Review Article

Dental Stem Cells

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Abstract

Stem cells are pluripotent cells that can divide and multiply for an extended period of time, differentiating into specialized cell types and tissues. Dental decay which is the commonest dental disease needs proper dental treatment. Dental origin stem cells could be used for regenerative therapies. Dental tissue replacement, pulp regeneration, alveolar bone augmentation using stem cells may become the common modes of treatment in years to come.

Key Words: Stem cells, Pulp regeneration

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Introduction

The term "stem cell" was proposed by Russian histologist, Alexander Maksimov in the year 1868. Stem cells are capable of self renewal, potent multi lineage differentiation and have plasticity. For a cell to undergo plasticity there should be a tissue injury or stress which can up- regulate stem cells and release chemo attractants and growth factors. We have progressed a long way in treatment from surgical model to medical model and now a biological model of treatment. Dental pulp stem cells could be considered as a major site for mesenchymal cell collection. It could be collected from a child, adult or from a wisdom tooth. Stem cells have given us a biological way of treating a disease. Unlike blood, muscle, nerve cells, stem cells can divide and replicate themselves. They can differentiate and perform special function.

Types of Stem Cells

Based on plasticity they can be classified as totipotent, pluripotent, and multipotent. Embryonic cells within the first couple of cell divisions after fertilization are the only cells that are totipotent. They have greatest differentiation potential. Cells from the early embryo are totipotent while blastocysts and fetal stem cells are pluripotent. Pluripotency refers to a stem cell that has the potential to differentiate into any of the three germ layers endoderm, mesoderm or ectoderm. Umbilical cord cells are multipotent. They have gene activation potential to differentiate into multiple but limited cell types. Adult or post natal stem cells produce the cell kind in which they are present.

Dental stem cells

Pulp contains three zones. The outer part of dental pulp is the odontoblastic zone containing odontoblasts which lays down dentin, beneath is the cell-free zone (of Weil) containing numerous bundles of reticular fibers. Under the cell-free zone is the cell-rich zone made up of numerous fibroblasts. Undifferentiated mesenchymal cells differentiate into odontoblasts, fibroblasts or macrophages. Reparative dentine is formed by differentiation of new odontoblasts from these multipotent cells of the pulp. Stem cells isolated from teeth are :

- Dental pulp stem cells (DPSC): The special environment housing the stem cells is called as niche. In pulp, mesenchymal cells are present in perivascular niche[1]. Adult dental pulp contains precursors capable of forming odontoblasts under appropriate signals. Dental pulp stem cells were isolated by Gronthos et al[2]. The isolated cells had the ability to regenerate dentin-pulp like complex composed of matrix of dental tubules lined with odontoblasts and fibrous tissue containing blood vessel. This arrangement was similar to dentin-pulp complex of normal human teeth.
- Dental follicle Stem Cell (DFSC): Dental follicle surrounding the developing tooth germ has been considered a multipotent tissue. This is due to the fact that from the follicle cementum, bone and periodontal ligament forms. DFSC have been isolated from follicle of human third molars. They are able to form cementum in-vivo3. Handa et al found that bovine -DFC contained cementoblast progenitors that were able to differentiate to cementoblasts in vivo[4]. These cells were morphologically distinct from bovine alveolar osteoblast and bovine periodontal ligament.
- Periodontal ligament stem cells (PDL-SC): The PDL is a specialized tissue located between the cementum and alveolar bone and has as a role in maintenance and support of the teeth. The

characteristic heterogeneity of PDL and remodeling is due to presence of progenitor cells. PDL contains progenitors, which can regenerate other tissues such as cementum and alveolar bone. Seo et al reported that under defined culture conditions, PDLSCs differentiate into cementoblast-like cells, adipocytes, and collagen-forming cells[5]. When PDLSC cells are transplanted into immune compromised rodents, cementum/PDL-like structure was found. These findings suggest that PDL contains stem cells that have the potential to make cementum/PDL-like tissue in vivo. This finding has potential to be used in reconstruction of tissues destroyed by periodontal diseases.

- Stem cells from the apical part of the papilla (SCAP): It exhibits higher proliferative rate and appear more effective than PDLSC for tooth formation. Sonoyama et al found that SCAP are capable of forming odontoblast like cells[6]. SCAP cells could be considered as a primary cell source for formation of root dentin. SCAPs can only be isolated at an earlier stage of tooth development. Yet they have a greater capacity for dentin regeneration than DPSCs because the dental papilla contains a higher number of adult stem cells compared to the mature dental pulp.
- Bone marrow derived mesenchymal stem cells (BMSC): These cells are able to form in vivo cementum, PDL and alveolar bone after implantation into defective periodontal tissues. They have lower odontogenic potential than dental pulp stem cells[7]. STRO-1 is a cell surface protein expressed by bone marrow stromal cells and erythroid precursors. Yu et al found that STRO-1 DPSCs consist of several subpopulations which can differentiate into odontoblasts, osteoblasts, and chondrocytes[8].
- SHED(Stem cells from human exfoliated deciduous teeth) cells – are isolated from deciduous teeth. Mesenchymal cells from human deciduous incisors exhibits a high plasticity, they could differentiate into neurons, adipocytes, osteoblasts and odontoblasts. SHED cells are distinct from DPSCs by having higher proliferation rate, osteoinductive capacity[9,10]. Miura et al found that SHED could not differentiate directly into osteoblasts[1,9]. Induction of new bone formation occurred by creating a template and with murine osteogenic cells. SHED cells, holds a promise as they are easier to procure, the tooth from the child could be used for future regenerative purpose.

Application of stem cells in dentistry

- Pulp regeneration: Dental pulp stem cells (DPSCs) are capable of forming dentin and associated pulp[11,12] when seeded in a collagen scaffold supplemented with dentin matrix protein.
- Bone augmentation: Stem cells are used for alveolar ridge augmentation and regeneration of oral tissues. Using tissue engineered osteogenic material, comprising platlet rich plasma and autologous mesenchymal cells, alveolar cleft autologous mesenchymal cells, alveolar cleft osteoplasty was done in a 9 year old girl[13,14]. It showed regenerative bone covering the cleft walls[15].
- Entire tooth regeneration: Human SCAP and periodontal ligament stem cells (PDLSCs) transplanted into pig model led to generation of tissue which was tooth like in strength and appearance. Tooth could be bioengineered with tooth derived stem cells, growth factors and scaffold matrix[16].
- Stem cell markers: Alteration in stem cell marker has been found with oral lichen planus and oral hyperkeratotic lesions. Lichen planus is a T cell mediated auto immune disease[17]. Ding G proposed that mesenchymal stem cells can be utilized to treat oral lichen planus patients via systemic infusion or local application[18,19].
- Salivary gland regeneration: Stem cells isolated from mouse salivary glands have shown to increase saliva production in experimentally induced, irradiated salivary glands[20,21]. This has a promise to be translated in a human model.

Conclusion

Stem cells have created a new field of regenerative dentistry. Dental stem cells has a novel approach in treating periodontitis, dental caries,auto immune diseases, bone regeneration and many more. These dental origin stem cells appear to be in experimental stages and many procedures require validation in human studies. It holds promise to translate the research into a clinical setting.

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Eat trans-fat and pay with your memory

Plant oils are partially hydrogenated to improve the shelf life and reduce the need for refrigeration. They are used as cheaper alternative to semisolid oils like palm oil. But hydrogenation leads to formation of trans- fat. Consumption of excessive amounts of trans-fat is associated with increased risk for cardiovascular disease, obesity, diabetes mellitus, aggression etc. In a new study conducted in University of California, San Diego, 700 men and 300 post-menopausal women were evaluated for memory performance after obtaining detailed information about their dietary habits (particularly about the consumption of trans-fat). Analysis of the results of the memory performance showed, that in men younger than 45 years of age, higher consumption of tras-fat was associated with poorer memory. Such individuals recalled 10-11% less words than those who ate less trans-fat. Similar association was observed in post-menopausal women. Trans-fats produce their effects by increasing the oxidative stress and adversely affecting the cell energy. So, if you want to remember what you ate, don't eat trans-fat! [Paddock, C. (2014, November 20). "High consumption of trans fats linked to poorer memory in men." http://www.medicalnewstoday.com/articles/285775.php]

- Dr. K. Ramesh Rao