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# Nanotechnology In Periodontics

**[1]Dr. A. Muthukumaraswamy, [2]Dr. Vedhavani. M, [3]Dr. Shabbir Ahamed. M,**
Associate Professor, [2]Post Graduate Student, [3]Assistant Professor,
Departmet of Periodontics, Tamilnadu Government Dental College and Hospital, Chennai- 600003

***Corresponding Author:**
**Dr. Vedhavani. M**
Post Graduate Student, Departmet of Periodontics,
Tamilnadu Government Dental College and Hospital, Chennai- 600003

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**Abstract**

Nanotechnology is a science, engineering and technology conducted at the nanoscale, which is about 10 to 100 nm. Nanotechnology and nanoscience are the studies and applications of extremely small things and can be used across all fields of science such as chemistry, biology, physics, material science, and engineering. Nanotechnology offers significant benefits in the field of medicine and dentistry in upcoming days. It showers inclusive scale of applications in counteraction and therapy of various dental and periodontal conditions. Periodontal diseases are common but largely preventable dental diseases, which is characterized by inflammation of supporting tissues of teeth, caused by specific or a group of micro organisms. This review highlights the approaches and applications of nanotechnology in prevention and treatment of periodontal diseases.

**Keywords**: Nanotechnology in Dentistry, Nanotechnology in Periodontics

## Introduction

Periodontal diseases is one of the most prevalent dental diseases, which is fairly preventable. Periodontitis holds 6th place in the list of most frequent diseases, globally. According to Carranza, Periodontitis is defined as an inflammatory disease of supporting tissues of teeth caused by specific micro organisms or group of specific micro organisms, resulting in progressive destruction of the periodontal ligament and alveolar bone with periodontal pocket formation, gingival recession or both. Mechanical debridement of plaque and calculus by means of scaling and root planing remains the benchmark therapy for treating periodontitis, where the healing takes place either by repair or regeneration [1]. Usage of chemotherapeutic antimicrobial agents in the form of topical (gel/ liquid), local (strips/ films/ microparticles/ fibers/ irrigation solution/ gel), and systemic ( tablets/ capsules) applications play secondary role in treating various periodontal conditions[2]

One of the current revolution in the field of science and technology is Nanotechnology, which also plays a sustained role in the field of medicine and dentistry. Nanotechnology deals with understanding and control of matter at nanoscale (1-100nm). From the definition of National Nanotechnology Initiative, Nanotechnology exploits specific phenomena and direct manipulation of materials on nanoscale (molecular/atomic levels). Though it is smaller in size, nanoparticles are known for its biological, optical, mechanical and electrical properties, compared to their microscopic equivalents (BAPAT ET AL- 2019). Nanodentistry is a trending area with immense applications including oral care, oral cancer diagnosis, anesthesia, hypersensitivity relief, periodontal regeneration etc.,via numerous nanomaterials such as nanotubes, nanofibers, nanopores, dentrimers, quantum dots, nanofillers and

so on. Thus the applications of Nanotechnology to dentistry and periodontics is undoubtedly a breakthrough in prevention and treatment of oral and periodontal diseases, respectively.

**History Of Nanotechnology:**

James Clerk Maxwell in 1867 proposed the advanced concept of Nanotechnology. Quantification of nanoparticle was first reported by Richard Zsigmondy in 1914[3]. In 1959, Richard Feynman took a lecture "there is plenty room

in the bottom" at American physical society, about matter manipulation and wind up his lecture by saying 'this is the development, which I think cannot be avoided'. In 1960, lipid based nanoparticles was explored by Alec Bangham. In 1974, Norio Taniguchi was the one, who first used the term 'Nanotechnology'. In 1986, Binning and Rohrer discovered scanning tunelling microscope. In the same year, Eric Drexler issued a book called " Engines of creation"- The coming era of Nanotechnology and reported the usage of atoms and molecules in construction of nanomachines[4]. In 1990, first journal in Nanotechnology was published in united kingdom and the term 'nanomedicine' was coined by Drexler in the same year. In medical field, Nanorobots was first described by Robert Freitas. In 2000, National Nanotechnology Initiative was refined by Michael Roco.

**Generations Of Nanotechnology:**

The generations of Nanotechnology was given by MC.Roco from National Nanotechnology Initiative (NNI). There are 4 generations in the development of Nanotechnology.

*First generation (2000+)*: It comprises of passive nanostructures like nanotubes, nanoclay platelets etc

*Second generation (2005+):*

It comprise of active nanostructures with balanced function. Drug delivery devices and sensors come in this category

*Third generation (2010+):* It constitutes three dimensional nanosystems. Example : Bioassembly

*Fourth generation (2015+):*

It comprises of molecular nanosystems, which are heterogenous and multi- tasking in nature

**Nanomaterials And Nanodiagnostics:**

Nanomaterials are materials having atleast one dimension in nano metric scale and the grain size is less than 100nm (US Food and Drug Administration & ISO). Nanomaterials are extensively used in various fields like Engineering, Electronics, Information technology, Consumer goods, Medicine etc. Nanotechnology utilizes nanomaterials for enormous functions in biomedical field for diagnosis, prevention and treatment of various diseases. Several nanomaterials used for nanodiagnostics in medical field are as follows;

**a) Nanotubes:**

Nanotubes are used to identify and locate DNA mutation in cancer. It also enables DNA maping for prediction of disease activity[5]

**b) Nanopores:**

These material renders well organised DNA sequencing, associated with cancer diagnosis and treatment[5]

**c) Nanoshells:**

These are bead-like structures with gold coating, which is designed to absorb particular wavelength of light, say near-infrared light and offers extreme heat which results in cell death in cancer patients

**d) Dentrimers:**

Dentrimers are branched nanomaterials meant for drug delivery. Being a branched structure, it offers more surface area for attachment of therapeutic agents and other biologically vital molecule. It aids cancer detection and cell death monitoring

**e) Quantum Dots**

These are crystalline structures used to detect specific region of DNA, when stimulated by UV light. It is used in generation of DNA probes.QD'S without lead and cadmium are being used for periodontal therapy (KARTHIKEYAN& HARINI-2017)

**f) Magnetic Nanoparticles:**

MNP'S has its own applications in Magnetic Resonance Imaging, Biosensors etc. Iron and nickel derivatives are frequently used magnetic elements. Super- paramagnetic iron oxide nanopaticle (SPION) are multifaceted medium used for cancer diagnosis.



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SPION is being used as a contrast medium in MRI and acts as a channel for biomarker detection[6,7].

**Approaches In Nanotechnology :**

Blending of nanomaterials in Nanotechnology has been done with the help of two approaches.

**A) Top Down Approach:**

Conversion of voluminous products into nanosized or microsized structures come under this approach. Surface structure deformity is one of the frequent drawback see in top down approach.

**B) Bottom Up Approach:**

It is the most economial and established approach, which comprise of intensification of nanomaterial from an atom/ molecule. This approach favours both organisation and homogenous configuration of nanomaterials.

**Nanodentistry And Its Applications:**

The scope of nanomaterials in the field of dentistry is bounteous. Nanoparticles and nanomaterials aids oral cancer diagnosis and treatment with the help of nanosensors, nanoshells and various nanoelectromechanical systems

Nanorobots, the so called Dentifribots occupies a major area in dental field and serves as a tool in oral cancer diagnosis, oral anaesthesia, dental desensitisation, tooth alignment, drug targeting etc[8]

In restorative dentistry, Nanocomposites( filler particle size less than or equal to 100 nm) promotes better finishing and polishing, flexural strength and hardnes when compared to traditional composites. Nanoadhesives in bonding agent can elevate higher enamel and dentin bond strength and longer shelf life[9,10].

Recently, vaccines and antibiotics are available in nanocapsules in specifically Targeted release systems. Nanosterilizing solution containing nanosized oil particles (Ecotrue nanosilver based) helps in destruction of microbes, which is also an upcoming arrival in dental field[9].

**Nanotechnology In Periodontics:**

**1) Regional Anesthesia And Nanoneedles:**

Local anaesthetic solution infused with innumerable dental nanorobots being administered in human gingiva, under the supervision of computers. Thus inturn causes transient pulpal anesthesia by blocking nerve impulses. Main advantages of nanoanesthesia than conventional one is the pain control and quick onset of action[11,12]. For better pain control, nanodimension silver parties and crystals of nanosized stainless steel are impregnated into suture needles

**2) Oral Hygiene Maintenance And Biofilm Control:**

Dentifrices and mouthwashes infused with nanoparticles and nanorobots are being used for destruction of bacteria, control of halitosis, debris and plaque control and prevention of gingival diseases[13].

Nanomaterials like Copper oxide, titanium oxide, carbon nanoparticles, gold, quaternary ammonium components manifests biofilm control activity by production of Reactive Oxygen species, which inturn decreases pathogenicity of micro organisms[14].

**3) Dentinal Hypersensitivity:**

Relief of Dentinal hypersensitivity is achieved by closure of dense Dentinal tubules via nanohydroxyapetite containing toothpaste. Thes toothpaste containing dental nanorobots, promotes rapid and permanent relief of hypersensitivity[15]

**4) Dentifrobots ( Nanorobotic Dentifrices):**

Dentifrobots resides in subgingival surface after intake and pin down the organic food particles and turns them into harmless gas. These are customade for maintenance of better oral hygiene. Dentifrobots are about 1-100 micron, which movie at a speed of 1-20 micron/ second, which is more economical and can shut off themselves when swallowed[16].

**5) Subgingival Irrigation:**

Ozone nanobubble water was used for subgingival irrigation in periodontal therapy for promotion of antimicrobial activity ( HAYAKUMO ET AL )[16]

**6) Chronic Periodontitis:**

In treatment of chronic periodontitis, nanoproresolving lipid mediators are being used. Combination of scaling and root planing with silver infused nanoparticle gel reports good results than tetracycline gel in controlling of periodontitis and it was also reported in a study done by KADAM ET AL[17].



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**7) Periodontal Drug Delivery:**

In nanotechnology, various drug delivery agents like polymers, dentrimers, liposomes, nanowires etc are used. The main advantages of nanotechnology in drugs delivery are selective release, decrease virulence, decreased resistance and biocompatible. Medications are loaded within the nanostructures, which are made up of non- toxic bioabsorbable polymers, which enables controlled release of drugs. In a study, PINOM SEGUNDO ETAL, have reported that Triclosan loaded nanoparticles acts as an emerging delivery agent for management of periodontal diseases[18].

Nanovectors like calcium phosphate nanoparticles are used for gene delivery in specific fibroblasts to promote periodontal regeneration[5,19].

**8) Bone Grafts And Nanomembranes:**

Bone is a natural nanostructure. These nanoparticles mimics the natural structure of bone via nanoscale bone grafts. These nano bone grafts are widely used for management of intrabony defects[20], sinus augmentation and socket preservation procedures[21].

The main advantage of using these bone grafts in infrabony defects is its higher surface area to mass ratio. Hydroxyapetite nanoparticles are also being used for management of bone defects.

Nanoguide( silk fibroin nanomembrane) enhances the bone quality and promotes bone formation with Guided bone regeneration ( KS HONG ET AL )[22]

**9) Dental Implants And Peri-Implantitis :**

In implants, modification of nanoscale topography promotes better osseointegration and higher success of implant. Mechanical alterations like creation of nanogrooves favours better strength[23]. Chemical coatings with Tititanium oxide, Hydroxyapetite, diamond also promotes better osseointegration. Studies reported that nanoparticles infused zinc oxide and titanium oxide reduces S. epidermidis over the implant surface[5,24]. Reduced marginal bone and enhanced osseointegration have been seen with nanoself assembling implants when compared to traditional implants

For management of Peri-implantitis, nanohydroxyapetite is being applied over citric acid constrained surface for enhanced clot stability. PDGH-BB delivered with calcium phosphate nanoparticle promotes better fibroblastic proliferation around the implant surface (ELANGOVAN ET AL )[19]

**10) Laser And Photodynamic Therapy:**

Nanotitanium coated implant surface are irradiated with laser beam for development of collagen synthesis. Diode laser along with nanoparticles helps in decontamination of Dentinal surfaces[13,25].

PLGA Nanoparticles with methylene blue and indocyanin green loaded nanoparticles are some recent innovations in photodynamic periodontal treatment[5,26].

**11) Tissue Engineering:**

One of the recent advances of nanotechnology in Tissue engineering is 3D matrix scaffolding system, which owns inherent properties, that are better than traditional technology. For therapeutic purposes, some dymanic molecules and proteins have been added in nanoscales with these scaffolds to enhance cells and tissue damage[27]. Scaffolds made of periodontal ligament stem cells and Hydroxyapetite nanoparticles promotes better fibroblastic adhesion and periodontal regeneration.

**12) Wound Healing:**

Wound healing with nanoparticles is more appropriate recently. Metal- based nanoparticles promotes less scaring and carbon based nanoparticles reported better neovascularisation and wound healing[28]. Lipid based nanoparticles shows antibacterial trait with better healing.

**13) Host Modulation Therapy:**

A study done by CAFFERATA ET AL focuses on the immunomodulatory effects of host- regulating agents through nanocarriers for management of periodontal diseases. They have noted the decreased levels of bone resorbing T- lymphocytes and pro-inflammatory cytokines through this nanobased approach[29]

**14) Nanobiotics:**

Nanobiotics or nanoantibiotics constitute broad spectrum antibiotics which are delivered via nanocarriers. These nanocarriers are coated with exclusive antibiotics on their surface and used for prevention of infection and promotion of healing[30]



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**Covid-19 And Nanotechnology:**

Covid - 19 is an open ended worldwide illness, which ruined millions of lives. Various strategies have been taken for the prevention and treatment of COVID-19. The field of nanotechnology plays an important role in prevention, diagnosis and treatment of COVID-19.

**Prevention:**

Nanofibres and nanofibre webs in mask[31], silver nanoparticles in gloves and metallic nanoparticles ( Tio2 and Ag nanoparticles) in disinfectant solution favours virucidal effects against covid 19. Engineered water nanodisinfectants and nano sanitizers with de-ionized water, H2O2 helps in neutralization of microbes[32].

Gold, ferritin, spike protein, polymeric protein and lipid based nanoparticles have been add on to vaccines for viral gene inactivation and enhancing immune/ dentritic cell function[33,34].

**Diagnosis:**

Early diagnosis aids in early identification of pathogen. Conventional diagnostic test of COVID-19 include CT chest and molecular ( nucleic acid/ protein test)[35]. In nanotechnology, gold nanoparticles ( DNA detection) , magnetic nanoparticles ( nucleic acid seperation and extraction), Quantum dots ( molecular imaging), carbon based nanomaterials ( biosensing and bioimaging), nanozymes ( nano- artificial enzymes with fast catalytic activity) aids tremendous assistance in diagnosis of SARS-COV-2[36,37].

**Treatment:**

Innovative therapies are needed to counteract these rapidly growing and assorted behavioured nature of SARS-COV-2. Nanotechnology favours antiviral therapy through various nanoparticles. Metal and metal oxide nanoparticles promotes new strategy for elimination of disease severity and virus inactivation through ROS production.

Carbon based nanoparticles prevent viral RNA genome amplification[38] and used as antiviral agent. Quantum dots produce ROS and prevents viral replication. Exosomes are biological carriers against COVID-19, which carry therapeutic agents/ stem cells. They are widely used in immunotherapy because of its hypoimmunogenic property[39].

**Conclusion:**

Nanotechnology remains as an upcoming field in last few decades. It has extensive advantages in the field of engineering, biotechnology, medicine and dentistry. In dentistry, various applications like cancer diagnosis, nanobiotics, nanorestoratives, nanovaccines hold an important place. In the field of periodontics, it has immense entities such as drug delivery, bone regeneration, anesthesia, hypersensitivity cute, dental implants, host modulation, nanoantibiotics etc. Though nanotechnology having functions in multiple fields, most of the studies and researches are in initial stage. So, further studies and researches are much needed for the betterment of techniques and treatment modalities for clinical applications.

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