

NEW ERA IN PROSTHODONTICS – NANOTECHNOLOGY

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Abstract:

The future holds in store an era of dentistry in which every procedure will be performed using equipments and devices based on nanotechnology. Researchers have predicted that high-tech and effective management at the microscopic level, termed nano technology, will become an important part of future dental and periodontal health. At present, the revolutionary development of nanotechnology has become the most highly energized discipline in science and technology. Nanotechnology is the field of science and technology pertaining to the creation and use of materials or devices at nanometer scale. Nanotechnology has numerous applications in the field of nanomedicine, nanomaterials, nanorobotics, implantology, and biotechnology. The present article focuses on the various applications of nanotechnology in the field of dentistry, especially prosthodontics.

Keywords: Nanomaterials,
Nanomedicine, Prosthodontics.

Introduction

To start with I will say that essence of knowledge is have it, to apply it. Nanotechnology is the buzz word of today's world and discussion for the

growth of science and technology. It is justified that nanotechnology is the nature's technology which lies in every natural creation all around us and just we have to master the technology for its benefits by putting hold on its side-effects or disadvantages. Understanding, shaping and combining matter at the atomic and molecular scale is called nanotechnology. Nanotechnology encompasses science, medicine, engineering, computing and robotics at this scale, called the nanoscale. It is defined as "The art and science of manipulating matter at the nanoscale (1-100 nm)." The future trend in dentistry – Nanodentistry. Nanodentistry offers the potential for new and faster kinds of computers, more efficient power sources and life-saving medical treatments.

History

- Discovery of nanotechnology Dr. Richard Phillips Feynman.
- The first use of the word "nanotechnology" Taniguchi in 1974.
- Introduced and popularized the term "nanotechnology" by Eric Drexler in 1986 in his book "Engines of Creation"¹.
- Introduced into dentistry first as nanocomposites in the year 2002 by Filtek Supreme².

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Need for nanotechnology in prosthodontics??

Materials reduced to the nanoscale can suddenly show very different properties enabling unique applications. For instance, opaque substances become transparent (copper); inert materials become catalysts (platinum); stable materials turn combustible (aluminum); solids turn into liquids at room temperature (gold); insulators become conductors (silicon). Materials such as gold, which are chemically inert at normal scales, can serve as a potent chemical catalyst at nanoscales. When reduced to a nanoscale that highlights the importance of applied nanotechnology in various fields including dentistry³.

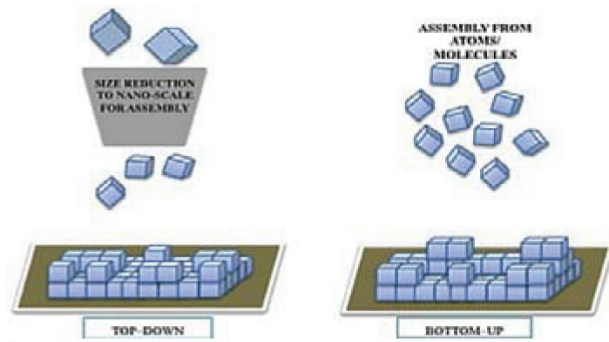


Fig 1

Approaches in Nanotechnology !!!!

Current research is directed towards the production of a wide array of different nanoscale structures. The fabrication techniques of these structures can be divided into two approaches:

Top down approach:

Top down fabrication reduces large pieces of materials all the way down to the nanoscale.

Bottom up approach:

The bottom up approach to nanomanufacturing creates products by building them up from atomic and molecular scale components, which can be time consuming



Fig 2



Fig 3 Carbon Nanotubes

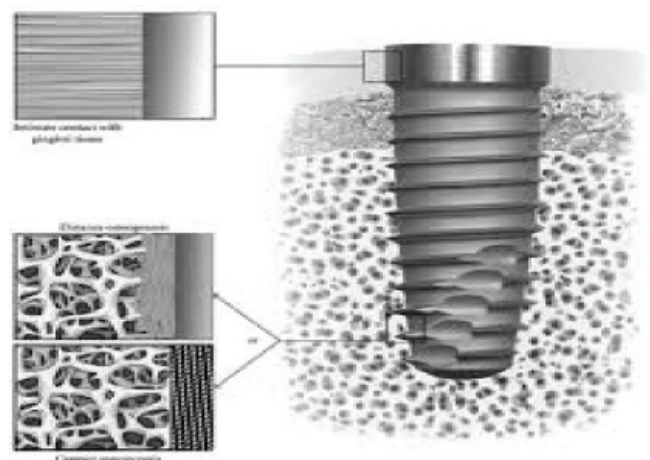


Fig 4

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Nanomaterials applied in Prosthodontics:

Research of nano technology in dental materials is mainly focused on two ways

Preparation of new inorganic nano particles

Modify the surface with inorganic nano fillers. These materials are widely used in ceramics, metals, resins and composites providing huge space for the improvement and innovation of dental material. Studies of nano metal shows that it has better antibacterial property.

1. Nanoceramics applied in prosthodontics:

Nanoceramic refers to the ceramic material with nanoscale dimensions in the microstructures phase. Compared with the conventional ceramics, nanoceramics have unique properties like good toughness and ductility. Nanoceramic has the superior mechanical properties, such as strength and hardness. The hardness and strength of many nanoceramics are four to five times higher than those of the traditional materials. Most importantly toughness of nanoceramics is much higher than that of traditional ceramics. Carbon nanotubes (CNTs) have attracted remarkable attention as reinforcements of materials because of their exceptional mechanical and electronic properties.

2. Nano resin based materials

Nanohybrid and nanofilled are generally the two types of composite restorative materials characterized by filler-particle sizes of ≤ 100 nm referred to under the term "nanocomposite". Nanomers and nanoclusters are the two types of monodispersed non agglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce nano composites. Nanomaterials available as titanium dioxide, aluminium oxide and silicaoxide are used in small amounts (1%–5%) to improve powder flow of composites. Eg. Isopast® and Heliomolar® by

Ivoclar Vivadent

Light cure Nanocomposites

The introduction of nano fillers into the resin matrix has lead to the development of newer light cure nano composites with numerous advantages as: Newer light cure nanocomposites has Improved mechanical strength, wear resistance comparable Superior flexural strength, modulus of elasticity, and translucency, Superior polish and gloss resistance comparable to microfillcomposites.⁵

3. Impression materials

Nanofillers are integrated in vinylpolysiloxanes, producing a unique addition of siloxane impression materials. The material has better flow, improved hydrophilic properties hence fewer voids at margin and better model pouring. (Trade name: Nanotech Elite H-D)

4. Nano composite teeth

Nanocomposite denture teeth are made of Polymethyl methacrylate (PMMA) and homogeneously distributed nanofillers.

- Excellent polishing ability and stain-resistant
- Superb aesthetics, lively surface structure
- Enhanced wear resistance and surface hardness. Trade name: Veracia (Shofu, Kyoto, Japan)]

5. Nanoparticles in polymethyl methacrylate resin.

Nanoparticles are added to polymethyl methacrylate as antimicrobial agents to increase the viscoelastic property of resins. Oral pathological condition like denture stomatitis is mainly caused by adherence of biofilm onto the denture base. Incorporation of nanoparticles into the denture base materials is mainly in the form of silver and platinum nanoparticles as an effective antimicrobial agent. Some researchers showed that

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the addition of metal nanoparticles such as TiO₂, Fe₂O₃ and silver to PMMA materials could increase the surface hydrophobicity to reduce bimolecular adherence. The AgNPs incorporation within the acrylic denture base material can improve its viscoelastic properties. Other nanoparticles such as ZrO₂, TiO₂, and carbon nanotubes (CNT) have been used to improve the performance of PMMA.

Removable Prosthodontics:

Incorporation of carbon nanotubes into heat cure monomer has reduced the polymerization shrinkage and improved the mechanical properties. Incorporation of metal oxide nanoparticles into conventional polymethyl methacrylate has improved the flexural strength, antimicrobial property and reduced porosity.

6. Nanoadhesives in prosthodontics

The new bonding agents manufactured from nanosolutions contain stable nano particles homogeneously dispersed throughout the solution.

The silica nano filler technology contributes to higher bond strength performance. Since the nanoparticles are stable, they do not cluster nor do they settle out of dispersion. "Nano Interaction Zone" (NIZ - <300 nm) with minimal decalcification and almost no exposure to collagen fibres producing an insoluble calcium compound for a better bond less likely to deteriorate from enzymes contained in the mouth.

NANO ADHESIVE POSS: Polyhedral Oligomeric Silsesquioxane (Poss) enables the design of additives that make plastics that are unusually lightweight, durable, heat-tolerant and environment friendly. Poss combines organic & inorganic materials in molecules with an average diameter of 1.5 nanometers. They can be used as either additives or replacements for traditional plastics. Current applications of Poss include dental adhesives in which a strength resin provides a strong interface between the teeth and the restorative material. Poss

materials are much more resistant to radiation damage and erosion than conventional polymers.⁶

7. Coating agents in prosthodontics

These light cured agents contain nanosized fillers and are used as a final coating over composite restorations, glass ionomer restorations, jacket crowns, veneers and provisionals. These coating agents have higher wear resistance, preventing abrasion and discolouration⁶.

8. Nanotechnology in implants

The application of nano technology in dental implants can be made by coating of nano particles over the dental implants. It has been demonstrated that different cell types respond positively to nanotopography. The surface of the implant plays a critical role in determining biocompatibility and biointegration because it is in the direct contact with the tissues. Implant surface composition, surface energy, surface roughness and surface topography are the four material factors which can influence events at bone implant interfaces. Biomimetic implant may be the next development in the field. Coating implants with nano textured titanium, hydroxyl apatite and pharmacological agents such as bisphosphonates may induce cell differentiation and proliferation, and promote greater vascularity in cortical bone thereby improving conditions for early and long-term bone remodelling. It is a powerful way of altering protein interactions with the surface. There is an increase in vitronectin adsorption on nano structured surfaces when compared to conventional surfaces. This led to increased osteoblast adhesion when compared to other cell types such as fibroblast on the nano surfaces.

9. Bone replacement materials:

Bone is comprised of natural nano composite made up of nanohydroxyapatite (HA), which is reinforced by collagen fibrils and this interaction

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is known to significantly dictate its strength and toughness. The fibrous collagen matrix transfer load to apatite crystals and provide resistance to fracture (i.e. high toughness), whereas the apatite deposit between fibrils can mechanically stabilize the collagenous fibers. In addition, trace elements in bone are known to be involved in its growth and mineralization shows Osteo inductive, Non-sintered, Extremely porous, Nano-structured, Degradation by osteoclasts. Various HA nanoparticles used in repairing osseous defects include Ostim® HA, VITOSS® HA.

10. Maxillofacial prosthodontics

Main reasons for mechanical failure in maxillofacial prostheses include tensile and tearing loads. The use of polyhedral oligomeric silsesquioxane, as a reinforcing agent, has enhanced the tensile and tearing strengths of conventional materials. Nanocomposite denture teeth are stain and impact resistant with lively surface texture

Conclusion:

Nanomaterials have been playing a significant role in basic scientific innovation and clinical technological change of Prosthodontics. It shows that many properties such as modulus of elasticity, surface hardness, polymerization shrinkage, and

filler loading, of materials used in prosthodontics can be significantly improved after their scales were reduced from micron-size into nanosize by nanotechnology and that the performances of composites can also be enhanced by adding appropriate nanomaterials. Nano science is a new approach and will bring changes in fields of medicine, dentistry, research, and healthcare. It will help dentists with more equipment, drugs and precision-made materials by which patient compliance is enhanced.

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