



NANOTECHNOLOGY IN DENTISTRY: A BRIEF REVIEW

Dental Sciences

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ABSTRACT

The field of nanotechnology has tremendous potential, which if harnessed efficiently, can bring out significant benefits to the human society such as improved health, better use of natural resources, and reduced environmental pollution. The future holds in store an era of dentistry in which every procedure will be performed using equipments and devices based on nanotechnology. This article reviews the current status and the potential clinical applications of nanotechnology in dentistry.

KEYWORDS

Nanotechnology, Nanodentistry, Nanocomposites.

Introduction

Nanotechnology has come a long way to find its application in Supramolecular chemistry-Self assembling drug carriers and gene delivery systems, Nanoparticles and nanocapsules, Antibody technologies, Polymer-drug conjugates, Polymer-protein and antibody conjugates, Nano-precipitation, nanocrystals, Emulsification technologies, Liposome technology, In situ polymerization, Tissue engineering and repair, Dendrimer technologies, Molecular imprinting including recent innovations in dental diagnostics, material and therapeutics. It has been proposed that nanodentistry will make it possible to maintain near-perfect oral health through the use of nanomaterials,[1,2] biotechnology [3-6] and nanorobotics. Some dental applications of nanotechnology are explained briefly in the following sections:

Local Nanoanesthesia

Ongoing research to induce local anesthesia in the era of nanodentistry, is working on colloidal suspension containing millions of active analgesic dental nanorobotic particles that could be instilled on the patient's gingivae. These nanorobots, after contacting the surface of the crown or mucosa, reach the dentin by migrating into the gingival sulcus and pass painlessly to the target site. On reaching the dentin, the nanorobots enter dentinal tubule holes that are 1 to 4 μm in diameter [7,8,9] and proceed toward the pulp, guided by a combination of chemical gradients, temperature differentials, and even positional navigation, all under the control of the onboard nanocomputer as directed by the dentist. 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 completion of the treatment procedure, 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.

Major tooth repair

Nanodental techniques for major tooth repair may evolve through several stages of technological development, first using genetic engineering, tissue engineering and tissue regeneration, and later involving the growth of whole new teeth in vitro and their installation. Ultimately, the nanorobotic manufacture 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 economic constraints of a typical office visit, through the use of an affordable desktop manufacturing facility, which would fabricate the new tooth, in the dentist's office.

Tooth Repositioning

Orthodontic nanorobots could directly manipulate the periodontal tissues, including gingivae, periodontal ligament, cementum and alveolar bone, allowing rapid and painless tooth straightening, rotating and vertical repositioning within minutes to hours. [10] This offers an advantage over molar uprighting techniques currently in use, which require weeks or months to complete.

Dentin Hypersensitivity

Another pathological phenomenon that may be benefited by nanodental treatment is dentin hypersensitivity. Dentin hypersensitivity is a common condition of transient tooth pain associated with a variety of exogenous stimuli. There is substantial variation in the response to such stimuli from one person to another. Except for sensitivity associated with tooth bleaching or other tooth pathology, the clinical cause of dentin hypersensitivity is exposed dentinal tubules as a result of gingival recession and subsequent loss of cementum on root surfaces[11-13]. Reconstructive dental nanorobots could selectively and precisely occlude specific tubules within minutes, offering patients a quick and permanent cure. As nanorobots pass through the journey of enamel, dentin, reach into the pulp. Once installed in the pulp, having established control over nerve impulse traffic, the analgesic dental nanorobots may be commanded by the dentist to shutdown 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 nerve is immediately anesthetized. After the oral procedures 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.[14,15]

Durability and Appearance

The appearance and durability of teeth may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire[16] or diamond, which have 20 to 100 times the hardness and strength of natural enamel. 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)

A subocclusal-dwelling nanorobotic dentifrice delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day, metabolizing trapped organic matter into harmless and odorless vapors and performing continuous calculus debridement.

Nanodiagnostics

Nanotechnologies already afford the possibility of intracellular imaging through attachment of quantum dots (QDs) or synthetic chromophores to selected molecules, for example proteins, or by the incorporation of naturally occurring fluorescent proteins that, with optical techniques such as confocal microscopy and correlation imaging, allow intracellular biochemical processes to be investigated directly. Even though microarray/ biochip methods making use of the detection of specific biomolecular interactions are now an indispensable tool for molecular diagnostics, there are some limitations. Nanotechnology is being applied to overcome some of the limitations of biochip technology. [16,17] Therapeutic aid in oral diseases Drug delivery Nanotechnology is opening new therapeutic opportunities for many agents that cannot be used effectively as conventional oral formulations because of their poor bioavailability. In

some cases, reformulation of a drug with smaller particle size may improve oral bioavailability.[18] Nanoparticles formulations provide protection for agents susceptible to degradation or denaturation in regions of harsh pH, and also prolong the duration of exposure of a drug by increasing retention of the formulation through bioadhesion. Ideally, all these systems would improve the stability, absorption, and therapeutic concentration of the drug within the target tissue, as well as permit reproducible and long-term release of the drug at the target site.

Conclusion

Nanotechnology has a potential to transform the field of dentistry, but further research is required to explore the utility of nanotechnology in the dental field in order to make its full use in dentistry.

References

1. West JL, Halas NJ. Applications of nanotechnology to biotechnology commentary. *Curr Opin Biotechnol.* 2000;11:215-7.
2. Shi H, Tsai WB, Garrison MD, Ferrari S, Ratner BD. Template imprinted nanostructured surfaces for protein recognition. *Nature* 1999;398:593-7.
3. Sims MR. Brackets, epitopes and flash memory cards: a futuristic view of clinical orthodontics. *Aust Orthod J.* 1999; 15:260-8.
4. Slavkin HC. Entering the era of molecular dentistry. *J Am Dent Assoc.* 1999 Mar;130:413-7.
5. Farr C. Biotech in periodontics: molecular engineering yields new therapies. *Dent Today.* 1997;16:92,94-7.
6. Pruzansky S. Letter to the editor. Effect of molecular genetics and genetic engineering on the practice of orthodontics. *Am J Orthod.* 1972;62:539-42.
7. Goracci G, Mori G. Micromorphological aspects of dentin. *Minerva Stomatol.* 1995;44:377-87.
8. Arends J, Stokroos I, Jongebloed WG, Ruben J. The diameter of dentinal tubules in human coronal dentine after demineralization and air drying. A combined light microscopy and SEM study. *Caries Res.* 1995;29:118-21.
9. Dourda AO, Moule AJ, Young WG. A morphometric analysis of the cross-sectional area of dentine occupied by dentinal tubules in human third molar teeth. *Int Endod J.* 1994;27:184-9.
10. Sahoo SK, Parveen S, Panda JJ. The present and future of nanotechnology in human health care. *Nanomedicine: Nanotechnology, Biology, and Medicine.* 2007;3:20-31.
11. Addy M, West N. Etiology, mechanisms, and management of dentine hypersensitivity. *Curr Opin Periodontol.* 1994;2:71-7.
12. Absi EG, Addy M, Adams D. Dentine hypersensitivity. A study of the patency of dentinal tubules in sensitive and non-sensitive cervical dentine. *J Clin Periodontol.* 1987;14:280-4.
13. Graham L. Identifying, diagnosing, and treating dentin hypersensitivity. *Dent Today.* 2005;24:72-3.
14. Freitas RA Jr. Exploratory design in medical nanotechnology: A mechanical artificial red cell. *Artificial Cells Blood Substitute Immobile Biotechnology.* 1998;26:30-32.
15. Whitesides GM, Love JC. The Art of Building Small. *Scientific American.* 2001;285(3):33-41.
16. Jain KK. Nanodiagnosics: application of nanotechnology in molecular diagnostics. *Expert Rev Mol Diagn* 2003; 3:153-61.
17. Jain KK. Nanotechnology in clinical laboratory diagnostics. *Clin Chim Acta* 2005;358:37-54.
18. El-Shabouri MH. Positively charged nanoparticles for improving the oral bioavailability of cyclosporine. *Int J Pharm* 2002;249:101-8.