

Nanotechnology: Future of Dentistry

Devina Pradhan¹, Pratik², Lokesh Sharma³, Ashutosh Chaudri⁴

1-PG student, Department of Public Health Dentistry, Rama Dental College, Kanpur. 2-Senior Lecturer, Department of Orthodontics & Dentofacial Orthopaedics-Rama Dental College, Kanpur. 3-PG student, Department of Public Health Dentistry, Sardar Patel Post Graduate Institute of Dental & Medical Sciences, Lucknow. 4-Senior Resident, Department of Orthodontics & Dentofacial Orthopaedics, M.L.N, Medical College, Allahabad.

Correspondence to:
Dr. Devina Pradhan, 3/99, Vishnupuri,
Kanpur- 208002
Contact Us: www.ijohmr.com

ABSTRACT

The branch of nanotechnology has a significant impact on our daily lives from security to medicine. The basic concept behind nanotechnology is that numerous potentials and possibilities of the basic particles can be discovered. Due to the growing technologies and interest in the dental applications of nanotechnology, there is an emergence of a completely new stream that is known as nanodentistry. Nanodentistry helps in attaining good oral health while using nanomaterials and various biotechnologies like nanorobots and tissue engineering etc. In dentistry, there are other treatment modalities where nanotechnology proves to be effective, and those include nanorobots, nanoneedles, nanorobotic dentrifices, bone replacement materials, nanocomposites, etc. In the near future, it is believed that nanotechnology will completely change the clinical dental practice and delivering oral healthcare to the patients will become less stressful and more acceptable to the patients. Hence, this review article focuses on the various uses of nanotechnology and their applications in the field of dentistry.

KEYWORDS: Nanotechnology, Nanodentistry, Nanocomposites, Orthodontic nanorobots

INTRODUCTION

The foremost goal in dentistry is to provide best dental care to the patients. However, this can be attained with the help of a skilled dental professional and its team.¹ Day by day, science is undergoing great evolutions that are leading the humanity towards a new era of dentistry i.e. the era of nanotechnology. Nanotechnology provides an insight to explore a coherent technology that is beneficial for the dental sciences.^{2,3}

The word nanotechnology originates from a greek word, 'nano' which means *dwarf*. It is a prefix actually refers to one-billionth of a physical size. One nanometer (nm) refers to a unit of length that equals to one-billionth of a meter.⁴ National Nanotechnology Initiative defines nanotechnology as the direct manipulation of materials at the nanoscale.⁵ In other words, we can say that it is a technology having a complete control on the matter's structure at the nanoscale level.

The field of nanotechnology and the nanomaterial science has a capability of providing benefits in the field of dentistry, electronics, and information technology, energy conservation, nano bio-systems, ecology, economy, synthesizing new materials with advanced properties, medical appliances etc.⁶ In addition, nanotechnology has a wider use in the field of medicine where it benefits in the development of drugs to the cells of cancer in the body which has proved to be safe and effective in treating cancer.⁷

Apart from other fields, nanotechnology has its uses in dentistry. It is believed that with the help of nanotechnology, the oral health of the patient can be improved by providing varying measures of treatment

with the help of nanomaterials, nanorobots, and biotechnology.⁸ According to the recent research in dentistry, nanoparticles are used with resin based composite restorations and in the management of bacterial bio-films.

USES OF NANOTECHNOLOGY IN DENTISTRY

Nanotechnology has various uses in many branches of dentistry that are as follows⁹:

Materials used

Nanogen, Arestin
Keta C-N100 Light curing Nano Ionomers
Nano- Care Gold
Epiphany, AH plus
Nanonite- Implant
Nanotechnology elite HD plus

Branch

Periodontics
Orthodontics
Preventive Dentistry
Endodontics
Implantology
Prosthodontics

HISTORICAL BACKGROUND

1. 1959- Vision of nanotechnology introduced by Nobel Physicist Richard P. Feynman⁶
2. 1974- The term Nanotechnology was used for the first time by a researcher at the University of Tokyo named Norio Taniguchi. The term was basically used to refer the ability of the engineering materials at the nanometer level.¹⁰
3. 1980- A book was published by Mr. Eric Drexler which focused on the possibilities associated with the ideologies in nanotechnology.¹¹
4. 2000- Nanodentistry was first introduced by a scientist named Robert Frietas.¹²

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The present article focuses on nanotechnology, nanomedicine, and nanodentistry with future aspects.

NANOMATERIALS

These are materials with less than 100nm components in minimum one dimension. They comprise of grains, fibers, clusters of atoms, nanoholes etc. in one dimension, these materials are referred as sheets, in two dimensions as nanotubes, and in three dimensions they are considered as quantum dots.¹³

NANOTECHNOLOGY

Nanotechnology is widely used in various fields that are as follows:¹⁴

- Medicine
 1. Tissue engineering
 2. Diagnostics
 3. Drug delivery
- Chemistry and environment
 1. Filtration
 2. Catalysis
- Energy
 1. Recycling batteries
 2. Minimizing consumption of energy
 3. Increasing the production of energy
 4. Use of eco-friendly systems of energy
- Communication and information
 1. Quantum computers
 2. Novel semiconductor devices
 3. Displays
 4. Novel optoelectronic devices
- Heavy industry
 1. Manufacturing of vehicles
 2. Aerospace
 3. Refineries
 4. Foods
 5. Consumer goods

Nanomedicine: Nanomedicine is the field of science that deals with the prevention, diagnosing and treatment of the disease by using nanosized particles in order to improve the health of the patient.¹⁵

The various nanotechnologies used in nanomedicine are as follows:

1. Nanoscale materials that can be used in advanced diagnostics and biosensors or targeted delivering of drugs.
2. It is applied in genomics, artificial biotics, and proteomics

Nanorobots: They possess a diameter of 0.5- 3 microns and consist of components that are of 1-100 nanometers in size. Nanorobots are used in pharmaceuticals, dental treatments, gerontology, repairing brain injuries, aiding in natural immunity, modifying cellular DNA sequences etc.¹⁶

Nanosensors: These are used for military application in identification of airborne harmful materials and weapons of chemical warfare.¹⁴

Nanodentistry: As we know, that nanotechnology provides a wider range of innovations in the diagnosis, prevention, and treatment of oral diseases. These are dependent on two approaches that are as:

1. Top down approach: It encompasses the building of nanostructures into smaller parts by using large pieces. It includes: nanocomposites, impression materials, nanoneedles, bone replacement materials and nano solutions.¹⁷
2. Bottom-up approach: It encompasses to form nanostructures from molecules and atoms. It includes: nanodentifices, tooth repair, diagnosis of oral cancer, dentinal hypersensitivity, local anesthesia and tooth repositioning.¹⁸

APPLICATIONS OF NANOTECHNOLOGY IN DENTISTRY

1. **Local anesthesia:** A colloidal suspension that comprises of millions of active analgesic dental nanorobot particles is induced onto the gingival in the oral cavity of the patient. These nanorobots reach the pulp and block the sensation of the particular tooth involved. After the completion of the procedure, the dentist orders the nanorobot to restore the sensation that was blocked.¹⁷
2. **Orthodontic treatment:** The orthodontic nanorobots directly have an impact on the periodontium and its associated tissue structures, which allows painless straightening of the tooth, rotation of tooth, and it's repositioning within few minutes to hours. However, the use of these nanorobots can help in minimizing the need for fixed orthodontic therapy.^{19,20}
3. **Diagnosis of oral cancer:** The diagnosis of oral cancer is done with the help of nano electromechanical systems or multiplexing modalities.¹⁷

Treatment:

- Nanovectors for gene therapy- Usage of nonviral gene systems
 - Nanomaterial for brachytherapy- Usage of Brachysil (Silva, Australia) delivers 32P (A drug under clinical trial)
4. **Nanoneedles:** A needle used to perform surgeries is just a few billionths of a meter. In addition, nanotweezers are under development that may aid in cell surgeries in the near future.¹⁷
 5. **Bone replacement materials:** There are some smart materials in nanotechnology that helps in repair and regeneration of the cellular tissue. One such material is Ostim (Hydroxyapatite nanoparticles). Another material that aids in the growth of the bone cells is calcium phosphate which is being commonly used.¹⁷ Some characteristics of these materials are:
 - Non-sintered

- Nano structured
 - Osteoinductive
 - Excellent processability
 - Completely synthetic
6. **Nanorobotic dentifrices (Dentrifrobots):** These dentifrices are delivered with the help of toothpaste or mouthwashes that could help in minimizing plaque and calculus formation. Dentrifrobots are variably smaller in size of about 1-10 micron crawling at 1-10 micron/ second.²¹
7. **Nanocomposites:** According to the Nanoproducts Corporation manufacturing, there are nano agglomerated discrete nanoparticles that are distributed homogenously in the form of coatings or resins to produce nanocomposites. It is available under the trade name of Filtek O Supreme Universal Restorative Pure Nano O. These nanocomposites have excellent handling properties and have 50% reduction in the filling shrinkage.²²

NANOTECHNOLOGY IN PREVENTIVE DENTISTRY

Nanotechnology plays a vital role in the prevention of oral disease. This is achieved by two means:

1. Nano toothbrushes: These help in the tremendous decline in gingivitis and periodontitis. There are colloidal silver and gold present in between the bristles of toothbrush that could lead to a reduction in gingival inflammation. There is higher affinity of silver towards the negative molecules which disrupts the cell wall and predisposes to the removal of plaque or biofilm.²³
2. Nano toothpaste: They have been found to be very effective. There is an agglomeration of the bacterial molecules in the porosities of hydroxyapatite crystals because of the porosities present in the enamel prisms. The toothpaste helps in closing these porosities and aids in tooth color as well. Recently, titanium oxide is used as a whitening agent in toothpaste.²⁴

CONCLUSION

Nanotechnology is a novelty for dentistry. It is foreseen that it will change the complete scenario of health care by diagnosis and prevention, gene therapy, drug delivery etc.²⁵ Nano-enabled technologies not only provide an alternative for treatment but some superior approaches in the prevention of diseases with the help of simple techniques and biocompatible materials.

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