Medical and Research Publications
International Open Access

Review Article **Journal of MAR Dental Sciences (Volume 4 Issue 4)**

Nanotechnology in Dentistry: A Review

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Received Date: January 17, 2022

Published Date: February 01, 2022

Abstract

***Aim**: To evaluate the effectiveness of aromatherapy in the reduction of dental anxiety of pediatric Nanotechnology is the field of science and technology pertaining to the creation and use of materials or devices at a nanometer scale. The nanoscale is small in size, but its potential is vast. Nanotechnology has numerous applications in the field of nanomedicine, nanomaterials, nanorobotics, implantology, and biotechnology. Nanomaterials in dentistry can be metals, ceramics, polymers, implant modifications, and composite materials that demonstrate novel properties when compared with conventional materials due to their nanoscale features.*

***Keywords**: Nanotechnology, Nanodentistry, Nanoparticles.*

Introduction

Nanotechnology is a science that deals with the development of new materials with new properties and functions through controlling and restructuring of the materials on a nanometer scale of less than 100 nm. The reference of Nanotechnology was initially given by Richard P. Feynman in the year 1960. The word NANO is a Greek word meaning DWARF. The concept of nanorobots was proposed by James Clerk

Maxwell in 1867 and was called Maxwell's demons. Nanomaterial refers to the naturally occurring or synthetic material in an unbound state or an aggregate material with the particle size 1 - 100 nm.**[**1-4**]**

Nanotechnology is widely used in medicine in areas such as drug development, and imaging. Furthermore, the targeted delivery of drugs to diseased cells, such as cancer cells, is an effective, and safer way of treating a disease. The potential applications of nanotechnology are very vast; however, one of the greatest values of nanotechnology will be in the development of new and effective medical treatments. The advances of nanotechnology in dentistry have been relatively slow in comparison to the application of nanotechnology in areas like medicine. **[**5,6**]**

Nanodentistry is defined as "the science and technology of diagnosing, treating and preventing oral and dental disease, relieving pain and of preserving and improving dental health, suing nanoscaled structures. **[**7**]** Purpose of this article is to review the current status of nanotechnology in dentistry.

Application of Nanotechnology in Dentistry

Nanotechnology in Operative Dentistry

Nano Ionomer: Nano Ionomer is glass ionomer cement whose formulation is based on bonded nanofiller technology. Mechanical properties of nano-ionomer are improved by the combination of fluoroaluminosilicate glass, nanofillers, and nanofiller clusters. The nanofiller components also improve some physical properties of the hardened restorative. It also shows high fluoride release that is rechargeable after being exposed to a topical fluoride source. Additionally, in vitro tests showed that the nano ionomer (Ketac N100) has the ability to create a caries inhibition zone after acid exposure. This product meets a wide range of clinical indications ranging from Class I, III, V, Sandwich restorations and core build-ups. Advantages of this material: superb polish, excellent esthetics, improved wear resistance. **[**8**]**

Nanocomposite: Nano Products Corporation has successfully manufactured non-agglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce Nano Composites. The nanofiller used includes an aluminosilicate powder having a mean particle size of about 80 nm and a refractive index of 1.508. Superior hardness, superior flexural strength, superior modulus of elasticity, superior translucency and esthetic appeal, excellent colour density, high polish and polish retention, about 50% reduction in filling shrinkage, and excellent handling properties, all these characteristics make the nanocomposites superior to the conventional composites and blend with natural tooth structure much better. **[**9**]**

Ultrafine Polishing: Polishing the teeth results in roughness, this provides a medium for biofilm formation. Ultra-fine polishing of teeth leads to nanoscale roughness which is few in

nanometers. It protects the teeth from cariogenic bacteria, which can be easily removed from these ultrafine polished surfaces, therefore preventing staining and leading to superior esthetics of the restorations. **[**10**]**

Nanotechnology in Endodontics

Disinfection of root canals: The most efficient disinfection of root canals with nanoparticles has gained popularity in recent years. This is mainly due to the broad-spectrum antibacterial activity. The nanoparticles evaluated in endodontics include Chitosan, zinc oxide and silver. The efficacy of chitosan and zinc oxide nanoparticles against Enterococcus fecal has been attributed to their ability to disrupt the cell wall. In addition, these nanoparticles are also able to disintegrate the biofilms within the root canal system. Silver nanoparticles are being evaluated for use as root canal disinfecting agents. It has been shown that 0.02% silver nanoparticle gel is able to kill and disrupt Enterococcus faecalis biofilm. **[**11-13**]**

Regenerating Endodontics: Teeth with degenerated and necroses pulps are routinely saved by root canal therapy. Although current treatment modalities offer high levels of success for many conditions, an ideal form of therapy might consist of regenerative approaches, in which diseased or necrotic pulp tissues are removed and replaced with healthy pulp tissues to revitalize teeth. In their study, Fioretti et al. (2010) showed that a-MSH (melanocortin peptides) possess anti-inflammatory properties and also promote the proliferation of pulpal fibroblasts. They reported the first use of nanostructured and functionalized multilayered films containing a-MSH as a new active biomaterial for endodontic regeneration. **[**14**]**

Nanotechnology in Prosthodontics

Nanoceramics: Nanoceramics refers to the ceramic material with nanoscale dimensions in the microstructures phase. Compared with conventional ceramics, nanoceramics have unique properties like good toughness and ductility. As far as the arrangement of atoms in the nanoceramics interface is quite confusing, the atoms are very easy to migrate under the conditions of force deformation. Secondly, compared to conventional ceramics, nanoceramic has superior mechanical properties, such as strength and hardness. The hardness and strength of many nanoceramics are four to five times higher than those of traditional materials. For example, at 100 degrees Celsius, the microhardness of nano-TiO2 ceramics is 13,000 KN/mm^2, while that of ordinary TiO2 ceramic is lower than the 2000KN/mm^2. 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. **[**15**]**

Coating agent: These light cured agents contain nanosized fillers and are used as a final coating over composite restorations, glass ionomer restorations, jacket crowns, veneers and provisional. These coating agents have higher wear resistance, preventing abrasion and discoloration. Recently, a nanotechnology liquid polish system was designed to overcome the limitations of liquid polishers. The addition of nanofillers provides excellent results such as a glossy surface for direct or indirect resin composite restorations. **[**15**]**

Nanotechnology in Implant dentistry

The application of nanotechnology in dental implants can be made by a coating of nanoparticles over the dental implants. It has been demonstrated that different cell types respond positively to nano topography. The surface of the implant plays a critical role in determining biocompatibility and bio integration because it is in direct contact with the tissues. Implant surface composition, surface energy, surface roughness and surface topography are the four material factors that can influence events at bone-implant interfaces. Various surface textures have been created and used to successfully influence cell and tissue responses. The surface textures are of three types macro, micro and nano. The nanostructured materials can exhibit enhanced mechanical, electrical, magnetic and optical properties compared with their conventional microscale or macro scale counterparts. Nanostructured materials contain a large volume fraction of defects such as grain boundaries, inter-phase boundaries and dislocations and this strongly influences their chemical and physical properties. **[**16**]**

Nanotechnology in Orthodontics

Nanoparticle delivery from elastomeric ligature Elastomeric ligatures can serve as a carrier scaffold for the delivery of nanoparticles that can be anti-cariogenic, antiinflammatory and antibiotic drug molecules embedded in the elastomeric matrix. The release of anti-cariogenic fluoride from elastomeric ligatures has been reported in the literature previously [30-32]. The studies conclude that the fluoride release is characterized by an initial burst of fluoride during the first few days followed by a logarithmic decrease. For optimum clinical benefit, the fluoride ties should be replaced monthly. **[**17**]**

Smart brackets with nanomechanical sensors: Quantitative knowledge of the three-dimensional (3D) force moment systems applied for orthodontic tooth movement is of utmost importance for the predictability of the course of tooth movement as well as the reduction of traumatic side effects. The concept of a smart bracket with an integrated sensor system for 3D force and moment measurement has recently been published. Nanomechanical sensors can be fabricated and be incorporated into the base of orthodontic brackets in order to provide real-time feedback about the applied orthodontic forces.

This real-time feedback allows the orthodontist to adjust the applied force to be within a biological range to efficiently move teeth with minimal side effects. **[**18**]**

Nanotechnology in Management of Dentinal Hypersensitivity

Dentine hypersensitivity is an acute pain condition that typically occurs when the surface of the root becomes exposed. Among the many approaches to treating dentine hypersensitivity, one primary approach is occluding dentine tubules, open tubules are sealed and isolated from external stimuli, preventing fluid movement from triggering a pain response.

Dental nanorobots can selectively and precisely occlude the specific tubules within a minute, offering patients a quick and permanent cure. Gold nanoparticles, the world's smallest gold fillings, so to speak are used by researchers to fill the affected dentinal tubules. **[**19**]**

Nanotechnology in tissue regeneration: Currently, tissue engineering concepts for periodontal regeneration are focused on the utilization of synthetic scaffolds for cell delivery purposes. Although the usage of such synthetics scaffold systems offers promise, it is very likely that the next generation of materials will rely mainly on nanotechnology and its potential to produce nonbiologic self-assembling systems required for tissue engineering purposes. The clinical utility of these nano constructed self-assembling materials is their capacity to be developed into nanodomains or nanophases, leading to unique nano building blocks with inbuilt nano control and nano delivery capabilities. **[**20**]**

Nanotechnology in Surface disinfection

A new sterilizing solution following the nanoemulsion concept has been developed by Gandly Enterprises Inc., Florida, the USA. Nanosized oil droplets attack and destroy pathogens. Eco-True is a surface disinfectant that safely kills 100% of HIV and other particles. It has been used to sterilize tools and incisions to prevent postoperative infections. **[**21**]**

Scope of Nanotechnology: As of now, the use of nanotechnology is limited to the available sources of materials. In the future, there will be more developments that will lead to better outcomes. The future utilization of nanotechnology will yield better results in the improvement of oral health status.

Although we have numerous ideas and dreams for nano dentistry, actually most of them, in reality, are not possible to date due to various challenges such as engineering challenges, biological challenges and social challenges. It is really challenging to position and assemble the nanomolecular scale part

precisely. Biological compatible molecules which are environmentally friendly, economically and ethically acceptable still are a distant site in the field of nanodentistry. **[**20,21**]**

Challenges faced by Nanotechnology

Biocompatibility: It is essential to develop biofriendly nanomaterials and ensure compatibility with all intricacies of the human body. Smaller particles are more bioactive and toxic. Their ability to interact with other living systems increases because they can easily cross the skin, lungs and in some cases the blood-brain barriers. Once inside the body, there may be further many biochemical reactions like the creation of free radicals that damage cells. While the body has built- defense for natural particles it encounters, the danger of nanotechnology is that it is introducing new types of particles.

Ethics: The dominance of the drastic opposition of utopian dreams and apocalyptic nightmares in the debate on the future perspective of nanotechnology holds the risk of undesirable conflicts and unnecessary black lashes. Hence the present state of debate on nanotechnology calls for the development of more balanced ethical views.

Human safety: Nanotoxicity is still a new field but there is the possibility that some nanomaterials may present a health risk. The properties that allow nanomaterials to penetrate the body in new ways are not necessarily bad, but in fact may be beneficial, such as in the development of targeted cancer therapies. It is also crucial to bear in mind that not all nanomaterials are created equal toxicity will likely vary depending not only on the material but also vary based on the particle size. **[**15,21**]**

Conclusion

The science and applications of nanotechnology are constantly evolving as we witness new products being introduced into the market. This comes with great responsibility to ensure the safety, efficiency, and applicability of such new technologies. Their level of effectiveness as shown in the literature diverge, being more effective than some materials and less effective than others. Although the science behind nanotechnology is intriguing, the lack of long-term clinical evidence addressing their clinical performance restricts their wide clinical use.

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