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Stem Cells: A Boon for Dentistry

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Editorial

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Editorial

In dentistry it has found its way in the restoration of lost teeth and its contiguous tissues to restore the function through the delivery of the stem cells, bioactive molecules, or synthetic tissue engineered in the laboratory.

Contemporary dental practice is largely based on conventional, non-cell-based therapies that rely on durable materials from outside the patient's body. Amalgam, composites, metallic implants, synthetic materials, and tissue grafts from human cadavers and other species have been the mainstream choices for the restoration of dental, oral, and craniofacial structures. In the past, mankind has been replacing the missing body parts with inanimate objects that were created by him. But with advancing research in biotechnology, regenerative capability of our own living body tissue has opened a new era of tissue engineering.

Despite various levels of clinical success, conventional materials suffer from intrinsic limitations, such as potential immune rejection, transmission of pathogens from the donor, and the general inability of conventional materials to remodel with recipient tissues and organs. An often-preferred approach by surgeons to use autologous grafts, such as bone grafts, necessitates donor site morbidity.

In contrast, tissue engineering relies on the principle that mesenchymal stem cells are capable of generating virtually all craniofacial structures, and temporary bio mimetic scaffolds are necessary for accommodating cell growth and tissue genesis. Stem cell research has long been a much-debated and highly-controversial scientific field. It was a Russian histologist named Alexander Maksimov who, in 1908, first put forward the existence of the stem cell as part of his theory of haematopoiesis.

Stem cells also known as “progenitor or precursor” cells are biological cells found in all multi cellular organisms, that can divide (through mitosis) and differentiate into diverse specialized cell types and can self-renew to produce more stem cells. Stem cells are unspecialized cells that develop into the specialized cells that make up the different types of tissue in the human body.

Biologically, mesenchymal cells are primarily responsible for the formation of virtually all dental, oral, and craniofacial structures. Mesenchymal stem cells, the reservoir of mesenchymal cells in the adult, have been demonstrated, in tissue engineering, to generate key dental, oral, and craniofacial structures. Many dental and craniofacial structures are readily accessible, thus presenting a convenient platform for biologists, bioengineers, and clinicians to test tissue-engineered prototypes.

There is a plethora of regions in and around oral cavity where in the concept of tissue engineering is being applied. It can be used to repair and regenerate craniofacial bone tissue and for periodontal regeneration. Bioengineered tooth tissue regeneration is an interesting phenomenon which would open up an entire era of evolution of third natural dentition. Adult dental ecto-mesenchymal stem cell seems promising for future therapy. Human stem cells have been isolated from the dental pulp, exfoliated deciduous teeth, the periodontal ligament, the dental follicle and the dental papilla.

Advances in this field have led to significant progress in tissue repair and regeneration processes in dental tissue. Efforts are being focused on formation of the bioengineered dental tissues and whole teeth of predetermined size and shape. Adult stem cells, with the capacity of self-renewal and multiline age differentiation have paved the way of modern Prosthodontics to a more scientific and biological practice by unleashing tissue engineered human biological tooth regeneration. They play a crucial role in postnatal tissue development and provide an attractive progenitor cell source. Our strategy to develop a future clinical application for human biological teeth generated from adult stem cells follows. Epithelial stem cells are harvested from the dental epithelium or oral epithelium, while dental pulp stem cells can be obtained from either dental pulp tissues or bone marrow stromal cells. Periodontal ligament stem cells can be obtained from either periodontal ligament tissues or dental follicle tissues. Isolated epithelial, dental pulp, and follicle stem cells are then multiplied in vitro using an appropriate supportive culture environment. After combining epithelial, dental pulp, or dental follicle stem cells, a tooth primordium begins to develop in vitro or in vivo with the support of appropriate signalling molecules; these are distributed with a precise spatial and temporal organization. Subsequently, the mimic tooth primordium is transplanted back into the jaw where there is a missing tooth. The best location for growing new teeth, such as inside bone or in vitro, needs further consideration.

Stem cells engineering have proved outstanding in the field of implant dentistry also by generating a new hope by formation of periodontal structures around titanium implants. For decades, successful Osseo integration has provided thousands of restorations that maintain normal function. With the increasing need to utilize dental implants for growing patients and enhance their function to simulate normal tooth physiology and proprioception, there appears to be an urgent need for the concept of periodontal tissue regeneration around dental implants. It is now clear that undifferentiated mesenchymal stem cells are capable of differentiating to provide the 3 critical tissues required for periodontal tissue regeneration: cementum, bone, and periodontal ligament. Tissue-engineered bone constructs have the potential to alleviate the demand arising from the shortage of suitable autograft and allograft materials for augmenting bone healing. They also can serve as controllable in vitro models of high biological fidelity for studies of bone development, disease or regeneration. Each of the sources of osteogenic human cells - primary cells, MSCs, ESCs and induced pluripotent stem cells - has distinct advantages when used for bone tissue engineering, and the quest for an 'ideal' cell source is still in progress. Because bone is a vascularised tissue that is actively remodelled through coordinated sequences of bone growth and resorption, the requirements are much more complex than 'just' the formation of mineralized bone matrix. The potential use of human embryonic stem cells and their cell derivatives in regenerative medicine is possibly the main reason why public awareness is so high in this particular scientific field.

Thus, stem cells derived from all sources hold immense medical promises. Stem cell therapies have virtually unlimited medical and dental applications, with regard to their differentiation capacity, accessibility and possible immune- modulatory properties. A team effort engaging the expertise of the molecular biologists, immunologists, biomaterial scientists, cell biologists, matrix biologists, and practicing dental surgeons is crucial in attaining the desired goal. Further studies are necessary to establish evidence-based practices to educate dentists and patients regarding the use of stem cells in autologous regenerative therapies.