Review Article

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Nanodentistry: A Comprehensive Review

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ABSTRACT

Background: Dentistry has seen many eras of revolution in past, making it more reliable and comfortable for patients. It is undergoing yet another change in helping the mankind enter a new era-"the era of nano technology. In the astonishing 20th century, new scientific knowledge promises to revolutionize the practice of dentistry and medicine. Nano is derived from νανος, the Greek word for dwarf, and usually is combined with a noun to form words such as nanometer, nanotechnology or nanorobot. A nanometer is 10-9 meter, or one billionth of a meter. Nanotechnology is based on known laws of physics and chemistry, not theories that still need to be proved. Nanotechnology will change dentistry, healthcare and human life more profoundly than many developments of the past.

Keywords: Nanodentistry, Nanoceranics, Nanorobots, Filler particles.

INTRODUCTION

Science makes difference in our lives. Scientific discoveries changes our perception, our ways of thinking and our attitude about today and tomorrow. Today the revolutionary development of nanotechnology has become the most highly energized discipline in science and technology[1,2]. Nano technology is a natural end result of scientific development and our ability to understand and manipulate matter at smaller levels.

ONE NANOMETER (nm) IS ONE OUT OF BILLIONTH OF A METER (10^{9})

DEFINITION

Albert frank defined nanotechnology as "the area of science and technology where the dimension and tolerances are in range of 0.1nm to 100 nm[1,3]. Nanodentistry is defined as the science and technology of diagnosing, treating, and preventing oral and dental diseases, relieving pain, and of preserving improving dental health, using nano materials biotechnology including tissue engineering[4].

NANODENTISTRY

Development of "nanodentistry" will make possible the maintenance of near perfect oral health through the use of nanomaterials biotechnology including tissue engineering and nanorobotics[5]. New treatment modalities have been suggested in literature such as tooth repair, tooth renaturalization, tooth hypersensitivity, orthodontic nanorobots, dental cosmetics, local anesthesia, photosensitisers, carriers,impression materials, nanoencapsulation, nanoneedles, bone replacement materials and dentifrices etc[6]. Further developments of nanotechnology in dentistry are composites restoration, bonding agents, emerging of link between biomolecules and nanotechnology through the generation of biomaterials.In addition to the growth of nanotechnology new treatment modalities has come up such as complete orthodontic realignments during a single office visit, covalently bonded diamondized enamel and

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continuous oral health maintenance through the use of mechanical dentifrobots[7].

NANOPARTICLES FOR DENTAL MATERIALS

There are two approaches to nanotechnology and these are termed bottom-up and top down approaches. The bottom-up approach involves synthesis of nanostructures from atomic level or molecular level whereas the top-down approach involves depositing, for example thin films, and then removing unwanted regions using lithography and etching leaving behind nanostructures[8,9,10]. The latter has been used widely for making components for electronic devices at the nanoscale. Both approaches have been used widely and the success of the approaches is highly dependent on the particular requirements of the application. The essence of nanotechnology is the ability to control and manipulate the nanostructures to provide unique properties of materials.

LIST OF DENTAL MATERIALS USING NANOPARTICLES

1. NANOCOMPOSITES

There are two distinct types of dental nanocomposites available which are nanofills and nanohybrids[11,12]

1. Nanofills—these contain nanometer-sized particles (1–100 nm) throughout the resin

matrix, with no other large primary particles being included.

2. Nanohybrids—these consist of large particles (0.4–5 μm) with added nanometersized

particles.

2. NANOPARTICLES IN GLASS IONOMER SYSTEMS

A novel resin modified material has been developed in which nanoclusters of silica and zirconia as well as unagglomerated zirconia nanomers were added[13]. The visual opacity of the resultant nanoionomer, mechanical properties, fluoride release, remineralization ability, adhesion strength, and mechanical properties is improved compared to conventional glass ionomer[14]

3. NANOTECHNOLOGY IN DENTAL ADHESIVES

Silane-treated nanoparticles of silica or zirconia in the size range of 5–7 nm have been added to dental adhesives[15,16]. Stable suspensions were obtained with no decrease in bond strength

Advantage of Nanofillers in dental adhesives[17]

- Increase cohesive strength of the adhesive
- Uniform film thickness
- Low polymerisation shrinkage and post operative sensistivity
- Stabilizes and reinforces the hybrid layer
- Exhibits an unparalleled propensity to penetrate into the tubules and horizontal tubule interconnects
- Increase the adhesion to both enamel and dentin
- Improve the marginal integrity

4. NANO CERAMICS

The Organically Modified Ceramic nano-particles comprise a polysiloxane backbone. The chemical nature of the siloxane is similar to that of glass and ceramics. Meth acrylic groups are attached to the siloxane via silicon-carbon-bonds[18]. These Nano-Ceramic particles can be best described as inorganic-organic hybrid particles where the inorganic siloxane part provides strength and the organic methacrylic part makes the particles compatible and polymerizable with the resin matrix. The good resistance to micro-crack propagation might be related to the strengthening effect of the nano-ceramic particles. Propagating cracks are either more often reflected or absorbed by the nano-ceramic particles[19].

5. NANO IMPRESSION MATERIAL

Nanofillers are integrated in vinyl polysiloxanes, producing a unique addition of siloxane impression materials. The material has better flow, improved hydrophilic properties and enhanced detail precision[20].

Benefits:

- 1 minute working time, 2 minute oral set time
- Low contact angle of ˜30° for accurate, reliable impressions in the oral environment

- Outstanding tear strength ensures reliable impressions
- Minimized out gassing time for immediate pour of models

Zhermack Elite H-D + silicone impressions formulation incorporates a combination of organic polymers, inorganic particles and nano fillers[21]. The result is a Silicone with increased fluidity, high tear resistance, hydrophilic properties, resistance to distortion and heat resistance. The inclusion of nano particles has enabled Elite H-D+ to obtain a degree of fluidity completely different from the initial viscosity. When pressure is exerted during impression taking an excellent reproduction of infinitely small details is obtained. Elite H-D+ has also been design to produce a snap set that consequently reduces errors caused by micro movements. Elite H-D + is available in light fast, light regular set, medium and heavy viscosities and is delivered in the new safety cartridges[22]. Medium and heavy viscosity is also available in poly bags for machine mixing like the Pentamix™ [2] Automatic Mixing Unit from 3M ESPE which dispenses a completely homogeneous mix.

6.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[23]. Nanocomposite denture teeth are made of comonomer of urethane dimethacrylate (UDMA) and methylmethacrylate (MMA) and homogeneously distributed nanofillers. Which carries advantages of

- Stain resistant.
- Highly polishable
- Impact resistant .
- Enamel layer of highly cross-linked, nano-filled composite
- Available in wide variety of shades

7. DENTAL IMPLANT

It is defined as a prosthetic device or alloplastic material implanted into the oral tissues beneath the mucosal or periosteal tissues, and on/or with in the bone to provide retention and support for fixed or removable prosthesis [24]. Implants are commonly used in dental surgery for restoring teeth. One of the challenges in implantology is to achieve and maintain the osseointegration as well as the epithelial junction of the gingival tissue with implants. The structural and functional fusion of the surface of the dental implant with the surrounding bone (osseointegration) is crucial for the short and long term outcome of the device[25]. In recent years, the enhancement of bone formation at the bone-implant interface has been achieved through the modulation of osteoblasts adhesion and spreading, induced by structural modifications of the implant surface, particularly at the nanoscale level[26]. Nanotechnology aids in better osseointegration of implant by[27]

- Nanoscale Surface Modifications
- Titanium Nanotubes as Carriers of Osteogenic Growth Factors
- Nanotopography alters Cellular Responses
- Tissue Integration

CONCLUSION

Despite of many advantages, Nanodentistry still faces many significant challenges in realizing its tremendous potential. Basic engineering problems run the gamut from precise positioning and assembly of molecular-scale parts to economical mass-production techniques to biocompatibility and the simultaneous coordination of the activities of large numbers of independent micrometer-scale robots. In addition, there are larger social issues of public acceptance, ethics, regulation and human safety that must be addressed before molecular nanotechnology can enter the modern medical armamentarium[28]. However, there are equally powerful motivation surmount these various challenges, such as the possibility of providing high-quality dental care to the 80 percent of the world's population that currently receives no significant dental care [29]. As with all technologies, nanotechnology carries a significant potential for misuse and abuse on a scale and scope never seen before. Nanodevices cannot be seen, yet carry powerful capabilities[30]. However, they also have the potential to bring about significant benefits, such as improved health, better use of natural resources and reduced environmental pollution[31]. This science might sound like a fiction now, but Nanodentistry

has a strong potential to revolutionize dentistry as to diagnosing and treating dental diseases in future as it opens up new avenues for vast & abundant research. Nanotechnology will change dentistry, health care and human life more profoundly than other development[32].

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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