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REVIEW ARTICLE

NANOTECHNOLOGY IN DENTISTRY: A REVIEW OF LITERATURE

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ABSTRACT

Nanotechnology is a scientific approach of altering the properties by manipulating a material in nanoscale. This emerging field has the potential to bring enormous changes in the field of dentistry by the means of nanorobots, nanomaterials, nanodiagnostic aids and nanotherapeutic approaches. Nanodentistry will be engaged soon in maintaining a near perfect oral health. But human safety, biocompatibility, cost effectiveness should be considered before its wide application in the field of dentistry. This article reviews the current status of nanotechnology in the field of dentistry with its possible applications.

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INTRODUCTION

The word nano originates from the Greek word nanos, which means "dwarf". In 1959 a Nobel prize winning physicist Richard Feynman first discussed the concept of nanotechnology during his lecture "plenty of room at the bottom" (Feynman, 1960). In 1974 Norio Taniguchi introduced the term "nanotechnology" (Taniguchi, 1974) and in 1986 K. Eric. Drexler came with the concept of molecular nanotechnology in his publication "Engines of creation: the coming era of nanotechnology". (Drexler, 1986). One nanometer is equal to 10^{-9} of a meter and nanotechnology deals with the development of materials having properties much different from those of the same materials found in large scale.[4] Nanoparticles have altered physical, electrical, thermal, optical and magnetic properties due to increase in surface area and pronounced quantum effect (Drexler, 2006). In the field of medicine and dentistry this technology can be used to identify the disease at molecular and cellular level and also in treating the disease and improving human health (Kubik, 2005). With the wide spread application of nanotechnology in the field of dentistry, a new province called nanodentistry is emerging.

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Approaches to nanodentistry: There are two approaches. In bottom-up approach small components are assembled into compound structures (Herzog, 2002) whereas in top-down approach small structures are created from bigger one (Ashley, 2001).

Nanotechnology in the field of diagnosis: The nanotechnology can be used for diagnostic purpose with higher sensitivity, simplicity and accuracy. In prompt diagnosis of oral cancer and precancerous condition this nanotechnology is very helpful and the following nanostructures are important in this respect (Kanaparthy, 2011; Khosla, 2009; Weiss, 2005 and Kairemo, 2013).

- **Nanoscale cantilevers:** These are flexible elastic beams with special type of endings that can attach to cancer related molecules, specific proteins and altered deoxy ribonucleotide (DNA) sequences. Hence helps in detection of oral cancer.
- **Nanopores:** These are small pores that allow the passage of single strand of DNA and asses the shape and electrical properties of each base in that strand. Thus DNA sequencing can be assessed and any genetic defect with potential risk of cancer is evaluated.

- **Nanowire sensor:** Silicon nanowires are helpful in detecting viruses and proteins in saliva sample.
- **Nanotubes:** These are the nano-carbon rods having diameter half that of a DNA. It can detect the change in DNA sequence and the exact location of the defect.
- **Quantum dots:** Under UV light they glow very brightly and have the property to attach to the proteins expressed by cancer cells and thus helps in diagnosis.

Administering local anesthesia with nanorobots: The nanorobotic technology is used for local anesthesia where a colloidal suspension with millions of nanorobots is deposited in gingival tissue (Shetty, 2013). These robots reach the pulp via dentinal tubules and their movements are controlled by temperature difference, chemical signaling and by a nanocomputer under the control of the dentist (Shetty, 2013). Once they reach the pulp these nanorobots cease all sensations in that specific tooth and after completion of treatment they can be ordered to rejuvenate the lost sensation (Shetty, 2013). This technology is particularly helpful in anxious and apprehensive patient as well as in small children where we can administer local anesthesia painlessly by using this method (Jr Freitas, 2000).

Nanorobotic dentifrice (Dentifrobots): Nanorobotic technology is used in toothpaste and mouthwashes in the form of dentifrobots are useful in monitoring the gingival and tooth surfaces regularly and removal of harmful materials and calculus (Jr Freitas, 2000).

Tooth repositioning by nanorobots: Nanorobots can be used to manipulate periodontal tissue like gingiva, alveolar bone, cementum and thereby allow painless corrective movement of malaligned teeth (Chandki, 2012).

Nanorobotic technology in hypersensitivity cure: Nanorobots using local organic materials may occlude dentinal tubules effectively and reduce hypersensitivity (Jr Freitas, 2000).

Nanocomposite: The nanofiller particles are incorporated into composite to enhance its restorative properties. Nanocomposite defined as filler particle size of less than 100 nm and can be divided into nanohybrid and nanofilled composite. Nanocomposite have increased hardness, improved handling properties, better translucency, increased flexural strength and 50 % reduction in polymerization shrinkage (Kanaparthy, 2011; Chandki, 2012; Nagpal, 2011). Buen et al. compared the physical properties of nanofilled composite with universal hybrid and microfilled composite and found higher modulus of elasticity with nanofilled one (Beun, 2007). As an antibacterial agent quaternary ammonium nanoparticles can be added to the composite. Addition of zinc nano particles in composite enhances antibacterial effect and improves the clinical service of the restoration (Niu, 2010 and Fang, 2007). Adhesion of microorganism and formation of biofilm can be minimized by incorporating titanium dioxide nanoparticles in composite that enhances the hydrophilic activity of the resoration (Farbod, 2010).

Nanoadhesives: Nanoparticles incorporated bonding agents have higher dentin and enamel bond strength, increased shelf life, high stress absorption property and improved marginal seal with less chances of marginal leakage and secondary caries (Jhaveri, 2005 and Robert, 2010). It also ensure homogenous and perfectly mixed consistency in every mixing (Patil, 2008).

Nanocoatings

- **Implant surface coating with nanotechnology:** Titanium is now being widely used for reconstruction in orthopedics and dentistry. This material has high fracture resistance with adequate ductility and strength. But it does not stimulate osteoblast adhesion and proliferation (Salata, 2004). Under in vitro conditions Arg-Gly-Asp-Ser nanofibres were incorporated in nickel titanium alloy and it have been found that pre-osteoblasts can survive and proliferate within this compound and can differentiate into osteoblasts to form bone (Sargeant, 2008). Implant surface can also be coated with nanohydoxyapatite crystals but studies have demonstrated that this material has no role in osteoblastic activity around implant surface (Schouten, 2010 and Svanborg, 2011). Nanohydoxyapatite coating in conjunction with silver nanoparticles have also tried to improve osteoblastic activity and antibacterial property, and it have been found that there is significant reduction in biofilm formation around implant surface when silver nanoparticles are used (Allaker, 2010; Almaguer-Flores, 2010)
- **Surface coating of root canal filling materials:** Silver nanoparticle coating on gutta percha is used to reduce microleakage around root canal filling material (Shantiae, 2011) Studies have also demonstrated that use of disinfectant nanoparticle gel of 0.02% silver is effective in preventing biofilm formation by *E.faecalis* (Kishen, 2008).

Applications of nanotechnology in the field of preventive dentistry: Enamel is made of hydorxyapatite crystal which has a porous structure. Deposits on tooth surfaces are usually lodged in these porosities and bacterial accumulation and proliferation take place (Figueiredo de Magalhães, 2008) Nanohydroxyapatite crystals present in toothpaste can penetrate and fill these porosities and thereby reduce the formation of plaque and calculus and also control biofilm formation (Jeong, 2006 and Kim, 2006). The concept of nano-toothbrush uses colloidal silver or gold in between toothbrush bristles and enhances removal of microbial plaque and calculus and by doing this it helps in maintaining good periodontal health (Gatti, 2004).

Correction of bony defects: Nanotechnology is also used in correction of bony defects and induction of bone growth. Nanoparticles of hydroxyapatite in various form is used in bony defect correction. With reduction in particle size, surface area increases and make the material more porous and nano-structured. Nano-bone have used this rule to produce bone graft (E Pinon –Segundo, 2005).

Nanotechnology in Guided tissue regeneration: A concept of 3 layered guided tissue regeneration (GTR) membrane containing 8% nanocarbonated hydroxyapatite/ collagen/ polylactic-co-glycolic acid (nCHAC/PLGA) porous inner membrane, 4% nCHAC/PLGA middle membrane and PLGA non-porous outer membrane has introduced (Fioretti, 2010). This membrane is highly flexible, more osteoconductive and more biocompatible than pure PLGA membrane (Liao, 2007).

Nanotechnology in pulp regeneration: Nanotechnology is also used in the field of regenerative dentistry. The alpha melanocyte stimulating hormone possess anti-inflammatory properties and nanofilms containing this hormone have been

tried to revitalize damaged pulp tissue (Fioretti, 2010). Further research is needed to evaluate the role of nanotechnology in this regenerative approach.

Nanoneedles: RK 91, Bioline, Sandvik are some commercially available nanoneedles where nano structured stainless steel crystals have been used. Currently research on nanotweezer is going on. Nanoneedles along with nanotweezers will make surgery at cellular level more precise (Kanaparthy, 2011 and Chandki, 2012).

Nanosterilizing solution: The concept of nanosterilizing solution based on the nanoemulsion concept where nanosized oil droplets attack and destroy pathogenic organisms (Kairemo, 2013). It has several advantages like, it is broad spectrum, hypoallergic, eco friendly, noncoroding and doesnot stain clothes.

Challenges faced in the field of nanotechnology: Ethical issue, inadequate data of clinical research, lack of funding, precise positioning and nanoscale parts manufacturing are some of the challenges faced by this emerging field. Social issues of public acceptance, human safety and biocompatibility should also be considered before its application into dentistry. The major challenges faced in the field of dentistry are to synchronize numerous independent nanorobots and to position nanoparticles precisely for various purpose (Kanaparthy, 2011 and Chandki, 2012).

Conclusion

This emerging field has bring revolutionary changes in the field of medicine and dentistry. It also posses a lot of risk to the human beings. Its safety and biocompatibility should be evaluated before its application in human and further research in this field is needed before wide application.

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