

Nanotechnology Based Solutions for Periodontal Diseases.

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ABSTRACT

Small things have a big impact and so does the field of nanotechnology, because greatness is never determined by its size. Almost every dimension of survival; from security to medicine nowadays is dominated by nanotechnology. The nano-world is blooming rapidly in recent years and like other medical fields it has till date transmuted the sphere of dentistry in a huge way. Periodontitis refers to the inflammation of the gums and supporting tissues of the tooth. With its progress in various fields, nanotechnology has also evolved as a promising mode of treatment of periodontitis. Nanotechnological methods involve utilization of nano-materials, nano-biotechnology and nano-robots for the treatment and aftercare of periodontal health. This paper focuses on the possible applications of nanotechnology towards periodontics.

Keywords: Periodontitis, Nano-robots, Dentistry, Nanotechnology, Applications.

INTRODUCTION

Periodontal ailment is an inflammatory disorder which involves escalating and episodic degradation of the periodontal adjunct equipment, ultimately resulting in loss of tooth in vulnerable patients.^[1] Periodontal diseases are pervasive in developed as well as developing countries and strike about 20-50% of universal population. Extensive ubiquity of periodontal disorders in adolescents, adults, and older individuals makes it a public health perturbation. Multiple menace like smoking, poor oral hygiene, diabetes, medication, age, hereditary, and stress are associated with periodontal diseases. Sturdy authentication shows the amalgamation of periodontal diseases with systemic disorders such as cardiovascular disease, diabetes, and adverse pregnancy outcomes.^[2]

With the unstoppable vogue of a soaring aging population in both developing and developed countries, researchers of regenerative medicine and tissue engineering are regularly looking for novel approaches to apply the propositions of cell transplantation, materials science, and bioengineering to assemble biological replacements that will reinstate and maintain normal functions in defected and injured tissues.^[3] Implementations of such technology in dentistry, and periodontics in

that has the capability to form ideal articulation with tissues. The affix 'nano' indicates 10^{-9} or one billionth of a meter. Nanotechnology is expounded as a field involved in the design, synthesis, characterization and applications of materials and devices whose most minute functional organization in at-least one of the dimensions is on the nanometer range.^[4] Nanotechnology is best narrated as a comprehensive amalgamation of technologies from divergent fields like material science, engineering, chemistry, biochemistry, medicine, and physics, all of which have different attributes and applications. The momentum at which advancement has been made in science has launched nanotechnology to dentistry from its theoretical basics instantaneously into the actual world. Two major perspectives are used in nanotechnology. In the 'bottom up' approach components are constructed from molecular components which associate themselves chemically by theory of molecular recognition. On the other hand in the 'top down' approach, nano objects are built from larger substances without atomic level control.^[5] Nanotechnology and its contributions in periodontics have enhanced the diagnosis, treatment, prognosis and prevention of the periodontal disorders. It exploits nano-biotechnology, nano-materials, and nano-robots for the therapy and maintenance of periodontal health. Thus, the applications of nano-materials can be an asset for periodontal management as far as its power is considered in managing, diagnosing, and treating periodontal diseases.

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specification, are no exception. Currently, various biomaterials have been constructed at 'nano' level

The Rising Graph of Periodontal Diseases

Periodontal disease is a persistent inflammatory condition of periodontium. Its advanced manifestation is designated by periodontal ligament loss and demolition of neighboring alveolar bone.^[6] It is the preliminary reason of tooth loss and is contemplated as one of the two biggest menace to the oral health.^[6,7] There are approx. 800 bacterial species identified in the oral cavity and it is postulated that complex interrelationship of bacterial infection and host response, influenced by behavioral factors such as smoking, can cause periodontal disease.^[8,9]

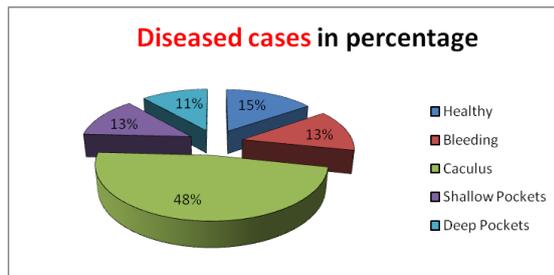


Figure 1: Different periodontal diseases and their occurrence in percentage

Periodontal disease is the most common oral ailment in humans.^[10] Compared to developed areas, developing nations have higher ubiquity of calculus and bleeding on probing among adolescents. The percentage of juveniles with calculus deposits ranged from 35% to 70% in developing nations while it ranged from 4% to 34% in developed countries.

Greater segment of older individuals (65-74 years) manifest periodontal pockets of 6 mm or above when contrasted with adults in both developed and developing countries. Overall, periodontal disease affects about 20-50% of the population around the globe.^[11]

Nanotechnology as A Potential Solution to Periodontal Diseases

Due to the soaring interest in the future of dental application of nanotechnology, a new field called nano-dentistry is emanating. The progress of nano-dentistry is focused to allow nearly perfect oral health by exploiting nano-materials and biotechnology including tissue engineering and nano-robots. This field of dentistry is receiving unrivalled assistance from the biotechnological sector, in the form of new renovations including extemporized diagnostic aids and therapeutic devices. Recent dental research involves accelerating access into the preventive, diagnostic, reconstructive, regenerative, restorative, and rehabilitative realms. The contribution of nanotechnology in the periodontal management was first put forth by Kong et al.^[12,13] Dental nanorobots desensitize tooth, employ the tissues to realign and straighten irregular teeth set, help in oral

analgesia, and also used in preventive, restorative and curative procedures and major repair of tooth.^[14] Nanotechnology has also got the capacity to produce non-biologic self-assembling systems for tissue engineering. The different modes by which nanotechnology contributes towards periodontics are discussed.

Nanomaterials for Periodontal Tissue Engineering

Presently, tissue engineering notions for periodontal tissue regeneration are pivoted around implementation of synthetic scaffolds for cell delivery purposes.^[15] Though the employment of such technologies offer promise, the next generation of materials will mostly count on nanotechnology and its prospective to develop non-biologic and self-assembling structures for tissue engineering.^[16] Utilizing these propositions, it is possible to fabricate systems on a nano-, micro- or even macro level. Current materials accessible for such constructs are metals, ceramics, polymers, and composite materials. The therapeutic benefits of these nano-built self-assembling materials are their capability to be constructed into nano-domains or nano-phases, leading to distinctive nano-building blocks with inbuilt nano-control and nano-delivery abilities.

Non biologic nano-systems are expected to automatically undergo self-assembly with biologic systems associated with cells and tissues and hence help in tissue engineering by reducing rejection chances. It is possible to create polymer scaffolds in the future for multiple applications like cell seeding, growth factor delivery and tissue engineering, using nano-devices implanted to sites of tissue damage.

Nanomaterials for Periodontal Drug Delivery

Nano-materials are of engrossment from an elemental point of view because some of the properties of a nano-material differ when the size of these particles that make up the structure becomes nano-scopic. Applications of the nano-materials and their varied properties have been exhibited in areas as miscellaneous as microelectronics, coatings and paints, and biotechnology.^[17] Nano-materials have substantial distinction in the field of local, or targeted, drug delivery. Lately, Pinon-Segundo et al.^[18] formulated and characterized triclosan-laden nanoparticles by the emulsification-diffusion procedure, to obtain a novel drug delivery system ample for the nursing of periodontal ailments. These triclosan-nanoparticles deport itself as a congruent polymer matrix-type delivery system, with triclosan molecularly diffused.

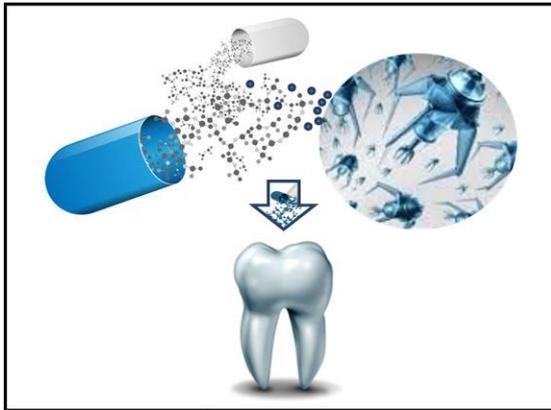


Figure 2: Nanotechnology based drug delivery in periodontal disorders

Drugs can be subsumed into nano-spheres comprising of a biodegradable polymer, and this allows for timed release of the drug as the nanospheres degrade.^[19,20] This also authorizes for site-specific drug delivery. A perfect example of how such technology can be developed is the recent development of Arestin where tetracycline is integrated into microspheres for drug delivery by local means to a periodontal pocket.^[21]

Nanorobotic dentifrices (Dentifrobots)

Dentifrobots or nanorobotic dentifrices in the incarnation of mouthwash or toothpaste can help clean organic remnants by traversing throughout the supragingival and subgingival exteriors, metabolizing confined organic matter into innocuous and odorless vapors and performing uninterrupted calculus debridement when left on the occlusal teeth surface. These nano-robots can migrate as fast as 1-10 μ /s and are securely self-deactivated once they are engulfed.^[22]

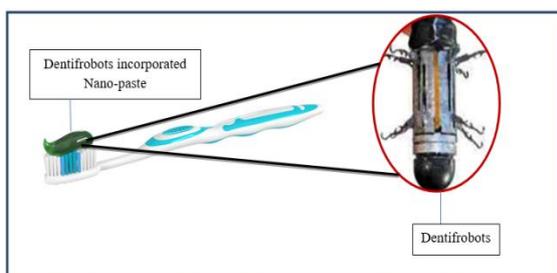


Figure 3: Dentifrobots and its applications

Laser Plasma Application for Periodontia

Use of nano-sized Titanium particle colloid on skin followed by laser shaft, results in degeneration of the particles along with other conditions like: Shock waves, Micro abrasion of hard tissues and impulse to generate collagen.^[23] Clinical applications of this technique in periodontia include periodontal therapy, melanin ejection and soft tissue slits without anesthesia.^[24]

Problems Faced by Nanodentistry

Despite of countless ideas and propositions for nano-dentistry, most of them have not been possible till date due to various confrontations like engineering, biological and social challenges. It is really difficult to design at the nano molecular scale promptly. Biocompatible molecules which are ecofriendly, economic and ethically admissible still are a remote site in the field of nano-dentistry.

A transpiring area such as nanotechnology has a consequential prospect to yield new generation of technologically sound novel clinical tools for oral healthcare. It can serve as a surrogate and supreme approach in evaluation of the onset or advancement of diseases, recognition of the targets for treatment intercessions as well as the designing of more bio reconcilable, microbe resistant dental grafts and implants. But for such success to be achieved nano-dentistry yet needs to conquer various barriers. Nanotechnology also carries a remarkable potential for abuse on a scale and scope never observed before. Due to inadequate evidence on possible human health and environmental hazards, nanotechnology has become a disputable issue.^[25] More researches on nano-materials and nano-devices is necessary to attain the great goals in the area of periodontics. The substratum has been laid and it is anticipated that this trend will be further upgraded in the mere future as more and more nanomaterials and devices are commercially exploited.^[26]

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