

The next door to prosthodontics: Nanotechnology

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Abstract

The medical and dental field has seen several technological revolutions that have changed clinical practice. One concept which has and holds further promise in bringing about a paradigm shift in the field of diagnostics and management is nanotechnology. Nanotechnology has several applications in nanomedicine, and dentistry, from diagnosis of pathological conditions to local anesthesia, orthodontic tooth movement and in periodontics and implantology. Nanodentistry will make the maintenance of near-perfect oral health possible by the use of nanomaterials, biotechnology and nanorobotics. Nanomaterials in dentistry include metals, ceramics, polymers, implant modifications, and composite materials that demonstrate novel properties when compared with conventional materials due to their nanoscale features. This article provides a detailed insight on the potential applications of nanotechnology in dentistry, especially in the specialization of prosthodontics. It has been shown that the performances of many biomaterials used in prosthodontics have significantly improved after their scales were reduced from micron-size to Nano size, by nanotechnology.

Keywords: Nano dentistry, Nanomaterials, Nanotechnology.

Introduction

According to the definition of the National Nanotechnology Initiative, nanotechnology is the direct manipulation of materials at the nanoscale. The term defines 'the creation of functional materials, devices and systems through control of matter at the nanometer scale (1-100nm), and exploitation of novel phenomena and properties (physical, chemical and biological) at that length scale. The availability of nanotechnology has permitted dramatic progress in newer fields, such as nanomedicine and nanodentistry. Nanodentistry is defined as 'the science and technology that will make possible the maintenance of comprehensive oral health by employing use of nanomaterials, biotechnology including tissue engineering and ultimately dental nanorobotics'. Thus, nano-enabled technologies provide an alternative and a more superior approach in assessing the onset or initiation of disease, and identifying the targets to assess the treatment options which also include the ability to design biocompatible, microbe resistant dental materials and implants, which improves the overall oral health of the patient.

History

As early as 1867, James Clerk Maxwell proposed a revolutionary concept of nanotechnology. When the whole world was looking at making things bigger and bigger, he envisaged sub-microscopic machines with the ability to handle individual atoms and molecules. He called these Maxwell's demons, which were what we call 'Nanorobots' these days. So, although nanotechnology has been around since the beginning of time, the discovery of nanotechnology is widely attributed to the American Physicist and Nobel Laureate, Dr. Richard Phillips Feynman. In 1974, the

term nanotechnology was defined by Norio Taniguchi as consisting of the processing, separation, consolidation and formation of material by one atom or one molecule.

The field started to develop in 1980s with the birth of cluster science and the development of Scanning Tunneling Microscope. Eric Drexler popularized nanotechnology in 1986 in his book "Engines of Creation: The coming era of Nanotechnology". In the early 20th century, Richard Zsigmondy brought about the concept of nanomaterials." Nanotubes, Nanowires and Nanoparticles have been developed and are under investigation for possible uses in everyday areas, including medicine.

Nanotechnology in the field of prosthodontics

An ample number of mechanical and physical properties of dental materials can be amended by smearing the nanotechnology concept. Epitomized here is a general gestalt of the uses of various Nanoparticles in prosthodontics. In particular, suitable applications are appraised in the following:

- Impression materials
- Nano Ceramic
- Implant materials
- Nanocomposite denture teeth
- Nano sterilizing solution

Impression Materials

These days Impression materials are available with the use of nanotechnology. Polyvinylsiloxane is one of the materials being used. In this material, nanofillers improve the physical properties of the impression material imparting it better flow, and improved hydrophilic properties making possible the presence of fewer voids and enhanced precise detailing.(Fig-1)



Fig. 1

Implant Materials

Dental implant therapy has been one of the most significant advances in dentistry in the past three decades. Osseointegration is widely accepted in clinical dentistry as the basis for dental implant success. Failure to achieve osseointegration can be attributed to one or more implant, local anatomic, local biologic, systemic or functional factors.

Hence,, coating the implant surface with nanoceramics, such as hydroxyapatite (HA) particles and nanopolymers, has markedly enhanced interfacial attachment to bone tissue with advantages of faster healing time, enhanced bone formation, firmer implant bone attachment, and a reduction of metallic ion release.⁽⁹⁾ The use of nano-titanium implants wherein modifying the surface topography of the implant down to its nanosize has been recognized to offer fast and optimum osseointegration. This approach is based on the basic concept of significantly increasing the mechanical bonding of the cells by roughening its surface to a nanolevel in order to induce better implant stability.⁽¹⁰⁾ (Fig. 2)

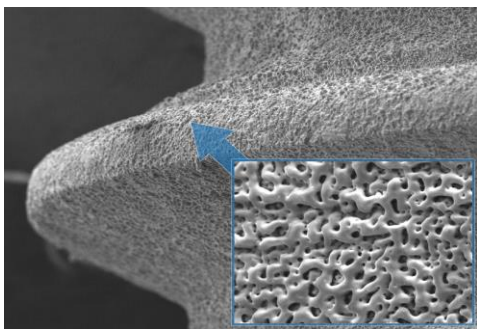


Fig. 2

Nano Ceramics

Advantages of this material over ceramic were easier clinical finishing & polishing, no need of use of porcelain oven, good strength, and good surface gloss. E.g. Lava Ultimate contains a blend of nano particles agglomerated in clusters and individual bonded nano particles embedded in a highly cross-linked polymer matrix. This Nano ceramic material is not as brittle as ceramic material and does not require considerable time & effort to polish. It has a modulus of elasticity very

close to dentine so it absorbs more stress and less prone to fracture that can be used for implant restoration as well replacing resin veneer.⁽¹¹⁾

Nanocomposite Denture Teeth

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.⁽¹²⁾ (Fig. 3)



Fig. 3

Nanotechnology has been incorporated in various aspects of removable and fixed prosthodontics.

In Removable Partial Denture

Incorporation of carbon Nanotubes into heat cure monomer has reduced the polymerization shrinkage and improved the mechanical properties.⁽¹²⁾ (Fig. 4)

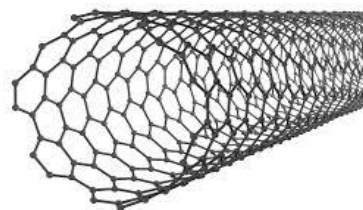


Fig. 4

Incorporation of metal oxide Nanoparticles (Fig. 5) into conventional polymethyl methacrylate has improved the flexural strength, antimicrobial property and reduced porosity.



Fig. 5

Nano Sterilizing Solution

A new sterilizing solution following nanoemulsion

concept has been developed by Gandy Enterprises Inc., Florida, and the USA. It is a surface disinfectant that safely kills 100% of HIV and other particles. Nanosized oil droplets attack and destroy the pathogens. It has been used to sterilize tools and incisions to prevent postoperative infections.⁽¹³⁾ (Fig. 6)



Fig. 6

Conclusion

With emerging technologies and upcoming of nanotechnology in the field of dentistry there is improvement in all aspects of diagnostics, therapeutics and cosmetic dentistry. In the coming years, molecular technology will be destined to become core technology in medicine and dentistry. Future development of prosthodontics technology has been recognized to be dependent on the progress of materials science. Nanomaterials have been playing a significant role in basic scientific innovation and clinical technological change of prosthodontics.

The evolution of nanotechnology will help us with more precision materials, drugs and equipments which will enhance patient compliance. However, as with all technologies, nanotechnology carries a significant potential for misuse and abuse on a scale and scope never seen before if not properly controlled and directed. Despite of the changes occurring in dentistry, role of the dentist will continue to evolve along the lines of currently visible trends. The best technical abilities, professional judgement and strong interpersonal skills will always remain the hallmark of the contemporary dentist.

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