

## Stem Cell Therapy in Regenerative Medicine and Tissue Engineering

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### Abstract

Stem cell therapy is introduction of new adult stem cells into damaged tissue in order to treat disease or injury. Any disease in which there is tissue degeneration can be a potential candidate for stem cell therapy: Alzheimer's disease, Parkinson's disease, Spinal cord injury, Heart disease, Severe burns, Diabetes. Stem cells could be used to repair or replace damaged neurons (Regenerate spinal cord), repair of damaged organs such as the liver and pancreas. Stem cell transplantation (SCT) is the term now used in preference to bone marrow transplantation (BMT). Potential uses of stem cells include restoring blood cell production, therapeutic cloning for tissue repair, and cancer treatment. Stem cells are used in basic research for clarification of complex events that occur during human development, and understanding molecular basis of cancer, molecular mechanisms for gene control. Stem cells can provide specific cell types (pluripotent stem cells) to test new drugs, and to reduce animal testing. This article summarizes the evolution of stem cell therapy to highlight its importance and further research.

### Keywords

Regenerative medicine; Stem cell therapy; Tissue engineering

## Introduction

Since antiquity, repairing or regenerating damaged tissues or organs fully and restoring their functions has been a dream of human beings, and it existed in ancient Hindu civilization. The elephant headed Hindu God Lord Ganesha can be viewed as an example of tissue engineering and transplantation. The Great Hindu Sanskrit epic Mahabharata says the great warrior Karna was not born from his mother's womb. There is another reference to Dronacharya (Drona=pot; Acharya=scholar), the Royal Guru of Pandavas and Kauravas, who was born from an earthen pot. This means, the use of genetic cloning (reproductive genetics) or test tube or artificial womb kind technique was present at that time.

## Stem Cell Therapy

In contemporary biomedical research, the most promising and exciting, and recently emerging branch of medical science receiving increasing attention with an ever growing interest is stem cell therapy (stem cell technology), that combines the efforts of cell biologists, geneticists, and clinicians. Stem cells have the ability to build every tissue in the human body, and offer great promise and potential for new medical treatments for curing a variety of malignant and non-malignant diseases such as injury, spinal cord injury, stroke, amyotrophic lateral sclerosis, multiple sclerosis, rheumatoid arthritis, systemic lupus erythematosus, type 1 diabetes, Parkinson's disease, Alzheimer's disease, heart diseases (myocardial infarction, congestive heart failure), burns, osteoarthritis, tennis elbow, frozen shoulder, muscular dystrophy, cancer, congenital diseases, and skin diseases. New drugs can be tested for the safety and effectiveness on tissues generated from stem cells *in vitro*, eliminating the need to test them on animals, leading to faster drug development [1-4].

A stem cell is essentially the building block of human body. A stem cell is an undifferentiated, blank cell or precursor cell, that has the ability to continuously divide (self-renewal) and differentiate (develop) into any kind of cells/tissues (such as skin, muscle, or nerve cell etc.) that serve numerous functions in different parts of the body.<sup>3</sup>This remarkable ability and potential of stem cells to generate new healthy tissue for use in transplantation and to regenerate or repair diseased or damaged cells, and aging cells, is made use of in stem cell therapy or regenerative medicine and tissue engineering. Stem cells have the ability to build every tissue in the human body, hence have great potential for future therapeutic uses [3].

## Sources of stem cells

Regenerative medicine is an emerging field of medicine deals with the process of replacing, engineering or regenerating human (or animal) cells, tissues or organs damaged by disease, trauma, or congenital defects to restore or establish normal function. Research on stem cells is advancing - How an organism develops from a single cell? And how healthy cells replace damaged cells in adult organisms? There are several sources of stem cells. Embryonic stem cells come from human embryos that are three to five days old, can give rise to virtually any other type of cell in the body, hence known as pluripotent stem cells. Adult (non-embryonic) stem cells come from developed tissues and organs in the body and have a misleading name, because they are also found in infants and children; which repair and replace damaged tissue in the same area. For example, hematopoietic stem cells are a type of adult stem cells

found in bone marrow (which make new RBCs, WBCs, and other blood cells) have been used as bone marrow transplants (stem cell transplants) to treat certain types of cancers. Adult stem cells can not differentiate into as many other types of cells as embryonic stem cells can. Induced pluripotent stem cells (iPSCs) can differentiate into all types of specialized cells in the body. They are created by genetically reprogramming the adult stem cells so that they behave like embryonic stem cells. Stem cells from cord blood and amniotic fluid (perinatal stem cells) have the ability to change into specialized cells [5-7].

### **Types of stem cells**

There are different types of stem cells that serve different purposes in the body. The fertilized egg is said to be totipotent stem cell. It has the potential to generate all types of cells and tissues that make up an embryo and placenta, and all post-embryonic tissues and organs (e.g. embryo). Pluripotent stem cells are descendants of totipotent stem cells of embryo, develop about 4 days after fertilization, and can differentiate into any cell type, except for totipotent stem cells and placenta. These cells can re-create most, but not all tissues of an organism. (e.g. cells from inner cell mass of blastocyst). Multipotent stem cells are descendent of pluripotent stem cells and antecedents of specialized cells in particular tissues. They can differentiate into multiple specialized cells of a closely related family of cells. For example, hematopoietic stem cells, which are found primarily in the bone marrow, give rise to all blood cells (RBCs, WBCs, and platelets). Oligopotent stem cells are able to differentiate into a few cells (e.g. lymphoid cells). Unipotent stem cells are capable of differentiating along only one lineage (produce one cell type only), but have the property of self-renewal which distinguishes them from non-stem cells (e.g. muscle stem cells, cardiac stem cells) [5-7].

Pluripotent, embryonic stem cells are derived from the inner cell mass of the developing blastocyst of embryos 5 to 8 days after fertilization. Multipotent stem cells are found in the developing gastrula or derived from pluripotent stem cells and are restricted to give rise to only cells of their respective germ layer [5].

Stem cells independent of fertilized eggs can be created by a technique called therapeutic cloning, also called somatic cell nuclear transfer. In this technique, the nucleus, which contains the genetic material, is removed from an unfertilized egg, and the nucleus from the cell of a donor is also removed. This donor nucleus is then injected into the egg, replacing the nucleus that was removed, in a process called nuclear transfer, and the blastocyst stage is formed from the developing egg. This process creates a line of stem cells that is genetically identical to the donor's cells.

The best-defined and most extensively used stem cell treatment is hematopoietic (or blood) stem cell transplantation. Some bone, skin and corneal injuries and diseases can be treated by grafting or implanting tissues. All other applications of stem cells are yet to be proven in clinical trials and should be considered highly experimental [8,9].

## Conclusion

Stem cell therapy has the potential to find solutions to some of the most challenging medical problems faced by mankind, and impact the whole spectrum of health care. Regenerative Medicine is growing and maturing steadily, however, many challenges lie ahead. Stem cells can create miracles, give hope to the hopeless and rewrite medical science and could make life immortal. As far as ethics considered, there is a debate - Is it morally right? How far can we go with this? Will embryo farms be around in the future? Will cloning factories produce human organs? Are humans playing God? However, stem cells can create miracles, and rewrite medical science and could make life immortal [9].

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