

# Futuristic Application of Nano-Robots in Dentistry

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## Abstract

Nanorobots which are considered as the most useful gift of nanotechnology to medical sciences, having size of few nanometers ( $10^{-9}$ )meters are produced by a modern technology called Nanorobotics. These micron-sized devices aid in précised interaction with objects of nanoscale and manipulate with high power resolution. The advents of nanotechnology involve the application of nanorobots in various aspects of dentistry like, Local Anesthesia, Dentition Re-naturalization, and permanent Hypersensitivity cure, complete Orthodontic Realignments during single office visit, and continuous oral health maintenance using mechanical dentifrobots. It is envisioned that Dental Nanorobots could be constructed to destroy caries-causing bacteria or to repair tooth blemishes. Eventhough research work and clinical trials on Nano robots are in the early stage, researchers are quite optimistic regarding the use the these microrobots in dentistry.

**Keywords:** Dentistry, Nanorobots, Nanotechnology.

## Introduction:

“Nano” comes from a greek word “dwarf”. The word nano is a measure of length equalling to one-billionth of a meter. Nano materials are those materials, involving parts that are less than 100 nm in at least one dimension.<sup>1</sup>

The increasing interest in the use of nanotechnology in dentistry has led to the emergence of a new field called Nanodentistry. New ideas in technological research using nanotechnology as a tool for construction of nanorobots will prove an indispensable step in medical and dental science. Nanorobot have a potential to show its effectiveness in inducing oral analgesia, desensitizing tooth, and manipulating the tissue to re-align and straighten irregular set of teeth and improving durability of teeth. These devices are in the development phase and only hypothetical Nanorobot has been produced.

## Nanorobots:

Nanorobots are also known as nanites, or nanomachines, they are theoretical microscopic devices that are measured on the scale of nanometres.<sup>2</sup> Nanorobotics involves manipulation of nanoscale objects by using micro or macro devices, then constructing and programming the robots with overall dimensions that of the nanoscale level. It has been planned to give Nanorobot a smooth surface that will provide streamlined path during their functioning. It is also thought that Glucose, naturally occurring body sugars and oxygen might be a source for propelling the nanodevice in specified direction. Size of a blood born medical nanorobot ranges from 0.5-3 micrometers. These nanorobots are envisioned to be manufactured in desktop nanofactories specialized for this purpose. The ability to build and place large numbers of medical nanorobots into the human body

would, help in elimination of diseases more effectively and provide painless recovery to patients.

### **Parts of Nanorobots:**

Nanorobots are planned to have a diameter of 0.5-3 microns and parts of dimension 1-10 nanometers. There are four Major parts in a Nanorobot. They are camera, pay load , capacitor, swimming tail. The chief element comprising the build of nanorobot are Carbon, Sulphur, hydrogen, oxygen, fluoride which were used for the preparation of nanoscale gears and other nano components.<sup>3</sup> Building nanorobots will involve sensors, actuators, control, power, communications and interfacing across spatial scales and between organic/inorganic as well as biotic/abiotic systems.

### **Mechanism of Action:**

The powering of Nano robots is expected to be done by metabolism of local glucose, oxygen and externally supplied acoustic energy. They can be made to work under control by on-board computers capable of performing around 1000 or more computations per second. Communication with the device can be obtained by acoustic signaling navigational network installed in the body that would provide high positional accuracy to all passing Nano robots and help in keeping track of various devices in the body. When the task of the nanorobots is completed, they can be retrieved by allowing them to effuse themselves via the usual human excretory channels. These can also be removed by active scavenger systems.<sup>4</sup>

### **Nanorobots in Dentistry:**

The growing interest in the development of nanotechnology in dentistry is leading to explore a new field called nanodentistry. Nanorobots have the potential to induce oral analgesia, desensitize tooth, manipulate the tissue to re-align and straighten irregular set of teeth and to improve durability of teeth. Further nanorobots are used to do preventive, restorative, curative procedures.<sup>5</sup>

### **Developments of Nanotechnology in the field of Dentistry:**

**1) Nanocomposites:** Composite with nanofillers has two types of nanofillers – nanomeric and nanocluster type.<sup>6,7</sup>

#### **Advantages**

- a) High filler loading
- b) Desirable handling characteristics
- c) Superior physical properties like modulus of elasticity and flexural strength etc.
- d) 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.

**2) Nanoimpression:** The introduction of Nanofillers into Polyvinylsiloxanes yields a siloxane impression material with properties superior to conventional impression materials.

#### **Advantages**

- a) Better flow
- b) Improved hydrophilic properties leading to fewer voids at margin and better model pouring.
- c) Enhanced detail precision.

**3) Nanosolutions:** These are unique, dispersible nanoparticles with superior properties that can be produced from nanosolutions. This can be made use of dentin bonding agents (Adper™) because of better dentin bond strength and better performance.

**4) Nanoencapsulation:** Trials on controlled drug release has been best experimented in Nano materials with hollow spheres, nanotubes, core-shell structure and nanocomposite.<sup>8,9</sup> Target delivery system has been developed successfully by SWRI [South West Research Institute] that involves nanocapsules including antibiotics ,vaccines and drug delivery.

**5) Nonsurgical Devices:** A surgical knife has been designed from micro structured-silicon with a diamond-layered tip has. Diamond is a material that is chemically rigid, and silicon is non-magnetic and

biocompatible. Nano-sized stainless steel crystals incorporated in suture needles have been developed.

Advantages

- 1) Sharper incisions
- 2) Lower penetration pressure

#### 6) Nanorobotic Dentifrices:

Nanorobotic dentifrices introduced into mouth by mouthwash or tooth paste can cover the sub gingival surfaces. Properly configured dentifrorobots have the potential to identify and destroy pathogenic bacteria existing in the plaque and elsewhere that will help in decreasing halitosis. These mechanical devices crawling at 1-10 microns /sec would be inexpensive and would be programmed in such a manner that they would deactivate themselves if swallowed.<sup>10</sup>

#### 7) Nanoadhesives:

These are unique and dispersible nanoparticles which prevent agglomerations and these are produced from nanosolutions.

Advantages:

- a) Higher dentine and enamel bond strength
- b) High stress absorption
- c) Longer shelf life
- d) Durable marginal seal

#### 8) Nanodiagnosics:

It involves the use of nanodevices or machines for early diagnosis of disease or predisposition at cellular and molecular level. In in-vitro diagnostics, nanomedicine could increase the efficiency and reliability of the diagnostics using human fluids or tissues sample by using selective nanodevices, to make multiple analyses at sub cellular scale, etc.

#### 9) Orthodontic wires:

Nanotechnology derived orthodontic wire is a new and advanced stainless steel wire which has the following properties

- a) ultra-high strength
- b) good deformability
- c) corrosion resistance
- d) good surface finish.

#### 10) New electrochemical process for coating implants:

The modern-day implant after coating with nanoparticles improves function and longevity. This process involves an electrochemical deposition of synthetic hydroxyapatite 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 resembled with the biological materials.

#### Dental Applications:

There are various applications which Nanorobots can offer:

**1) Inducing anesthesia:** after instillation of colloidal suspension containing millions of active analgesic nanorobots into the patients gingiva, the nanorobots reach dentin by migrating into the gingival sulcus and pass painlessly through the lamina propria. Upon reaching the dentin, they enter the dentinal tubules upto 4  $\mu$  depth and proceed toward the pulp guided by a combination of chemical gradient under nanocomputer control. The ingress of nanorobots from tooth surface to the pulp occurs in 100 s. Once installed in the pulp, they establish control over the nerves. Then, nanorobots act according to the commands of the dentist shutting down all sensitivity in any particular tooth requiring treatment.<sup>11,12,13</sup>

**2) Tooth repair:** involves manufacturing and installation of a biologically autologous whole replacement teeth by using genetic engineering, tissue engineering that includes both mineral and cellular parts.

**3) Hypersensitivity cure:** Natural hypersensitive teeth have eight times higher surface density of dentinal tubules and diameter with twice as large than nano-sensitive teeth. Reconstructive dental robots using native biological materials could selectively and precisely occlude specific tubules within minutes, offering a quick and permanent cure.<sup>14,15,16</sup>

**4) Tooth durability and appearance:** Sapphire, a nanostructured composite material has been obtained from nanodentistry, which has enhances tooth

durability and esthetics. This is used to replace the upper enamel layers. This material has 100 to 200 times the hardness and failure strength than ceramic.

**5) Orthodontic treatment:** The treatment generally involves a frictional type of force which provides the desired movement. Orthodontic nanorobots would directly manipulate the tissues of periodontium, which would allow rapid tooth aligning.

#### 6) Diagnosis of oral cancer

**a) Nano Electromechanical Systems (NEMS):-** Nanotechnology based NEMS biosensors that exhibit exquisite sensitivity and specificity for detection of abnormal cells at molecular level are being developed. They convert (bio) chemical to electrical signal.<sup>17</sup>

**b) Oral Fluid NanoSensor Test (OFNASET):-** The Oral Fluid NanoSensor Test (OFNASET) technology is used for multiplex detection of salivary biomarkers for oral cancer.<sup>18</sup>

**c) Optical Nanobiosensor:-** The nanobiosensor is a unique fiberoptics-based tool which allows the minimally invasive analysis of intracellular components (Cytochrome C).<sup>19</sup>

#### 7) Treatment of Oral Cancer:

Nanotechnology in field of cancer therapeutics has offered highly specific tools in the form of multifunctional Dendrimers. 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.<sup>20,21,22,23</sup>

#### 8) Surgical Nanorobotics:

A surgical Nanorobot, operated or guided by an expert dentist, are envisioned to act as on-site surgeon. Such a device are expected to perform various procedures such as detection of pathology and then diagnosing abnormal lesions by nano scale manipulations.<sup>24</sup>

#### 9) Personalized Treatment:

Dentists will perform routine examinations that will include use of high-resolution imaging devices to better visualize the subsurface tomography of each tooth. Advanced Nanorobotic technology will exist that will deliver biologically based therapies to promote remineralisation naturally.

#### Problems for Research in Nanotechnology in India:

The production and application of Nanorobots in India might find the following problems:<sup>25,26</sup>

- Poor and slow strategic decisions
- Inappropriate funding
- Lack of involvement of private agencies
- Inadequate trained manpower and problem of retaining them

#### Conclusion:

Nanotechnology has brought dentistry a miniature technology which has the ability to lessen the burden of dentist in near future. It is envisioned that Nanorobot will help dentists in managing complicated cases of microscopic level with easy and preciseness. It will be of prime help for dentists practicing both conventional and four handed dentistry.<sup>27,28</sup> It has shown effectiveness in various routine clinical procedures like induction of anesthesia and plaque removal. More of clinical trials are required to prove its efficacy in solving other complicated problems. If research work on nanorobots brings success in healing dental ailments then, it will prove boon to dentistry in future decades to come.

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