

# Nanotechnology and Its Applications in Dentistry

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## ABSTRACT

“Nano” is a word derived from Greek meaning “dwarf.” One Nano is  $10^{-9}$  of a meter. It is a scientific approach of altering, manipulating the properties of atoms on a nanometer scale. Nanotechnology involves commonly two approaches that are the Bottom Up approach and Top Down approach. It is possible to maintain a near perfect oral health using nanomaterials, nanorobotics and through the advances in the field of biotechnology. The wider application of nanotechnology in the field of dentistry leads to the emergence of a new field called nanodentistry. It can be used for administering local anesthesia and can also be used to manipulate periodontal tissues in the future thereby allowing a rapid and painless correction of malaligned tooth and that too in a very short time which will save time and less painful compared to the conventional orthodontic treatment. Vinyl poly-siloxane incorporated with nanofillers produce high-quality addition silicone impression materials with better flow, adhesiveness, and improved hydrophilic properties. Failure of implants mainly occurs due to insufficient bone formation around the biomaterial placed, which can be overcome by coating the dental implants with nanoparticles. Dental robots can be used to occlude the dentinal tubules selectively thereby preventing the dentin hypersensitivity permanently within minutes. It can be used in the local delivery of drugs. Mouthwash or toothpaste incorporated with nanorobots prevents the accumulation of calculus by metabolizing trapped organic matter and converts it into odorless and harmless vapors and can be used for replacement of damaged enamel layers. Incorporating nanoparticle in the disinfectant has found to be useful in increasing the efficacy. So that, the rebuilt tooth structure cannot be distinguished from the original structures.

**Keywords:** Nanodentistry, Nanoparticles, Nanorobots, Nanotechnology

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## INTRODUCTION

Nanotechnology and its applications in the field of medicine and dentistry were unheard about three decades back. In 1959, Richard Feynman introduced the term nanotechnology, but the term was coined by Professor Keric E. Denler a researcher and writer in this field.<sup>1</sup> “Nano” is a word derived from Greek meaning “dwarf.” One Nano is  $10^{-9}$  of a meter. It is a scientific approach of altering, manipulating the properties of atoms on a nanometer scale. Using this technology in medical field diagnostics, prevention, treatment, and preservation of biological tissues can be made done based on genetics of the patient.<sup>2</sup>

In nanotechnology, functional structures can be created by manipulating and altering the atoms at the nanometer

level.<sup>3</sup> The various nanostructures thus produced include nanopores, nanotubes, quantum dots, nanoshells, dendrimers, etc. These nanostructures can be used in medical field to diagnose disease in the early phase of development and sometimes it can be used to decipher the encoded information from the genes responsible for causing the disease.<sup>4</sup> As the nanoparticles are so small in size, it can easily interact with biomolecules present on the surface and inside the cells so that it can revolutionize the field of medicine in diagnosis and treatment.<sup>5</sup> The material properties drastically change when manipulation happened at the nanometer level in the atoms and with the invention of high-resolution the microscope, it becomes possible to identify atoms individually which widens the scope of nanotechnology in medicine and dentistry.<sup>6</sup> This technology can be used to identify diseases at the cellular and molecular level.

Nanotechnology involves commonly two approaches that are the Bottom Up approach and Top Down approach. It is a simple, inexpensive, and non-toxic method which enhances the efficacy and reduces the side effects of many drugs ensuring a better quality of life for humans.<sup>7</sup> It is possible to maintain a near perfect oral health using nanomaterials, nanorobotics, and through the advances in the field of biotechnology.<sup>8</sup> The wider application of nanotechnology in the field of dentistry leads to the emergence of a new field called nanodentistry. Hence, this review aims to elaborate the use of nanotechnology in the field of dentistry.

### ADMINISTERING LOCAL ANESTHESIA

Most of the patients denied the dental treatment due to fear of injection. Nanotechnology solution can be used to administer anesthesia painlessly.<sup>9</sup> In this method, colloidal suspension containing millions of micron-sized analgesic dental robots will be instilled onto patient's gingiva.<sup>10</sup> After this solution touches the crown or mucosa, these nanorobots will reach the pulp from the gingival solution through the lamina propria and dentinal tubules under the control of dentist with the help of a nanocomputer.<sup>10</sup> Once it reaches the pulp, these nanorobots will shut down all the sensitivity in that specific tooth and this can be reversed with the help of the same computer to restore the normal physiologic nerve traffic and sensations.<sup>11</sup>

### CORRECTION OF MALALIGNED TEETH

Redelich *et al.* observed that giving orthodontic wire an inactive fullerene-like tungsten disulfide nanoparticle coating reduces the frictional force involved in resisting tooth movement, and thereby it reduce the chance of tooth resorption and loss of anchorage.<sup>12</sup> Nanorobots can also be used to manipulate periodontal tissues in the future thereby allowing a rapid and painless correction of malaligned tooth.<sup>13</sup>

### IMPRESSION MAKING<sup>14</sup>

Vinyl poly-siloxane incorporated with nanofillers produce high-quality addition silicone impression materials with better flow, adhesiveness, and improved hydrophilic properties.

### IMPLANT PLACEMENT<sup>15</sup>

Failure of implants mainly occurs due to insufficient bone formation around the biomaterial placed, which can be overcome by coating the dental implants with nanoparticles. Both the biocompatibility and biointegration can be improved through this method.

### HYPERSENSITIVITY<sup>16</sup>

Dental robots can be used to occlude the dentinal tubules selectively thereby preventing the dentin hypersensitivity permanently within minutes. The time required for the nanorobots to reach pulp was found to be 100 s and provides rapid relief against sensitivity.

### DELIVERING THE DRUGS<sup>17</sup>

Local delivery of drugs is important in the treatment of periodontal disease. Tetracycline incorporated microspheres and triclosan-loaded nanoparticles are found to be efficient in delivering drug locally for the treatment of periodontal diseases.

### NANOROBOTIC DENTRIFICES<sup>18</sup>

Mouthwash or toothpaste incorporated with nanorobots prevents the accumulation of calculus by metabolizing trapped organic matter and converts it into odorless and harmless vapors.

### TOOTH DURABILITY AND APPEARANCE<sup>19</sup>

Replacement of damaged enamel layers, with covalently bonded artificial materials such as diamond and sapphire, improves the hardness and failure strength by 20 times.

### RESTORATIVE MATERIALS

Nanocomposite incorporated composite resin found to have superior hardness, flexural strength, modulus of elasticity, tensile strength and 50% reduction in filling shrinkage compared to conventional ones. Incorporation of nanoparticles produces non-agglomerated discrete nanoparticles with homogeneous distribution of contents.<sup>20</sup> A study done by Xu *et al.* showed that incorporating nanosized calcium phosphate particles into resin based composites improves the stress-bearing capacity of composites.<sup>19</sup>

### BONDING AGENTS<sup>21</sup>

Nanoparticle incorporated bonding agents ensure perfect mixing and homogeneity every time.

### DISINFECTION OF ROOT CANALS

Incorporating nanoparticle in the disinfectant has found to be useful in increasing the efficacy. Nanoparticle incorporated disinfectant had a broad spectrum of antibacterial activity. The studies showed that nanoparticle gel of 0.02 % silver is effective against the

biofilm formation by *Enterococcus faecalis* biofilm.<sup>22</sup> This bioactive glass was found to elevate pH and maintain an alkaline environment for a longer period of time. Nanosterilizing solution produced by the Gandy Enterprises Inc., Florida based on the superior science of nanoemulsion technology has the capacity to bombard and destroy the pathogens. It also has the features of broad spectrum of activity against many microbes, hypoallergic, non-corroding and is found to be environment friendly.<sup>23</sup>

## TOOTH RENATURALISATION<sup>24</sup>

It is possible to manufacture the lost tooth structure with the use of this technology and computer applications.

## PHOTOSENSITIZATION<sup>25</sup>

Quantum dots can be used to bind to antibody present on the surface of the target cell and when stimulated by UV light produces reactive oxygen species which destruct the target cells.

## SUTURING NEEDLES AND SUTURE MATERIALS<sup>26</sup>

Sandvik Bioline and RK 91™ needles are some of the nanosized stainless steel crystals incorporated commercially available suture needles. Currently, researches are going on to develop nanotweezers which will make cell surgery possible in near future.

## BONY DEFECTS CORRECTION<sup>27</sup>

Correction of bony defects and induction of bone growth possible through this technology.

Ostim HA, VITOSSO, and HA + TCP NanoSS are some of the commercially available hydroxyapatite nanoparticles used to treat bone defects. Bone Gen -TR, which resorbs more slowly and helps in bone regeneration consistently.

## NANOTECHNOLOGY IN ORAL CANCER DETECTION AND DIAGNOSIS

### Challenges Faced<sup>28</sup>

Even though nanotechnology is foreseen to revolutionize the health care, there are some concerns too. These includes the ethical issues, suboptimal funding, slow strategic decisions, lack of engagement of private enterprises, and problem of retention of trained manpower.

## CONCLUSION

Nanotechnology can revolutionize the field of dentistry and can bring in enormous changes. Along with a lot of advantages, it also poses a lot of risk to the human beings. So, further research in this field is necessary for its wide application.

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