

Will Nano Take Over the World?

Dr. Shruti D. Nayak

Asst. Professor
Dept. of Oral Pathology
Yenepoya Dental College
Mangalore

Dr. Amarnath Shenoy

Asso. Professor
Dept. of Conservative Dentistry & Endodontics
Yenepoya Dental College
Mangalore

Dr. Gary Ignatius

Asst. Professor
Dept. of Orthodontics

Dr. U.S Krishna Nayak

Dean-Academics, Sr. Professor & HOD
Dept. of Orthodontics
A B Shetty Memorial Institute of
Dental Sciences, Mangalore

Abstract

Nano technology is used in almost all fields including dentistry. Nano robots, nano spheres, nano fibres etc are being introduced into dentistry also. This field has remarkable potential that can bring considerable improvements to human health, enhanced use of natural resources and reduced environmental pollution. However Nanotechnology can become controversial also because the long term effects of nano particles in humans is still not known.

Introduction

Nano in Greek means 'dwarf'. The word nanotechnology was first used in 1974 by the researcher Norio Taniguchi. This technology is used to engineer materials at precisely the nanometer level.¹ Richard Feynman was the person who proposed the use of machine tools to make smaller machine tools till molecular level is reached.²

"Nanotechnology" is defined as the research and development of materials, devices and systems exhibiting physical, chemical and biological properties that are different from those found on a larger scale.³ Nano technology symbolize inexpensive control of the structure of matter. This is based on molecule to molecule control of products and by products.¹

How Small Is The Nanoscale⁴

- One nanometer (nm) is one billionth, or 10⁻⁹ of a meter.
- One human hair (cross section) is about 100,000 nanometers
- Larger than Nano scale is the micro scale and smaller than that is the atomic scale.

Though the developments in dentistry have been slower than those in medicine, the last ten years have shown promising theoretical predictions based on potential applications for nano-technology in dentistry.⁵

Nano dentistry applied to dentistry has the ability to bring significant advances to diagnosis, treatment and prevention of diseases.⁶

There are different types of nano particles. They are Nano pores, nano tubes, quantum dots, nano shells, dendrimers, Liposomes, fullerenes, nano rods, nano belts, nano wires, nano spheres, nano rings, and nano capsules.⁷

Two approaches have been used for the fabrication of nano particles in dentistry.⁸

- Top down approach
- Bottom up approach

Top down approach

- Nano composites
- Nano solutions
- Impression materials

Bottom up approach

- dentine hypersensitivity
- local anesthesia
- tooth repair

- Nano encapsulation
- Nano needles
- Bone replacement

- tooth positioning
- nano dentifrices
- diagnosis of oral cancer

In top down approach nanostructures of progressively smaller and smaller sizes are built using larger parts. In bottom up approach consists of assembling of nanostructures from atoms and molecules.⁸

Application of Nanotechnology in Dentistry

Oral Anaesthesia Induction: nano robots will be a powerful role in induction of anaesthesia. A colloidal suspension which contains millions of anaesthetic micro-sized dental robots will be instilled on patients' gingiva. These micro-robots will reach the pulp via gingival sulcus, lamina propria and dentinal tubules.⁵ The dentist can control the movement of these micro-robots and instruct them to anaesthetise a particular tooth or a group of teeth and when the procedure is over these nano robots can be commanded to allow the sensations back. Following this the micro robots can be instructed to return in the same pathways they had been introduced.¹

Nano robotic analgesics provide greater analgesia, more comfort and lesser anxiety. They have greater selectivity and controllability of the analgesic effect. The action of anaesthesia will be reversed rapidly and there will be no complications, side effects associated with local anaesthetic injections.⁷

All these nanorobot functions may be controlled by an on board computer. Pre-programmed instructions will be executed in response to local sensor stimuli.⁵

Treating Dentine Hypersensitivity

In hypersensitive teeth the number of dentinal tubules is eight times of that of the normal non sensitive teeth. The reconstructive dental robots, using native bio-materials may have the ability to selectively and precisely occlude the dentinal tubules. This occlusion of the tubules can occur within minutes and offer a rapid and permanent cure.¹

CPP ACP nano complexes: this nano technology combines specific phospho-protein from bovine milk forming nano particles of amorphous calcium phosphate (ACP). The exact ratio is 144 calcium ions, 44 phosphate ions and 6 peptides of CPP (casein phosphopeptides)

E.g.: Recaldent chewing gums²

Nano Composites

These composites have the advantage of superior hardness, modulus of elasticity, translucency, flexural strength and aesthetic appeal. The shrinkage will be 50% less and handling properties will be excellent allowing easier placement and contouring.

There will universal applicability for both anterior and posterior teeth.⁷

Aluminosilicate powder with a mean particle size of 80 nm is the nano filler used. The ratio of alumina to silica is 1:4 and refractive index is 1.508.⁹

Nano Solutions

They produce unique and dispersible nano particles and can be added to various polymers, solvents and paints in which they will be homogeneously dispersed. They can be used in bonding agents also. Thus the homogeneity ensures that the adhesive is perfectly mixed every time.^{9,1} when added to bonding agents their bond strength is increased several times. Nano solutions have the ability to disrupt even the biofilms. Triclosan and zinc oxide have been used for this purpose.

Nano Sterilizing Solution: nano sized emulsifier droplets of oil that bombard the pathogens.¹

Impression Materials

Impression materials made using nano technology have improved hydrophilic properties, better flow and enhanced detail precision. Siloxane impressions can be made unique by addition of nano fillers in vinyl poly siloxane.¹⁰

Nano-Orthodontics

In contrast to contemporary orthodontic techniques which take several weeks to months for completion of the desired treatment Orthodontic nano robots may manipulate the periodontal ligament, cementum or alveolar bone in minutes or few hours. The rotation of teeth, vertical repositioning etc will done with much ease, perfection and speed.⁵

Orthodontic Wires: Allows ultra high structures combined with good formability, corrosion resistance and excellent surface finish.¹

Tooth Replacement

By utilizing the principles of genetic engineering, tissue engineering and tissue regeneration it will be possible to generate a whole tooth or dentition in future.

Nanorobot Dentifrice (Dentifrobots)

Nanorobotic dentifrices when delivered into the oral cavity through mouth rinses or tooth pastes may be able to patrol supra gingival and sub gingival surfaces at least once a day, thus metabolizing the hidden organic matter into harmless, odourless vapours and perform a continuous calculus debridement.⁸

These nano robots would be inexpensive and safe. They would deactivate themselves if swallowed. When properly configured, these robots will be able to distinguish between



harmful and helpful bacteria, thus maintaining a healthy eco system. There will also be a continuous barrier to halitosis.¹¹

Nano Technology in Oral Cancer

Nano drug delivery can cross the blood brain barrier and can be more effective in the treatment of Parkinson disease, Alzheimer disease and other tumours of the brain.¹

Nano electrochemical systems (Nems), Cantilever Array sensors and Multiplexing modality can be used in diagnosing oral cancer.

The nano material for brachytherapy is Brachysil (Sivida, Australia) delivers 32P, a drug under trail.⁸

Dendrimer nano particles can be efficient drug delivery vehicles and are known to be capable of targeting tumour with large dose of anticancer drugs.⁸

Durability & Appearance

Tooth durability and appearance may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire or diamond, which have 20 to 100 times the hardness and failure strength of natural enamel or contemporary ceramic veneers, as well as good biocompatibility. Sapphire can be manufactured in virtually any color of the rainbow. Pure sapphire and diamond are brittle and prone to fracture if sufficient shear forces are imposed, but they can be made more fracture resistant as part of a nano structured composite material that possibly includes embedded carbon nano tubes.¹²

Renaturalization Procedures

Dentition renaturalization procedures may become a popular addition to the typical dental practice, providing perfect treatment methods for esthetic dentistry. Patients who desire to have their old dental amalgams restorations removed and their teeth remanufactured and remodelled with native biological materials so that the affected teeth become indistinguishable from the original teeth can undergo this procedure.¹¹

Photosensitizers & Carriers

Quantum dots are very helpful as photosensitizers and carriers. They have the ability to bind on the surface of antibodies on the target cells and when stimulated by u v light can give to very reactive oxygen species which can destroy the target cells.¹³

Nano Needles

These needles help in suturing during delicate operations performed on even single cells. Nano tweezers which can be of tremendous help in cell surgeries is under development.¹⁴

Bone Replacement Materials

Calcium hydroxide based nano sized biomaterials is easily flowable, mouldable paste that can interdigitate with the host bone. It supports the growth of bone cells and cartilage.⁵

These smart materials created through nano technology can help in the repair and regeneration of cellular tissue in the bone.³

Salivary Diagnostics

With only minor amount of body fluid a lot of information can be obtained that reflects health and disease status of the patient. This allows real-time and simultaneous assessment of multiple diseases.³

Coating Agents

These nano sized fillers when used to provide final finishing for composites, jacket crowns, glass ionomers, and veneers provide additional and much improved resistance against abrasion and discoloration. An excellent glossy surface finish can be provided by the addition of these fillers.³

Ultrafine Polishing- Aesthetics & Cavity Prevention

The roughness left on the human teeth after ultrafine polishing is only of few nano meters. Cariogenic bacteria can be removed from such polished surfaces very easily. This leads to less staining and better aesthetics.³

Root End Sealant

Nano material enhanced retro fill polymers (NERPs) provide better bond strength and adaptability to the tooth structure. These materials showed effective sealing and prevention of microleakage in models.¹⁵

Microscope

Terahertz radiation can be made use of in detecting tumours in the skin and pinpointing dental caries. This radiation occupies the area between light and radio waves in the electromagnetic spectrum.³

Nano Particles as Antimicrobials

Nano particulates are poly anionic or poly cationic in nature with higher charge density and surface area. Thus there will be greater degree of interaction with the bacterial cells and higher anti bacterial activity. Nano antimicrobials can remove the non adherent and adherent bacteria from within the root canals, thus improving the disinfection. They can also make the root canal sealers more effective by improving the diffusion of their antibacterial components.¹⁶

Dental Bio-films & the Role of Nano Technology

Nano technology tools such as atomic force microscopy can detect bacteria induced demineralisation at ultrasensitive level. The inter species interaction can be understood more clearly using nano technology.

Another nanotechnology application used is the ¹⁶O/¹⁸O reverse proteolytic labelling to determine the effect of biofilm culture on cell envelope proteome of an oral pathogen, Porphyromonas gingivalis which is linked to chronic periodontitis.³ A nano chip helps uses to detect and differentiate between cultivable and non cultivable bacteria. Silver nano

technology has proven to be very effective against biofilms. Silver attacks the negatively charged cell groups on the biological molecules such as carboxyl, sulphhydryl etc.

Critical physiological functions like cell wall synthesis, membrane transport, nucleic acid synthesis, translation, protein function and electron transport are inactivated by silver. It is effective against E.coli, S.aureus .etc¹⁷

Threat to Humans

Nano technology is a very recent discovery. The long term effects of nano-technology are not known. Potential hazards if any will not show up for many years. When nano materials are released in the atmosphere they can be further modified by temperature, pH, biological conditions and pollutants. This interaction can cause the alteration of atmosphere, soil and water which leads to harmful health effects.

Entry of nano particles into the body can occur through different portals. Once entered there is a possibility of a rapid translocation to vital organs through the bloodstream. Carbon black nano particles have been implicated in cell signalling interference. Unwanted genetic changes may be another hazard that these particles may cause. There is a need of developing systemic solutions for these potential hazards and also monitor and record them.¹

Recent Studies on Nano Particles & Bio-Film Interaction

Recent studies have focussed on using nano-particulate materials to disinfect root canals. They exhibit high antibacterial activity as a result of their polycationic or polyanionic nature with higher surface area and charge density. This results in greater degree of interaction with the bacterial cell. Smaller nanoparticulates have shown higher antibacterial activity than macroscaled ones.¹⁸

Nano particles such as Chitosan (Cs-np) and Zinc oxide Eugenol (Zno-np) are known to possess significant antibacterial properties. One study concluded that the rate of bacterial killing depended on the concentration and time of interaction. There was a significant reduction in the thickness of biofilms. The study also showed that aging up to 90 days did not reduce their antibacterial properties much.¹⁹

Conclusion

Nano technology is an emerging field with a significant potential to expand and to yield new generation both dentist and patient friendly tools and devices for oral healthcare. Just like any other advanced science nano technology and tools will continue to intrigue, dazzle and surprise our imagination.

References

References are available on request at editor@healtalkt.com

