IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 21, Issue 4 Ser.4 (April. 2022), PP 01-06
www.iosrjournals.org

Nanotechnology in Restorative Dentistry and Endodontics

Dr. Priya Mishra[1], Dr. Akhil Mudgal[2], Dr. Ajay Kumar Nagpal[3], Dr. Abhishek Sharma[4]

[1]*(Postgraduate Student of Department of conservative dentistry and endodontics, Kanti Devi Dental College and Hospital, Mathura, Uttar Pradesh)*
[2]*(Postgraduate Student of Department of conservative dentistry and endodontics, Kanti Devi Dental College and Hospital, Mathura, Uttar Pradesh)*
[3]*(Professor & HOD of Department of conservative dentistry and endodontics, Kanti Devi Dental College and Hospital, Mathura, Uttar Pradesh)*
[4]*(Senior Lecturer of Department of conservative dentistry and endodontics, Kanti Devi Dental College and Hospital, Mathura, Uttar Pradesh)*

Abstract
In the sphere of medical science, the nanomaterial age has left an indelible mark. Because of tremendous achievement and improvement in physical, chemical, and biological sciences, it has considerable benefits for both patients and physicians. Better dental care is made possible by nanoparticles with such unique and increased properties. This article explains how nanotechnology is used in dentistry and illustrates how it can have a far-reaching impact on clinical dental practice.

Keywords: *nanodentistry, dentifrobots, nanotechnology, nanodentistry, nanoionomers.*

Date of Submission: 02-04-2022 Date of Acceptance: 15-04-2022

I. Introduction Of Nanotechnology

Nanotechnology has transformed every facet of health care, including dentistry. It's the science of creating useful materials and structures with dimensions ranging from 0.1 to 100 nanometers. Prof. Kerie E. Drexeler created the phrase in the 1980s, taken from a Greek word that meaning "dwarf."[1] The term "nanotechnology" refers to the study and development of materials, devices, and systems with physical, chemical, and biological characteristics distinct from those found on a larger scale.[2]

The use of nanomaterials and biotechnology in dentistry has given rise to a new concept known as "nanodentistry," which may be described as the improvement and maintenance of oral health using nanomaterials and biotechnology, including tissue engineering and nanorobotics. Nanodentistry research encompasses a wide variety of topics, including disease detection (nanodiagnosis), caries prevention (nanoprevention), and dental therapies (nanotreatment).[3] In 1993, Robert Freitas is credited with introducing the new and developing area of nanomedicine. Since then, new terms in disease management have emerged, including "nanoscaffolds" for tissue regeneration and "nanorobotics" for diagnostics and therapy. Dentistry, dental care, and dental biomaterials are all beneficiaries or products of nanotechnology's "ocean," in which molecules and atoms are actually manipulated to produce new goods, structures, and services.[4]

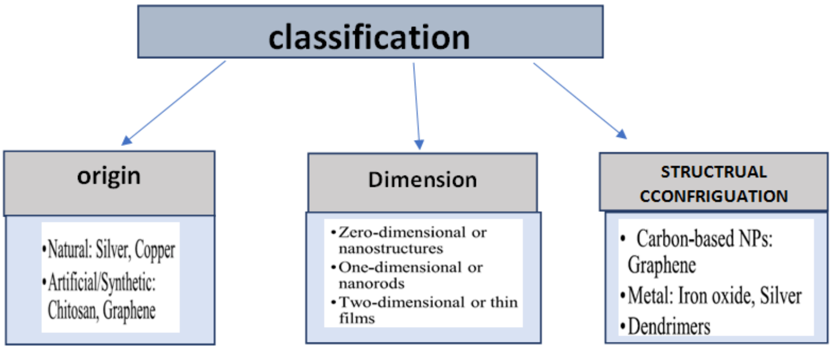
HISTORY OF NANOTECHNOLOGY

The sight of nanotechnology was came into light by Noble Physicist Richard Feynman by a talk given on “There’s Plenty of Room at the Bottom,” at an American Physical Society meeting at Caltech in 1959. Feynman elaborated how much we lack in our vision and methods, the manipulation of single atom or molecule by the laws of physics that does not limit us for doing so.[5]

The nanotechnology in relation to the dentistry was introduced by Dr Robert A. Freitas in the year 2000. He created nanomaterials and nanorobots, assisted in dentition regeneration, and produced dentifrobots(dentifrice robots). He explained that through the application of nanomaterials, biotechnology, and nanorobotics, nano dentistry will aid in the maintenance of ideal oral health care.[6]

In recent years, dentistry has made substantial use of nanotechnology especially in field of endodontics by introduction of various nano particles based dental materials e.g. nano-composites, nano glass ionomer cements, nano bonds, nano ceramics etc.[7]

CLASSIFICATION[8]



CHARACTERIZATION OF NANOPARTICLES

Nanoparticles have unique chemical, optical, magnetic, and electrooptical properties that set them apart from individual molecules and bulk spices. Toughness, stiffness, transparency, scratch, abrasion, solvent, and heat resistance, as well as lowered gas permeability, are among the improved important features.[9] They are characterised on the basis of size of particles, morphology, composition, protein adsorption and surface charge. These are measured by using advanced microscopic techniques such as scanning electron microscopy (SEM), transmission electron microscopy (TEM) and atomic force microscopy (AFM).[10]

Particle Size

The most essential parameters in nanoparticle characterisation are particle size distribution and shape. They need to be in the 10–100 nm size range to be effective. Electron microscopy and dynamic light scattering (DLS) are the most commonly used to determine morphology and nanoparticle size. DLS works on the principle of dispersion of nanoparticles and their size are determined by small volumes of dilute dispersions whereas, electron microscopy determines the surface features, size and shape, and composition with the help of scanning the high-energy electron beam over the surface.[9,11]

Surface Charge

Another aspect that influences how nanoparticles interact with proteins and cell membranes, as well as their subsequent absorption into cells, is surface charge. The distribution of ions in the surrounding interfacial region is affected by the surface charge of a nanoparticle in dispersion, resulting in an increased concentration of counterions near the surface. Colloidal dispersion of nanoparticles is stabilised with the help of Zeta potential to achieve high positive or negative potential in order to maintain particle stability and prevent aggregation.[12]

Surface Composition

Surface composition is an important property for nanoparticles because of their enormous surface area to volume ratio. For application in biomedical field the surface of nanoparticles must be modified with a hydrophilic and biocompatible coating and ligands may be attached to the nanoparticle surface to increase interactions with cellular receptors, depending on the intended use. As a result, examination of the nanoparticles surface composition is required to establish the effectiveness.[13]

Protein Adsorption

Inhibition of protein adsorption by polymers such as polyethylene glycol (PEG) and hyperbranched polyglycerol (HPG), have been grafted on nanoparticle surfaces. Because circulating plasma proteins have a high affinity for the surface of the NP, and a large number of these proteins have the capacity to behave as opsonins, it is susceptible to identification and phagocytosis by monocytes and macrophages, resulting in fast evacuation from the body.[14,15]

NANOTECHNOLOGY IN ENDODONTICS

The use of nanotechnology in endodontics encompasses disinfection of root canal, placement of intracanal medicaments, obturation of root canal and its use in endodontic sealer.

NANOTECHNOLOGY AS ANTIMICROBIAL AGENT

The effective elimination of biofilms from the root canal system, a combination of mechanical instrumentation and chemical irrigation has been recommended.[16] Nanoparticle application property such as biodegradability, bioactivity, and ability to kill wide range of microbes including Enterococcus faecalis bacteria, which are known to be widely implicated in most endodontic infections, enhances the properties of irrigants. Silver nanoparticles solution, zinc oxide nanoparticles solution, and chitosan solution have been used effectively for disinfection of root canal.[17]

Nanoparticle solution	Antimicrobial Effect	Mechanism of action	Antibiofilm efficacy
Chitosan	Broad range of gram-positive & gram-negative bacteria as well as fungi	Alteration of cell wall by organised release of singlet oxygen species exhibited increased bacterial breakdown.[18]	Yes
Silver oxide	gram-positive & gram-negative bacteria as well as fungi	Reactive oxygen species (ROS) generation is inhibited by respiratory enzymes and ATP synthesis and leads to damaging the cell membrane.[19]	Yes
Zinc oxide	More effective on gram positive bacteria than on gram negative	Increased permeability of the cell wall membrane and release of cytoplasmic content causes cell death.[20]	Yes

NANOTECHNOLOGY IN INTRACANAL MEDICAMENT

The main objectives of intracanal medicaments are destruction of micro-organisms, alter the inflammatory effect, deactivate the residual bacteria remains in pulp space, enhancing anaesthesia and control of persistent diseases. Calcium hydroxide is a commonly utilised intracanal medicament in contemporary endodontics.[21] Silver nanoparticles (size 20 nm) incorporated with calcium hydroxide had shown a greater antibacterial effect than conventional medicament either with chlorhexidine or without it.[22] Commercially available products NanocarePlus Silver and Gold (NanoCare Dental, Nanotechnology, Katowice, Poland) has shown better effects.

NANOTECHNOLOGY IN ROOT CANAL SEALERS

Root canal sealers are utilised in combination with physiologically appropriate semisolid or solid obturating agents. Zinc oxide, eugenol, and guttapercha have been employed as root canal filling materials over the past eight decades. The area between the filling material and the root dentinal wall is filled with root canal sealant.[23]

Nanosized particles can be used into zinc oxide-based sealers to increase technical and practical qualities as well as ideal physicochemical qualities for optimum root canal filling and sealing. A study was performed by Versiani et al. in which zinc oxide nanoparticles were incorporated in zinc oxide based Grossman sealer. Result showed that Grossman sealer's setting time, flow, solubility, dimensional stability, and radiopacity were all enhanced by replacing 25% of conventional ZnO powder with ZnO-Np, which met ANSI/ADA criteria.[24] Commercially available product is NanoSeal-S (Prevest DenPro) as zinc oxide nanoparticle based sealer.

NANOTECHNOLOGY IN RESTORATIVE DENTISTRY

NANOCOMPOSITE

The nanofiller used include an aluminosilicate powder having a mean particle size of 80 nm and a 1:4 M ratio of alumina to silica and a refractive index of 1.508.

Superior hardness, flexural strength, modulus of elasticity, translucency, and aesthetic appeal of Nanocomposites, excellent colour density and shade matching with surrounding, high polish retention, 50% reduction in filling shrinkage, excellent handling that allows for easier placement and contouring, and universal applicability for both posterior and anterior teeth are all advantages of Nanocomposites.[2] Nanocomposites are made up of two types of nanofiller particles: nanomeric (NM) and nanoclusters (NCs). NM particles are silica nanoparticles that are monodisperse, nonaggregated, and unagglomerated. NCs particles - The principal particle size of this NC filler varies from 2 to 20 nm, with an average particle size of 5-75 nm.[8]

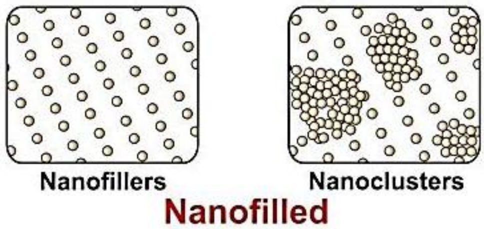


Figure 1

A nanohybrid resin composite based ormocer is an example of a recently developed nanohybrid resin composite. After four years of testing, the clinical performance of such resin composites in Class II cavities was determined to be satisfactory (using slightly modified USPHS criteria), and the performance did not differ depending on the type of adhesive material employed.[3]

Premise (KerrHawe Bioggio, Switzerland), Ceram X (Dentsply DeTrey, Konstanz, Germany), Filtek Supreme universal restorative pure nano (3M Espe, St. Paul, USA), Grandio (Voco, Cuxhaven, Germany), and Tetric EvoCeram (Ivoclar Vivadent, Schaan, Liechtenstein) are all examples of commercially available nanocomposites.[3]

Types of nanocomposites

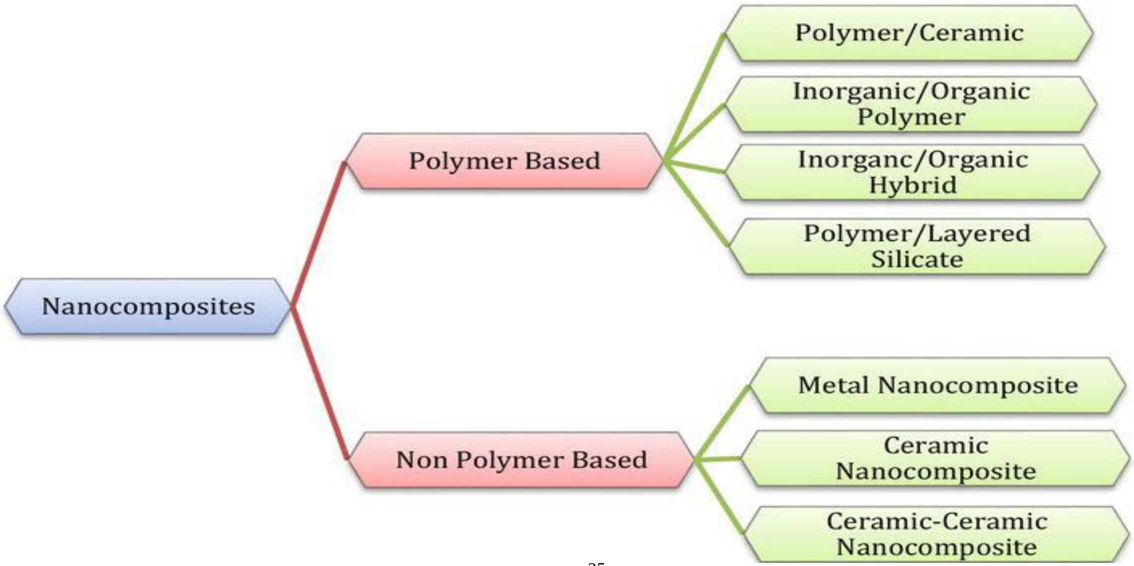


Figure2[25]

NANOTECHNOLOGY IN BONDING AGENT

The novel bonding agents made from nano solutions have stable nano particles distributed evenly throughout the solution. The use of silica nano filler technology helps to improve bond strength. The nano particles do not cluster or settle out of dispersion because they are stable. Nano Interaction Zone" (NIZ 300 nm) with little decalcification and practically no exposure to collagen fibres produces an insoluble calcium compound for a stronger connection that is less prone to degrade from oral enzymes. [3] Hoshika et al. examined at the effects of varying concentrations of colloidal platinum nanoparticles, they discovered that when dentin was treated with a lower concentration of the material, bond strength between resin and dentin increased. [26] One-step application is available with the latest generation of bonding agents. The nanofillers are uniformly distributed, ensuring optimum bond strength and preventing particle settling Adper O Single Bond Plus Adhesive Single Bond.[8]

NANOINOMERS

Nanoionomers are glass ionomers that contain nanoparticles. Because of its chemical bonding to the tooth surface, glass ionomer cement is widely used. Fluoroaluminosilicate glass is reinforced with nanomers and nanoclusters. Aesthetics and fluoride-releasing characteristics are produced by the nanoionomer. When compared to ordinary GIC, the nano glass ionomer has a higher translucency and optical characteristics. By physically mixing the nanoparticles with the cement by hand, the porosity of the cement is reduced by filling the gaps between the glass particles. Pre-reacted glass ionomer technology was developed utilising GIC and composite 'Giomer,' as well as hydroxyapatite and glass powder 'Mainomer.' Bioactive glass, CPP-ACP, Reinforced GIC, zirconomer, chlorhexidine GIC, Nano Bioceramic impregnated GIC, and ceramirand Giomer are amongst the most recent advancements in GIC. On the enamel surface, the bioactive glass exhibits remineralization capability. Bioactive glass nanoparticles can be incorporated to the resin modified glass ionomer. Nanoionomers have the advantages of being chemically stable, having enhanced bond strength and being insoluble, having a superior polish, great aesthetics, and stronger wear resistance, and being quicker, simpler to mix and dispense.[8]

IMPRESSION MATERIALS

Incorporation of the nanofillers to vinyl polysiloxanes improved the hyrophilic characteristics, flow, and accuracy of siloxane imprint materials. As a result, nanofillers could be used into traditional vinyl polysiloxanes to improve their characteristics and generate fewer voids, better model casting, and more precision. Nanotech elite H-D plus (Zhermack Italy) is an example of a commercially available impression material. High tear resistance, improved fluidity, resistance to distortion, hydrophilic characteristics, snap set and heat resistance are a couple of the advantages of this material, which helps to reduce mistakes caused by micromovements.[3]

ADVERSE EFFECT

"The smaller the particles, the more toxic they become," Nanotechnology has been found to be venomous to the communities in which humans dwell, and nanoparticles are known to biomagnify in mammalian organs. Soil and plant life are also a source of worry for scientists.[7] Nanomaterials have the potential to harm the environment and human health. However, because the long-term consequences of nanotechnology are yet unknown, these potential dangers may only become apparent after many years. Nanomaterials can enter the body through the lungs or skin and translocate to critical organs, raising problems. Furthermore, the toxicity of nanoparticles cannot be determined only by their chemical makeup. As a result, more study into the possible dangers of nanoparticles is required, as well as care.[3] Nanotoxicology is the exposure to hazardous nanoparticles by the entrance of nanomaterials into a biotic and abiotic environment, and it can induce toxicity.[27]

II. Conclusion

Nanotechnology has grown in importance as a result of its better physical, mechanical, chemical, and biological capabilities. When compared to traditional competitors, these characteristics have resulted in greater performance..

Nanotechnology goods are improving in terms of physical and chemical characteristics, paving the way for the creation of "smart" endodontic and restorative treatment agents and materials in the near future. The science of dental materials is anticipated to alter substantially in the future as a result of greater knowledge and the introduction of novel nano-biomaterials.

References

[1]. Gurvanit Lehl, Markan S, and Kapoor S, Recent Advances of Nanotechnology in Endodontics, Conservative and Preventive Dentistry-A Review Journal of Dentistry and Oral Biology 2017;2(10);1-4.

[2]. Mikkilineni M, Rao A, Tummala M, Elkanti S. Nanodentistry ‑ New buzz in dentistry European Journal of General Dentistry 2013;2(2):109-113.

[3]. Kasimoglu Y, Tabakcilar D, Guclu Z, Nemoto S, Tuna E, Ozen B, Tuzuner T, Ince G Nanomaterials and Nanorobotics in Dentistry: A Review Journal of Dentistry Indonesia 2020;2(2):77-84.

[4]. Alenazy, Mosadomi1 H, Al-Nazhan S, Rayyan M Nanobiomaterials in endodontics Saudi Endodontic Journal 2018;8(3):163-169.

[5]. Toumey, Reading Feynman Into Nanotechnology Techné 12:3 Fall 2008

[6]. Freitas Jr RA. Nanodentistry. J Am Dent Assoc 2000;131:1559-66.

[7]. Sasalawad S, Naik S, Shashibhushan K, Poornima P, Hugar S, Roshan N Nanodentistry: The next big thing is small International Journal of Contemporary Dental and Medical Reviews (2014),. "Nanodentistry: The next big thing is small,". Int J Contemp Dent Med Rev. Article ID 101114, 6 Pages.

[8]. Raura Garg A, Arora A and Roma M. Nanoparticle technology and its implications in endodontics: a review Biomaterials Research 2020;24(21):2–8.

[9]. Bhushan J, Maini C. Nanoparticles: A promising novel adjunct for dentistry. Indian J Dent Sci 2019;11:167-73.

[10]. Pal S, Jana U, Manna P, Mohanta G, Manavala R Nanoparticle: An overview of preparation and characterization Journal of Applied Pharmaceutical Science 2011;01(06): 228-234.

[11]. Heera P and Shanmugam S. Nanoparticle Characterization and Application: An Overview Int. J. Curr. Microbiol App. Sci 2015;4(8): 379-386.

[12]. Otsuka, H., Nagasaki, Y., & Kataoka, K. PEGylated nanoparticles for biological and pharmaceutical applications. Advanced Drug Delivery Reviews, 2003;55(3):403–419.

[13]. Mourdikoudis S, Pallares R and Thanh N Characterization techniques for nanoparticles: comparison and complementarity upon studying nanoparticle properties Nanoscale, 2018;10:12871–12934.

[14]. Lynch, I., & Dawson, K. A. Protein-nanoparticle interactions. Nano Today 2008;3(1-2):40–47.

[15]. Sulek, Selim & Mammadov, Busra & Mahcicek, Davut & Sözeri, Hüseyin & Atalar, Ergin & Tekinay, Ayse & Guler, Mustafa. Peptide functionalized superparamagnetic iron oxide nanoparticles as MRI contrast agents. journal of materials chemistry. 2011;21:15157-15162.

[16]. Paul J Recent trends in irrigation in endodontics Int. J. Curr. Microbiol. App. Sci 2014;3(12):941-952.

[17]. Gupta P, Shetty H Nanotechnology: Its Role in Restorative Dentistry and Endodontics Journal of Pharmaceutics and Nanotechnology 2016;4(1):19-21.

[18]. Tanikonda R, Ravi R, Kantheti S & Divella, S.. Chitosan: Applications in dentistry. Trends in Biomaterials and Artificial Organs. 2014;28:74-78.

[19]. Rajeshkumar, S., Bharath, L. V., & Geetha, R. Broad spectrum antibacterial silver nanoparticle green synthesis: Characterization, and mechanism of action. Green Synthesis, Characterization and Applications of Nanoparticles, 2019:429–444.

[20]. Mishra, P. K., Mishra, H., Ekielski, A., Talegaonkar, S., & Vaidya, B. Zinc oxide nanoparticles: a promising nanomaterial for biomedical applications. Drug Discovery Today, 2017;22(12):1825–1834.

[21]. Krittika Ravi Antimicrobial Efficacy of Various Intracanal Medicaments against Enterococcus faecalis J. Pharm. Sci. & Res. 2017;9(10):1861-1863

[22]. Afkhami F, Akbari S, Chiniforush N. Entrococcus faecalis elimination in root canals using silver nanoparticles, photodynamic therapy, diode laser, or laser-activated nanoparticles: an in vitro study. J Endod. 2017;43(2):279–82.

[23]. Komabayashi T, Colmenar D, Cvach N, Bhat A, Primus C, & Imai Y. (2020). Comprehensive review of current endodontic sealers. Dental Materials Journal.

[24]. Versiani, M. A., Abi Rached-Junior, F. J., Kishen, A., Pécora, J. D., Silva-Sousa, Y. T., & de Sousa-Neto, M. D. Zinc Oxide Nanoparticles Enhance Physicochemical Characteristics of Grossman Sealer. Journal of Endodontics, 2016;42(12):1804–1810.

[25]. Sen Mousumi Nanotechnology and the Environment. intechopen 2020:1-12.

[26]. Hoshika S, Nagano F, Tanaka T, Wada T, Asakura K, Koshiro K, et al. Expansion of nanotechnology for dentistry: Effect of colloidal platinum nanoparticles on dentin adhesion mediated by 4-META/MMA-TBB. J Adhes Dent. 2011;13(5):411–6.

[27]. N.E. Kaviya, Jayalakshmi Somasundaram, Anitha Roy Advancement in nanotechnology for restorative dentistry European Journal of Molecular & Clinical Medicine 2020;7(1):3295-3306.

Dr. Priya Mishra, et. al. "Nanotechnology in Restorative Dentistry and Endodontics." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 21(04), 2022, pp. 01-06.