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Nanotechnology: A Changing Face in Modern Era.

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ABSTRACT

The tremendous growth in scientific and innovative research has provoked scientists to concentrate on the field of regenerative medicine and tissue engineering to construct a biological substitute that will restore and maintain the normal function in diseased and injured tissues. Since then, nanotechnology has been a part of mainstream scientific research with potential medical and dental applications. Nanomedicine helps in the development of devices that are able to work inside the human body to identify the early presence of a disease and quantify toxic molecules [tumor cells]. Nanodentistry will make possible the maintenance of comprehensive oral health by employing nanomaterials and, ultimately, dental nanorobots.

INTRODUCTION

Nanotechnology refers broadly to a field of applied science and technology whose unifying theme is the control of matter on the molecular level in scales smaller than 1μm, normally 1-100nm, and the fabrication of devices within that size range [1]. It is derived from the Greek word for “dwarf” and it is the science of manipulating matter measured in the billionths of meters or nanometers, roughly the size of 2 or 3 atoms [2,3] .

The vision of nanotechnology was introduced in 1959 by late Nobel Physicist Richard P Feynman who proposed employing machine tools to make smaller machine tools, which are to be used in turn to make still smaller machine tools, and so on all the way down to the atomic level [4]. In his historical lecture in 1959, he said “this is a development which I think cannot be avoided” [5].

Nanomedicine

It is the science and technology of diagnosing, treating and preventing disease and it is the science and technology of diagnosing, treating and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using nanoscale structured materials, biotechnology and genetic engineering and eventually complex machine systems and nanorobots [4,6].

Nanodentistry

It will make possible the maintenance of comprehensive oral health by employing nanomaterials, biotechnology, including tissue engineering, and ultimately, dental nanorobotics. New potential treatment opportunities in dentistry may include, local anesthesia, dentition renaturalization, permanent hypersensitivity cure, complete orthodontic realignments during a single office visit, covalently bonded diamondised enamel, and continuous oral health maintenance using mechanical dentifrobots [7].

Nanodiagnostics

It is the use of nanodevices for the early disease identification or predisposition at cellular and molecular level. In *in-vitro* diagnostics, nanomedicine could increase the efficiency and reliability of the diagnostics using human fluids or tissues samples by using selective nanodevices, to make multiple analyses at subcellular scale, etc. In *in vivo* diagnostics, nanomedicine could develop devices able to work inside the human body in order to identify the early presence of a disease, to identify and quantify toxic molecules, tumor cells [7].

Nanomaterial properties

Nanomaterials are of interest from a fundamental point of view because with new materials, comes new properties, which result in new opportunities for technological and commercial development, and applications of nanoparticles have been proposed in areas as diverse as microelectronics, coatings and paints, and biotechnology. From these applications has come the development of nanopharmaceuticals, nanosensors, nanoswitches, and nanodelivery systems.

Two principal factors cause the properties of nanomaterials to differ significantly from other materials: the increase in relative surface area and quantum effects. For example, a particle of 30 nm has 5% of its atoms on its surface, at 10 nm 20% of its atoms, and at 3 nm 50% of its atoms. Nanoparticles have a greater surface area per unit mass compared with larger particles [8].

Nanostructures and their dental applications

Nanoparticles

Nanoparticles with molecular units typically defined as having diameters of between 0.1 and 100 nm of various compositions represent the most widespread use of nanoscale units in dentistry [9]. They are currently being used in RBC restorations; together with the evolution of nanoparticles for dental composites, focus is being applied to reformulations of interfacial silanes [10]. These have been used to coat and bond inorganic fillers into RBC matrices in dental restoratives. Organosilanes such as allyltriethoxysilane have demonstrated good compatibility with nanoparticle fillers such as TiO_2 [11].

Nanorods

Nanorods are of particular interest in a restorative context. Chen and colleagues have synthesized enamel-prism-like hydroxyapatite (HA) nanorods that have exhibited self assembly properties. Since they are similar to the enamel rods that make up the basic crystalline structure of dental enamel, nanorods could contribute to a practical artificial approximation of such a naturally-occurring structure [12].

Nanospheres

In a similar direction, such a potential transition to restorative systems that also mimic nanoscale processes already inherent in natural tooth development will also be explored in this article. Specifically, nanosphere assembly in conjunction with calcium phosphate deposition and amelogenin nanochain assembly will be discussed in a restorative context.

Nanotubes

Nanotubes of various types have been investigated for dental applications in a number of interesting directions. Titanium oxide nanotubes have been shown *in vitro* to accelerate the kinetics of HA formation, mainly in a context of bone-growth applications for dental implant coatings. More recently, modified single-walled carbon nanotubes (SWCNTs) have been shown to improve flexural strength of RBCs. These SWCNTs had silicon dioxide applied to them in conjunction with specialized organosilane bonding agents [13, 14].

Nanotechnology and nano particles in dentistry

Local nanoanaesthesia

In the era of nanodentistry a colloidal suspension containing millions of active analgesic micron-size dental robots will be instilled on the patient’s gingiva. After contacting the surface of crown or mucosa, the ambulating nanorobots reach the pulp via the gingival sulcus, lamina propria and dentinal tubules. Once installed in the pulp, the analgesic dental robots may be commanded by the dentist to shut down all sensitivity in any particular tooth that requires treatment. After oral procedures are completed, the dentist orders the nanorobots to restore all sensation, to relinquish control of nerve traffic and to egress from the tooth by similar pathways used for ingress [15].

Dental hypersensitivity

Natural hypersensitive teeth have eight times higher surface density of dentinal tubules and diameter with twice as large as nonsensitive teeth. Reconstructive dental nanorobots, using native biological materials, could selectively and precisely occlude specific tubules within minutes, offering patients a quick and permanent cure. On reaching the dentin, the nanorobots enter dentinal tubular holes that are 1 to 4 μm in diameter and proceed toward the pulp, guided by a combination of chemical gradients, temperature differentials and even position of navigation, all under the control of the onboard nanocomputer as directed by the dentist. There are many pathways to travel nanorobots from dentin to pulp. Because of different tubular branching patterns, tubular density may present significant challenge to navigation. Assuming a total path of length of about 10 mm from the tooth surface to the pulp and a modest travel speed of about100 μm\second.

Nanorobots can complete the journey into the pulp chamber in approximately 100 seconds. The presence of natural cells that are constantly in motion around and inside the teeth including human gingival, pulpal fibroblasts, cementoblasts, odontoblasts, and bacteria inside dentinal tubules, lymphocytes with in the pulp or lamina propria suggests that such journey be feasible by cell-sized nanorobots of similar mobility [16].

As nanorobots pass through the journey of enamel, dentin reaches into pulp. Once installed in the pulp, having established control over nerve impulse traffic, the analgesic dental nanorobots may be commanded by the dentist to shut down all sensitivity in selected tooth that requires treatment. When the dentist passes the icon for the desired tooth on the hand held controlled display monitor, the immediately anesthetized. After the oral procedure are completed, the dentist orders the nanorobots via the same acoustic data links to restore all sensation, to relinquish control the nerve traffic and to retrieve from the tooth via similar path. This analgesic technique is patient friendly as it reduces anxiety, needle phobia, and most important one is quick and completely reversible action

Tooth durability and appearance

Durability and appearance of tooth may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire or diamond, which have 20-100 times the hardness and failure strength of natural enamel or contemporary ceramic veneers and good biocompatibility [2]. Pure sapphire and diamond are brittle and prone to fracture, can be made more fracture resistant as part of a nanostructured composite material that possibly includes embedded carbon nanotubes.

Nanorobotic dentifrice (dentifrobots) delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day metabolizing trapped organic mater into harmless and odorless vapors and performing continuous calculus debridement. Nanotechnology has improved the properties of various kinds of fibers Polymer nanofibers with diameters in the nanometer range, possess a larger surface area per unit mass and permit an easier addition of surface functionalities compared to polymer microfibers [4]. Polymer nanofiber materials have been studied as drug delivery systems, scaffolds for tissue engineering and filters. Carbon fibers with nanometer diamensions showed a selective increase in osteoblast adhesion necessary for successful orthopedic/dental implant applications due to a high degree of nanometer surface.

Orthodontic treatment

Orthodontic nanorobots could directly manipulate the periodontal tissues, allowing rapid and painless tooth straightening, rotating and vertical repositioning within minutes to hours [8].

How safe are these nanorobots?

The nonpyrogenic nanorobots used in vivo are bulk teflon, carbon powder and monocrystal sapphire. Pyrogenic nanorobots are alumina, silica and trace elements like copper and zinc. If inherent nanodevice surface pyrogenicity cannot be avoided, the pyrognic pathway is controlled by in vivo medical nanorobots. Nanorobots may release inhibitors, antagonists or dowmegulators for the pyrognic 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.

CONCLUSION

Nanotechnology will change dentistry, healthcare, and human life more profoundly than many developments of the past. As with all technologies, nanotechnology carries a significant potential for misuse and abuse on a scale and scope never seen before. However, they also have potential to bring about significant benefits, such as improved health, better use of natural resources, and reduced environmental pollution. Current work is focused on the recent developments, particularly of nanoparticles and nanotubes for periodontal management, the materials developed from such as the hollow nanospheres, core shell structures, nanocomposites, nanoporous materials, and nanomembranes will play a growing role in materials development for the dental industry. Nanomedicine needs to overcome the challenges for its application, to improve the understanding of pathophysiologic basis of disease, bring more sophisticated diagnostic opportunities [17], and yield more effective therapies and preventive properties. Molecular technology is destined to become the core technology underlying all of 21st century medicine and dentistry.

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