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Application Of Nanorobots In Dentistry : Small Packets With Large Potential

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Abstract

Nanorobots, that square measure thought of the foremost helpful gift of applied science to medical sciences, square measure made by a contemporary technology known as Nanorobotics and have a size of some nanometers (10-9)metres. These nanoscale devices modify precise interaction with nanoscale objects and manipulation with high power resolution.Nanorobots square measure getting used in varied aspects of odontology, like anesthesia, dentition re-naturalization, and permanent hypersensitivity cure, complete dentistry Realignments in an exceedingly single workplace visit, and continuous oral health maintenance victimization mechanical dentifrobots, because of the advancements of applied science. Dental Nanorobots might be designed to destroy caries-causing bacterium or repair tooth blemishes, consistent with the researchers. Despite the actual fact that analysis and clinical trials on Nano robots square measure still in their early stages, researchers square measure optimistic regarding their use in odontology.

Keywords: Dentistry, Nanorobots ,Nanotechnology

Introduction

Nature has always used nanotechnology to make molecular structures in the body, such as enzymes, proteins, carbohydrates, and lipids, which are all components of cellular structures.The last century has changed the face of our planet with inventions never thought possible before .Our life has changed absolutely, from regulated heavier-than-air flights and antibiotic medical care to smartphones. With technology advancing at a galloping rate , Nanorobotics is no longer a fairy tale like idea but a soon to become a reality, helping mankind enter a new era, the era of nanotechnology .

Nanotechnology has been defined in numerous ways. According to the dictionary, nanotechnology is "the art of manipulating materials on an atomic or molecular scale, particularly to build microscopic devices.." According to the US government [1]:

Nanotechnology is the research and technology development at the atomic, molecular or macromolecular level, in the length scale of approximately 1–100nm range, to provide a fundamental understanding of phenomena and materials at the nanoscale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size.

Whatever definition is used, properties of matter are controlled at a scale of 1–100nm. Chemical properties, for example, make use of large surface-to-volume ratios for catalysis, interfacial and surface chemistry in a variety of applications . Mechanical properties are dependent on the nanoscale for improved strength, hardness, lightweight nanocomposites and nanomaterials, altered bending and compression properties, and nanomechanics. Improved absorption and fluorescence of nanocrystals, single-photon phenomena, and photonic band-gap engineering are examples of optical properties involving the nanoscale. Fluidic properties lead to improved flow when nanoparticles and adsorbed films are used. Thermal properties improve thermoelectric performance and interfacial thermal resistance in nanoscale materials[1] . The fact that nanoparticles are smaller than the critical lengths defining many physical events is what makes them interesting and endows them with unique properties. Nanotechnology is commonly translated as "the science of the small." .[2]

From Ant-Man to the Incredible Shrinking Machine, society has long dreamed of creating devices small enough to enter human cells . As we learn more, we realise that sometimes the most profound effects can be achieved by shrinking down to the nanoscale.

Size does not describe magnificence , surprises also come in small packages. There is an emerging need for advanced technologies in today's era , taking into account the setbacks in research , biotechnology and advances in dental materials. Nanorobots are an excellent tool for future and are giving rise to better dental materials and improved methods of diagnosis and treatment related to oral healths leading to the emergence of a new field called Nanodentistry . We can imagine a day when we could infuse billions of these nanorobots that would float around in your body[3]

Nanorobotics is a technology, an excellent tool for future where the robots and machines are produced at a nanoscale built from individual atoms . Nanorobotics is a challenging field that deals with microscopic objects at the molecular level and is used in medical and dental applications, including disease monitoring , diagnostic procedures , treatment ,and prevention of oral and dental diseases while reducing the need for invasive procedures . The invention of ‘nanorobot hardware architecture for medical and dental defense' provide the basis for advanced ‘computational nanomechatronics’.

The journey of nanorobots started with its first application in medicine where they were used to identify and destroy cancer cells and were also used to maintain and protect the human body against pathogens . Nanorobots are complex molecular machines that are used for disease diagnosis, treatment, and prevention, pain relief, and preserving and improving human health [4]. These medical nanorobots freely diffuse into the human body and interact with the body cells in order to fulfil task in medical field . Using nanotechnology, a new field of research emerged in the last ten years: dental nanomedicine, which will employ new tools, nanorobots [5] . These dental nanorobots are used for preventive , restorative and curative procedures in dentistry .

Robots, humanity's most wonderful invention, have made their way into dentistry. The necessary technologies have been developed and tested, allowing it to be used in dentistry.

History Of Nanorobots

The formal discovery of nanotechnology, on the other hand, is widely credited to American physicist and Nobel Laureate Richard Phillips Feynman, who presented a paper titled "The plenty of room at the bottom" at the American Physical Society's annual meeting at California Institute of Technology on December 29, 1959. Feynman discussed information storage on a very small scale, writing and reading in atoms, computer miniaturisation, building tiny machines, tiny factories, nanorobots, and nanoelectronic circuits made of atoms. The first application of nanotechnology concepts describes how individual atoms and molecules can be manipulated[7].

The first use of the term “ nanotechnology” was coined by a Professor Norio Taniguchi in a paper published in 1974 called “ On the basic concept of nanotechnology” . He defined the term nanotechnology as ‘ the processing of the separation , consolidation and deformation of the materials by the molecule /atom’ . Since its inception, the definition of nanotechnology has been broadly expanded to include features as small as 100 nm. Nano means "dwarf" in Greek, and when combined with a noun, it forms words like nanometer, nanotechnology, and nanorobot [10]. Dr. Eric Drexler, an MIT graduate, later expanded on Feynman's concept of a billion tiny factories by adding the idea that they could make more copies of themselves using computer control

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rather than human control [6] .He published several scientific articles promoting nanoscale phenomena and devices in the 1980s. In his book " Engines of Creation: The Coming Era Of Nanotechnology " which was published in 1986 popularised the potential of nanotechnology . He believes that in the not-too-distant future, this type of technology will be used to assemble atoms and molecules in order to construct nanocircuits and nanomachines [8].

Working Of Nanorobots [9]:

When a nanorobot is introduced into the body, it must be small and agile enough to navigate the human circulatory system, which is an incredibly complex network of veins and arteries. As a result, it detects the disease, travels to the appropriate system, and administers medication to the affected diseased area. Ultrasonic signals would be sent into the patient's body by doctors . The signals would either pass through the body or reflect back to their source, or both.

The nanorobot could emit pulses of ultrasonic signals, which doctors could detect using ultrasonic sensors on special equipment. Doctors could follow the nanorobot's progress and direct it to the right part of the patient's body. Doctors could also track nanorobots in patients' bloodstreams by injecting a radioactive dye. They would then use a fluoroscope or other similar device to detect the radioactive dye as it circulated through the body.

Complex three-dimensional images would show the location of the nanorobot. Alternatively, the nanorobot could emit the radioactive dye, forming a pathway behind it as it moves through the body. X-rays, radio waves, microwaves, or heat, as well as a Magnetic Resonance Imaging (MRI) device, are other methods of detecting the nanorobot.

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Footsteps Of Nanoparticles/Nanorobots In Dentistry :

Nanodiagnostics:

Early detection of diseases such as cancer at the cellular and molecular levels, pharmacokinetics, and detection of biomarkers and pathogens are all potential applications of nanorobotic devices in medicine[11]. For example, a novel type of biosensor surface modification for the highly specific detection of short RNAs has been used to achieve early cancer diagnosis and disease progression monitoring .

In general, oral cancer can be clinically identified by the presence of premalignant symptoms, and its incidence and mortality can be effectively reduced through early detection. Saliva can be used as a non-invasive diagnostic tool for analysing proteomic and genomic biochemical indices [12].

Human saliva contains a subset of 100 nanometers of secretory vesicles known as "exosomes," which represent a specific set of biomarkers . Exosomes can transport mRNA and microRNA, which can be translated into proteins in target cells. Exosomes, which are released from the salivary gland epithelium, have a cell-specific membrane and exocytose proteins surrounded by a lipid bilayer into the salivary fluid. Exosome secretion is increased in cancer and other diseases, and tumour antigen increases exosomes linked to cancer cells. Because of their small size, salivary exosomes necessitate the use of precise and quantitative detection tools.

Using polymeric nanoparticles[13] to identify cancer-related cell changes and then detecting cancer at an early stage using minimally invasive techniques greatly improves prognosis [14]. Sensor systems such as nanoelectromechanical systems (NEMSs), oral fluid nano-sensor test (OFNASET), and optical nanobiosensors are examples of nanodiagnosis applications.

Nano Electromechanical Systems (NEMS): Nanotechnology-based NEMS biosensors with high sensitivity and specificity for detecting abnormal cells at the molecular level are being developed. They convert (bio)chemical signals into electrical signals .

OFNASET (Oral Fluid NanoSensor Test):- The OFNASET (Oral Fluid NanoSensor Test) technology is used for multiplex detection of salivary biomarkers for oral cancer [15].

The optical nanobiosensor is a one-of-a-kind fiberoptics-based tool that allows for the minimally

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invasive analysis of intracellular components (Cytochrome C) [16]

Local Aneasthesia

In the age of nanodentistry, ongoing research is focusing on colloidal suspensions containing millions of active analgesic dental nanorobotic particles that could be instilled on the patient's gingivae.

After contacting the surface of the crown or mucosa, these nanorobots migrate into the gingival sulcus and reach the dentin painlessly. When the nanorobots reach the dentin, they enter dentinal tubule holes 1 to 4 Am in diameter (10-12) and proceed toward the pulp, guided by a combination of chemical gradients, temperature differentials, and even positional navigation, all under the control of the dentist's onboard nanocomputer.

Once installed in the pulp, the dentist can instruct the analgesic dental robots to turn off all sensitivity in any particular tooth that requires treatment. After the treatment procedure is completed, the dentist instructs the nanorobots to restore all sensation, relinquish control of nerve traffic, and egress from the tooth via the same pathways used for ingress.

Major Tooth Repair

Nanodental techniques for major tooth repair could go through several stages of technological development, starting with genetic engineering, tissue engineering, and tissue regeneration, and then moving on to in vitro growth.

Finally, the nanorobotic fabrication and installation of a biologically autologous whole-replacement tooth that includes both mineral and cellular components—that is, complete dentition replacement therapy—should become feasible within the time and financial constraints of a typical office visit, thanks to the use of an affordable desktop manufacturing facility in the dentist's office that would fabricate the new tooth. Nanodentistry may also play an important role in natural tooth preservation.

Nanodentistry is important in natural tooth repair because it allows for genetic engineering, tissue engineering, and regeneration, as well as the production and installation of a whole new tooth in vitro.

The use of nanorobotic technology to create and install new teeth with the same mineral and cellular components as the original tooth structure would significantly improve the overall treatment plan.

Tooth Repositioning

Orthodontic nanorobots could directly manipulate periodontal tissues such as gingivae, periodontal ligament, cementum, and alveolar bone, allowing for painless tooth straightening, rotating, and vertical repositioning in minutes to hours. This has an advantage over current molar uprighting techniques, which take weeks or months to complete.

Gene Therapy

Gene therapy is a relatively new method of treating or preventing genetic disorders by correcting defective genes that cause disease development through the delivery of repaired genes or the replacement of incorrect ones .

There are three types of gene delivery systems: viral vectors, nonviral vectors (in the form of particles such as nanoparticles, liposomes, or dendrimers), and direct injection of genetic materials into tissues using so-called gene guns[17] . Davis reviewed extensively the applications of nanotechnological tools in human gene therapy, describing nonviral vectors based on nanoparticles (typically 50-500 nm in size) that had already been tested to transport plasmid DNA . He emphasised that nanotechnology would be used in gene therapy to replace currently used viral vectors with potentially less immunogenic nanosize gene carriers. Thus, nanoscale objects could be successfully introduced in fields such as delivering repaired genes or replacing incorrect genes[18].

Dentin Hypersensitivity

Dentin hypersensitivity is another pathological phenomenon that may benefit from nanodental treatment . Dentin hypersensitivity is a common condition characterised by transient tooth pain in response to a variety of exogenous stimuli .

Dental nanorobots could occlude specific tubules selectively and precisely in minutes, providing patients with a quick and permanent cure.As nanorobots travel through the enamel, dentin, and pulp, they reach into the pulp. Once installed in the pulp and in control of nerve impulse traffic, the dentist can instruct the analgesic dental nanorobots to turn off all sensitivity in a specific tooth that requires treatment.

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The nerve is immediately anaesthetized when the dentist passes the icon for the desired tooth on the hand-held controlled display monitor. The dentist instructs the nanorobots to restore all sensation, relinquish control of nerve traffic, and retrieve from the tooth via a similar path using the same acoustic data links after the oral procedures are completed.This analgesic technique is patient-friendly because it reduces anxiety and needle phobia, and it has a quick and completely reversible action .

Drug Delivery

Many agents that cannot be used effectively as conventional oral formulations due to poor bioavailability are finding new therapeutic avenues thanks to nanotechnology. Reformulation of a drug with smaller particle size may improve oral bioavailability in some cases [41]. Nanoparticle formulations protect agents susceptible to degradation or denaturation in harsh pH environments, and they also extend the duration of drug exposure by increasing formulation retention via bioadhesion .

All of these systems, ideally, would improve the drug's stability, absorption, and therapeutic concentration within the target tissue, as well as allow for repeatable and long-term drug release at the target site through bioadhesion of the formulation .

Nanorobotic Dentifrice

A nanorobotic dentifrice delivered via mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day, metabolising trapped organic matter into harmless, odourless vapours and performing continuous calculus debridement.

Durability And Appearance

To improve the appearance and durability of teeth, replace upper enamel layers with covalently bonded artificial materials such as sapphire or diamond, which have 20 to 100 times the hardness and strength of natural enamel.

Reconstructive dental nanorobots will preserve the natural tooth while improving its aesthetic aspect (in terms of colour and texture) and durability by replacing the upper layers of the enamel with artificial biocompatible materials such as sapphire and diamond, which have a hardness 20-100 times greater than natural enamel and thus a greater resistance to fracture. The numerous reconstructive dental nanorobots will be able to excavate old amalgam restorations and will be used to prepare cavities and restore the teeth with biological materials, so that the newly formed teeth cannot be distinguished from the original tooth .

Nanoneedles

Suture needles with nano-sized stainless steel crystals have been created. (Needles Sandvik Bioloine, RK 91 TM) (AB Sandvik, Sweden). Nanotweezers are also being developed, which will allow for cell surgery in the near future.

Nanomaterials For Periodontal Drug Delivery

Hollow spheres, core-shell structures, nanotubes, and nanocomposite are some of the nanomaterials being studied for controlled drug release. Drugs can be incorporated into biodegradable polymer nanospheres, allowing for timed drug release as the nanospheres degrade, facilitating site-specific drug delivery .

Various types of nanoparticles being used for biomedical applications. Some of which are metallic, semiconductor and organic molecule nanomaterials with varieties of shapes, sizes, and structures .

Nanoparticles (NPs) in targeted strategy. The bioactive component of NPs encapsulated in a hydrogel is distributed specifically in the colon when taken orally. NPs are coated with an antibody whose ligands are overexpressed in inflamed areas as part of the targeting strategy. The drug is released in the specific area after the NPs have accumulated.

Nanoencapsulation

SWRI (South West Research Institute) has created targeted release systems that include nanocapsules containing novel vaccines, antibiotics, and drug delivery with minimal side effects.

Osaka University in Japan developed targeted delivery of genes and drugs to the human liver in 2003. Engineered Hepatitis B virus envelope L particles were allowed to form hollow nanoparticles containing a peptide required for the virus's liver-specific entry in humans.Future specialised nanoparticles could be engineered to target oral tissues, including periodontal cells .

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Nanox

It's the portable toothbrush revolution, complete with automatic paste refill. It's a one-touch portable toothbrush with toothpaste built in. Toothpaste and toothbrush are combined with a built-in toothbrush. With a smooth one-touch operation, it has proven its high quality all over the world. Pushing the button twice or three times, depending on the volume required, produces an adequate volume of toothpaste smeared with the brush.

Conclusion

The advancement of nanotechnology has had a significant impact on human lives, as well as the field of health and dental sciences. For the diagnosis, treatment, and prevention of various oral diseases, nanodentistry is a revolutionary era. According to Dr. Gregory Fahy, nanorobots are "living organisms, naturally existing, fabulously complex systems of molecular nanotechnology." Nanorobotics, like all technologies and inventions, has the potential to be misused because the line between harmonious and judicious use and deleterious misuse is very thin.

Molecular technology is on track to become the foundation for all of 21st-century medicine and dentistry.

Nanotechnology will change the future of dentistry, and it will have a significant impact on health care and human life . However, social issues such as public acceptance, ethics, regulation, and human safety may become more prevalent. Before molecular nanotechnology can be used in modern medicine and dentistry, these issues must be resolved.

One might wonder why, given the relatively simple functions required, robots have not yet been introduced to dentistry. One explanation is that robotics in dentistry is a disruptive technology, which means that current dental equipment manufacturers may be concerned about a negative impact on their current business and dentist alienation, as robots may be perceived as a threat to dental professionals. The future of dentistry is uncertain due to the emergence of new technologies.The main source of concern is the vision and feasibility of incorporating these technologies into today's classrooms and clinical experience

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