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Role of stem cell in medical care and treatment

Faizan Khan [1], Kailash Sahu [1, *], Saman Pathan [2] and Bhaskar Kumar Gupta [1]

[1] *Department of Pharmacy, School of Pharmacy and Research, People's University, Bhopal (M.P.), India.*

[2] *Department of Pharmacology, All India Institute of Medical Science, Bhopal (M.P.) India.*

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Abstract

In stem cell transplants, stem cells replace cells damaged by serve as a way for the donor's immune system to fight some types of cancer and blood-related diseases, such as leukemia, lymphoma, neuroblastoma and multiple myeloma. This research has the potential to affect the lives of Millions of people by offering unprecedented opportunities for developing new medical Therapies for debilitating diseases and a new way to explore fundamental questions of Biology. Stem cells can be guided into becoming specific cells that can be used in people to regenerate and repair tissues that have been damaged or affected by disease. People who might benefit from stem cell therapies include those with spinal cord injuries, type -1 diabetes, Parkinson's disease, amyotrophic lateral sclerosis, Alzheimer's disease, heart disease, stroke, burns, cancer and osteoarthritis. Stem cells may have the potential to be grown to become new tissue for use in transplant and regenerative medicine. Researchers continue to advance the knowledge on stem cells and their applications in transplant and regenerative medicine. Specialized types of stem cells have the ability to stop immune responses. Stem cells may therefore be very useful as a therapy for diseases in which organs are damaged or where the immune system is too active. Some types of stem cells are already used for therapy, such as the hematopoietic (blood) stem cells, which are used for the treatment of bone marrow cancer.

Keywords: Cancer cells; Stem cell; Hematopoietic; Leukemia

1. Introduction

Stem cell biology is presently one of the most exciting areas of biomedical research, as enthusiasm for the application of this technology in the direction of regenerative remedy continues to expand. The application of cells in a healing style can also come to be a natural extension of the presumed potential of those precise cell populations with extensive-ranging capabilities. As with many new and exciting technologies, an awful lot stays to be examined, proved, and added to separate the wish from the hype. In this review, we strive to deliver the current "state of the art" in stem cell research and to provide a conceptual framework that can be utilized by surgeons as a basis for important evaluation of this quickly expanding and fascinating field.

The widely publicized large mammal cloning experiment in 1997 gave new impetus to the possibility of regenerative medicine through stem cell research [1]. In Dolly's case, an entire adult ewe was successfully cloned as an exact phenotypic and genetic match of its founder organism [1]. This startling achievement becomes a reminder that DNA is conserved all through the improvement of complex multi-cellular organisms. If an entire adult ewe could be recapitulated from a postnatal somatic cell, then clearly the genetic potential ought to persist to regenerate whole tissue and organ systems. Nuclear transfer, the same technology that created Dolly, could be used to create the raw material to replace defective or senescent tissue as a natural extension of the biology of stem cells [2-5]. The specter of human cloning and nuclear transfer as a means of creating autologous embryonic stem (ES) cells (each individual's identically

*Corresponding author: Kailash Sahu

Department of Pharmacy, School of Pharmacy and Research, People's University, Bhopal (M.P.), India.

matched ES cells) has also stirred a parallel political debate [6-7]. The controversy divides the capacity hope given to many present-day suffers against the requisite and ethically contentious creation of human blastocysts for therapeutic intent [6].

Stem cells have the incredible ability to become many different cellular kinds inside the frame during adolescence and growth. Similarly, in many tissues they function as a sort of internal restore system, dividing essentially without limit to refill other cells as long as the person or animal continue to be alive. Whilst a stem cell divides, every new cell has the ability either to remain a stem cell or grow to some other type of cell with a more specialized characteristic, such as a muscle cell, a red blood cell, or a brain cell [8, 9].

In the 3 to 5 day old embryo, called a blastocyst, the internal cells deliver an upward push to the whole body of the organism, together with all the many specialized cell sorts and organs such as the heart, lung, skin, sperm, eggs and different tissues. In some grownup tissues, consisting of bone marrow, muscle, and mind, discrete populations of adult stem cells generate replacements for cells that are misplaced via ordinary wear and tear, harm, or disorder.

Given their unique regenerative abilities stem cell research has the potential to impact not Just one disease but numerous ones e.g. diabetes, cancer, cardiovascular disease, Alzheimer's disease, burn victims, leukemia, tooth regeneration, bone regeneration and many more but to be able to harness such therapeutic potential of stem cells, Scientists need to learn how to direct them to differentiate appropriately, their therapeutic potential and to ensure that they do not continue to multiply in an uncontrolled way and not form a tumor [10,11].

These cells provide the prospect of restoring dental tissues such as dentin, cementum, and periodontal ligament and supporting bone. Individual teeth generally do not last the lifetime of the individuals without requiring at Least some repair. The need for replacement of teeth and dental tissue repair therapies is Significant. As the close association between oral health, systemic health and nutrition becomes more apparent, the necessity of proper oral health for long term quality of life becomes more appreciated [12].

Conventional dental treatment has relied on symptomatic treatment and prosthetic restoration using artificial materials, and clinicians have tended to concentrate on improving Skills rather than developing new modes of treatment. To accelerate the clinical application of newly developed periodontal therapy, the important issues should be addressed while developing the periodontal therapeutic techniques. The ideal system for clinical use will be a simple procedure that provides one step delivery of the gene/protein of interest with minimal manipulation. The development of such a therapeutic approach will enable wider clinical [13, 14].

1.1. The Basic Biology of Stem Cells

A stem cell is defined as any cell type with two fundamental capacities (1) self-renewal and (2) differentiation. Self-renewal refers to the ability of a cell to divide and form other cells with similar properties. Differentiation refers to its ability to make other cell types, performing other biological functions [15].

1.2. Classification of stem cells

There are different types of stem cells which are usually considered for their potential use in research and medicine. They can be classified on the basis of-

- The extent to which they can be differentiate into different cell types;
- Source of stem cells(based on their origin)

1.3. Extent to which they are differentiate into

- Totipotent cells
- Pluripotent cells
- Multipotent cells
- Oligopotent cells
- Unipotent cells

1.3.1. Totipotent cells

Totipotent stem cells are capable of dividing and differentiating into cells of the whole organism. Totipotency has the highest differentiation potential and allows cells to form both embryonic and extra-embryonic structures. An example of a totipotent cell is a zygote, which is formed after a sperm has fertilized an egg. These cells can later develop into any of the three germ layers or form the placenta. After about 4 days, the inner cell mass of the blastocyst becomes pluripotent. This structure is the source of pluripotent cells.

1.3.2. Pluripotent cells

Pluripotent stem cells (PSCs) form cells of all germ layers but not extra embryonic structures, such as the placenta. Embryonic stem cells (ESCs) are an example. ESCs are derived from the inner cell mass of pre-implantation embryos. Another example is induced pluripotent stem cells (iPSCs) derived from the epiblast layer of implanted embryos.

1.3.3. Multipotent cells

Multipotent stem cells have a narrower spectrum of differentiation than PSCs, but they can specialize in discrete cells of specific cell lineages. An example is hematopoietic stem cells, which can develop into many types of blood cells. After differentiation, a hematopoietic stem cell becomes an oligopotent cell. Its differentiation capabilities are then confined to the cells of its offspring.

1.3.4. Oligopotent cells

These can differentiate into several cell types. A myeloid stem cell is an example that could be divided into white blood cells however not red blood cells.

1.3.5. Unipotent cells

These can only produce cells of one kind, which is their own type. But, they still stem cells because they can renew themselves. Examples include adult muscle stem cells.

1.4. Source of stem cells (based on their origin)

Stem cells are the foundation for every organ and tissue in your body. There are many different types of stem cells that come from different places in the body or are made at different times in our lives. They can be two types:

1.4.1. Embryonic stem cells

Embryonic stem cells (ESCs) were first reported by Damjanov & Solter. Embryonic stem cells are derived from the inner cell mass of the *blastocyst*, which is primarily a hollow ball of cells that, in humans, forms three to five days after the egg cell is fertilized by a sperm. A human blastocyst is about the size of the dot above this "i". In normal development, the cells inside the inner cell mass will give rise to the more specialized cells that give rise to the entire body – all of our tissues and organs. However, when scientists extract the inner cell mass and grow these cells in special laboratory conditions, they retain the properties of embryonic stem cells [16].

Embryonic stem cells are pluripotent, meaning they can give rise to every cell type in a fully formed body, but not the placenta and placenta. These cells are incredibly valuable because they provide a renewable resource for the study of normal development and disease, and for testing drugs and other therapies. Human embryonic stem cells have been derived primarily from blastocysts created by in vitro fertilization (IVF) for assisted reproduction that were no longer needed [16].

1.4.2. Tissue-specific stem cells

Tissue-specific stem cells (also referred to as *somatic* or *adult* stem cells) are more specialized than embryonic stem cells. Typically, these stem cells can generate different cell types for the specific tissue or organ in which they live.

For example, blood-forming (or *hematopoietic*) stem cells in the bone marrow can give rise to red blood cells, white blood cells and platelets. However, blood-forming stem cells don’t generate liver or lung or brain cells, and stem cells in other tissues and organs don’t generate red or white blood cells or platelets [17].

Some tissues and organs within your body contain small caches of tissue-specific stem cells whose job it is to replace cells from that tissue that are lost in normal day-to-day living or in injury, such as those in your skin, blood, and the lining of your gut. Tissue-specific stem cells can be difficult to find in the human body, and they don’t seem to self-renew in culture as easily as embryonic stem cells do. However, study of these cells has increased our general knowledge about normal development, what changes in aging, and what happens with injury and disease [17].

1.5. Some other types of stem cells are there

1.5.1. Mesenchymal stem cells

Mesenchymal stem cells or MSC refer to cells; isolated from *stroma*, the connective tissue that surrounds other tissues and organs. Cells by this name are more accurately called "stromal cells" by many scientists. The first MSCs were discovered in the bone marrow and were shown to be capable of making bone, cartilage and fat cells. Since then, they have been grown from other tissues, such as fat and cord blood. Various MSCs are believed to have stem cell, and even immunomodulatory, properties and are being tested as treatments for many disorders, but to date, there is little evidence that they are beneficial. Scientists do not fully understand whether these cells actually stem cells or what types of cells they are capable of producing. They agree that not all MSCs are the same and that their characteristics depend on where in the body they come from and how they differentiate and develop [18].

1.5.2. Induced pluripotent stem cells

Induced pluripotent stem (iPS) cells were have been engineered in the lab by converting tissue-specific cells, such as skin cells, into cells that behave like embryonic stem cells. iPS cells are important tools for helping scientists learn more about normal development and the onset and progression of the disease, and they are also useful for developing and testing new drugs and therapies.

While iPS cells share many of the same characteristics as embryonic stem cells, including the ability to give rise to all types of cells in the body, they are not exactly the same. Scientists are figuring out what these differences are and what they mean. For one thing, the first iPS cells were produced by using viruses to insert extra copies of genes into tissue-specific cells. Researchers are experimenting with many alternative ways to create iPS cells so that they can ultimately be used as a source of cells or tissues for medical treatments [19].

1.5.3. Adult Stem Cells (ASCs)

ASCs are undifferentiated cells residing living specific differentiated tissues in our bodies that can renew themselves or generate new cells that can fill dead or damaged tissue. The term "somatic" refers to non-reproductive cells (eggs or sperm). ASCs are generally rare in native tissues making them difficult to study and extract for research purposes.

Resident in most tissues of the human body, discrete populations of ASCs arises to replace cells that are lost due normal repair, disease, or injury. ASCs are found throughout one's lifetime in tissues such as the umbilical cord, placenta, bone marrow, muscle, brain, fat tissue, skin, gut, etc. The first ASCs were extracted and used for blood production in 1948. This process was expanded in 1968 when the first adult bone marrow cells were used in clinical treatments for blood diseases.

Studies proving the specificity of developing ASC are controversial; Some show that ASCs can generate only the cell types of their resident tissue while others have shown that ASCs may be able to generate other tissue types than those. More studies are necessary to confirm the dispute [20].

1.6. Properties of stem cells

Stem cells are different from the other types of cells in the human body. Although they can be harvested from various sources, they all share some of the same properties like Stem cells can divide and renew themselves Stem cells have a special ability to divide and renew themselves for extended periods of Time. In fact an initial population of stem cells can produce millions of cells within few Months in a laboratory setting. When the produced cells remain unspecialized for a longer duration, it indicates the long term self renewal capacity of the cells. Stem cells are unspecialized the unspecialized nature of stem cells is an important one [21].

It means that stem cells lack the specific parts that allow them to perform specialized functions in the body. A stem cell does not have a specialized function but it has the capacity to differentiate into a specialized cell that can carry out these functions. The exact factors that allow stem cells to be unspecialized are still not known but once they are determined, stem cell culture will be made possible in the laboratories with a greater success. Stem cells can give rise to specialized cells the ability of stem cells to give rise to specialized cells is a crucial one. In this process of differentiation, unspecialized stem cells produce specialized cells. It is thought that a cell's genes regulate the internal signals that trigger this process. These genes carry the specific code, or instructions, for all the parts and functions of a cell. External signals are those outside of the cell, which include chemicals released from other cells, physical connections with nearby cells and various other molecules in the surrounding area [21].

1.7. Stem cell-based therapies

Stem cell-based therapies are defined as any treatment for a disease or a medical condition that fundamentally involves the use of any type of viable human stem cells including embryonic stem cells (ESCs), iPSCs and adult stem cells for autologous and allogeneic therapies [22].

1.8. Parkinson's disease (PD)

PD is characterized by a rapid loss of midbrain dopaminergic neurons. The first attempt for using human ESC cells to treat PD was via the generation of dopaminergic-like neurons, later human iPSCs was proposed as an alternative to overcome ESCs controversies [23].Based on the research presented by different groups; the "Parkinson's Global Force" was formed which aimed at guiding researchers to optimize their cell characterization and help promote the clinical progress toward successful therapy.

1.9. Multiple sclerosis (MS)

MS is an inflammatory and neurodegenerative autoimmune disease of the central nervous system. Stem cell-based therapies are now exploring the possibility of halting the disease progression and reverse the neural damage. A registered phase 1 clinical trial was conducted by the company CelgeneTM in 2014 using placental-derived mesenchymal stem cells (MSCs) infusion to treat patients suffering from MS [24].

1.10. Amyotrophic lateral sclerosis (ALS)

ALS is a neurodegenerative disease that causes degeneration of the motor neurons which results in disturbance in muscle performance. The first attempt to treat ALS was through the transplantation of MSCs into a mouse model. The results of this experiment were promising and resulted in a decrease of the disease manifestations thus providing evidence of principal [25].

1.11. Spinal cord injury

Other neurologic indications for the use of stem cells are spinal cord injuries. Although the transplantation of various forms of neural stem cells and oligodendrocyte progenitors increased axons in addition to neural connectivity that presents a potential for repair [27 rigorous clinical trials have not yet established evidence of recovered function.

1.12. Ocular disease

A huge number of the currently registered clinical trials for stem cell-based therapies target ocular diseases. This is mainly due to the fact that the eye is an immune privileged site. Most of these trials span various countries including Japan, China, Israel, Korea, UK, and USA and implement allogeneic ESC lines [26, 27].

1.13. Diabetes disease

Pancreatic beta cells are destructed in type 1 diabetes mellitus, because of disorders in the immune system while in type 2 insulin insufficiency is caused by failure of the beta-cell to normally produce insulin. In both cases, the affected cell is beta cells, and since the pancreas does not efficiently regenerate islets from endogenous adult stem cells, other cell sources were tested [28]. Pluripotent stem cells (PSCs) are considered the cells of choice for beta cell replacement strategies [29].

1.14. Stem cells in dentistry

Stem cells have been successfully isolated from human teeth and were studied to test their ability to regenerate dental structures and periodontal tissues. MSCs were reported to be successfully isolated from dental tissues like dental pulp of permanent and deciduous teeth, periodontal ligament, apical papilla and dental follicle [30].

1.15. Regeneration of mandibular bony defects

The first clinical study using DPSCs for oro-maxillofacial bone regeneration was conducted in 2009 [31]. Patients in this study suffered the excessive bone loss following the extraction of third molars. A bio-complex composed of DPSCs cultured on collagen sponge scaffolds was implemented to the affected sites.

1.16. Stem cells and tissue banks

The ability to bank auto-logos stem cells at their most potent state for later use is an essential adjuvant to stem cell-based therapies. In order to be considered valid, any novel stem cell-based therapy must be as effective as routine treatment. Thus, when evaluating a type of stem cells for application in cellular therapies, issues such as immune rejection should be avoided as well as a large number of stem cells should be readily available prior to clinical implementation [32].

2. Conclusion

Stem cells derived from all sources hold immense scientific promises, stem cell therapies have virtually unlimited medical and dental applications. We have moved from a surgical model of care to a medical model and are likely to move on to a biological model of care. The need of the hour is high-quality research with collaboration between basic scientists and practitioners. A team effort involving the expertise of practicing molecular biologists, immunologists, biomaterials scientists, cell biologists, matrix biologists, and dental surgeons is critical to achieving the desired goal. Stem cell therapy is no longer science fiction. Recent developments in stem cell isolation and expansion techniques, as well as advances in growth factor biology and biodegradable polymer fabrication, have set a stage for the successful tissue engineering of tooth/tooth-related tissues. Stem cell therapy has brought great hope among researchers and doctors, and let's not forgets the patients who are the main beneficiaries of this innovation. Stem cells regenerate hope and not all that is happening in research is hype. While there are several barriers that need to be broken down before this novel therapy can be translated from lab to clinics, it is certain that the future is going to be exciting for all of us "Hope is a prerequisite for any successful scientific innovation".

Compliance with ethical standards

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Disclosure of conflict of interest

The author has no conflicts of interests to declare.

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