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Short Communication

Dental Stem Cell Applications in Oral Tissue Regeneration

Wataru Yoshida*

Department of Biomaterials Science, University of Novi Sad School of Medicine, Novi Sad, Serbia

DESCRIPTION

Dental stem cell research has expanded significantly in oral science, particularly due to the presence of multiple stem cell populations within teeth and surrounding tissues. These cells include dental pulp stem cells, periodontal ligament stem cells, stem cells from the apical papilla, and dental follicle progenitor cells [1]. Each population exhibits distinct biological activity, yet all share the ability to differentiate into specialized cells involved in mineralized tissue formation and connective tissue maintenance. Their accessibility from routine dental procedures such as extractions of third molars or exfoliated deciduous teeth has made them an attractive focus for biological investigation [2].

The regenerative behavior of dental pulp stem cells has been widely examined in controlled laboratory conditions. These cells originate from the soft connective tissue inside teeth and demonstrate strong proliferative capacity when cultured in suitable environments. Experimental studies have shown that they can generate odontoblast-like cells capable of producing dentin-like mineral deposits [3]. These findings suggest that pulp-derived cells may contribute to biological repair of internal tooth structures following injury or decay. Research models using three-dimensional culture systems have demonstrated organized mineral deposition resembling natural dentin formation patterns, indicating functional adaptability under controlled stimulation [4].

Stem cells isolated from the apical papilla represent a younger and more proliferative cell population compared to other dental-derived cells. Located at the tip of developing tooth roots, these cells contribute to root elongation during tooth maturation. *In vitro* studies have demonstrated that apical papilla cells can differentiate into odontogenic and osteogenic lineages, producing mineralized matrices that resemble early root dentin. Their high replication rate makes them particularly useful in experimental models focused on immature teeth where root formation has been interrupted due to trauma or pulpal infection [5].

In addition to cellular properties, delivery systems for dental stem cells are an active area of investigation. Biomaterial scaffolds such as collagen matrices, calcium phosphate structures, and polymer-based frameworks are used to support cellular attachment and growth. These scaffolds provide spatial organization that allows cells to form structured tissue layers. Experimental data suggest that scaffold porosity, mechanical strength, and degradation rate significantly influence cellular differentiation outcomes. Controlled delivery of signaling molecules within these systems has been shown to enhance mineral formation and cellular alignment [6].

Cryogenic preservation of dental stem cells has introduced new possibilities for long-term biological storage. Cells obtained from extracted teeth can be preserved under low-temperature conditions while maintaining viability and differentiation potential. Several studies indicate that properly stored dental stem cells retain functional properties even after extended periods. This has led to the establishment of biological storage facilities in which extracted dental tissues are preserved for future experimental or clinical use. Although practical applications are still under evaluation, stored cell systems represent a growing area of interest in oral regenerative science [7].

Another important area of dental stem cell research is periodontal tissue regeneration. Periodontal ligament stem cells have demonstrated the ability to differentiate into cells associated with cementum formation, bone development, and connective tissue maintenance. These properties make them promising candidates for investigating the repair of periodontal defects caused by inflammation, trauma, or advanced periodontal disease [8]. Researchers are examining the use of stem cells in combination with bioactive scaffolds and growth factors to improve the regeneration of tissues supporting the teeth. Experimental studies suggest that the local microenvironment, vascular supply, and interactions between stem cells and surrounding cells play important roles in determining regenerative outcomes. However, further research is necessary to establish reliable methods for controlling cell

Correspondence to: Wataru Yoshida, Department of Oral Health Care Education, Graduate School of Medical and Dental Sciences, Tokyo, Japan, E-mail: yoshida.wataru@wac.jp

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differentiation, promoting stable tissue integration, and achieving predictable results in clinical applications [9,10].

CONCLUSION

Molecular signaling pathways play an important role in regulating dental stem cell behavior. Proteins such as bone morphogenetic factors, fibroblast growth regulators, and vascular signaling molecules influence differentiation and tissue organization. Experimental modulation of these pathways has shown improved mineral deposition and structured tissue formation in laboratory conditions. The interaction between genetic expression patterns and environmental signals remains a central focus of ongoing research, particularly in understanding how stem cells respond to injury and developmental cues.

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