Nanotechnology In Periodontics: Small Is The New Essential

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Abstract

Nanotechnology is an emerging arena during recent years in dentistry. In comparison to conventional materials used, nanotechnology sparked a research interest in their potential applications in comparison to traditional materials. Nanotechnology is the research and development of materials, devices and systems exhibiting physical, chemical and biological properties that are different from those on a large scale. Further, it also provides a broad range of innovation in diagnosis, treatment and prevention of oral diseases including periodontitis. With an increased advancement in nanotechnology, procedures like drug delivery and implant placement too have shown superior results over the conventional methods. This article will overview the history, classification, applications, and future of nanotechnology in periodontics.

Keywords: Nanotechnology, Periodontics, Disease prevention, Advancement.

Introduction:

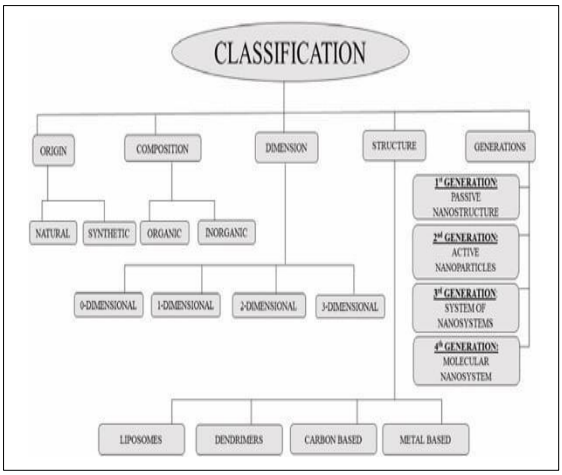
Nanotechnology is a rapidly growing field with significant implications for periodontics. This branch of science focuses on the manipulation of materials on an atomic or molecular scale, typically less than 100 nanometers in at least one dimension.[1]The term "nanotechnology" was first defined by Norio Taniguchi from Tokyo Science University in a 1974 paper. According to Taniguchi, nanotechnology primarily involves the processing of separation, consolidation, and deformation of materials by one atom or one molecule. Nanomaterials are distinguished by their extremely small size, which grants them an increased surface area per unit mass compared to larger particles. This enhanced surface area results in unique properties and behaviors that can be highly beneficial in various applications within periodontics.

History:

The use of nanoparticles dates back to the 9th century, when they were used to create glittering pots in Mesopotamia.[2] The concept of nanotechnology was introduced by Nobel laureate Richard P. Feynman. In 1993, Freitas coined the term "nanomedicine," defining it as the observation, control, and treatment of biological systems at the molecular level using nanostructures and nanodevices.

Nanotechnology became more practical with the discovery of the scanning tunneling microscope by Nobel Prize winners Gerd Binnig and Heinrich Rohrer in 1986. To further research in this field, the "National Nanotechnology Initiative" was established by Michael Roco in 2000.

Classification:



Properties:

The properties of nanomaterials were first introduced by Michael Faraday. Due to their surface area, dimensions, and quantum effects, nanoparticles exhibit enhanced rigidity, increased abrasion resistance, stability, fire resistance, and gas penetrability. Another remarkable property of nanomaterials is their self-assembling capacity, allowing them to form various arrangements without the need for external agents.[3]

Applications in dentistry:

Dental diagnostics

In an effort to enhance medical diagnostics, the concept of nano-biosensing was introduced. A biosensor is defined as "an analytical device that incorporates a biologically active element with an appropriate physical transducer to generate a measurable signal proportional to the concentration of chemical species in any sample."[4] By replacing microsized particles with nanosized ones, the biosensor becomes a nanobiosensor, capable of rapidly identifying targeted biological tissues at an ultra-low molecular level. This high sensitivity is particularly beneficial in cancer diagnosis, as nanobiosensors can detect cancer cell molecules at very early stages and in extremely low concentrations, surpassing the capabilities of conventional biosensors.[5]

Applications in periodontics:

Prevention:

Nanoparticle-derived antimicrobial agents are highly effective due to their large surface area. A commercially available nanotechnology-based disinfectant, Eco-True, contains silver salts and is used for disinfecting instruments and surgical areas.

Oral Hygiene Maintenance:

Mouthwashes and dentifrices containing nanoparticles aid in maintaining oral hygiene. Mouthwash with nanorobots and selenium nanoparticles controls halitosis by destroying bacteria that produce volatile sulfur compounds.

Nanotubes:

Nanotubes are used for detecting and locating disease-causing genes. Quantum dots, a type of nanotube, emit bright light when stimulated and are utilized in cancer diagnosis.

Lab-on-a-Chip Method:

These devices integrate multiple functions onto a single chip and are used in periodontics to detect IL-1ß, CRP, MMP-8, and TNF-α from whole saliva using minimal sample amounts.

Dentinal Hypersensitivity:

Hypersensitive teeth have a higher surface density and diameter of dentinal tubules compared to non-sensitive teeth. Reconstructive dental nanorobots, using native biological materials, can selectively and precisely occlude the dentinal tubules

within minutes, providing a quick and permanent cure for dentin hypersensitivity.

Bone Grafts:

Nanoscale-based grafts are observed to have superior outcomes due to their small dimensions that closely mimic natural bone particles. They can be successfully used for the treatment of intrabony defects,[6]socket preservation and sinus augmentation procedures.[7]

Nanomembranes:

KS Hong et al have used silk fibroin nanomembrane (Nanoguide) in guided bone regeneration and declared them to exhibit superior bone formation in comparison to biomesh.[8]

Tissue Engineering:

Polymer-based scaffolds can be constructed for cell seeding, growth factor delivery, and tissue engineering. These scaffolds, embedded with nanoparticles at the site of tissue damage, facilitate tissue repair and regeneration.[9]

Subgingival Irrigation:

Hayakumo et al has described the use of ozone nanobubble water produced by nanobubble technology in subgingival irrigation. The results of their study demonstrated that it can be used as an adjunct to periodontal therapy because of their enhanced antibacterial activity.[10]

Chronic periodontitis:

Kadam et al. hypothesized that the adjunctive use of silver nanoparticle gel, combined with scaling and root planing, has a superior effect compared to tetracycline gel in the management of chronic periodontitis.[11]

Wound Healing:

Improved wound healing with the use of nanomaterials has been reported in many studies. Polymer and lipid-based materials revealed excellent antimicrobial and antiinflammatory property with enhanced wound healing capacity. Carbon based particles showed good wound healing and angiogenesis, besides the metal-based nanoparticles showed scarless healing.[12], [13]

Local Drug Delivery:

Drug delivery using nanotechnology has been formulated as they have increased biocompatibility, targeted release, decreased antimicrobial resistance, long duration of action and less toxicity.[14] Nanoencapsulation technique is a recent technique developed by SWRI for delivering antibiotics and vaccines. Besides nanocomposite hydrogel-based delivery system through the use of triclosan, chitosan and biodegradable nanoparticles are also productive delivery vehicle.[15]

Nanoscale particles in dental implantology:

Chemical and mechanical modifications dental implants are said to have better osseointegration. Various nanoscale mechanical modifications include creation of nanoareas like nanogrooves, nanopillars and etc. Nanohydroxyapatite coated implants are commercially available as Nono Tite BIOMET 3i and have around 50% of nanohydoxyapatite.

Biomet dental implant

Future of nanotechnology in periodontics:

Most of the nanoparticles-based studies in Periodontics are in-vitro, the productive outcome of in-vivo studies is to be demonstrated. Materials with enhanced antibacterial effect, self-repairing property and compatible drug carriers are to be developed. The self-assembling antimicrobial peptides are under study and may be used for the treatment of periodontal diseases.[16]

Conclusion:

Nanotechnology is a promising technology that is playing an increasingly important role in the diagnostics, prognostics, prediction, and management of various treatments. With the emergence of nanoparticles, disease detection and treatment has become swift and prompt. Advanced regenerative and dental implant procedures are being carried out. Although the field of nanotechnology is fascinating, data on long term in-vivo effect of nanoscale particles are essential for clinical application.

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