WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 6.805
Volume 5, Issue 7, 380-388. Review Article ISSN 2277– 7105

NANOROBOTICS: A MINIATURE MIRACLES

[1]Dr. Asha M. L., [*2]Dr. Priyanka Basavaraj Lasune, [3]Dr. Basetty Neelakantam Rajarathnam, [4]Dr. H. M. Mahesh Kumar, [5]Dr. Srilakshmi Jasti, [6]Dr. Poulomi Dey

[1] Prof & Head of the Department of Oral Medicine and Radiology, Department of Oral Medicine and Radiology, Dr. Syamala Reddy Dental College, Bangalore, Karnataka.

[3,4]Senior Lecturer, Department of Oral Medicine and Radiology, Dr. Syamala Reddy Dental College, Bangalore.

[2, 5, 6]Post Graduate Student, Department of Oral Medicine and Radiology, Dr. Syamala Reddy Dental College, Bangalore, Karnataka.

Article Received on
20 April 2016,

Revised on 11 May 2016,
Accepted on 02 June 2016

DOI: 10.20959/wjpr2017-6469

***Corresponding Author**
Dr. Priyanka Basavaraj Lasune
Post Graduate Student, Department of Oral Medicine and Radiology, Dr. Syamala Reddy Dental College, Bangalore, Karnataka.

ABSTRACT

Science is evolving continuously and the state-of-the-art research in medicine is based on the diagnosis and treatment at the molecular level, thereby ushering in the new era of Nanotechnology. One of the aspects of nanotechnology that is gaining widespread interest, is the development of miniature machines known as "nanorobots". The word 'Nano' is derived from the Greek word 'Nanos' meaning 'dwarf'. These miniature devices, chiefly composed of carbon in the form of diamond and fullerenes, use specific motility mechanisms to penetrate human tissues with navigational precision to acquire energy and to sense and manipulate their surroundings in real time. This property of nanorobots has been exploited to provide new treatment opportunities in dentistry including precise local anaesthesia, caries excavation and tooth reconstruction, permanent desensitization, diagnosis and treatment of oral cancer, single-visit orthodontic realignment, enamel reinforcement and regular oral health maintenance. Through these novel applications, it can increase efficacy, accuracy and speed of treatment while decreasing the cost. However, 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 miniature wonders to revolutionize the future of dentistry. This paper gives an insight into the potentials and capabilities of Nanorobots in the field of dentistry.

KEYWORDS: nanorobots, dentifrobots, respirocytes, clottocyes.

INTRODUCTION

Since ages, science has revolutionized mankind with the advent of various technologies. One such recent innovation is the field of Nanotechnology. With the increasing research in this field it was successfully possible to introduce a nano scale particle known as the nanorobot. These are miniature devices that have the potential to function at the molecular level. That day is not far away when we will be able to use these nanorobots to penetrate human tissues and exploit their benefits in the field of modern diagnostics and therapeutics. Nanorobots can be used to program a specific motility mechanism to crawl or swim through the human tissues to achieve safe cytopenentration and manipulate their surroundings or alter nerve impulse traffic in individual nerve cells.[1] No wonder this technology will herald enormous changes in dentistry, both in day to day patient care and in the diagnosis and management of dental diseases, which can be achieved painlessly and promptly.[2]

Thus, this article aims to provide a glimpse on the future dental applications of these nanorobots.

Back ground

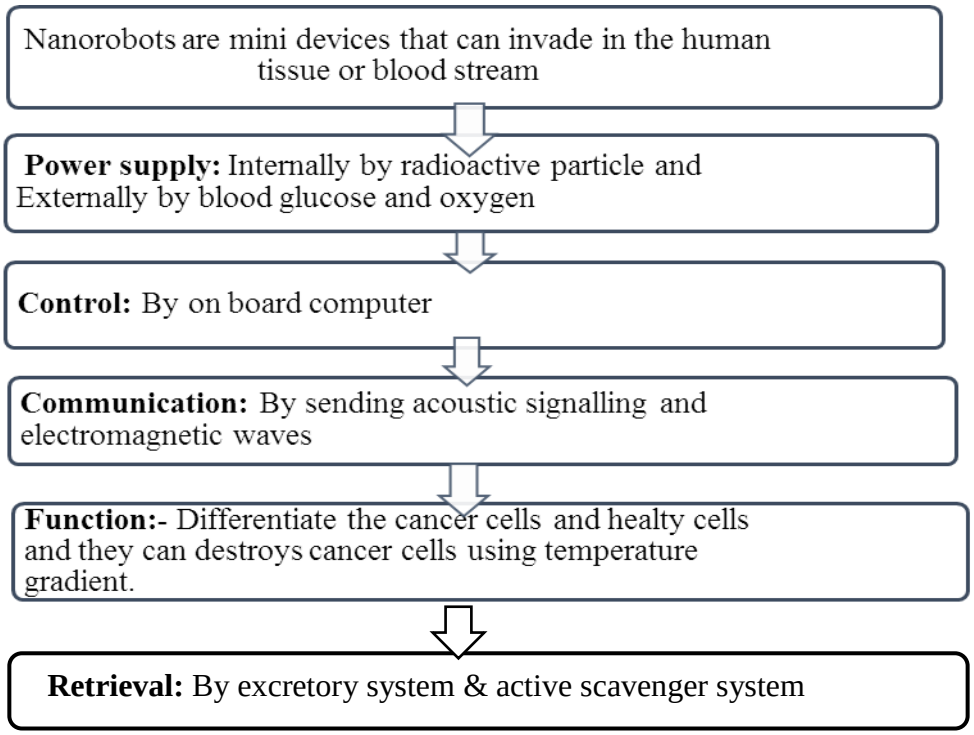
The word 'Nano' originated from the Greeks and means dwarf. Richard Feynman was the scientist to first describe nanorobots in American Physical Society meeting in 1959. (Zsigmondy, 1914).[3] The first technical paper on nanomedical device design was published in 1998 by Robert A. Freitas J.D. titled "A Mechanical Artificial Red Cell: Exploratory Design in Medical Nanotechnology," which discussed about the medical applications of nanorobotics.[4]

Component of nanorobots

Each nanorobots consist of these basic parts like payload, micro camera, swimming tail, capacitor and the functions are as below.

1. Payload- This void section holds a small dose of drug/medicine which is released at the site of infection/injury.
2. Micro camera- The nanorobot may include a miniature camera. The operator can steer the nanorobots when navigating through the body manually.[4, 5]
3. Swimming tail- This part acts as a means of propulsion to get into the body as they travel against the flow of blood in the body.
4. Capacitor- helps in power supply to the nanorobots.[6]

Mechanism of nanorobots: [1, 3, 7]



Types based on the Manufacture

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

Organic nanorobots

They are based on the development of Ribonucleic acid and Adenosine triphosphate devices, or modified microorganisms to attain biomolecular computation, sensing and actuation for nanorobots. They are also known as "bionanorobots".

Inorganic nanorobots

The inorganic nanorobots is based on fabrication of customized miniature nanoelectronic devices. In comparison with bionanorobots, a considerably higher complexity of incorparated nanoscale components could be achieved in this field that is suitable for nanorobotic dentistry. The main element is used in the nanorobots is carbon in the form of fullerence.[3]

Types of nanorobots (Based on the function as artificial blood cell)

Robert A. Freitas Jr designed the following types of nanorobots as artificial blood are:

i. Respirocytes.

ii. Microbivores.

iii. Clottocytes.

Respirocytes: They are artificial mechanical red blood cells which are spherical in shape and circulate in the blood. The outer shell is made of diamondoid 1000 atm pressure. They are powered by endogenous glucose and deliver 236 times more oxygen to the body per unit volume than natural red blood cells.[8, 9]

Microbivores: These microbiovores are work as artificial white blood cell and also known as nanorobotic phagocytes. Their shape is spherical. They migrate into blood stream and they strive for the bacteria, fungi, viruses by phagocytosis.

Clottocytes: They function as artificial platelets. Haemostasis takes place within 1 second by Clottocytes. [10]

Nanorobots in the biomedical applications

Nanorobots are complex structured devices used for diagnosing, treating the disease at molecular level.

The various biomedical applications of nanorobots are as follows:

- Identify the cancer cells and destroy them.
- Applied in chemotherapy to combat cancer by delivering the chemical dosage
- Therapeutic administration of anti-HIV drugs.
  The drug delivery brought about by nanorobots has been termed as “pharmacytes” by R.A.Freitas in 2000.
- Protection of body from pathogens by transmitting inflammatory cells or WBC’s in healing process.
- It helps in minimally invasive surgical procedures using robotic arms to perform micro-movements in the cell injury.
- It helps in the diabetes by lowering glucose concentration in the body.
- It act as drug delivery vehicle to the target site without affecting other parts of the body.[11]

Dental applications

Tooth repair after decay

Nanorobots help in the detection of dental caries and remove the decay with the help of nanoassemblers. The advantage is that they repair and restore the tooth structure without any drilling thus, provide maximum conservation of tooth structure. [12]

Induction of Local anaesthetics

Induction of local anaesthesia is one of the most common procedures in the dental practice, which requires varying degrees of efficacy and may cause patient discomfort and complications. [3] In this present era, nanorobots can be used for painless and fast induction of local anaesthesia. The procedure is as follows:

- A colloidal suspension containing millions of active analgesic micrometer-sized dental nanorobots "particles" are installed on the patient's gingiva.
- These ambulating nanorobots reach the dentin by migrating into the gingival sulcus and lamina propria painlessly.
- The migration of these ambulatory nanorobots into the dentin is guided by a combination of chemical gradients, temperature differentials which are controlled by on board Nano computer, as directed by the dentist. [3]
- These dental nanorobots further reach the pulp, where they establish control over nerve-impulse and shut down all the sensitivity in the tooth requiring the treatment.
- When the dentist presses the icon for the desired tooth with automatic controlled remote, the selected tooth immediately loses the sensation.
- After the completion of oral procedures, the dentist orders the nanorobots (via the same acoustic data links) to restore all sensation.

  Large Nanorobotic analgesics offer greater comfort to the patient and reduce anxiety, thus resulting in a reversible process that is more capable and has lesser side effects. [3, 13, 14]

Dentin Hypersensitivity cure

Dentin hypersensitivity is caused by change in hydrodynamic pressure in the pulp of a sensitive tooth, due to the higher surface density of dentinal tubules than non-sensitive tooth. Specific nanorobots seal these dentinal tubules in few minutes, using a desensitizing agent, thus offering patients a quick and permanent relief from pain. [13, 14]

Dentifrobots

These are nanorobot infused materials that are supplied in the form of toothpaste and mouthwashes. They can traverse over supragingival and subgingival surfaces. The infused nanorobots convert the trapped metabolised organic matter into harmless and odourless vapour. They also destroy the pathogens and bacteria and help to prevent halitosis. [15, 16]

Nano dentifrobots would be relatively inexpensive. In case they are swallowed by the patient, these devices can deactivate themselves safely. Thus, they will prevent further tooth caries or gingival and periodontal diseases from early age. [13, 3, 14]

Dental durability and cosmetics

Tooth durability and appearance may be improved by replacing upper enamel layers with pure sapphire and diamond which are covalently bonded, fracture resistant nanostructured composites. They have 20-100 times the hardness. [14]

Nano Tite dental implants

Biomet 3i, a new dental implant material. The NanoTite Implant builds benefits of Biomet 3 i's OSSEOTITE Implant by adding deposits of nano-scale calcium phosphate crystals to approximately 50% of the surface. This calcium phosphate is recognised by human bone, and allowing the bone and implant to bond during healing. [13]

Orthodontic treatment

Universidad Carlos 3 de Sadrid, Spain (UC3M), in the year 2012 brought a nanomaterial containing hard alumina embedded in polysulfone for making orthodontic Nano brackets. These nanorobotic brackets help in the painless and spontaneous tooth straightening, rotating and vertical repositioning by manipulating the periodontal tissue structure which reduces the duration of procedure within minutes to hours and reduces patient discomfort. [3, 15, 17]

Photosensitizers and carriers

Photosensitizers like quantum dot are used to destroy the target cell. They have the ability to bind to the antibodies present on target cell. Thus, when these quantum dots are stimulated by UV light, they give rise to reactive oxygen species and thus can destroy the target cells. [12]

Nanorobots in diagnosis and treatment

Nanorobots used in the diagnosis and treatment during initial stages of cancer. It detects the cancer cells before metastasis has started. Nanorobots can be injected in the cancerous lesions, they recognize neoplastic cells and destroy them by increasing the intracellular pressure or temperature by utilizing focal lasers, microwaves or ultrasonic waves.[3]

Another important treatment modality is by using intensity of e-cadherin signals. The nanorobots deliver the drug at the site of target area which will bind to chemical biosensors so they can detect the tumour cells at an early stage.

Recently, a hardware architecture based on Nano bioelectronics is used for the application of nanorobots for cancer treatment which provides analysis and conclusion produced by 3D simulation.[11]

Oral Fluid NanoSensor Test (OFNASET)

The Oral Fluid Nano Sensor Test (OFNASET) can be utilized for the identification of salivary biomarkers used for diagnosis of oral cancer. It has been proved that the combination of two salivary proteomic biomarkers (Thioredoxin and IL-8) and four salivary mRNA biomarkers (SAT, ODZ, IL-8, and IL-1b) detect oral cancer with high specificity and sensitivity.[14]

Optical Nanobiosensor

The Nano biosensor is a unique fibre optics-based tool which allows for minimally aggressive technique for analysis of intracellular components such as Cytochrome C, which is a very important protein to the process. It produces cellular energy and is well-known as the protein involved in apoptosis.[14]

DISADVANTAGES OF NANOROBOTS

Even with its myriad uses, these materials may pose with certain drawbacks, for example:

1. The cost of design is expensive.
2. The design is a very complicated.
3. Hard to interface, customize and design.[11]

CONCLUSION

With the ever increasing development in science and technology it is possible that nanorobots can be used in routine day to day dental practice in the near future. Their capability to diagnose and treat the disease at molecular level will enable to eliminate the problem from its root cause, thus promising better outcome and prognosis especially in the field of oncology.

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