REVIEW ARTICLE

Stem Cells: A Revolution in Dentistry

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ABSTRACT

Stem cells are generally defined as cells that have the capacity to self-renewal and differentiate to specialize cells. Stem cells can self-renew and produce different types of cell, thus developing new strategies in regenerating missing tissues and treating diseases. In Dentistry, adult mesenchymal stem cells (MSCs) act as a rich source of stem cells. The ability of differentiation of these stem cells has led to the capacity to repair and regenerate structures that were once impossible to restore or repair. With the discovery of stem cell, it has brought light to the fact that they can be isolated, stored and used for an array of diseases. This paper highlights the use of these tiny but yet powerful cells in relation to dentistry and what the future of dentistry holds.

KEYWORDS: Stem Cells, Regeneration, Dentistry

INTRODUCTION

Loss of tooth is a common and frequent situation that can result from numerous pathologies such as periodontal and carious lesion, any sort of fracture, injuries or genetic alterations. The focus of stem cell research in dentistry is the regeneration of these missing oral tissues. Stem cells play vital roles in the repair of every organ and tissue through their capacity of self-renewal and differentiation.[1] Stem cell can be described as an immature or undifferentiated cell that is capable of producing an identical daughter cell. Stem have few basic features which differentiate them from other cells. First is, they have the ability to renew themselves through the process of cell division. The second is that at certain conditions, they can be induced to become cells with specific functions.[2]

The backbone of regeneration and repair ability of stem cells is due to the unique character referred as potency. Potency specifies the differentiation potential (the potential to differentiate into different cell types) of the stem cell. Totipotent stem cells are produced from the fusion of an egg and sperm cell[2]. Totipotency is the ability of a single cell to divide and produce all the differentiated cells in an organism, including extra-embryonic tissues. Pluripotent stem cells e these are true stem cells, with the potential to make any differentiated cell in the body. Pluripotent, embryonic stem cells originate as inner mass cells within a blastocyst. Multipotent stem cells

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are the forerunners in the field of dentistry. These are also true stem cells but can only differentiate into a limited number of types; perhaps most organs in the body (e.g., brain, liver) contain them where they can replace dead or damaged cells.

SOURCES OF STEM CELLS

There are two primary sources of stem cells: adult stem cells and embryonic stem (ES) cells.[3] In addition to these stem cells, which are naturally present in the human body, induced pluripotent stem (iPS) cells, have been recently generated artificially via genetic manipulation of somatic cells. ES cells and iPS cells are collectively referred to as pluripotent stem cells because they can develop into all types of cells from all three germinal layers. In contrast, most adult stem cells are multipotent, i.e., they can only differentiate into a limited number of cell types.

TYPES OF STEM CELLS

Human Dental Pulp Stem Cells

Although it is assumed that dentin-pulp complex does not have regenerative capacity, but during injury reparative dentin is formed as protective barrier for the pulp. Therefore one might think that dentin pulp contains dentinogenic progenitors that are responsible for dentin repair and these are referred as human dental pulp stem cells (DPSCs). Recently, dental pulp stem cells (DPSCs) have been isolated from extracted human third molars. Gronthos et al, [4] explored their ability to regenerate, and quantitatively established the presence of dental pulp stem cells with conclusive evidences by proving the expression of various perivascular markers such as STRO-1, VCAM-1, MUC-18, and smooth-muscle actin. This provides clues that DPSCs are a heterogeneous population of mesenchymal stem cells (MSCs) and likely located in the perivascular niche in the pulp; human dentin SialoPhosphoProtein (DSPP) was expressed in dentin like structures, confirming the human origin of the odontoblast/ pulp cells.

Properties of Human dental pulp stem cells are as follows:

- Human DPSCs have the ability to self-renew in vivo.
- DPSCs are similar to other stem cell populations, such as BMSSCs (bone marrow skeletal stem cells), in possessing the ability to develop into developmentally diverse phenotypes.[5]
- DPSCs may contain subpopulations of cells with different proliferative rates and developmental potentials, a property similar to that of BMSSCs.[5]
- DSPCs belong to a novel population of post-natal. These cells can serve as a model for study and research of adult stem cell differentiation in vitro and tissue regeneration in vivo.

Periodontal Ligament Stem Cells (PDLSCs)

For decades, cryopreserved hematopoietic stem cells have been utilized for disease treatment in clinics. Seo et al (2005) was the pioneer for first deriving cryopreserved periodontal ligament stem cells (PDLSCs). These cryopreserved periodontal ligament stem cells maintained normal periodontal ligament stem cell characteristics, including expression of the mesenchymal stem cell surface molecule STRO-1,single colony- strain generation, multipotential,differentiation,cementum/periodontal-ligament-like tissue regeneration.[6,7]

Properties of Periodontal ligament stem cells (PDLSCs) are as follows

- These PDL stem cell culture following 4 weeks of induction, show calcium accumulation in vitro, hence aid in bone formation.

- Ability of cryopreserved periodontal ligament stem cells to develop into adipocytes, cementum /periodontal-ligament like tissues upon in vivo transplantation has been proved.
- Cryo-preserved periodontal ligament stem cells maintain characteristics of regular periodontal ligament stem cells.

Stem Cells from Human Exfoliated Deciduous Teeth (SHED)

The ability to extract stem cells from the pulp led for exploration for regeneration of stem cells from the exfoliated pulp. This was explored by Masako Miura et al (2003)[8] who extracted Stem Cells from Human Exfoliated Deciduous Teeth (SHED) from exfoliated incisor. SHED expressed a variety of osteoblast/odontoblastic markers, including alkaline phosphatase (ALP), matrix extracellular phosphoglycoprotein (MEPE), bone sialoprotein (BSP), and human dentin sialophosphoprotein (DSPP). After implantation into immunocompromised mice, with hydroxyapatite/tricalcium phosphate (HA/ TCP) as a carrier, SHED differentiated into odontoblast-like cells that formed small dentin-like structures. These results suggest that SHEDs are distinctive from DSPCs with respect to odontogenic differentiation and osteogenic induction.[9]

Properties of Stem Cells from Human Exfoliated Deciduous Teeth (SHED) are:

- The ability to differentiate into odontoblasts in vivo.
- SHED represents a population of postnatal stem cells capable of extensive proliferation and multipotential differentiation. It has the potential to develop into other cell lineages such as neural cells and adipocytes.
- It may also be involved in inducing bone formation during the eruption of permanent teeth.

Deciduous teeth therefore may be an ideal resource of stem cells to repair damaged tooth structures, induce bone regeneration, and possibly to treat neural tissue injury or degenerative diseases.

Stem Cells Derived From Apical Area Of Root

Rat's incisors grow continuously throughout life. This growth is supported by the division of dental epithelial stem cells that reside in the cervical loop region. They form the basis of the stem cells derived from the root end papilla (SCAP). In vitro, SCAP cells can be stimulated to form mineralized tissue, however, induced SCAP cells also express dentin sialoprotein (DSP): a protein which is involved in dentine synthesis.[10] Similarly, in vivo; transplantation of human SCAP into immunocompromised mice resulted in the generation of odontoblasts capable of depositing new dentine.[10] These results suggest that although SCAP can display certain osteogenic characteristics, they preferentially differentiate into dentine producing cells, reminiscent of odontoblast-like cells. Stem cells derived from the root apical papilla (SCAP) can be isolated from unerupted extracted wisdom teeth at an early age. Therefore, it may be possible to bank these high quality dental stem cells for future autologous use.

Properties of Stem cells derived from the root apical papilla (SCAP). They are as follows:

- Similar to DPSCs and SHED; ex vivo expanded SCAP can undergo odontogenic differentiation in vitro.
- Significantly, CD24 is expressed by SCAP which is not detected on DPSCs or BMMSCs.

- SCAP also demonstrates the capacity to undergo adipogenic differentiation following induction in vitro.
- SCAP are derived from a developing tissue that may represent a population of early stem/progenitor cells which may be a superior cell source for tissue regeneration.

USES OF STEM CELLS IN DENTISTRY

Regeneration

Stem cells play an important role in regeneration of oral tissues. These are:

- Regeneration of tooth
- Dentin regeneration,
- Craniofacial bone regeneration after ablative cancer surgery and radiation therapy[11]

Tissue Engineering

Tissue engineering is another aspect where stem cells are widely used. These are:

- Tissue engineering of the temporo-mandibular joint.
- Tissue engineering of periodontal tissue defects.[12]
- Tissue engineering of craniofacial bone, 12- There have been only a few human clinical trials of stem cell based strategies to treat muscular dystrophy, myocardial infarction and stress urinary incontinence.[13]
- Engineering salivary gland function

CONCLUSION

Despite extra ordinary achievements in the therapeutic field of medicine equal advancements are yet to be achieved in the field of dentistry. With the research of stem-cells still in its budding stages and with a majority of in vitro and a handful of in vivo animal studies. The need of the hour seems to be more in vivo human studies to be of any practical use for routine chair side use. There is still so much to learn of the nature, potentiality and behaviour of dental stem/progenitor cells, but the opportunities for their exploitation in dental tissue regeneration are immense and will lead to significant benefits for the management of the effects of dental disease

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