

Nanorobotics - A Sci-Fi Reality in Medicine and Dentistry

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Abstract

Dentistry is frequently facing revolutions in order to provide a most reliable and comfortable therapeutic option for the patients. Nanotechnology has emerged as a new science exploiting specific phenomena and direct manipulation of materials on the nanoscale. A technology of creating machines or robots at or close to microscopic scale of nanometers is known as nanorobotics. According to nano robotic theory "nanorobots are microscopic in size, it would probably be necessary for very large number of them to work together to perform microscopic tasks". Nanorobots may release inhibitors, antagonists or down regulators for the pyrogenic pathway in a targeted fashion to selectively absorb the endogenous pyrogens, chemically modify them and then release them back into the body in a harmless inactivated form. The present review highlights the use of nanorobotics in dentistry.

Keywords: Nanorobotics; Sci-Fi; Medicine; Dentistry

Introduction

The science of today would be the technology of tomorrow. In a world of fantasies and imagination it was a matter of time before both these fields would lead to evolution of species that think similar ways to us with artificial intelligence meaning robots. The fascination with science fiction and robots is because of creating a world which only we would imagine in dreams, usually these are reflections of ourselves which we see in them [1].

The development of all things nano scale started in the 18th and 19th century. The Historic credit of nanorobots goes to Richard Friedman. He in a conference quoted the line "there's plenty of room at the bottom" meaning starting from a scale nano would lead to greater opportunities, inspiring scientist to view the things around us at a much smaller scale leading to development of newer therapeutic treatment outcomes, drug deliveries, newer treatment planing strategies. This caused the development of emerging field called Nanoscience which would apply this knowledge in the field of medicine and dentistry [2].

The term nanotechnology was coined in 1974 at the state conference in "Tokyo Science University" [3]. Nano is derived from Greek word which means "dwarf". In future a new field would emerge in medicine and dentistry where these imagined small sized robots would

be embedded within our body controlled by human mind. Various applications of nanorobots in the field of medicine and dentistry and their possible future outcome of these fantasy derived nanoscale robots in a therapeutic approach will be enlightened in this review.

History

1867 was the pioneer year where first use of nanotechnology was reported. Maxwell clerk James was the principal scientist who invented a tiny molecule called "Maxwell Demon" through his experiments which was capable of detecting and reacting to motions. Later in 19th century Zsigmondy was the first scientist to observe changes in size and shape of molecule. Massachusetts institute created several robots of these size to sense the environment [4]. The application in medicine was brought to light by joint research by Arizona state university and Chinese academy of national science center for nanotechnology, who tested it for fighting cancer cells [5]. Later Taiwan National Chia Tung University developed a new nano medicine-based immunotherapy to cure cancer. A combination of fucoidan based magnetic nano medicine was used [6].

Design of nanorobots [7]

The system used is NCD (Nanorobot controlled design) which is being used as a test for medical nanodevices where its stimulation shows how to interact and control these devices inside the body. It has two parts: 1) Sensor and 2) Propulsion.

Evolution and use in medicine

Nowadays nano medicine has a vital role in treatment of cancers, cerebral aneurysm, and elimination of defect DNA parts. These range from about 50 to 100 nm in size i.e. about 0.1 to 1 micron meter. The exterior is coated with a diamond material which may contain glycolax that minimizes fibrinogen adsorption and makes it biocompatible.

Nanorobots under research in field of medicine

These include:

1. Nano swimmers
2. Biochips
3. Bacteria powered bots
4. Nubots.

Nano swimmers

These were developed by ETH Zurich and Technion, they are nano carriers that are about 15 μm in length and 20 μm thick. Their small size helps them move through the field more accurately delivering the drug to the target specific site by a magnetically controlled force [8].

Biochips

These small scaled robots use a nano electronic and photolithography technology to get implanted with in the body to dynamically transmit the information to target site and monitor changes *in vivo* [9].

Bacteria powered bots

Developed in Drexel University and Upenn University, which use electric field to help navigate through the human system and make these microscopic bacterial robots identify an obstacle. Also, it would reach the defect site directly and help building the bacterial cell defect [10].

Nubots

These target the site-specific DNA and genetic makeup of the cell. These are nano mechanical devices which use protein to act as a carrier and help assemble 2D and 3D DNA structures.

Application of nanorobots

Medicine

Several drug deliveries based nanorobots are being developed which would be the basis of cancer treatment. Cancer uses anaerobic glycolysis a process that creates limited energy per glucose molecule and for input requires high sugar. These are programmed to defect different cells of E cadherin and β catenin [11,12]. In recent trend a semi-automated programmed on site robot which acts as a surgeon inside the body is being developed these robots use ultrasound signals and can be controlled from the outside by a human surgeon. Injected nanorobots for target specific action are also being developed in the field of cardiovascular and neural surgery. In case of atherosclerosis or other cardiovascular diseases these are injected by intravenous infusion against fatty deposits, whereas for neurological disorders such as Alzheimer's disease they act via a magnetic field based off amyloid protein for detection and treatment [13].

Immune system and blood

Several risks are associated with blood transfusions, to overcome these artificial red blood cells and white blood cells are being developed as biomimetics. One among them is Respirocyte which is an artificial red blood cell used for treating anemias and lung problems. They travel pass the blood vessel as a regular RBC would and deliver about double the amount of oxygen required than compared with a macromolecule. Functions of these Respirocyte as stated apart from oxygen collection is also helping in diffusion of CO_2 [12]. Additionally in case of thrombocytopenia and for effective treatment of immune disorders overcoming the hazards of standard approach an artificial platelet molecule and phagocyte molecule called "Clottocyte and Microbivores" are being researched. These are mesh like about 0.8 μm with proteins fired at arrears of vessel injury to carry out hemostasis and to fight against viral infections such as HIV or Bacteria such as *E. coli*, and also in cases of antibacterial resistance [12].

Dentistry

The scope for use of nano robots in dentistry would be enormous. Virtually every aspect can be controlled programmed affair where these could be introduced i.e. starting from initial analgesic agent a dentist uses to alleviate pain to cosmetic treatments and routine hygiene maintenance care. Emergence in field of nanotechnology in dentistry is mostly in the field of nano materials being used as a scaffold for regeneration. Very little research has been done in the use of nanorobots in dentistry.

Local anesthesia

A suspension of anesthetic dental robots is being studied which can be directly introduced into the area where the anesthesia is desired, upon activation by the dentist these will block the pain receptors and after completion of procedures these can be commanded to unblock. These ambulatory devices travel from gingiva to the pulp within 100 seconds, these act as selectively delivering drugs, nano needles are also being developed with shorter length, grater tensile strength for delivery [14].

Endodontics

These can be used for pulpal anesthesia and can be placed inside the root canal, incases of bleaching. It can be used in dental hypersensitivity.

Orthodontics

These are currently under research, and the proposed elusive mechanism by which they can act is by interacting with the cells with in PDL and Alveolar bone creating signals which can act as receptor for RANK/RANKL OPG and activate tooth movement straightening teeth.

Dentiforts

These are being targeted for children in case of early childhood caries, nursing bottle caries and for adults for maintaining oral hygiene care by potential bactericidal action containing about 500 different species of bacteria float through the oral cavity numbering about 10^3 - 10^5 nano devices per oral cavity. These use a dye injecting agent which identify bacteria and acts subgingivally and are delivered via a mouthwash or a tooth paste.

Squid ink

In 2017 Jesse Jokerest used an oral rinse composed of squid ink made of cornstarch water as the main ingredient and works using the principle of photo acoustic ultrasound that detects gum disease in whole mouth rather than single tooth [15].

Conclusion

The growing interest in the future of dental applications of nanotechnology is leading to the emergence of a new field called nanodentistry. Nanorobots induce oral analgesia, desensitize tooth, manipulate the tissues to realign and straighten irregular set of teeth, and also used in preventive, restorative, curative procedures and major tooth repair.

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