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Nanotechnology - A Novel Strategy in Periodontal Regeneration?

R. Hemalatha[1], A. Sivachandran[2*], R. Kalaivani[3]

[1*] *Reader, Dept of Periodontics, Karpaga Vinayaga Institute of Dental Sciences, Kancheepuram*

[2] *Senior lecturer, Dept of Oral Pathology, SRM Dental Kattankulathur College, Potheri , Kancheepuram Dt*

[3] *Reader, Dept of Periodontics, Asan Dental College, Chengalpet*

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Abstract

Nanotechnology refers to the control and manipulation (10^{-9}m) of matter at nanometer dimension. Although the nanoscale is small in size, its potential is vast. Nanodentistry will make possible the maintenance of comprehensive oral health by employing nanomaterials and ultimately, dental nanorobots. This article is a review, which describes about the potential use of nanotechnology in the field of periodontics.

Keywords: nanotechnology, nanomaterials, nanorobots

Introduction

Nanotechnology is extreme diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on nanoscale to investigating whether we can directly control matter on atomic scale [1]. Nano is the Greek word which stands for 'dwarf '. Nanotechnology is the science of manipulating matter, measured in the billionths of meters or nanometer, roughly the size of two or three atoms [2]. The vision of nanotechnology was introduced in 1959 by late Nobel Physicist Richard P Feynman who proposed employing machine tools to make smaller machine tools, which are to be used in turn to make still smaller machine tools, and so on all the way down to the atomic level [3]. In his historical lecture in 1959, he said "this is a development which I think cannot be avoided" [4].

Properties of Nanomaterials

Nanomaterials are those materials with components less than 100 nm in at least one dimension, including clusters of atoms, grains less than 100 nm in size, fibers that are less than 100 nm diameter, films less than 100 nm in thickness, nanoholes, and composites that are a combination of these [5]. They exhibit much better performance properties than traditional materials which include enhanced toughness, stiffness, improved transparency, increased scratch, abrasion, solvent and heat resistance, and decreased gas permeability [3]. Nanoparticles have a greater surface area per unit mass than compared with larger particles [6].

Self-assembly is an important feature of nanostructured materials. Here, an autonomous organization of components into patterns or structures without human intervention occurs [7]. Two main approaches are used in nanotechnology. In the 'bottom up' approach materials and components are built from molecular components which assemble themselves chemically by principles of molecular recognition. In the 'top down' approach, nano objects are constructed from larger entities without atomic level control [8].

*Corresponding Author
E-mail: drannasiva@yahoo.co.in

The various nanoparticles are as follows [9];

1. Nanopores
2. Nanotubes
3. Quantum dots
4. Nanoshells
5. Dendrimers
6. Liposomes
7. Fullerenes
8. Nanospheres
9. Nanowires
10. Nanobelts
11. Nanorings
12. Nanocapsules.

Nanorobotics

Nanorobotics is the technology of creating machines or robots at or close to the microscopic scale of nanometers [10]. According to nanorobotic theory, 'nanorobots are microscopic in size, it would probably be necessary for very large numbers of them to work together to perform microscopic and macroscopic tasks [11, 12]. Nanorobots are able to distinguish different cell types by checking their surface antigens. When the task of nanorobot is completed they can be retrieved by allowing them to exfuse themselves via the human excretory channels.

Nanotechnology -Role in periodontics

Periodontal drug delivery

Recently, Pinon-Segundo et al [13] produced and characterized triclosan-loaded nanoparticles by the emulsification–diffusion process, in an attempt to obtain a novel delivery system adequate for the treatment of periodontal disease. The nanoparticles were prepared using poly (D, L-lactide-coglycolide), poly (D,L-lactide) and cellulose acetate phthalate. poly (vinyl alcohol) was used as stabilizer. These triclosannanoparticles behave as a homogeneous polymer matrix-type delivery system, with the drug (triclosan) molecularly dispersed. A preliminary in vivo study using these nanoparticles has been performed in dogs with only the gingival index (GI) and bleeding on probing (bleeding on probing) being determined [13]. With respect to the gingival index (GI), at days 1 and 8, it was found that a severe inflammation was detected in control and experimental sites (GI ¼ 3). It was concluded that triclosan nanoparticles were able to effect a reduction of the inflammation of the experimental sites. Timed release of drugs may occur from biodegradable nanospheres. A good example is Arestin in which tetracycline is incorporated into microspheres for drug delivery by local means to a periodontal pocket [14].

Oral prophylaxis

Nanorobots incorporated in mouthwash could identify and destroy pathogenic bacteria leaving behind harmless oral flora to flourish in the oral ecosystem. It would also identify food particles, tar tar, plaque lift them from the teeth to be rinsed away. Being suspended in liquid and able to swim about, they reach surfaces beyond bristles of tooth brush or the fibres of floss. Continuous debridement of supra and sub gingival calculus would be done by nanorobots incorporated in dentifrices. They provide a continuous barrier to halitosis [11].

Periodontal tissue engineering

Nanotechnology has got the potential to produce nonbiologic self-assembling systems for tissue engineering purposes [15]. Self-assembling systems are those which automatically undergo prespecified assemblies much in line with known biologic systems associated with cells and tissues. It is possible to create polymer scaffolds in the future for cell seeding, growth factor delivery and tissue engineering via nanodevices implanted to sites of tissue damage.

Dentinal hypersensitivity

Natural hypersensitive teeth have eight times higher surface density of dentinal tubules and diameter with twice as large as nonsensitive teeth. Reconstructive dental nanorobots, using native biological materials, could selectively and precisely occlude specific tubules within minutes, offering patients a quick and permanent cure [16].

Tooth repair

Chen et al [17] made use of nanotechnology to simulate the natural biomineralisation process to create the hardest tissue in the body, the enamel by using highly organized microarchitectural units of nano-rod like calcium hydroxapatite crystals arranged parallel to each other.

Role of nanotechnology in dental biofilm

Silver nanotechnology chemistry has proven to be effective against biofilms. Silver disrupts critical funct-

-ions in a microorganism. It has high affinity towards negatively charged side groups on biological molecules such as sulfdryl, carboxyl, and phosphate groups distributed throughout microbial cells. Silver attacks multiple sites within the cell to inactivate critical physiological functions such as cell wall synthesis, membrane transport, nucleic acid synthesis (DNA and RNA) and translation, protein folding and function and electron transport.

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