Review Article

NANOROBOTICS IN DENTISTRY

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Abstract

Nanorobots are miniature devices measured on the scale of nanometers (1n equals one millionth of 1 millimeter) constructed with nanoscale or molecular components. Other terms used to mention these devices include nanobots, nanoids, nanites or nanomites. Till date, nanorobotics remains a largely hypothetical concept with countless ideas and theories being proposed for their design and usage in several fields, including dentistry. This article tends to give a brief overview of the machines and their potential applications in the dental field.

Key Words: - **N**anodentistry, Nanorobots, Nanotechnology.

Introduction

In our near future, healthcare is predicted to undergo a sea change. Majority of research will be based diagnosis and treatment at the molecular level, what is now known as 'nanomedicine', involving the use of molecular tools and molecular knowledge of the human body. One of the aspects of nanomedicine gaining widespread interest is the development of miniature machines called as nanorobots. The prefix is derived from the Greek word *"nano"* meaning dwarf. The concept of nanorobotics was perhaps first conceived by American Physicist, Richard Feynman, in a lecture titled "There's plenty of room at the bottom" at an annual meeting of American Physics Society. He considered the possibility of making objects, similar to size of a living cell, which can perform functions at the bidding of a controller.[1]

Hypothetically, nanorobots would have the ability to work at the atomic, molecular and cellular level. The applications for such devices in a vast number of fields such as medicine, science and industry can be limitless. Robert Freitas Jr. hypothesized the use of micrometer-sized dental nanorobots that will be capable of several functions including precise local anesthesia, caries excavation and tooth reconstruction, permanent desensitization, single-visit orthodontic realignment, enamel reinforcement and regular oral health maintenance.[2]

Manufacture

Adriano Cavalcanti, a researcher at Centre for Automation of Nanobiotech, Brazil, suggested two approaches for manufacturing nanorobots: organic and inorganic.

Organic nanorobots

These are primarily ATP and DNA based molecular machines, also known as bionanorobots. This is based on the development of ribonucleic acid and adenosine triphosphate devices, or modified microorganisms to attain biomolecular computation, sensing and actuation for nanorobots.[3]

Inorganic nanorobots

The development of inorganic nanorobots is based on building customized miniature nanoelectronic devices. In comparison with bionanorobots, a considerably higher complexity of integrated nanoscale components could be achieved in this field that is suitable for nanorobotic dentistry.

Circular saturated hydrocarbons with a diamond like structure known as diamondoid materials have been widely proposed for son. Due to their exceptional molecular structure they are chemically and thermally stable, can self-assemble and light in weight, making them suitable materials for nanorobot construction. Another type of material holding promise are spherical shaped aromatic carbon compounds called as fullerenes.[3]

Design

The dental nanorobot could have a nanocomputer on board which will store and perform pre-programmed actions and will be able to receive and process signals and external stimuli. Several designs of nanorobots have been proposed, of which a multi-armed spider-like configuration seems the most ideal design as it may enable rapid motility and multi-tasking capability (Fig 1).[4]

The dental nanobot can be designed to utilize energy from internal sources (radioactive particles, solar cells) or external sources (body heat, blood glucose). They can be programmed with two-way communication with the operating dentist by means of acoustic signals or electromagnetic waves. They can also interact with other nanorobots with light signals, optical nanosensors or chemical nanosensors.[5, 6]

Applications[2, 7]

Inducing local anaesthesia

A suspension of anesthetic dental nanorobots can be introduced into the area where anesthesia is desired. Upon activation by the dentist, these robots will then block the sensory nerves from transmitting pain sensation. After completion of the dental procedure, the devices can be commanded to unblock the nerves and de-activate. Several advantages of this technique over the conventional method can be thought of: lesser anxiety and better patient compliance as it is a needleless procedure, better control over areas to be anesthetized, anesthesia can be maintained as long as desired, lack of side-effects and minimizing the risk of complications.

Treatment of Dentine Hypersensitivity

Nanorobots can identify teeth with hypersensitivity and seal their dentinal tubes with desensitizing agents. This would offer immediate and long-lasting relief to the patient as compared to conventional methods.

Orthodontic Treatment

Nanorobots may dramatically reduce the duration of orthodontic therapy by their ability to manipulate the periodontal structures, including gingiva, periodontal ligament and alveolar bone, thus doing away with the need for wearing appliances for prolonged periods and minimizing patient discomfort.

Tooth Reconstruction and Maintenance

Natural teeth can be grown in vitro and implanted into extraction sockets followed by their integration into the surrounding tissues by developing vascular and neurological networks with the help of nanorobots. Reconstructive dental nanorobots can be utilized to improve the aesthetics and durability of teeth by replacing superficial enamel with materials, such as sapphire and diamond. They can also excavate dental caries and restore cavities with tissue engineered biological materials, enabling teeth to regain their original form.

Treatment for the Oral Cancer

Nanorobots can be programmed to penetrate cancerous lesions, identify neoplastic cells and destroy them by increasing the intracellular pressure or temperature utilizing focal lasers, microwaves or ultrasonic waves.

Maintaining an Almost Perfect Oral Hygiene

Nanorobots can be incorporated into dentifrices and mouthrinses for enhancing oral hygiene. These robots will be able to reach remote, difficult to access regions of the dentition such as distal aspect of third molars and selectively destroy pathogenic plaque microorganisms. They also will be capable of limiting bacterial growth in 'incubation zones' such as tonsillar crypts and pericoronal flaps thus minimizing the incidence of re-colonization of clean tooth surfaces. They can control oral halitosis by converting volatile sulphur compounds into odourless metabolites.

Challenges and Risks

Although the field of nanorobotics presents a high potential in a vast spectrum of applications, it is beset with several challenges and risks. The initial input costs for research and development of these miniature devices will be, without doubt, very high. Initiation of research maybe severely hampered due to bureaucratic hurdles and unavailability of funds.

Another aspect that is no less challenging is the design and customization of nanorobots for specialized functions. Shielding these devices from electromagnetic fields may prove to be difficult leading to their malfunctioning. They may also create stray electric fields resulting in unwanted activation of biological molecular systems.

These devices need be synthesized with biocompatible materials to avoid foreign body reaction and rejection by host tissue. They also should be non-replicating and capable of self-destruction once they have achieved their function because there is a risk of self-replicating devices rapidly multiplying and consuming their host in entirety.[8]

Conclusion

The development of semi-autonomous nanorobots could further enhance their capabilities as they will be able to patrol the human body, diagnose pathoses and take necessary actions while surviving for prolonged periods by utilizing exogenous energy sources such as glucose or heat. So far, nanorobots have been confined to the realm of science fiction. Extensive research needs to be done and the challenges posed in the development of nanorobots need to be dealt with in order to pave a way for these breath-taking devices to revolutionize the future of healthcare, including dentistry.

References

1. Feynman R. "There's Plenty of Room at the Bottom." - An invitation to Enter a New Field of Physics. <http ://www.zyvex.com /nanotech / feynman html>
2. Freitas RA Jr. Nanodentistry. J Am Dent Assoc 2000;131(11):1559-1565.
3. Cavalcanti A. Manufacturing Technology for Medical Nanorobots. Asia Pacific Nanotechnology Forum News Journal 2007;6(1).
4. Solarz PS. Nanomedicine Art Gallery: Dental Nanorobots IV. <http:// www foresight. org/ Nanomedicine/Gallery/Captions/Image160 html>
5. Cavalcanti A, Shirinzadeh B, Zhang M, Kretly LC, Nanorobot Hardware Architecture for Medical Defense, Sensor 2008;8:2932-2958.
6. Hogg T, Freitas RA Jr. Chemical power for microscopic robots in capillaries. Nanomedicine, 2010;6(2):298-317.
7. Abhilash M. Nanorobots. Inter J Pharma and Bio Sci 2010;1(1):1-10.
8. Drexler KE. Engines of Creation: The Coming Era of Nanotechnology, Anchor Press/Doubleday, New York, 1986.

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