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STEM CELLS IN ORTHODONTICS- A REVIEW

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Abstract

Mesenchymal cell derivatives make up the craniofacial structures. The progeny of mesenchymal cells after asymmetrical division are mesenchymal stem cells, which are found in the adult's numerous craniofacial features. Dental pulp, deciduous dentition, and periodontium have all yielded cells that resemble adult stem cells in their features. Researchers from all over the world are now paying attention to stem cell therapy. Cleft lip and palate, craniofacial microsomia, and head and neck malignancies are only a few examples of the craniofacial malformations that are not only a serious disease, but also a significant burden in daily life. This article provides an overview of the state-of-the-art research on stem cells and their widespread application in orthodontics and dentofacial orthopaedics.

Introduction

The heart of multicellular organisms in both plants and animals are stem cells.

They are surrounded by complex signals that enable them to divide, either to make more of th emselves (self-renew) or to produce offspring that can produce a particular type of tissue. They reside in "nic hes" that resemble caves.

The word "stem cell" was originally used in 1896 by E. D. Wilson in his seminal textbook The Cell in Development and Inheritance, and it has since become widely used.Stem cells are characterized as cells with clonogenic, self-renewing, and the capacity to develop into a variety of cell lineages.

From the earliest stages of human development to the end of life, stem cells are present in all living things. All multicellular organisms have stem cells, which can alter into a wide range of adult cells.[1]

SOURCES OF STEM CELLS IN ORAL CAVITY.

Dental Stem Cells

The development of a new dentition requires the fusion of mesenchymal (which produces odontoblasts, osteoblasts, cementoblast and fibroblasts) and epithelial (which produces ameloblasts) stem cells because oral epithelial and neural crest-derived mesenchymal cells continuously interact to form teeth. Several oral tissues from adults or infants have so far

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yielded mesenchymal stem cells (MSCs). Contradicting to dental mesenchymal cells, the majority of epithelial cells of the tooth vanish once the tooth erupts. Because of this, it is very challenging to find epithelial stem cells (Epithelial Stem Cells) in adult dentition. The majority of the existing understanding of dental Epithelial Stem Cells comes from animal models like rodents, where adult Epithelial Stem Cell have already been identified as the primary source of epithelium renewal in the incisors which are continuously developing .[2]

Dental mesenchymal stem cells

MSCs have been discovered to exhibit markers including STRO-1, CD146, and CD44 since they were initially identified from bone marrow in 1970. The mesodermal lineages that gives birth to connective tissues like cartilage, bone and fat tissue could be formed from MSCs. The dental pulp of permanent human teeth served as the initial site of discovery for dental mesenchymal stem cells (DMSCs). Additionally, pulp from shredded primary teeth, the apical portion of the dental papilla, the dental follicle, and the periodontal ligament have all been found to contain DMSCs.[2]

Dental pulp stem cells (DPSCs)

Dental Pulp Stem Cells

Third molar dental pulp, which is frequently removed, is the most frequent source of DMSCs. In 2000, dental pulp stem cells were first discovered. At the junction of the cementum and enamel, the tooth must be divided to isolate the dental pulp. In vitro expansion of single-cell suspensions is possible. The most widely utilised identification approaches rely on the morphology, selective adhesion properties, growth and differentiation potential, and tissue healing capacity of the cells because of the lack of particular dental stem cell markers. STRO-1, CD146, and CD44 are typical MSCs markers that are frequently used to identify dental stem cell populations. In vitro, DPSCs have the capacity to produce lineages that are odontogenic, adipogenic, chondrogenic, osteogenic, myogenic, and neurogenic.[2]

(SHEDs) Stem Cells From Human-Exfoliated Deciduous Teeth

Multipotent (SHEDs) is extracted from exfoliated human primary teeth using a similar technique as dental pulp stem cells. Similar to dental pulp stem cells, SHEDs also express STRO-1 and CD146 on their surface, as well as a number of glial and neural markers such nestin, III tubulin, GAD, NeuN, GFAP, NFM, and CNPase, likely as a result of their neural-crest ancestry. SHEDs proliferate more quickly than DPSCs but are less able to assemble dentin-pulp complexes in vivo. SHEDs have been found to be myogenic and chondrogenic as well as odontogenic, osteogenic, adipogenic, and neurogenic. SHEDs can stimulate the production of bone and dentin in living things.[2]

Stem cells from the apical part of the papilla (SCAPs)

SCAPs could be removed from the root apical papillae, a soft tissue at the tips of developing permanent dentition, SCAPs outperform DPSCs in terms of proliferative rate, telomerase activity, potential for tissue regeneration, and migratory ability. [2]

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Periodontal ligament stem cells (PDLSC)

The Periodontal ligament is made up of connective tissue fibres that are situated in the middle of the alveolar bone and the tooth root cementum (Fig. 1)[12]. PDL helps keep teeth stable and supports homeostasis, nutrition, and tissue repair. First, third molars were used to isolate periodontal ligament stem cells or periodontal ligament stem cells from the root surface.[2]

Stem cells from the dental follicle (DFSCs)

Progenitors for the PDL, alveolar bone, and cementum are found in the dental follicle, a mesenchymal tissue. Coordination of tooth eruption is one of its biological purposes. By using plastic adherence, dental tissues that had been excised were used to isolate dental follicle stem cells (DFSCs).

Epithelial stem cells in human teeth

Among the potential sources of dental problems The wisdom tooth, also known as the third molars, develops postnatally in humans and is called epithelial stem cells. The enamel organ in the third molar develops about the 72nd month of a person's life. Unexpectedly, the human deciduous dental pulp can also be used to isolate epithelial cells. the deciduous pulp tissue was grown in serum without the medium for this research. During the culture process, rounded cells with an epithelial appearance proliferated in colonies and possessed cuboidal or polygonal forms. [2]

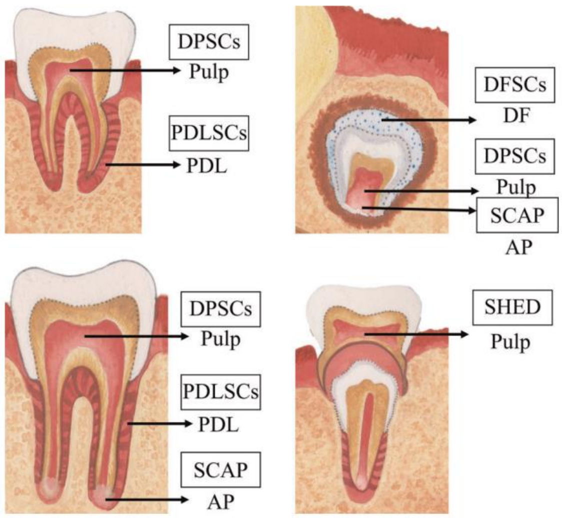

FIGURE 1 Different types of DSCs and their localization in associated tissues. AP, apical papilla; DF, dental follicle; DFSCs, dental follicle stem cells; DPSCs, dental pulp stem cells; PDL, periodontal ligament; PDLSCs, periodontal ligament stem cells; SCAP, stem cells from apical papilla; SHED, stem cells from human exfoliated deciduous teeth

Figure 1

THE PROMISE OF STEM CELLS TO ORTHODONTISTS

With the recent advances in the understanding of stem cell biology, certain opportunities can be provided to the orthodontist such as:

Shorter Treatment Time

Periodontal Health Consideration

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Correction of dentofacial anomaly
Correction of TMJ disorders

Shorter Treatment Time

- In a study, embryonic stem cells were transformed into cartilage cells and inserted into abnormalities in the cerebral osseous tissue that had been produced artificially. The group that got the implanted tissue responded substantially more quickly than the control group.[3]

Periodontal Health Consideration

Periodontitis is a periodontium disease that results in the permanent loss of alveolar bone support and connective tissue connection. A compromised dentition in terms of appearance and function is frequently the result of these alterations. Adult stem cell isolation from human PDL has recently opened up new possibilities for tissue engineering. The existence of different cell types (fibroblasts, cementoblasts, and osteoblasts) in the postnatal periodontal ligament has prompted scientists to hypothesise that these cells might have a shared ancestor.[4] A tissue-engineering strategy for regenerating periodontal components comprises putting progenitor cells and instruction signals into a ready-made three-dimensional construct and implanting it where the lesion is (Fig. 2)[5]. Since the recruitment of progenitor cells and growth factors is prevented there will be an improvement in healing, this method may solve a significant flaw in current regeneration strategies.[5]

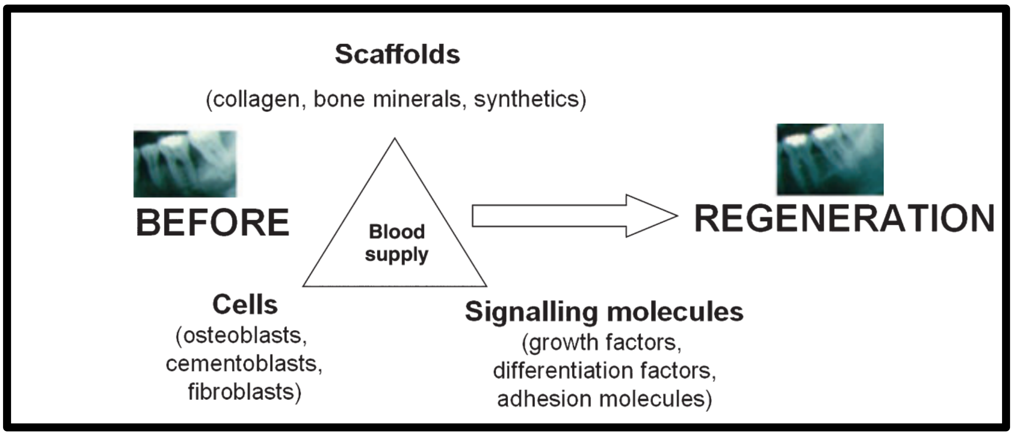

Fig. 2. Tissue engineering for periodontal regeneration is depicted schematically. A biodegradable scaffold with precise molecular instruction messages and stem cells may be used to completely regenerate a periodontal deficiency. Please take note that the radiographs are only being used as an example and do not actually depict a clinical result; instead, it is used to demonstrate a prospective consequence which is established on the principles of tissue engineering.

Correction of dentofacial anomaly

In order to give an advanced and dependable therapeutic strategy for craniofacial tissue reconstruction, stem cell-based tissue regeneration offers a promising approach. Craniofacial anomalies like congenital and developmental malformations, as well as those caused by trauma, tumor resection, and non-union of fractures, are some pathologies which is seen quite frequently clinically in craniofacial surgery.[6]

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It’s been shown that transplanting mesenchymal stem cells (MSCs), which could be extracted from both the trabecular compartment and the marrow cavity, may create new bone. To promote bone production, bone replacement materials can be mixed with essential cells like MSCs. Osteoblastic cells can adhere to and develop on synthetic and allograft materials, or osteogenic differentiation of precursor cells can occur in vitro.[7]

Stem cells in TMJ disorder

The temporomandibular joint (TMJ) is made up of cartilaginous and osseous components. The mandibular condyle develops as a result of the multiplication of stem cells that give rise to chondrocytes, causing an increase in the cartilage matrix that will eventually be substituted by lamellar trabecular bone. Stem Cells could be employed to maintain the mandible in a new posture and heal TMJ lesions since they have the capacity to develop into chondrogenic and osteogenic cells.[3]

MSCs play a biological role in inflammatory disorders and damaged tissues. Through transplantation in vivo, MSCs might repair tissue damage and create cartilaginous or even osseous compartments in animal models of TMJ osteoarthritis. These studies demonstrate MSCs' ability to regenerate cartilage in TMJ osteoarthritis patients.[8]

CONCLUSION

Stem cell therapy is becoming into a major game changer for medicine after decades of research. The potential of stem cells is expanding with every experiment, but there are still numerous challenges to be solved. Regardless, stem cells have a significant impact on transplantology and regenerative medicine. Presently incurable neurodegenerative illnesses may one day be managed using stem cell treatment.[9] Stem cells may be used in the field of craniofacial surgery to reconstruct various injuries. The use of the DDPSC has the benefit of not requiring a secondary surgical procedure (to achieve the bone graft of iliac crest), which has the potential to decrease operating room time, intraoperative loss of blood, pain post-procedure, costs, and duration of stay at the hospital —factors that could make regenerative medicine a trustworthy substitute for the present cleft care. This is especially true when it is about rehabilitating the alveolar bone in patient with cleft lip and palate.[10] According to recent research, it is possible to employ stem cells to speed up orthodontic tooth movement, regenerate resorbed roots, and broaden orthodontic tooth movement constraints while maintaining periodontal health. Additionally, periodontal tissues can be renewed using stem cells both before and after orthodontic tooth movement. Numerous preclinical animal studies have yielded encouraging results, and numerous clinical trials are currently being conducted all around the world to further validate these findings. Although in animal experiments, till date researchers been successful in creating certain tissues of dental origin or tooth-like structures, future developments in dental stem cell research will allow for the regrowth of functioning teeth in people.

Companies creating cell therapies confront a variety of risks because human stem cell research is still a young field, and some are unable to handle them, turning this endeavour into one that is very risky. Recombinant human fibroblast growth factor-2, human platelet-derived growth factor, and tricalcium phosphate are all now being tested in clinical trials

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(GEM-21). It is too soon to predict if all stem cell-based therapies shall verify to be efficient clinically, given the current clinical trials.[11]

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