Nano Dentistry : Future of Dentistry

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Abstract

Great things come in small packages. This holds true for the word 'Nano'. It has conjured up speculation about a seismic shift in almost every aspect of science and engineering.

Among the most prominent and rapidly emerging fields is nano-technology, including nano-medicine. Nano-technology is expected to pervade and further revolutionize the practice of medicine and dentistry and may well have important applications spanning all aspects of disease, diagnosis, prevention and treatment.

The aim of this paper is to provide a brief introduction of the enormous potential of nano-technology and its applications in dentistry.

Keywords : Nano-technology, Nano-dentistry, Nano-robot .

Introduction

Nano-technology is a natural end result of scientific development and our ability to understand and manipulate matter at smaller and smaller level. Current research is directed towards the production of wide array of different nano-scale structures. The fabrication techniques of the structures can be divided into 2 approaches: “top-down” and “bottom-up.” New potential treatment opportunities in dentistry may include, local anesthesia, dentition re-naturalization, and permanent hypersensitivity cure, complete orthodontic realignments during single office visit, covalently bonded diamondised enamel, and continuous oral health maintenance using mechanical dentifrobots. Nano-technology is foreseen to change health care in a fundamental way by providing novel methods for disease diagnosis and prevention, therapeutics selection, tailored to the patients profile, drug delivery and gene therapy.

The term “nano-technology” was coined by Prof. Kerie E. Drexler, a lecturer and researcher of nano-technology. Nano is derived from the Greek word for “dwarf”. Nano-technology is the science of manipulating matter measured in the manometer, roughly the size of 2 or 3 atoms[16]. The basic idea of nano-technology, used in the narrow sense of the world, is to employ individual atoms and molecules to construct functional structures. The late Nobel Prize winning physicist Richard P. Feynman in 1959 speculated the potential of nano size devices as early as 1959. In his historic lecture in 1959, he concluded saying, «this is a development which I think cannot be avoided[7].

The Various Nano-Particles are [7, 12]

1. Nanopores 2. Nanotubes 3. Quantum dots
4. Nanoshells 5. Dendrimers 6. Liposomes
7. Nanorods 8. Fullerenes 9. Nanospheres
10. Nanowires 11. Nanobelts 12. Nanorings
13. Nanocapsules

Researchers are looking for ways to use microscopic devices entities to perform tasks that are now done by hand or with equipment. This concept is known as nano-technology. Tiny machines, known as nano assemblers, could be controlled by computer to perform specialized jobs. The nano assemblers could be smaller than a cell nucleus so that they could fit into places that are hard to reach by hand or with other technology. Used to destroy bacteria in the mouth that cause dental caries or even repair spots on the teeth where decay has set in, by use of computer to direct these tiny workers in their tasks[2, 4, 3, 19].

Nano-technology has tremendous potential, but social issues of public acceptance, ethics, regulation, and human safety must be addressed before molecular nano-technology can be seen as the possibility of providing high quality dental care to the 80% of the world's population that currently receives no significant dental care[28,6].

Diagnosis and treatment will be customized to match the preferences and genetics of each patient. Treatment options will become more numerous and exciting. It will demand, even more so than today, the best technical abilities, professional skills that are the hallmark of the contemporary dentist and periodontist. Developments are expected to accelerate significantly Technology should be able to target specific cells in a patient suffering from cancer or other life threatening conditions. Toxic drugs used to fight these illnesses would become much more direct and consequently less harmful to the body[4, 27].

Nano Diagnostics

Is the use of nano devices for the early disease identification or predisposition at cellular and molecular level. In **in-vitro** diagnostics, nano-medicine could increase the efficiency and reliability of the diagnostics using human fluids or tissues samples by using selective nano devices, to make multiple analyses at sub-cellular scale, etc. In **in-vivo** diagnostics, nano-medicine 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[8, 17].

Nano-Dentistry

Nano-dentistry will make possible the maintenance of comprehensive oral health by employing nano-materials, including tissue engineering, and ultimately, dental nano-robots. New potential treatment opportunities in dentistry may include: local anaesthesia, dentition re-naturalization, and permanent hypersensitivity cure, complete orthodontic realignments during a single office visit, covalently bonded diamondised enamel, and continuous oral health maintenance using mechanical dentifrobots. When the first micro-size dental nano-robots can be constructed, dental nano-robots might use specific motility mechanisms to crawl or swim through human tissue with navigational precision, acquire energy, sense, and manipulate their surroundings, achieve safe cytopenetration and use any of the multitude techniques to monitor, interrupt, or alter nerve impulse traffic in individual nerve cells in real time. The senanorobot functions may be controlled by an on board nano-computer that executes preprogrammed instructions in response to local sensor stimuli. Alternatively, the dentist may issue strategic instructions by transmitting orders directly to in vivo nano-robotsvia acoustic signals or other means[7, 8].

Nanomaterials in dentistry [9].

Nanocomposites

Nano-products Corporation has successfully manufactured nona-gglomerated discrete nano-particles that are homogeneously distributed in resins or coatings to produce nano-composites. The nanofiller used include an aluminosilicate powder having a mean particle size of 80 ran and a 1:4 M ratio of alumina to silica and a refractive index of 1.508[1]

Advantages

- Superior hardness.
- Superior flexural strength, modulus of elasticity and translucency.
- 50% reduction in filling shrinkage.
- Excellent handling properties.

Nanosolution

Nano-solutions produce unique and dispersible nano-particles, which can be used in bonding agents. This ensures homogeneity and ensures that the adhesive is perfectly mixed every-time.

Impression Materials

Nano-fillers are integrated in vinylpolysiloxanes, producing a unique addition of siloxane impression materials. The material has better flow, improved hydrophilic properties and enhanced detail precision.

Nano-Encapsulation

SWRI [South West Research Institute] has developed targeted release systems that encompass nano-capsules including novel vaccines, antibiotics and drug delivery with reduced side effects. At present, targeted delivery of genes and drugs to human liverhas been developed by Osaka University in Japan 2003.Engineered Hepatitis B virus envelope L particles were allowed to form hollow nano-particles displaying a peptide that is indispensable for liver-specific entry by the virus in humans. Future specialized nano-particles could be engineered to target oral tissues, including cells derived from the periodontium.

Local Nano-Anaesthesia

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 nano-robots 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 nano-robots to restore all sensation, to relinquish control of nerve traffic and to egress from the tooth by

similar pathways used for ingress.[5,8,11,14,18,27]

Dental Hypersensitivity

Natural hypersensitive teeth have eight times higher surface density of dentinal tubules and diameter with twice as large than nonsensitive teeth. Reconstructive dental nano-robots, using native biological materials, could selectively and precisely occlude specific tubules within minutes, offering patients a quick and permanent cure.[8,20,25,27]

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.[8,10]

As nano-robots 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 nano-robots 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 nano-robots 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.[8,10,27]

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 bio-compatibility. Pure sapphire and diamond are brittle and prone to fracture, can be made more fracture resistant as part of a nano-structured composite material that possibly includes embedded carbon nano-tubes.[28] Nano-robotic dentifrice (dentifrobots) delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day metabolizing trapped organic matter into harmless and odorlessvapors and performing continuous calculus debridement.

Nano-technology has improved the properties of various kinds of fibers.[13,2.] 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. Polymer nanofiber materials have been studied as drug delivery systems, scaffolds for tissue engineering and filters.[13,15,21,22] Nanofillers are integrated in the vinylsiloxanes, producing a unique addition siloxane-impression material. Better flow, improved hydrophilic properties, hence fewer voids at margin and better model pouring, enhanced detail precision.[15,21]

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 Nano-robots?

The non-pyrogenic nano-robots used in vivo are bulk teflon, carbon powder and mono-crystal sapphire. Pyrogenic nano-robots are alumina, silica and trace elements like copper and zinc. If inherent nano-device surface pyrogenicity cannot be avoided, the pyrognic pathway is controlled by in vivo medical nano-robots. Nano-robots may release inhibitors, antagonists ordow-megulators 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.[23,24]

Conclusion

Nano-technology will change dentistry, healthcare, and human life more profoundly than many developments of the past. As with all technologies, nano-technology 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 nano-particles and nano-tubes for periodontal management, the materials developed from such as the hollow nano spheres, core shell structures, nano composites, nano-porous materials, and nano-membranes will play a growing role in materials development for the dental industry. Molecular technology is destined to become the core technology underlying all of 21st century medicine and dentistry.

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