NANOTECHNOLOGY IN DENTISTRY

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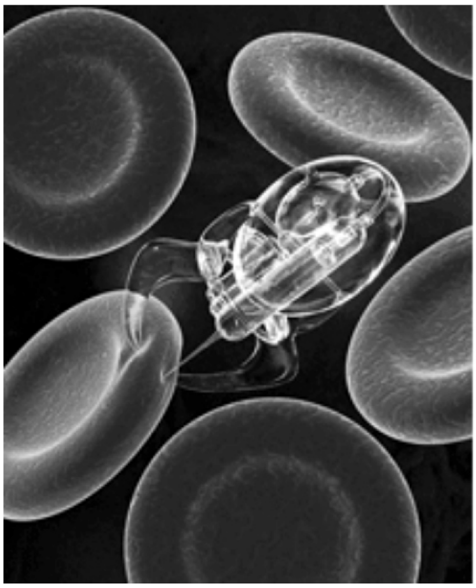
INTRODUCTION

Science is undergoing yet another change, in helping mankind enter a new era, the era of nanotechnology. "Nano" is derived from the Greek word for 'dwarf' .The vision of nanotechnology introduced in 1959 by late Nobel Physicist Richard P Faynman in dinner talk said, "There is plenty of room at the bottom," proposed employing machine tools to make smaller machine tools, these are to be used in turn to make still smaller machine tools, and so on all the way down to the atomic level, noting that this is "a development which I think cannot be avoided". He suggested nanomachines, nanorobots, and nanodevices ultimately could be used to develop a wide range of automically precise microscopic instrumentation and manufacturing tools, could be applied to produce a vast quantities of ultrasmall computers and various nanoscale microscale robots.



Feynman's idea remained largely undiscussed until the mid-1980s, when the MIT educated engineer K Eric Drexler published " Engines of Creation", a book to popularize the potential of molecular nanotechnology.

Nanotechnology is defined as the research and development of materials, devices, and systems exhibiting physical, chemical, and biological properties that are different from those found on a larger scale (matter smaller than scale of things like molecules and viruses). It is the science of manipulating matter measured in the billionths of meters or manometer, roughly the size of 2 or 3 atoms. The term "nano" refers to the nanometer, 1 millionth of a millimeter-- nanotechnology generally deals with structures 100 nanometers and below.Two types of methods exist for working with nanotechnology, each approaching the problem from a different direction. Bottom-up methods use various processes to induce structures to self-assemble at the scale desired. Top-down methods build a structure at a scale easily worked at to, in turn; build another structure at a smaller, unreachable scale.

Nanodentistry 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.

When the first micro-size dental nanorobots can be constructed, dental nanorobots 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.

These nanorobot functions may be controlled by an onboard nanocomputer that executes preprogrammed instructions in response to local sensor stimuli. Alternatively, the dentist may issue strategic instructions by transmitting orders directly to in vivo nanorobots via acoustic signals or other means

Inducing anesthesia

One of the most common procedure in dental practice, to make oral anesthesia, dental professionals will instill a colloidal suspension containing millions of active analgesic micron-sized dental nanorobot 'particles' on the patient's gingivae. After contacting the surface of the crown or mucosa, the ambulating nanorobots reach the dentin by migrating into the gingival sulcus and passing painlessly through the lamina propria or the 1-3-micron thick layer of loose tissue at the cementodentinal junction. On reaching dentin, the nanorobots enter dentinal tubules holes that are 1-4 microns in diameter 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 and having established control over nerve impulse traffic, the analgesic dental nanorobots may be commanded by the dentist to shut down all sensitivity in any particular tooth that requires treatment. When on the hand-held controller display, the selected tooth immediately becomes numb. After the oral procedures completed, the dentist orders the nanorobots to restore all sensation, to relinguish control of nerve traffic and to engress, followed by aspiration. Nanorobotic analgesics offer greater patient comfort and reduced anxiety, no needles, greater selectivity, and controllability of the analgesic effect, fast and completely reversible switchable action and avoidance of most side effects and complications.

Tooth repair

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.

Dentin hypersensitivity

Natural hypersensitive teeth have eight times higher surface density of dentinal tubules and diameter with twice as large than 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.

Tooth repositioning

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

Tooth renaturalization

This procedure may become popular, providing perfect treatment methods for esthetic dentistry. This trend may begin with patients who desire to have their (1) old dental amalgams excavated and their teeth remanufactured with native biological materials, and (2) full coronal renaturalization procedures in which all fillings, crowns, and other 20^{th} century modifications to the visible dentition are removed with the affected teeth remanufactured to become indistinguishable from original teeth.

Dental durability and cosmetics

Durability and appearance of tooth may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire or diamond, [20] which have 20-100 times the hardness and failure strength of natural enamel or contemporary ceramic veneers and good biocompatibility. 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 continous calculus debridement.

Properly configured dentifrobots could identify and destroy pathogenic bacteria residing in the plaque and elsewhere, while allowing the 500 species of harmless oral microflora to flourish in a healthy ecosystem. Dentifrobots also would provide a continous barriers to halitosis, since bacterial putrification is the central metabolic process involved in oral malodor. With this kind of daily dental care available from an early age, conventional tooth decay and gingival deseases will disappear into the annals of medical history.

Nanocomposites

Nanoproducts Corporation has successfully manufactured nonagglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce nanocomposites. The nanofiller used includes 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.Advantages include superior hardness, superior flexural strength, modulus of elasticity and translucency,50% reduction in filling shrinkage and excellent handling properties. Trade name: Filtek O Supreme Universal Restorative P Lire Nano O

Nanosolution

Nanosolutions produce unique and dispersible nanoparticles, which can be used in bonding agents. This ensures homogeneity and ensures that the adhesive is perfectly mixed everytime.Trade name: Adper O Single Bond Plus Adhesive Single Bond

Impression materials

Nanofillers are integrated in vinylpolysiloxanes, producing a unique addition of siloxane impression materials. The material has better flow, improved hydrophilic properties and enhanced detail precision.Trade name: Nanotech Elite H-D

Nanoencapsulation

SWRI [South West Research Institute] has developed targeted release systems that encompass nanocapsules including novel vaccines, antibiotics and drug delivery with reduced side effects.

At present, targeted delivery of genes and drugs to human liver has been developed by Osaka University in Japan 2003. Engineered Hepatitis B virus envelope L particles were allowed to form hollow nanoparticles displaying a peptide that is indispensable for liver-specific entry by the virus in humans. Future specialized nanoparticles could be engineered to target oral tissues, including cells derived from the periodontium

Medical appendages for instantaneous healing

- Biodegradable nanofibres - delivery platform for haemostatic

- Wound dressings with silk nanofibres in development
- Nanocrystalline silver particles with antimicrobial properties on wound dressings [Acticoat™, UK]

Nanoneedles

Suture needles incorporating nano-sized stainless steel crystals have been developed.

Trade name: Sandvik Bioline, RK 91™ needles [AB Sandvik, Sweden].

Nanotweezers are also under development which will make cell-surgery possible in the near future.

Bone replacement materials

Hydroxyapatite nanoparticles used to treat bone defects are

- Ostim® (Osartis GmbH, Germany) HA
- VITOSSO (Orthovita, Inc, USA) HA +TCP
- NanOSS™ (Angstrom Medica, USA) HA

Diagnosis of oral cancer

- NANO ELECTROMECHANICAL SYSTEMS(NEMS)
- CANTILEVER ARRAY SENSORS
- MULTIPLEXING MODALITY

Treatment of oral cancer

NANOMATERIALS FOR BRACHYTHERAPY

BrachySilTM (Sivida, Australia) delivers 32P, clinical trial

DRUG DELIVERY ACROSS THE BLOOD-BRAIN

BARRIER / More effective treatment of brain tumours, Alzheimer's, Parkinson's in development

NANOVECTORSFORGENE THERAPY

POTENTIAL BENEFITS OF NANOTECHNOLOGY

(1) The ability to exploit the atomic or molecular properties of materials.

(2) The development of newer materials with better properties.

CHALLENGES FACED BY NANODENTISTRY

- Precise positioning and assembly of molecular scale part
- Economical nanorobot mass production technique
- Biocompatibility
- Simultaneous coordination of activities of large numbers of independent micron-scale robots.
- Social issues of public acceptance, ethics, regulation and human safe

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. These truly are the days of miracle and wonder. Once nanomechanics are available, the ultimate dream of every healer, medicine man and physician throughout recorded history will, at last become a reality.

REFERENCES

1. Kaehler T, Nanotechnology: Basic Concepts and Definitions, Clinical Chemistry, 40[9]: 17971799,1994.
2. Herzog A: Of Genomics, Cyborgs and Nanotechnology: A Look into the Future of Medicine, Connecticut Medicine, 66[1]: 53-54, 2002.
3. Freitas RA Jr: Nanodentistry, Journal of the American Dental Association, 131(11):15591565,2000.
4. Jhaver HM and Balaji: Nanotechnology: The future of dentistry, 5:15-17, 2005
5. Jayraman K, Kotaki M, Zhang Y, Mox, Ramakrishna S. Recent advances in Polymer nanofibers. J Nanosci Nanotechnol 2004;4:52-65.
6. Saravana R Kumar, R Vijayalakshmi. Nanotechnology in dentistry . Indian journal of dental research 2006: 62-5