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Nanotechnology-the Era Of Molecular Dentistry

[1] Archana Nagpal
[2] Jasjit Kaur
[3] Shuchita Sharma
[4] Aarti Bansal
[5] Priyanka Sachdev

[1] Professor and Head,
[2,3] PG Student
Dept of Prosthodontics, HDC, Sunder Nagar, H.P.
[4] Reader, Dept. of Periodontics, HIDS, Paonta Sahib
[5] Pursuing, DDS Program in New York University, USA

Address For Correspondence:
Dr. Archana Nagpal
Prof and Head - Department of Prosthodontics,
Himachal Dental College, Sunder Nagar, H.P.
Mobile: 9418034799
Email ID : archana.saidental@gmail.com

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Abstract
Dentistry has seen many era of revolution in past, making it more reliable and comfortable for the patients. It is undergoing yet another change in helping mankind, this time with the help of nanotechnology combined with Nonomaterial's, Biotechnology and Nanorobotics. Nanodentistry will make possible the maintenance of comprehensive oral health by employing nanotissue devices which will allow precisely controlled oral analgesia, dentine replacement therapy, permanent hypersensitivity cure, complete orthodontic realignment etc, all in single office visit.

Key Words
Nanodentistry, Nanomaterials, Nanorobots, Tissue Engineering

Introduction

"Greatness does not come from size. Surprises come in small packages."The word nano is derived from Greek word "dwarf". The term nanotechnology was coined by Prof Keric E Dexler a lecturer, researcher and writer of nanotechnology. Nanotechology is the manipulation of matter on the molecular and atomic levels. It is measured in the billionths of meters or nanometer, roughly the size of two or three atoms. Nanomaterials are the materials with components less than 100 nm in at least one dimension, including clusters of atoms, grains less than 100 nm in size, fibres less than 100 nm diameter, films less than 100 nm in thickness, nanoholes and composites that are a combination of these.

History

In 1959, the late Nobel Prize winning physicist Richard P. Feynman presented a talk entitled "There's plenty of room at the bottom" at the annual meeting of the American physical society. Feynman proposed using machine tools to make smaller machine tools, which, in turn, would be used to make still smaller machine tools, and so on all the way down to the molecular level. He suggested that such nanomachines, nanorobots and nanodevices ultimately could be used to develop a wide range of atomically precise microscopic instrumentation and manufacturing tools. Feynman argued that these tools could be applied to produce vast quantities of ultra small computers and various micro scale and nanoscale robots. He concluded that this is "a development which I think cannot be avoided," and the vision of nanotechnology was born.[1]

Nanotechnology aims to manipulate and control particles to create novel structure with unique properties and promises advances in medicine and dentistry. Nanodentistry will make possible the near perfect oral health through the use of Nanomaterials, Biotechnology including Tissue engineering and Nanorobotics.

Nanomaterials: Nanomaterials are those materials with components less than 100 nm in at least one dimension, including clusters of atoms, grains, fibres, films, nanoholes, and composites that are a combination of these

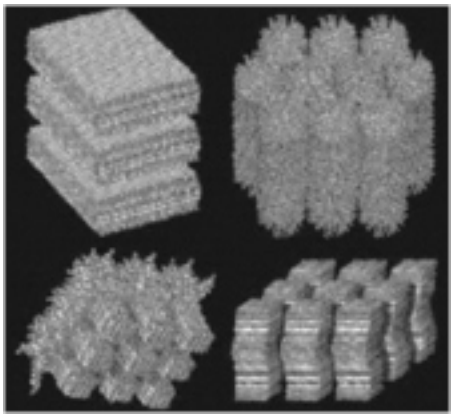

Figure 1: Nanoparticles In Various Shapes Sheets, Rods, Grains, Etc.

These nanomaterials if present in one dimension are called as sheets, if in two dimensions are nanowires and nanotubes, if present in three dimensions are called as quantum dots.

The various nanostructures are [2]

- Nanopores
- Nanotubes
- Quantum dots
- Nanoshells
- Dendrimers

These various nanostructures (nanodiagnostic aids) have an ability to diagnose a disease in early phase of development. These nanodevices also decipher the encoded information from the bases making up genetic codes underlying the pathogenesis of cancer.

Application of nanodentistry in Oral Diagnosis and Therapeutics

1. Photosenstizer and carriers: Quantum dots can be used as a photosenstizer and carriers. They can bind the antibody to surface of target cell and when stimulated by ultraviolet light, they give rise to reactive oxygen species which are lethal to target cells.[3]

2. Nanotherapeutics: These are the highly specific and targeted drug delivery systems. Nanotechnology in field of therapeutics will help to solve the solubility problems, reduce the drug dosages and

minimise the side effects.[3-5] They will be effective in treatment of brain disorders, Alzheimer's disease, Parkinson's disease etc.

3. Treatment of oral cancer: Nanotechnology in field of cancer therapeutics has offered highly specific tools in the form of multifunctional Dendrimers and Nanoshells. The unique property of Dendrimers such as their high degree of branching, multi valence, globular structure and well defined molecular weight make them promising in cancer therapeutics.[6,7]

Nanoshells are miniscule beads with metallic outer layers designed to produce intense heat by absorbing specific wavelengths of radiations that can be used for selective destruction of cancer cells leaving aside intact, adjacent normal cells.[6,7]

Application of nanodentistry in clinical dentistry[8,9]:

1. Nanocomposites: Composite with nanofillers has two types of nanofillers-nanomeric and nanocluster type. **Trade name:** Filtek Supreme universal restorative pure nano

Advantages
- High filler loading
- Desirable handling characteristics
- Superior physical properties like modulus of elasticity and flexural strength etc.
- High polish retention because of nanosize fillers which even if get plucked away by tooth brush abrasion, leave the surface with defects smaller than the wavelength of light.
- Higher translucency giving it more lifelike appearance
- 50% reduction in curing shrinkage

2. Nanoadhesives: They are nanosolutions which produce unique and dispersible nanoparticles which prevent agglomerations.

Advantages:
- Higher dentine and enamel bond strength
- High stress absorption
- Longer shelf life
- Durable marginal seal
- No separate etching required
- Fluoride release

3. Nanoimpression materials: Nanoimpressions are available with nanofillers integrated in the polyvinyl siloxane producing a unique addition siloxane impression materials. (Nano Tech Elite H-D+).

Advantages:
- Better flow
- Improved hydrophilic properties and hence few voids at margins and better model pouring

4. Dentifrices: They are nanosized hydroxyapetite crystals. These Dentifrices form a protective coating on tooth enamel and even restore the surfaces of damaged teeth. Dentifrices like Microbrite has microhydrin which consists of molecular cages, 1-5 nanometer in diameter and degrade the organic food particles.

5. Materials to induce bone growth: Calcium sulphate is used to fill small voids such as those found in post extraction sockets and periodontal bone defects and as adjunct to the longer lasting bone graft materials. Dr Ricci has formulated new calcium sulphate based composite. Bone Gen -TR which resorbs more slowly and regenerates bone more consistently.

6. Orthodontic wires: Sandirk Nanoflex is a new stainless steel which allows ultra-high strength combined with good deformability, corrosion resistance and a good surface finish.

7. New electrochemical process for coating implants: Prof Noam Eliaz is behind this innovation and he found that the new implant improves function and longevity. In this process there is electrochemical deposition of synthetic hydroxypatite over the implant surface. These new implants are more acceptable to human body as these are able to enhance the integration of the nanocoatings to the human tissues. These nanocoatings very much resemble with the biological materials.

8. Bone replacement materials : Hydroxyapatite nanoparticles used to treat bone defects are-
- Ostim® (Osartis GmbH, Germany) HA,
- VITOSSO (Orthovita, Inc, USA)
- HA +TCP NanOSS™ (Angstrom Medica, USA) HA

9. Nano sterilizing solution: Gandly Enterprises Inc Florida has introduced a new disinfectant based on super science of nanoemulsion technology. It uses nanosized emulsifier droplets of oil that bombard the pathogens. **e.g. Eco Tru Disinfectant.**

Advantages:
- Broad spectrum
- Hypoallergic
- Noncoroding
- Does not stain fabric
- Require no protective clothing
- Environment friendly
- Compatible with various impression materials

Applications of nanorobotics to dentistry[10]:

Around 10-20 years from today. Dental Nanorobots will be constructed. Nanorobots might use specific motility mechanism to crawl and swim through human tissues with navigational precision. These nanorobots will acquire energy, sense and manipulate their surroundings and pass through the odontoblastic process without disrupting the cells.

Nanorobotic function may be controlled by onboard computers that execute pre-programmed instructions in response to local sensor stimuli. Dentist may issue instructions by transmitting orders directly to in-vivo nanorobots via acoustic signals.

Nanorobots

Applications of Nanorobotics to Dentistry

1. Inducing local anaesthesia:

To induce local anaesthesia in the era of nanodentistry, colloidal suspension containing millions of active analgesics micron size dental nanorobots will be installed on the patient's gingiva which will crawl through mucosa, lamina propria and dentine painlessly reaching the pulp in

around 100s sec. Upon reaching the pulp these tiny machines will establish control over nerves impulse traffic which in turn will be controlled by the dentist on board. When the dentist presses the icon for the desired tooth on the hand held controller display, the selected tooth will numb immediately. After the oral procedures are complete, the dentist orders the nanorobots to restore all sensations, to egress from the tooth by similar pathways used for ingress.

Advantages:
- Greater patient comfort
- No anxiety, no needles
- Greater control of analgesia
- Fast and completely reversible
- No side effects and complications

2. Dentin Hypersenstivity:
It is a pathological phenomenon. It is caused by pressure transmitted hydrodynamically to the pulp.Main hypersensitive tooth has dentinal tubules with surface densities will be eight times higher than those of nonsensitive teeth.Dental nanorobots can selectively and precisely occlude the specific tubules within a minute offering patients a quick and permanent cure.

3. Orthodontic Robots:
Orthodontic robots can directly manipulate the periodontal tissues,including gingivae,periodontal ligament,cemental and alveolar tissues allowing rapid repair and painless tooth straightening,rotating and vertical repositiong within minutes to hours.

4. Nanorobotic dentrifices :
Nanorobotic dentrifices delivered by mouthwash or tooth paste can cover all subgingival surfaces, metabolizing trapped organic matter into harmless and oodourleses vapors.Properly configuered dentifrorobots can identify and destroy pathogenic bacteria existing in the plaque and elsewhere. They will also provide a barrier to halitosis. **Nanoneedles;** Suture needles incorporating nano-sized stainless steel crystals have been developed. Nanotweezers are also under development which will make cell-surgery possible in the near future. **Trade name:** Sandvik Bioline, RK 91TM needles [AB Sandvik, Sweden].

Nano Tisssue Engineering
We are not far away when we will be able to generate whole new tooth with the principles of genetic engineering, tissue engineering and tissue regeneration by manipulating cellular and mineral components at nanoscale. Chen et al by using nanorods like calcium hydroxyapatite crystals which were oriented roughly parallel to each other, were able to simulate the natural bio mineralization process and create hardest tissue in human body, i.e., dental enamel

Tooth Repair:
Major tooth repair will be possible through the combination of nanotechnology, genetic engineering and tissue engineering and later on whole tooth will be grown in vitro and installed in oral cavity. So complete dentition replacement therapy should become possible to understand within the time and economic constraints of an ordinary office visit, using an affordable desktop manufacturing facility in the dentist office.

Conclusions :
Naodentistry still faces many significat challenges in realizing its tremendous potential. There are larger social issues of public acceptance,ethics,regulations and human safety that must be addressed before molecular nanotechnology can enter the modern medical armamentarium. However there are equally powerful motivations to surmount these various challenges,such as the possibility of providing high quality dental care to the large amount of world population. Time, specific advances,financial and scientific resources and human need will determine which of the applications described in this article are realized first.

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