Stem Cells—The Future of Dentistry: A Review

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ABSTRACT

Research and development in the last millennium and in the present decade has brought about revolutionary changes in the way we understand and treat diseases. Stem cells are one of the most favorable areas of biology. Stem cell plasticity has resulted in a new field of medicine entitled regenerative medicine and dentistry. Scientists have successfully regenerated tooth root and supporting periodontal ligament to restore tooth function in an animal model. The breakthrough in stem cell research holds significant promise for clinical application in human patients.

Keywords: Stem cells, Regenerative medicine and dentistry.

INTRODUCTION

The regeneration or replacement of the oral tissues affected by inherited disorders, trauma and neoplastic or infectious diseases is expected to solve many dental problems. Within the next 25 years unparalleled advances in dentistry are set to take place with the availability of artificial teeth, bone and oral tissues using advances in stem cell research.

Recent advances in dental stem cell biotechnology and cell-mediated murine tooth regeneration have encouraged researchers to explore the potential for regenerating living teeth with appropriate functional properties.

What are these stem cells? Stem cell is defined as a cell that has the ability to continuously divide and produce progeny cells that differentiate (develop) into various other types of cells or tissues.

Stem cells are of two types—embryonic/fetal and adult/postnatal.

Embryonic stem cells are derived from embryos generated by in vitro fertilization. Whereas the source for postnatal stem cells are umbilical cord blood, umbilical cord, bone marrow, peripheral blood, brain, eyes, liver, muscles, skin almost all parts of the body tissues including the pulp tissues of teeth.

The reason why it is important to distinguish between embryonic and postnatal stem cells is because these cells have a different potential for developing into various specialized cells, i.e. plasticity. The plasticity of the stem cell defines its ability to produce cells of different tissues. Eventhough the greater plasticity of the embryonic stem cells makes these cells more valuable among researchers for developing new therapies, the source of embryonic stem cells is controversial and is surrounded by ethical and legal issues, which reduces the attractiveness of these cells for developing new therapies. This explains why many researchers are now focussing attention on developing stem cell therapies using postnatal stem cells donated by patients themselves or their close relatives.

The application of postnatal stem cell therapy was launched in 1968, when the first allogenic bone marrow transplant was successfully used in the treatment of severe combined immune deficiency.

The postnatal stem cells, such as stem cells from apical papilla and other stem cells for pulp/dentin regeneration and the combination of stem cells from apical papilla and periodontal ligament stem cells for bioroot engineering as shown by Sonoyama et al in a swine model if applied successfully in humans can provide future clinical approach to replace dental implants.

Current Scope of Applications of Stem Cells in Dentistry

1. In continued root formation
2. In pulp healing and regeneration
3. In replantation and transplantation
4. Pulp/dentin tissue engineering and regeneration
5. Bioroot engineering and reconstruction of the periodontium.

Potential Role of Stem Cells in Continued Root Formation

Using minipigs as a model, a pilot experiment was conducted. Although the finding suggests that root apical papilla is likely to play a pivotal role in root formation, further research is needed.
to verify the role of stem cells from apical papilla in continued root formation.  

Potential Role of Stem Cells in Pulp Healing and Regeneration

Recent research challenges the traditional approach in managing immature teeth by applying apexification treatment, where there is little to no expectation of continued root development. Instead, it is possible that alternative biologically-based treatments may promote apexogenesis/maturogenesis. A common aspect of many of these reported cases is the preoperative presentation of apical periodontitis with sinus tract formation, a condition normally associated with total pulpal necrosis and infection that requires apexification. Although Iwaya et al9 and Banchs and Trope10 applied the term ‘revascularization’ to describe this phenomenon, what actually occurred was physiological tissue formation and regeneration initiated by the stem cells.

Potential Role of Stem Cells in Replantation and Transplantation

Andreasen et al11,12 and Kling et al13 showed excellent radiographic images of the ingrowth of bone and periodontal ligament (PDL) (next to the inner dentinal wall) into the canal space with arrested root formation after the replantation of avulsed maxillary incisors, suggesting a complete loss of the space with arrest formation after the replantation of ligament (PDL) (next to the inner dentinal wall) into the canal radiographic images of the ingrowth of bone and periodontal

Stem Cells for Pulp/Dentin Tissue Engineering and Regeneration

Dental pulp tissue engineering was first tested by Mooney’s groups.15 Bohli et al16 reported that culturing pulp cells grown on polyglycolic acid (PGA) in vitro resulted in high cell density tissue similar to the native pulp. Buurma et al17 found that pulp cells seeded in PGA and implanted into the subcutaneous space of immunocompromised mice produced extracellular matrix. New blood vessels also penetrated the cells/PGA implants in vivo 3 weeks after the implantation.

Since, the isolation and characterization of DPSCs and SHED using these stem cells for dentin/pulp tissue regeneration has drawn great interest.18 These findings provide new light on the possibility of generating pulp and dentin in pulpless canals.

Stem Cells for Bioroot Engineering

Dental implants have recently gained momentum as a preferred option for replacing missing teeth instead of bridges or removable dentures. However, although dental implants have had great improvements over the past decades, the fundamental pitfall is the lack of a natural structural relationship with the alveolar bone (i.e. the absence of PDL). In fact, it requires a direct integration with bone onto its surface as the prerequisite for success, an unnatural relation with bone as compared with a natural tooth. The lack of natural contours and its structural interaction with the alveolar bone make dental implants a temporary option until a better alternative is available. This alternative may be tooth regeneration. Using animal study models, cells isolated from tooth buds can be seeded onto scaffolds and form ectopic teeth in vivo.19 Nakao et al20 recently engineered teeth ectopically followed by transplantation into an orthotopic site in the mouse jaw. Tooth regeneration at orthotopic sites using larger animals such as dogs and swine has also been tested.21,22 The study in dogs failed to show root formation21 whereas the swine model was able to show root formation with a 33.3% success rate.22

CONCLUSION

Understanding the biology of dental stem cells and the principle of tissue engineering regeneration provides us with a better knowledge base on which the clinical treatment plans can be established. Despite the challenges of isolating, expanding and defining stem cell population, mesenchymal stem cells hold tremendous promise for tissue regeneration at a clinically useful level. There are dramatic examples of the potential use of stem cells in regenerative medicine, but much work has to be done to characterize graft versus host stem cell immune interactions and to identify mechanisms enabling the delivery or homing of the stem cells to the site of interest in the times to come, it is expected that a multilevel approach involving cell biologists, matrix biologists, pharmacologists, biomaterials scientists engineers and nanotechnologists and dental researchers will arrive at an appropriate model to replicate the use of stem cells on a predictable basis in humans.

REFERENCES


