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Nanorobotics: The New Face of Nano Dentistry

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***Abstract*: Nanorobotics is the technology in which tiny machines or robots are created at or close to the microscopic scale of nanometre. They work at the atomic, molecular and cellular level to identify harmful cells and try to quarantine it. It requires specific controls, sensors and actuators. With the advancement of science, it is now possible to experiment with building nanorobotic systems and interface them with the larger environment for control. There are innumerable examples of these machines in nature, and it is possible to create more by copying nature. We will be able to treat many ailments quickly once we have access to nanorobotics. Their first useful application was in medicine to identify and destroy cancer cells. In dentistry nanorobotics can be used for cavity preparation, oral prophylaxis, drug delivery, root canal treatment, hypersensitivity, also. Thus, in the nearby future we can expect variety of application of nanorobots and the changing face of dentistry.**

***Keywords*: Nanorobotics, robots, microscopic, dentistry, technology.**

1. Introduction

An emerging area of applied science and technology called nanotechnology has the potential to significantly improve society's health. It opens up new directions for extensive, voluminous investigation. It is the branch of science that deals with atomic or molecule level modification of materials. The fundamental principle behind nanotechnology is the use of single atoms and molecules to create useful things. "The science and technology of diagnosing, treating and preventing oral and dental illness, reducing pain and preserving and improving dental health, using nanoscale materials," is how nanodentistry is defined. Nanorobots are also known as nanites, or nanomachines, they are theoretical microscopic devices that are measured on the scale of nanometres. Nanorobots can readily navigate the physical human body since they are so small. By using molecular tools and an understanding of the molecular makeup of the human body, nanorobots will be designed to handle the process that starts with diagnosing the condition, treats it, and then prevents the disease. This will allow for the early detection of diseases and the improvement of human health. Nanorobots will combine haptics and augmented reality with a surgeon's motor skills, diagnostic skill, and sensory perceptions.

2. Mechanism of Action

The metabolism of nearby glucose, oxygen, and externally supplied acoustic energy can be used to power nanorobots. On-board computers with processing speeds of up to 1000 calculations per second can control them. Acoustic signaling of the broadcast type can be used to communicate with the device. A navigational network that has been established inside the body keeps track of all the different bodily parts and gives passing nanorobots a highly accurate positioning reading. By comparing their surface antigens, nanorobots can tell one type of cell from another. Building nanorobots requires interfacial signals across spatial scales, between organic/inorganic as well as biotic/abiotic systems, as well as sensors, actuators, control, power, and communications. Nanoactuators can be triggered by electrical or light impulses. When the nanorobot's mission is over, it can be retrieved by enabling it to expel waste through the normal excretory routes used by humans. Scavenger mechanisms that are active can also get rid of them.

3. Classification of the Nanorobotic Systems

The four types of nanorobotic systems that have been elaborated are (1) bio-nanorobots; (2) magnetically driven nanorobotic systems; (3) large nanomanipulators with nanoscale manipulation ability (4) bacteria-based nanorobots.

A. Bio-Nanorobotic Systems

Bio nanorobots for medicinal applications have been created using modern engineering methods that were inspired by nature. These cutting-edge mechanical nano systems contain structural elements of various biological elements operating at the cellular level that can carry out their pre-programmed biological functions (bacterial propulsion mechanism, DNA-based conformational devices, etc.) in response to particular physicochemical stimuli in an artificial environment, without the need for a hardware mechanism for locomotion. Due to the numerous complications involved in using biocomponents (protein folding, the ability of various biomolecular machine components to interface or assemble/self-assemble), there are currently no predetermined methods for creating bio-nanorobots. As a result, a nanorobotic system for a variety of medical applications may use proteins, DNA, and carbon nanotubes as power sources, structural linkages, joint-like

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elements, transmission elements, or biosensors. Carbon nanotubes and DNA can embed bionano components into their structures and act as structural supports in addition to acting as structural elements. Additionally, because to their stability and elastic qualities, components like vorticellids and spring-like proteins like fibronectin have been investigated as compliant joints in the bio-nanorobotic systems.

B. Magnetically Driven Nanorobotic Systems

Magnetic propulsion has been widely employed to power nanorobots due to the non-intrusive technique of remote actuation and suitable navigational features. Engineering diverse magnetic nanopropellers, including surface walkers, helical propellers, and flexible propellers, has been accomplished using a variety of strategies based on such stimuli. This type of nanorobot is potential for a variety of medical applications, including minimally invasive surgery and targeted therapy. Magnetically driven nanorobots navigate in biological settings in low-resistance magnetic fields that are safe for cells and tissues.

C. Nanorobotic Manipulators

Large robots that can control things as small as a nanometre are known as nanorobotic manipulators. By organising these materials into building blocks and putting them together to create more complicated nano electromechanical systems (NEMSs), nanorobotic manipulation serves as the foundation for a hybrid approach for creating nanodevices. Following the development of the scanning tunnelling microscope, atomic force microscopy, and other varieties of scanning probe microscope, the creation of NEMSs has undergone a considerable evolution. A nanomanipulation system is essentially made up of a number of parts, such as nanorobotic manipulators for positioning microscopes for guidance and observation, probes and tweezers that act as fingers among other things, and various types of sensors used to make manipulation easier and/or determine the properties of objects.

D. Bacterial Nanorobotic Systems

New "biomimetic" nanorobotic systems and preparation techniques are now possible because to the nanoscale exploitation of microorganisms' propulsion capabilities. In order to create such systems, typically one of two methods is used: either artificial bacteria-like nanorobots that mimic the living bacteria's motile structure for propulsion in a fluid environment (flagella, cilia, and pseudopodia) or the use of living bacteria to impart motion to the nanorobotic system.

4. Applications of Nanorobots in Dentistry

There are various applications which Nanorobots can offer.

1) Inducing Anesthesia

After being injected into the patient's gingiva with a colloidal suspension containing millions of active analgesic nanorobots, the nanorobots migrate through the gingival sulcus to reach the dentin and then pass painlessly through the lamina propria. As soon as they enter the dentinal tubules, which are up to 4 μ deep, they move toward the pulp under the supervision of a nanocomputer and a mixture of chemical gradients. Nanorobots enter the pulp of the tooth from the surface in l00 s. They take over control of the nerves once they have been placed in the pulp. Then, nanorobots respond to the dentist's instructions and turn off all sensitivity in any individual tooth that needs to be treated.

2) Nanorobotic Dentifrices (DENTIFROBOTS)

These can cover all subgingival surfaces when administered by toothpaste, metabolising trapped organic materials into flavourless and harmless fumes. Dentifrobots with the right configuration can find and eliminate pathogenic bacteria both in the plaque and elsewhere. These invisibly tiny dentifrobots are entirely mechanical devices that safely turn off when ingested.

3) Orthodontics

Orthodontic nanorobots will enable painless tooth rotation, vertical repositioning, and uprighting, as well as quick tissue recovery. The ability of nanotechnology to destroy the human body at the molecular level makes it possible for orthodontic nanorobots to manipulate periodontal tissues in the near future, enabling rapid and painless tooth straightening as well as rotating and vertical repositioning within minutes to use of nanorobots that aim to taunt the communities.

4) Hypersensitivity Cure

Natural hypersensitive teeth have dentinal tubule surface densities that are eight times larger and twice as large as those of nano-sensitive teeth. Utilizing native biological materials, reconstructive dental robots could quickly and permanently occlude certain tubules by choosing and accurately occluding them.

5) Cavity Preparation

For cavity preparation and tooth repair, several invisible nanorobots may be used that cooperate on the patient's teeth. For maximal preservation of healthy tooth structure, the cavity preparation is very precisely limited to the demineralized enamel and dentin.

6) Tooth Repair

For extensive tooth repair, nanodental approaches use tissue engineering, tissue regeneration, and genetic engineering. For total dentition replacement therapy, nanorobotics primarily creates and install biologically autologous entire replacement teeth that include both mineral and cellular components.

7) Maintenance of Oral Hygiene

Smart nanorobots in mouthwash could recognise and eliminate harmful bacteria while promoting the growth of the mouth's beneficial flora in a stable environment. Additionally, the tools would recognise food, plaque, or tartar particles and lift them from the teeth so they could be cleaned away. Devices would be able to reach surfaces that are out of the reach of toothbrush bristles or floss threads because they are suspended in liquid and may swim about. Nanorobots that live sub-occlusally and are delivered by dentifrice patrol all supra- and subgingival surfaces, metabolising organic material that has been trapped and performing continuous calculus debridement. They guard against tooth decay and act as a permanent halitosis barrier.

8) Diagnosis and Treatment of Oral Cancer

The cantilever array sensor is an ultrasensitive mass detection method that can be utilised for the detection of 10–12 bacteria, viruses, and DNA. Nano electromechanical system (NEMS) transforms biochemical to electrical signal. These are very helpful for detecting bacteria, fungi, and viruses as well as for the diagnosis of oral cancer, diabetes mellitus, and other diseases. The development of novel techniques for detecting cancer relies heavily on nanoparticles. An important step in enhancing cancer treatment is early cancer detection. Cantilever, nanopore, nanotubes, and quantum dots are some of the different nanoparticles used.

9) Endo Micro Robot

This computer-controlled device will be fixed to the patient's teeth. The automated drilling, cleaning, and filling of the root canal will be carried out by the micro machine or robot with on-line monitoring and intelligent control. The outcomes of all other side projects will be applied to this robotic operation. An autonomous feed rate and travel distance control, which ensures that the tools can reach the necessary canal depth and halt at a defined location, as well as micro-position and orientation adjustment are features of micro endo robots. Also embedded micro sensors to track the probing, drilling, and reaming operations, apex sensing and control to avoid the possibility of overshooting (exceeding the apex of the canal) or root perforations, flexible drills or files that make it possible to clean and shape curved canals either vacuum attachments that can remove the chips or loose tissue from the root canal or pressured solution jets.

5. Drawbacks

The initial costs will be high. Complex systems will be involved, making it challenging to customise and interface with these. It is technique sensitive. Hazardous electrical systems could produce stray fields that would be able to trigger bioelectric-based molecular systems in the body. Nanorobots could provide a grave threat in the fight against terrorism. Due to the fact that nanotechnology is also capable of destroying the human body at the molecular level, terrorism and anti-groups may deploy nanorobots to terrorise communities. Some medical professionals are concerned that because nanoparticles are so tiny, they could easily pass through the blood brain barrier, a membrane that shields the brain. Nanorobotics also has some drawbacks, including precise positioning and assembly of molecular scale parts, biocompatibility, societal issues of public acceptance, ethics, regulation, and human safety.

6. Conclusion

Robotics may increase dental care's precision, predictability, safety, level of care, and treatment time. In just a few years, it could change the standard of dental health for everyone. The development of new technology like nanorobotics makes the future of dentistry uncertain. Nanorobots will have a greater impact on human life than other breakthroughs in dentistry, healthcare, and other fields. Although the study of nanorobots is still in its early phases, the possibilities are unlimited. Dental nanorobot applications have great promise for providing disease treatment extremely quickly.

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