Stem cell in dentistry: Today and tomorrow

Neha Atkaan ¹, Mrinalini ², and Seema Bukhari ²

¹ Manav Rachna Dental College, MRIIRS, Sec-43, Surajkund, Badkhal Road, Faridabad - 121001, Haryana, India.
² Department of Conservative Dentistry and Endodontics, Manav Rachna Dental College FDS, MRIIRS, Sec - 43, Surajkund, Badkhal Road, Faridabad - 121001, Haryana, India.

Abstract

Stem cells are cells that have the ability to differentiate into any cell type in the body. This makes them a powerful tool for treating a variety of diseases and injuries.

There are two main types of stem cells: embryonic stem cells and adult stem cells. Embryonic stem cells are derived from embryos, while adult stem cells are found in adult tissues.

Embryonic stem cells can differentiate into any cell type in the body, making them a powerful tool for treating various diseases and injuries. However, their use is limited by ethical concerns and the risk of rejection by the body.

Following review article will discuss some new fields in which these stem cells and their modifications can be used.

Keywords: Embryonic stem cells; Root canal vascularization; Induced pluripotent stem cells; Dental pulp stem cells; Mesenchymal stem cells; Pulp regeneration

1 Introduction

Stem cells are cells that have the unique ability to develop into specialised cell types in the body that are expected to replace damaged tissue in the future [1]. These are the undifferentiated and non-attached cytogenetic tissues of the embryo [2].

Basically of 3 types: Embryonic stem cells [E.S.C.], Induced pluripotent stem cells [IPSC], and Adult/postnatal stem cells [3]. Sources of adult stem cells in the oral cavity include dental pulp, dental follicles, gums, and periodontal ligaments [4]. Dental pulp stem cells are the most commonly used in research. Most research is directed at damaged dentin, pulp, resorbed roots, regeneration of periodontal tissue, and regeneration of restorative perforations [5].

Biologically designed procedures to restore structures including dentin, root structures, and pulp-dentin complex that have been destroyed known as endodontic regenerative therapy [6].

Using Stem Cells and Tissue Engineering plays an important role in success of stem cell therapy
1.1 Classification [7]

1.1.1 Based on Potency

- Totipotent: can form all the cells i.e. embryonic as well as extra embryonic cells. Cells made within the first couple of divisions after fertilisation.
  Ex: Zygote, Early blastomeres

- Pluripotent: give rise to all cells that make up the body.
  Ex: Inner cell mass

- Multipotent: develop more restricted than pluripotent, yet can produce more than one type of cell.
  Ex: Adult stem cells and stem cells from cord blood, haematopoietic.
  - Oligopotent: can develop into cells of 1 category only.
    o Ex: Vascular stem cells: endothelium and smooth muscles.
    o Ex: Lymphoid or myeloid: blood cells

- Unipotent: can develop into only 1 type of cell.
  Ex: liver cell and muscle cell.

![Diagram of stem cell classification](image)

**Figure 1** Types of stem cells based on potency

1.2 Based on Sources

- Embryonic stem cells: early embryos are the best source.
- Cord blood stem cells: harvested from umbilical cord.
- Mesenchymal stem cells: bone marrow is a good source.

2 Stem cells therapies

2.1 Regeneration of tissues and organs

For ex: skin grafts and burns [8].
After the transplant of allogeneic cells similar to fibroblasts mesenchymal stem cells, a study of the dynamics of wound healing was conducted, which demonstrated a rapid rate of wound healing after exposure to active neo angiogenesis. After fibroblast-like mesenchymal stem cell transplantation, auto dermoplasty of burn wounds produced positive effects as early as day 4. This led to quicker donor zone healing and quicker patient recovery [8].

2.2 Treatment of cardiovascular and neurological disease

For ex: Regeneration of blood vessels: Alzheimer’s and Parkinson’s disease

The replacement of lost heart muscle and improvement of cardiovascular revascularization are potential benefits of stem cell therapy [9]. Parkinson’s disease (PD) cell replacement therapies seek to offer patients long-lasting symptom relief. For some patients, the transplants continue to function, reinnervate the striatum, and produce sufficient symptomatic relief for more than ten years after surgery [10].

2.3 Replacement of deficient cells

For ex: Insulin producing type 1 diabetes. The blastocyst’s inner cell layer is where human ES cells are produced from. All differentiated cells in the adult are eventually produced by these cells through a sequence of cell destiny decisions involving self-renewal and differentiation. Therefore, they can theoretically transform into any specific cell type, including pancreatic beta-cells, if exposed to the right signals in the right order and for the right lengths of time [pluripotency] [11] [12] [13] [14] [15] [16].

2.4 Treatment of blood disorder

For ex: thalassemia (the first successful hematopoietic stem cell transplant in a patient with thalassemia is now a healthy young adult living a perfectly normal life, some 30 years after the procedure was originally performed) [17], and sickle cell anaemia (In children with Myeloablative allogeneic hematopoietic stem cell transplantation is effective in treating sickle cell disease) [18].

3 Mechanism of stem cells modification

Potency of a stem cell depends on its source. Stem cells bear several CELL MARKERS on their cell walls that give them specific identity [19]. Tempering of stem cells begins with cells being preserved under cryopreservation. Haematopoietic and mesenchymal stem cells have effective cryopreservation and storage techniques; however, iPS and embryonic cells have proven more difficult to work with [20].

Multiplication of stem cells include 2 ways:

- Cells specifically multiplied by lab procedures.
- Cells are put under a specific “environment” which leads to its differentiation into required progenitor cells. Subsequently, they are injected at the damaged part, where they are supposed to multiply on their own and do the repair. The activity of stem cells in the mesenchyme [the blastema] throughout this process has been studied in recent investigations of tissue regeneration in species with simpler development [21].
  - Embryonic stem cells: good models for studying effects of bacterial toxins and drugs. Pluripotent stem cells [PSCs] have distinct abilities for self-renewal and differentiation, which give them a significant advantage over somatic cells [22].

3.1 Advantages

Stem cells can be easily kept in an undifferentiated state, no special procedures need to be followed. Although they can be stimulated to differentiate into different cell types, these cells can be grown in culture in an undifferentiated state [23].

Can be very easily stimulated for long term self replication. Because mesenchymal stem cells may replicate themselves in multiple passages, they may be multiplied to a level that is necessary for the regeneration of tissues and organs [24].

- Allows complete control over the replication process.
- Replication process can be made conditional and highly regulated.
3.2 Types of dental stem cells

3.2.1 Dental pulp stem cells [DPSCs]
- Exhibit angiogenic, neurogenic, and odontogenic characteristics.
- According to studies, inflamed pulp tissue was a suitable source for isolating DPSCs since these cells have more capacity for regeneration, even though the regeneration was less than that of the control groups [25].
- Compared to dentinogenic cells, osteoblastic cells are more likely to differentiate from exposed pulp stem cells.

3.2.2 Stem Cells from Apical Papilla [SCAP] [25]
These stem cells are known for:
- More rapid proliferation
- Mineralization
- Better migration
- Better telomerase activity than DPSCs
More uniform dentine-like material from SCAP than DPSCs, greater similarities to natural dentine.

3.2.3 Periodontal Ligament Stem Cells [PDLSCs] [25]
- These cells, which were wrapped in a sheet of PDLSCs and mixed with hydroxyapatite, are currently being used in research to create new bio-roots right now.

3.2.4 Stem Cells from Human Extracted Deciduous Teeth [SHED] [25]
Completely non-invasive type.
Shows increased ability to regenerate bone and increased proliferation rate other than dental stem cells
- Mesenchymal stem cells from bone marrow, when combined with a scaffold made of dentine matrix, produce polarised odontoblast-like cells with penetrating processes in dentinal tubules.
- Adipose-derived stem cells are used as a substitute for DPSCs and produce the same outcomes.
- Mesenchymal stem cells from the umbilical cord [UCMSCs] are abundant and remarkably safe because the placenta protects them from viruses.

4 Clinical implications [26]

4.1 Revascularization of the root canal using blood clotting
- A number of case reports suggest revascularization by disinfection of necrotic root canals followed by instrumentation to establish bleeding into the root canal system [27] [28] [29].
- The general advantages of such revascularization procedures are, first, that They can be carried out using readily available tools and intraluminal agents without the use of pricey biotechnology because they are technically straightforward. Second, using the patient’s own blood cells to regenerate the root canal system circumvents immune defence and potential pathogen transmission by replacing the dental pulp with an engineered tissue architecture [26].

4.2 Postnatal stem cell therapy
- The simplest method of administering stem cells with sufficient regenerative potential into a disinfected root canal system is to open the tip and then inject postnatal stem cells derived from multiple tissues including skin, oral mucosa, fat and bone [30].
- A prime hurdle in the area of research is the identification of postnatal stem cells into the different cell populations found in the adult dental pulp [26].
- First, this technique has the benefit of using autologous cells, which can be collected easily, injected with a syringe, and have the capacity to repair dental pulp tissue. Already used in a recent review described its potential in endodontics [31].
4.3 Pulp implantation

- Some stem cells do not survive unless grown on a layer of feeder cells, despite the fact that the majority of in vitro cell cultures develop as a single monolayer attached to the bottom of culture flasks [32].
- An advantage of this system is the relative ease of culturing cells on filters in the laboratory. A potential issue with the implantation of sheets of pulp tissue that has been treated [33].

4.4 Injectable scaffold delivery

- Using syringes, injectable scaffolds called hydrogels can be administered [34] [35].
- These hydrogels can facilitate pulp regeneration by giving cells a place to grow and form a definite tissue structure. They are non-invasive and simple to administer [36].
- Previously, hydrogels had trouble controlling how tissues formed and developed, but recent formulation advancements have greatly boosted their ability to maintain cell survival [37].

4.5 Resurrection methods in permanent immature traumatised teeth

According to a review of regenerative techniques for developing teeth with trauma, the following conditions must be met for proper revascularization to take place, the tooth must be permanent, very immature, and have an open apex in order to be inappropriate for apexification and apexogenesis operations; Paste antibiotics can be utilised in addition to sodium hypochlorite as a disinfectant; and an anaesthetic without a vasoconstriction [38].

5 Conclusion

Stem cells have already shown promising results in regenerating lost tissues. Previously, its positive impacts were only recognisable in the medical field, but it has recently begun to work its magic in dentistry as well. With this article, we hope to highlight some foremost vital fields in dentistry where the use of stem cells can be beneficial.

Compliance with ethical standards

Acknowledgments

None to declare.

Disclosure of conflict of interest

The authors declare no conflict of interest

References


