EDITORIAL

Current Trends in Periodontal Regeneration: A Nanobiomaterial Perspective

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Periodontium is a complex structure that includes the investing and supporting tissues of the teeth, and it consists of the attachment apparatus and the dentogingival unit. Tooth loss is a possible consequence of trauma, carious lesions or periodontal disease and its complications have turned into a disturbing concern which leads to unacceptable appearance and negative social consequences.[1] To overcome this paralyzing ailment, numerous dental and craniofacial treatment approaches with a scope of periodontal tissue engineering coupled with nano-dentistry have been developed that are commonly based on specific biomaterials.[2] Significant advancements in such biomaterials have been halfway accomplished through the incorporation of filler components having somewhere around one aspect in the nanometre range for the improvement of the recuperating ability of the tissues. Nanometric surface changes of biomaterials are continually applied to enhance their physical and biological properties, thus enhancing the quality and the duration of tissue repair.[3] As dental-specific mineralized tissues i.e., dentine and cementum along with bone has a characteristics natural regenerative ability, enamel of the tooth failed to regenerate upon its damage by the various tooth insults once it is erupted in the oral cavity.

This current topic focuses on the use of different modern materials together with nanotechnology to improve the clinical performances in dentistry. Prominent researchers within the craniofacial and dental fields have contributed with important discoveries and generated exciting results concerning the repair or regeneration of the mineralized tissues using biomaterials

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For the treatment of enamel lesions and defects, the role of Leucine Rich Amelogenin Peptide (LRAP), a product of the amelogenin gene, in enamel mineralization is studied.[4] In a recent study, an innovative strategy was proposed to regenerate enamel-like tissue by constructing a microenvironment using biomimetic enamel matrix proteins (biomimetic EMPs) composed of modified LRAP and non-amelogenin analog. Notably, the regenerated enamel in this biomimetic EMPs on etched enamel surface produced prismatic structures and showed similar mechanical properties to natural enamel. The results of X-ray diffraction and Fourier transform infrared spectroscopy showed that regenerated crystal was hydroxyapatite (a mature enamel is 95% highly organized nanorod-like hydroxyapatite (HAP) crystals).[5]

Oral tissues have been considered as a potential reservoir of mesenchymal stem cells (MSCs), and the first clonogenic population of dental derived stem cells were isolated from a dental pulp in 2000.[6] Recent studies reported crucial role of extracellular vesicle (EVs) secreted from MSCs.[7] EVs are nano-sized membrane-bound vesicles that are non-replicable, containing nucleic acids, proteins, lipids, and various signalling molecules with a regenerative and anti-inflammatory functions.[8,9] Recently, the pivotal role of Transforming Growth Factor Beta (TGF-β) receptor II interacting protein-1 (TRIP-1), an extracellular matrix protein, was studied and it has been showed that TRIP-1 regulates both osteogenesis and angiogenesis and perform multiple functions during mineralization of bone and dentine.[10] Some evidence supports that MSC-derived EVs with or without conditioned medium (CM) can be useful in promoting periodontal ligaments regeneration as the secretomes of MSCs are known to be responsible for their regenerative effects, containing proteins, lipids, nucleic acid, and trophic factors as growth factors, chemokines, cytokines, hormones, and EVs. Kawai et al. have used Human bone marrow MSCs-CM and reported that it may lead to the enhancement of periodontal tissue regeneration by stimulating angiogenesis and even the mobilization of endogenous MSCs.[11]

Nanoparticles incorporated agents offer safest and effective drug delivery platforms where encapsulate drug molecules guide delivery of drug to localised areas affected by periodontal disease. This approach can reduce dosage-related side effects by selectively depositing the controlled amount of drug in the proximity of the area of interest. A timely release of drugs by controlled disintegration is also useful. For example, a long-term sustained release of minocycline to the periodontium is achieved by Arestin® (minocycline microspheres). However, being microspheres, they may not penetrate deeper lesions in severe periodontitis.[12] A chitosan-based hydrogel containing triclosan, an antimicrobial drug prepared as nanoparticles using poly-ε-caprolactone, and flurbiprofen, an anti-inflammatory drug, gives rise to dual antibacterial and anti-inflammatory actions for localised treatment of periodontitis.[13]

Erosion from carbonated drinks/acids and vigorous tooth-brushing elicits dentin hypersensitivity (DH) which presents with severe pain of short duration. Open dentinal tubules and demineralization favour DH. A recent study evaluated the effectiveness of different experimental nanoparticle solutions based on zinc, calcium, or doxycycline-loaded polymeric nanoparticles (NPs) applied on citric acid etched dentin, to facilitate the occlusion and the reduction of the fluid flow at the dentinal tubules. The results showed that all NPs based solutions are effective in terms of impairing tubules occlusion with calcium and zinc-loaded NPs giving the highest reduction of dentinal fluid flow. Thus zinc-based NPs are proved to be fasten active dentin remodelling, with increased maturity and high mechanical properties.[14]

Scaffolds play essential role during tissue regeneration. Dental implantology has benefited from recent advances in bone regeneration, due to the use of many osseous substitutes that can be clinically applied in regenerative approaches, such as sinus augmenting procedures. A biomimetic porous three-dimensional MgHA/collagen-based scaffold could be used for enhancing the poor quantity and/or quality of bone in delicate maxillary areas (e.g., nearby the sinus) where the placement of dental implants is envisaged. Tomographic, radiological, histological and histomorphometric analyses have demonstrated the enhancement of bone formation and the complete resorbing of the scaffold after 6 months of treatment.[15]

With the advent of stem cells and ongoing research in advanced tissue engineering products, these multidisciplinary strategies handle the challenges related to regenerative dentistry in a more sophisticated manner. Likewise, nanotechnology-related achievements had a great impact on the evolution of biomaterials, thus broadening more prospects for novel and definite treatment plans for the repair or replacement of damaged or lost periodontal tissues. However, several concerns still exist concerning their applicability in the dental clinics. Therefore, there is an urgent need for clinical trials that will demonstrate the reliability and accuracy of these alternative strategies for tissue regeneration. Nevertheless, all these novel biomaterials and technological tools, combined with the constantly increasing scientific knowledge, offer exciting perspectives for modern alternative therapies in the dental and craniofacial fields.

DISCLAIMER

None.

CONFLICT OF INTEREST

None to declare.

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REFERENCES

1. Santonocito S, Palazzo G, Indelicato F, Chaurasia A, Isola G. Effects induced by periodontal disease on overall quality of life and self-esteem. Mediterr J Clin Psychol. 2022;10(1):1-17

2. Orsini G, Pagella P, Mitsiadis TA. Modern trends in dental medicine: an update for internists. Am J Med. 2018;131(12):1425–30.

3. Kochan O, Boitsaniuk S, Levkiv M, Przystupa K, Manashchuk N, Pohoretska K, et al. Emergence of Nano-Dentistry as a Reality of Contemporary Dentistry. Appl Sci. 2022;12(4):2008.
4. Le Norcy E, Lesieur J, Sadoine J, Rochefort GY, Chaussain C, Poliard A. Phosphorylated and Non-phosphorylated Leucine Rich Amelogenin Peptide Differentially Affect Ameloblast Mineralization. Front Physiol. 2018;9:55.eCollection 2018. doi: 10.3389/fphys.2018.00055
5. Fang Z, Guo M, Zhou Q, Li Q, Wong HM, Cao CY. Enamel-like tissue regeneration by using biomimetic enamel matrix proteins. Int J Biol Macromol. 2021;183:2131–41. Available from: https://www.sciencedirect.com/science/article/pii/S0141813021012289
6. Gronthos S, Mankani M, Brahim J, Robey PG, Shi S. Postnatal human dental pulp stem cells (DPSCs) in vitro and in vivo. Proc Natl Acad Sci. 2000;97(25):13625–30.
7. Yáñez-Mó M, Siljander PR-M, Andreu Z, Bedina Zavec A, Borràs FE, Buzas EI, et al. Biological properties of extracellular vesicles and their physiological functions. J Extracell Vesicles. 2015;4(1):27066.
8. Zhang Y, Liu Y, Liu H, Tang WH. Exosomes: biogenesis, biologic function and clinical potential. Cell Biosci. 2019;9(1):1–18.
9. Gowen A, Shahjin F, Chand S, Odegaard KE, Yelamanchili S v. Mesenchymal Stem Cell-Derived Extracellular Vesicles: Challenges in Clinical Applications. Front Cell Dev Biol. 2020;8. Available from:https://www.frontiersin.org/article/10.3389/fcell.2020.00149
10. Chen Y, George A. TRIP-1 Promotes the Assembly of an ECM That Contains Extracellular Vesicles and Factors That Modulate Angiogenesis. Front Physiol. [Internet]. 2018;9. Available from: https://www.frontiersin.org/article/10.3389/fphys.2018.01092
11. Kawai T, Katagiri W, Osugi M, Sugimura Y, Hibi H, Ueda M. Secretomes from bone marrow–derived mesenchymal stromal cells enhance periodontal tissue regeneration. Cytotherapy. 2015;17(4):369–81.
12. Mok ZH, Proctor G, Thanou M. Emerging nanomaterials for dental treatments. Emerg Top Life Sci [Internet]. 2020;4(6):613–25. Available from: https://pubmed.ncbi.nlm.nih.gov/33200780
13. Aminu N, Chan S-Y, Yam M-F, Toh S-M. A dual-action chitosan-based nanogel system of triclosan and flurbiprofen for localised treatment of periodontitis. Int J Pharm. 2019;570:118659.
14. Toledano-Osorio M, Osorio E, Aguilera FS, Luis Medina-Castillo A, Toledano M, Osorio R. Improved reactive nanoparticles to treat dentin hypersensitivity. Acta Biomater. [Internet]. 2018;72:371–80. Available from: https://www.sciencedirect.com/science/article/pii/S1742706118301648
15. Scarano A, Lorusso F, Staiti G, Sinjari B, Tampieri A, Mortellaro C. Sinus Augmentation with Biomimetic Nanostructured Matrix: Tomographic, Radiological, Histological and Histomorphometrical Results after 6 Months in Humans. Front Physiol [Internet]. 2017;8. Available from: https://www.frontiersin.org/article/10.3389/fphys.2017.00565.

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