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Finding Hidden Gems: Nanoparticles in Oral Health- A Review

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Review Article

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ABSTRACT

Advances in nanotechnology are showing the future of oral care. Nanoparticles are mostly used for oral disease preventive drugs, prostheses, dental materials, and for teeth implantation. In dental care, various materials which are used are composed of nono particles. Nanomaterials deliver oral fluid or drugs, preventing and curing and maintain oral health care up to a high extent. Even nanomedicine act as devices that is able to work inside the human body in order to identify the early presence of a disease, and to identify and quantify toxic molecules and tumor cells. This review focuses on the possible applications of nanotechnology and the use of nanomaterials in the field of dentistry.

Keywords: Nanoparticles, Nanofillers, Zirconia.

Introduction

The biological and digital information revolutions are quickly converging with dentistry which is leading to the use of new nanoparticles. The word "nano" comes from the Greek word means dwarf. Nanoparticles are emerging as an interdisciplinary field that is undergoing rapid development and has brought about enormous changes in medicine and dentistry. Nanodentistry has evolved from nanotechnology that helps in diagnosing, treating, preventing oral and dental disease, and improving dental health by using nanomaterials. Nanotechnology becomes one of the most favorable technologies and one which will change the application of materials in different fields. A nanometer is equal to one billionth of a meter or numerically expressed as 1,000,000,000th of a meter[1] Nano material use analyzes and manipulate atoms, chemical bonds, and molecules present between various compounds. While choosing the nanoparticle for the use in the field of nano dentistry its chemical, physical, mechanical along the biological aspect of nanostructures are taken into account. At the nano-scale, physical, chemical, and biological properties are different from the properties at an individual atomic/molecular level and bulk matter. There are mainly four types of materials (metals, polymers, ceramics, and composites). Nano-materials have been developed in all these four categories for practical applications in

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health care. It studied in detail and applied in application to patients in dentistry as different dental materials.[2] Various Nanoparticles [NP] with their properties and purpose that are used in dentistry to protect the teeth.[3]

Nano particles	Compressive strength, Malleability, ductility	Physical property	Chemical Property	Purpose of use
Carbon nanotubes	Carbon nanotubes can offer tensile strength because of the hexagonal arrangement yet it has the malleability of rubber, high tensile ductility (8–13%), good mechanical strength	Surface area is large, ultra-light weight, heat stability, high strength, lower density	Heat transmission efficiency Strong bond between carbons atoms make this material quite stable; the carbon atoms in nanotubes are arranged in hexagonal rings	Teeth filling, a coating of the teeth surface
Graphene	Graphene is transparent, flexible (high malleability and ductility). stable	unique structure gives rise to a high planar surface area, superior mechanical strength, electronic properties are remarkable and alluring optical characteristic	Single, thick carbon sheets of honeycomb lattice orientation having two-dimensional (2D) origin make up the grapheme structure. Due to the structure, graphene has acquired a number of unique and exceptional characters	Teeth coating, suitable for implantation, biofilm reduction
Hydroxy apatite (HAp)		Hexagonal structure	It is a calcium phosphate. It is quite stable when compared to other calcium phosphates.	reduce dental hypersensitivity, also act as cavity filler, retard auxiliary demineralization, repairment of enamel surfaces
Silica	Compressive strength–1600 MPa with minimal ductility and significant hardness	Two types based on their structure – Ptype and S-type. Ptype is characterized by numerous Nano pores whereas Stype is having smaller surface area. P-type nano silica is having comparatively higher UV	Silica-46.8% Oxygen-53.3% Density- 2.4g/cm^3	Dental filling agent, tooth polishing, prevents dental caries, an antibacterial agent, to treat dental hypersensitivity
Zirconia	The ductile, soft and malleable matter which	Zirconium nanoparticles are	Nano fluids nanocrystals with	Reduces bacterial adhesion to the

	provide great resistance to corrosion	lighter and less susceptible to embrittlement by hydrogen	the white surface area. Provide great resistance to corrosion by acids, alkalis, salt wate	tooth surface, provide protection against dental carries, effective polishing agent.
Silver	Silver nanoparticles are having high ductility and malleability. They are also good conductors.	Small size, the surface area is large, having optical, electrical and thermal conductivity	Insoluble in water and organic solvent. Very stable.	Antimicrobial agent, dental restorative material, dental prosthetics, dental implants
Titania	Having a compressive strength of about 3675 MPa with null ductility, quite hard and an elasticity limit of 367.5 MPa.	Found as nanocrystals or nano drops having large surface area, having magnetic properties	Chemical composition Titania- 59.93% Oxygen- 40.55%	Mainly dental implant

Advantages of Nanodentistry[4]

1. Hardness, strength, elasticity, translucency, dura-bility of Nano-dental materials.
2. Small diagnostic machinery can lead to faster and accurate.
3. It can mimic some of the mechanical and structural properties of native tissue and can promote Biointegration.
4. Alter the treatment procedures with faster healing properties and less time-consuming.
5. Mortality and morbidity can be reduced due to more precise drug delivery.
6. Better aesthetics.
7. Reduced frequency of visits to the dental clinics for patients and less fatigue for the practitioners.

Disadvantages of Nanodentistry:[4]

1. Numerous ethical issues to deal with.
2. Side effects and allergy associated with the nanoparticles are harmful to humans.
3. Non-biodegradable nanoparticles can be deposited in various organs and that can lead to unwanted toxicity.

Application in Dentistry

1. Nanofillers integrated into vinylpolysiloxanes resulted in impression materials with better flow, improved hydrophilic properties, and enhanced reproduction of surface details.[5]
2. Artificial composite teeth having nanofillers id far superior to conventional acrylic teeth in terms of surface smoothness, abrasion resistance, and color stability.[6,7]
3. Artificial composite teeth containing homogeneously diffused nanofillers have been reported to be superior to conventional acrylic teeth in terms of surface smoothness, abrasion resistance, and color stability.[6,7]
4. Pulp tissue regeneration has done using self-assembling polypeptide hydrogels. The nanofiber mesh formed supported growing pulpal cells.[8]
5. Triclosan-loaded nanoparticles were effective in reducing periodontal inflammation.[9,10]

6. Osteoblast proliferation has been induced through the creation of Nano-size particles on the implant surface.
7. increases osteoblast proliferation. Implant coatings done by nanostructured diamond, has an ultra-high hardness, improved toughness, low friction, and good adhesion to titanium alloys. Hydroxyapatite implant coatings manufactured using nanostructured processing, increase the osteoblastic activity in terms of its adhesion, proliferation, and mineralization whereas nanostructured metalloceramic coatings on implant surface augments the osseointegration of dental implants by forming a nanocrystalline metallic bond.[11]
8. Nanosized stainless steel crystals are incorporated into commercially available needles.[12]
9. To reduce dentinal hypersensitivity NP is able to selectively and precisely block dentinal tubules.

Treatment success is limited by features of the biomaterials used. To counter these limitations, materials are incorporated with nanoparticles. Drug delivery in nanotherapeutics (leading to the reduction in dosage and adverse effects of drugs and can be used for Alzheimer's disease and Parkinson's disease).[13,14,15] Nanoencapsulation wherein new vaccines and antibiotics have been developed that have made possible the targeted delivery of genes and drugs to the human liver.[16] The disease initially starts at the molecular level, these nanoparticles helps to subside the pathogens at these initial phase to prevent the disease process. Specifically, the use of nanoparticles helps accurate precision in diagnosing, treating, and preventing dental ailments. These nanomaterials can selectively occlude the specific tubules within a minute, offering patients a quick and permanent cure in case of hypersensitivity in the tooth due to cold stimulus. Various Nanoparticles [NP] with their properties and purpose that are used in dentistry to protect the teeth.[3]

Conclusion

Nanomaterials used in the dental filling, polishing of the enamel surface to prevent caries, also used as implant materials that are more effective than the conventional materials. Some of the nanoparticles act as an antimicrobial agents thus prevent infection. Nanodentistry have to be cost-effective, time-saving which can be used easily. Antibacterial NP-based treatment has the potential to improve antibacterial/antibiofilm efficacy. They have distinct advantages when applied in dentistry. This technology has vast potential to show advancement and improvement in the field of dentistry. It also needs great responsibility to ensure the safety, efficiency, and applicability of such nanoparticles.

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