from patients with ALS.

Neural cells derived from human embryonic stem cells are found to repair stroke-related damage in the brains of rats and led to improvement in their physical abilities after a stroke. The research team led by Gary Steinberg hints that the study is small and more work is needed to determine whether a similar approach would work in humans, the study also shows the potential of stem cell therapies in treating strokes.

Human embryonic stem cells possess the ability to transform into any cell type in the body. Pushing embryonic stem cells to form neural stem cells and eliminating its possibility to form tumors when transplanted remain as the main hurdles. Embryonic stem cells are still immature and retain the ability to renew themselves and produce all tissue types, they tend to grow uncontrollably to become tumors consisting of a mass of different cells. Researchers overcame this hurdle by growing the embryonic stem cells in a combination of growth hormones that nudged the cells to mature into stable neural stem cells. After six months in a lab dish, those neural stem cells continued to form only the three families of neural cells, neurons, astrocytes and oligodendrocytes.

After ensuring the safety of neural cells, Daadi and co-author Anne-Lise Maag, a former research assistant, transplanted those cells into the brains of 10 rats with an induced form of stroke. At the end of two months, the cells had migrated to the damaged brain region and incorporated into the surrounding tissue. None of those transplanted cells formed tumors. Once in place, the transplanted cells helped to repair damage from the induced stroke. The researchers mimicked a stroke in a region of the brain that left one forelimb weak, this model parallels the kind of difficulties people experience after a stroke. Test conducted at fourth and eighth weeks after the stem cell transplants showed that the animals were able to use their forelimbs more effectively than rats with similarly damaged brain regions that had not received the transplants. Before testing this neural cells in humans, researchers are trying to ensure the effectiveness of this approach in animal stroke models.

Future

The past few years have seen major development in the field of NSC research with more emphasis towards its application in cell replacement therapy for neurological disorders. However, the clinical application of NSCs will remain largely unfeasible until a comprehensive understanding of the cellular and molecular mechanisms of NSC fate specification is achieved. This understanding will increase the possibility to exploit the potential of stem cells in order to manufacture transplantable NSCs that can able to provide a safe and effective therapy for previously untreatable neurological disorders. Since the pathology of each of these disorders is determined by the loss or damage of a specific neural cell population, it is necessary to generate a range of NSCs that can replace specific neurons or glia rather than generating a generic NSC population.

In the future, scientists may be able to implant the stem cells directly into patient's brains to improve mental illness. Contrary to past dogma, scientists have discovered that the brain is continually creating new neurons (neurogenesis) in the hippocampus, an area of the brain critical for long term memory. Depression has been associated with reduced neurogenesis in the hippocampus and antidepressant drugs have the ability to increase neurogenesis. Using the new deep transcranial magnetic stimulation (TMS) may allow researchers to selectively target the hippocampus with electrical stimulation so as to increase the brain's natural mechanism of generating new neurons. With a more sophisticated understanding of the brain, scientists may be able to achieve neurogenesis in brain areas not normally associated with new neuron growth.

Researchers have already devised techniques to guide the position of neurons in the brain. They have incorporated iron particles into single neurons created from stem cells. Using targeted magnetic pulses to precisely position these newly created neurons in specific brain areas to improve several conditions. So science will most likely progress to a better and more controlled creation of new neurons and the precise placement of those neurons into the requisite brain areas. For extreme life extension, replacing aging neurons may be necessary from time to time. In the future, we may be able to use these techniques to periodically replace dying neurons with new ones. Intelligence enhancement is another area that stem cells may have some value in the future. Scientists may be able to increase the amount of neurons in an individual's brain in areas that are associated with certain performance tasks, such as memory, general intelligence and attention. Overall, we can expect exciting developments in neuron replacement therapy that could improve many currently devastating health conditions and potentially enhance normal people's functioning as well.

Shalini Gupta