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Review Article

THE MIDGETS' MIRACLE: NANOTECHNOLOGY IN PROSTHODONTICS- A REVIEW

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A R T I C L E I N F O

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Nanotechnology, Nanotechnology in Dentistry, Nano dentistry in Prosthodontics and Nano dental materials.

A B S T R A C T

Aim: To review the summary of the role of Nanotechnology in dentistry and to assess how relevant it is in prevention and treatment of oral ailments.
Materials and Methods: A systematic literature search was performed electronically and also hand searched with the terms Nanotechnology, Nanotechnology in dentistry, Nano dentistry in Prosthodontics and Nanodental materials. The search was restricted to full text articles published in English language. A total of 142 articles were found relevant to the topic. After first-level screening, articles were selected for the review on the basis of title and abstract. The search was carried out through Medline and Google from 1980 to 2017. Then, full texts of selected relevant articles were included. Finally a total of 27 articles were found relevant to the topic. Articles selected were critically appraised to evaluate their quality.
Results: Different articles described various Nan technological methods and Nan materials in Prosthodontics. Literature search revealed 84 articles in PMC and45 in Google search. Additional 14 articles were identified by hand search.
Conclusion: Advancement in Nanotechnology has greatly influenced dental disease prevention and therapy significantly.

INTRODUCTION

According to the National Nanotechnology Initiative, USA, Nanotechnology is defined as the direct manipulation of materials at the nanoscale.[1]Itdefines a technology that enables almost complete control of the structure of matter at nanoscale dimensions. The focus of nanotechnology is to validate the analysis of structures at the nanoscale, to understand the physical properties of structures at the nanoscale dimension, to construct nanoscale structures, to expand devices with Nano-precision, and to set up a link between nanoscopic and macroscopic universes by inventing ample methods.

In 1959, Richard P. Feynman said "There is plenty of room at the bottom" at an American Physical Society meeting at Caltech describing molecular machines building with atomic precision it is often held to have provided insight for the field of nanotechnology.[2]In 1974, the Japanese scientist "Norio Taniguchi" of the Tokyo University of Science was the first to use the term "Nano-technology" in a symposium.[2]The word "Nano", which is obtained from the Greek word (nannos) meaning "dwarf," is a prefix that literally refers to 1 billionth of a physical size.

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One nanometer (nm) is a unit of length that equals 1 billionth of a meter.[2] Two techniques were described in the literature to approach for the synthesis of nanomaterials and fabrication of nanostructures.[3]

Top-down Technique

These strive to create smaller devices by using larger ones to direct their assembly.

Bottom-up Technique

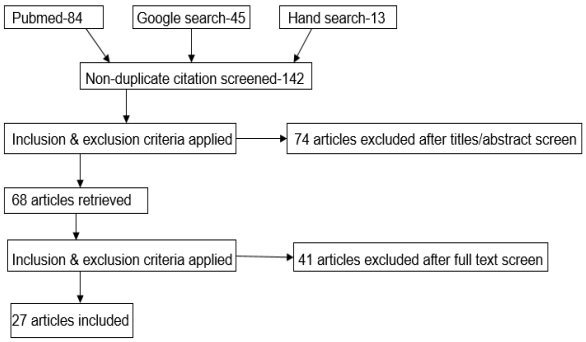
These seek to arrange smaller components into more complex assembly.

Everyday new technologies are being introduced into dentistry to make the procedures precise pertaining to diagnosis and treatment planning. Even in Prosthodontics, the Nanotechnology proved its good results already. Hence this study was undertaken to describe the ease and wonderful outcome of the treatment with the application of Nanotechnology.

MATERIALS AND METHODS

A systematic literature search was conducted in Medline and Google. The keywords used in the search were Nanotechnology, Nanotechnology in Dentistry, Nano dentistry

and Nanodental materials. . The search was restricted to full text articles published in English language. A total of 142 articles were found relevant to the article. After first-level screening articles were selected for the review on the basis of title and abstract. . Then, full texts of selected articles were studied and relevant articles were selected to be included in this review. A total of 27 articles were found relevant to the topic. Articles selected were critically assessed to evaluate their quality (flow chart 1).



Flow chart 1

Nanoscience and nanotechnology involve the ability to see and control individual atoms and molecules. This has been found very useful and beneficial to make things precise. Hence it has been introduced in the field of medicine and latter into dentistry with many advancements and newer inventions. Nanomedicine: Advances in the medical application of nanotechnology have resulted in the emergence of a new field called nanomedicine.[2] This concept was first put forward in 1993 by Robert A. Freitas Jr. and was defined as observing, controlling, and treating the biological systems of the human body at the molecular level using Nano-structures and nano-devices.[4,5]

Nano dentistry: It is the application of Nanotechnology in Dentistry andcan bediscussed under the following categories. a. Nanorobotics, b. Nanodiagnostics and c. Nanomaterials. Nanorobotics

Local Anesthesia: Micron sized active analgesic dental robots hanged in a colloidal solution when instilled on the patient's gingiva reach the pulp via the gingival sulcus, lamina propria and dentinal tubules.6 It is piloted by a combination of chemical gradients, temperature differentials and even positional navigation which are all under the control of a Nano computer as directed by the dentist.

Hypersensitivity Cure: Dentin hypersensitivity may be caused by changes in pressure imparted to the pulp. This is based on the certainty that hypersensitive teeth have 8 times higher surface density of dentinal tubules and tubule diameter twice as larger than non-sensitive teeth. Dental Nano robotsselectively occlude tubules in minutes, using native biological materials, providing patients a quick and permanent cure.7Nano diagnostics (Diagnosis of Oral Cancer and Other Diseases)

Quantum Dots: These are nanomaterials that glow very brightly when illuminated by UV light. The dots can be coated with a material that helps to attach to the molecules to be tracked. They bind themselves to proteins unique to cancer cells, literally bringing tumours to light.

Nano Electromechanical Systems (NEMS): Nanotechnology based NEMS biosensors that exhibit keen sensitivity and specificity for analyse detection, down to single molecule level are being developed. They convert (bio) chemical to electrical signal.5Oral fluid Nano sensor test (OFNASET).1

Oral Fluid Nano Sensor Test (OFNASET): This is the technology that combines self-assembled monolayers (SAM), bio nanotechnology, cyclic enzymatic amplification, and microfluidics for detection of salivary biomarkers for oral cancer. It was demonstrated that a combination of two salivary proteomic biomarkers (thioredoxin and IL-8) and four salivary mRNA biomarkers (SAT, ODZ, IL-8, and IL-1b) detected oral cancer with high specificity and sensitivity.8

Nanomaterials in Prosthodontics

Acrylic Resin: These resins commonly consist of methacrylate, especially poly methyl methacrylate (PMMA), and additional copolymers.9 However one of the major problems that patients and dentists commonly faced using these removable acrylic appliances is their potential for plaque accumulation due to surface porosities and food retentive configuration, which in turn increase bacterial activity of cariogenic oral flora.10 In efforts to add antimicrobial activities to dental materials, some nanoparticles have been applied. Titanium dioxide nanoparticles have been used as additives to biomaterials in order to induce antimicrobial properties.11 Antimicrobial activities of titanium dioxide against Candida albicans, Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Lactobacillus acidophilus, etc. have been proved by recent studies.12 Along with prominent catalytic effect, other characteristics such as white colour, low toxicity, high stability and efficiency as well as availability13 have made titanium dioxide an appropriate antimicrobial additive for use in acrylic resin.

Impression Materials: Nano fillers are integrated in vinylpolysiloxanes, producing a unique addition of siloxane impression materials. The material has better flow, improved hydrophilic properties and enhanced detail precision.14

Nanocomposites: Non agglomerated discrete nanoparticles are dispersed uniformly in resins or coatings to produce nanocomposites. The Nano filler used includes an aluminosilicate powder having a mean particle size of 80 mm and a 1:4 M ratio of alumina to silica and a refractive index of 1.508.14

Tissue Conditioners: Tissue conditioners have been commonly used to enhance the recovery of denture bearing tissues from trauma, damage or residual ridge resorption usually caused by ill-fitting dentures and are susceptible to colonization by microorganisms.15 So to overcome this problem silver nanoparticles are added in tissue conditioners. Because of their smaller size they provide large surface area and display antimicrobial properties.16

Dental Adhesives: Dental adhesives are the material used to promote adhesion or cohesion between two different substances or between a material and natural tooth structure. Polymerizable silane is added to dental adhesives in order to increase the cohesive strength. Since the adhesive liquid are not very viscous the filler particles tend to settle out during storage which leads to inconsistency in their performance. To overcome this disadvantage discrete silane treated nanoparticles of silica or zirconia in the size range of 5-7 nm17are added to dental adhesives.

Dental Cements: Antibacterial activity of dental luting cement is a very important property when applying dental crowns, bridges, inlay, onlay, veneers because bacteria may be still present on the walls of preparation or gain access to the cavity if there is micro leakage present after cementation.18 In order to overcome this, addition of silver nanoparticles in dental cements took place.

Dental Porcelain: Dental porcelains currently used for ceramic restorations are brittle, and it is sometimes imperative to replace fractured or chipped restorations. Porcelain is fragile and shows elastic deformation rather than plastic deformation, leading to fracture or chipping of restorations. The addition of silver nanoparticles significantly increased the fracture toughness and Vickers hardness of the porcelain.19 The addition of silver and platinum nanoparticles increased both the Young's modulus and the fracture toughness of dental porcelain. Silver nanoparticles increased the fracture toughness more than platinum.

Implants: Nanotechnologies are being usedto modifythe surface properties of dental implants such as chemistry and roughness which play a determinant role to achieve and maintain their long-term stability in bone tissue. Direct bone-to-implant contact is desired for a biomechanical anchoring of implants to bone rather than fibrous tissue encapsulation.20
Eg: Nanotite™, Nano-Coated Implant.

Nanostructured hydroxyapatite promotes bone formation around implant, increases osteoblasts function such as adhesion, proliferation and mineralization. Nano porous ceramic implant coatings improve implant properties with a different approach, i.e. anodization of aluminium. This technique creates a nonporousaluminium layer on top of titanium alloy implants.21It has the potential to load the porous structure with appropriate bioactive agents improving cell response and facilitate Osseo-inductive activity.

Nano-composite denture teeth: Conventional denture teeth have their own inherent disadvantage. Porcelain is highly wear resistant, but is brittle, lacks bonding ability to the denture base, and is not easy to polish. Acrylic on the other hand is to adjust, but undergo undue wear. Nanocomposite denture teeth are made of Polymethylmethacrylate (PMMA) and homogeneously distributed Nano fillers to improve its antibacterial characteristics and mechanical properties.22

Advantages

Excellent polishing ability and stain-resistant
Superb aesthetics
Enhanced wear resistance and surface hardness

Nano solution: Nanoparticles are used as sterilizing solution in the form of Nano sized emulsified oil droplets that bombard pathogens.23

Aesthetic Materials: With the integration of finishing and polishing procedures, a nanotechnology liquid polish application provides a glossier surface for resin composite restorations.

Dental Biomimetics: Chen *et al* by using nanotechnology simulated the natural biomineralization process to create the dental enamel using highly organized micro architectural units of Nano rod-like calcium hydroxyapatite crystals arranged parallel to each other.24 **Materials to Induce Bone growth:** Bone is a natural nanostructured composite composed of organic compounds (mainly collagen) fortifiedwith inorganic ions (HA). With this natural nanostructure, nanotechnology aims to emulate for dental applications. The smaller the particle size, the larger the surface area in volume. Nano bone uses this principle. The Nano crystalliteshave a loose microstructure, with Nano pores situated between the crystallites. This material structure will be completed by pores. By following this process, a rough surface area is formed on the boundary layer between the biomaterial and cell, which accounts for fast cell growth. All pores are interconnecting. Because the cells are too big for the small pores, blood plasma containing all the important proteins is retained in the interstices.25 eg: Ostium (Osartis GmbH, Germany) HA VITOSSO (Orthovita, Inc, USA) HA + TCP NanOSSTM (Angstrom Medica, USA) HA.

Maxillofacial Prosthesis: Maxillofacial prostheses are made of artificial substitutes like silicone and used to replace facial parts that are lost through disease or trauma. They are also used to restore and maintain the health of the tissues and to improve aesthetics for better social acceptance of facial injuries.26 Some of the materials used for facial prostheses give variable clinical results in terms of quality and stability, due to problems such as contamination and infection.27 Silver nanoparticles have been incorporated in maxillofacial prosthesis and their incorporation prevented the attachment of Candida albicans to maxillofacial prosthesis surface without any toxic effect to human dermal fibroblast cells.

CONCLUSION

It is now comprehensible that, recent developments in nanomaterials & nanotechnology will surely improve dentistry, health care and human life more greatly than other developments. Great changes come out with great challenges but in consideration with ethics regulation, human safety, cost effectiveness etc. A successful future for nanotechnology will only be achieved through open sharing of ideas and research finding, through testing and frank discussion.

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