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Review Article

Nanotechnology in Dentistry

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ABSTRACT:
Nanotechnology is the engineering of functional systems at the molecular scale. It deals with structures ranging in the size of 100 nanometers or smaller in at least one dimension and developing materials or devices within that size. Nanotechnology deals with the physical, chemical, and biological properties of structures and their components at nanoscale dimensions. Nanotechnology is based on the concept of creating functional structures by controlling atoms and molecules on a one-by-one basis. The use of this technology will allow many developments in the health sciences as well as in materials science, biotechnology, electronic and computer technology, aviation, and space exploration. With developments in materials science and biotechnology, nanotechnology is especially anticipated to provide advances in dentistry and innovations in oral health-related diagnostic and therapeutic methods.
Key words: Nanomaterials, Nanodentistry, Nanorobots, Nanotechnology

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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'. Nanotechnology is the science of manipulating matter measured in the billionths of meters or nanometer, roughly the size of 2 or 3 atoms.[1] The basic idea of nanotechnology is to employ individual atoms and molecules to construct functional structures. It gives us an understanding of how structures (such as polymers, crystals, drugs, and proteins) are made at a fundamental level (from their atoms up to molecular level) and how their molecular arrangements can be altered to alter the macroscopic properties of a material.[2]

The term 'nanotechnology' was coined by Prof. Kerie E. Drexler, a lecturer, researcher, and writer of nanotechnology.[3]

The aims of nanotechnology are to enable the analysis of structures at the nanoscale, to understand the physical properties of structures at the nanoscale dimension, to manufacture nanoscale structures, to develop devices with nano-precision, and to establish a link between nanoscopic and macroscopic universes by inventing adequate methods.[4]

NANOTECHNOLOGY IN DENTISTRY

The development of nanodentistry will allow nearly perfect oral health by the use of nanomaterials and biotechnologies, including tissue engineering and nanorobots.[4]

Nanodentistry includes:
• Nanorobotics,
• Nanodiagnostics,
• Nanomaterials

Nanorobotics

1. Local 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. This ambulated nanorobots reach the pulp via the gingival sulcus, lamina propria and dentinal tubules.[1] Once installed in the pulp and having established control over nerve-impulse traffic, the analgesic dental nanorobots maybe commanded by the dentist to shut down all sensitivity in any tooth that requires treatment. When the dentist presses the icon for the desired tooth on the hand-held controller display, the selected tooth immediately numbs. After the oral procedures are completed, the dentist orders the nanorobots (via the same acoustic data links) to restore all sensation.[2,5]
2. Hypersensitivity Cure: Dentin hypersensitivity may be caused by changes in pressure transmitted hydrodynamically to the pulp. This is based on the fact that hypersensitive teeth have 8 times higher surface density of dentinal tubules and tubule diameter twice as larger than non-sensitive teeth. Dental nanorobots could selectively and precisely occlude selected tubules in minutes, using native biological materials, offering patients a quick and permanent cure.[2,5]
3. Nanorobotic dentrifice: Subocclusal dwelling nanorobotic dentrifice delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces atleast once a day, metabolising trapped organic matter into harmless and odourless vapors and performing continuous calculus debridement.[1]
4. Orthodontic Treatment: 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. This is in contrast to current molar-uprighting techniques, which require weeks or months to complete.[2,5]
5. Dental Durability and Cosmetics Artificial materials such as sapphire or diamond, which have 20 to 100 times the hardness and failure strength of natural enamel or contemporary ceramic veneers, as well as good biocompatibility are nowadays used to improve the durability & appearance of tooth. Though sapphire is susceptible to acid corrosion, it can be manufactured in virtually any color, offering interesting cosmetic alternatives to standard whitening and sealant procedures. Pure sapphire and diamond are brittle are prone to fracture if sufficient shear forces are imposed, but they can be made more fracture-resistant as part of a nano-structured composite material that possibly includes embedded carbon nanotubes.[2,6]

Nanodiagnostics (Diagnosis of Oral Cancer & Other Diseases)

1. Nanoscale Cantilevers These are flexible beams resembling a row of diving boards that can be engineered to bind to molecules associated with cancer.
2. Nanopores These are tiny holes that allow DNA to pass through one strand at a time. They will make DNA sequencing more efficient.
3. Nanotubes These are carbon rods about half the diameter of a molecule of DNA that not only can detect the presence of altered genes but also may help researchers pinpoint the exact location of those changes.
4. Quantum Dots These are nanomaterials that glow very brightly when illuminated by ultraviolet light. They can be coated with a material that makes the dots attach specifically to the molecules to be tracked. Quantum dots bind themselves to proteins unique to cancer cells, literally bringing tumours to light.
5. Nano Electromechanical Systems (NEMS) Nanotechnology based NEMS biosensors that exhibit exquisite sensitivity and specificity for analyte detection, down to single molecule level are being developed. They convert (bio) chemical to electrical signal.[2, 7]

Nanomaterials in Dentistry

1. Nanocomposites: Non agglomerated discrete nanoparticles are homogeneously distributed in resins or coatings to produce nanocomposites. The nanofiller used includes an aluminosilicate powder having a mean particle size of 80 mm and a 1:4 M ratio of alumina to silica and a refractive index of 1.508 [1,2]. Advantages: Superior hardness, flexible strength, modulus of elasticity, translucency, esthetic appeal, excellent colour density, high polish & polish retention & excellent handling properties.
2. Nanosolution: Nanosolutions produce unique and dispersible nanoparticles, which can be added to various solvents, paints & polymers

in which they are dispersed homogenously. Nano technology in bonding agents ensures homogeneity and that the adhesive is perfectly mixed everytime [2,8]

3. Esthetic Materials With the combination of finishing and polishing procedures, a nanotechnology liquid polish application might provide a glossier surface for resin composite restorations. [2]
4. Nano-optimised Mouldable Ceramics • Nanofillers - Enhances polishing ability and reduces wear. • Nanopigments - Adjust the shade of the restoration to the surrounding teeth (chameleon effect). [2]
5. 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 [2,9]
6. 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. Future specialized nanoparticles could be engineered to target oral tissues, including cells derived from the periodontium [1,2]

CONCLUSION:

As of now the effect of nanotechnology on dentistry is limited to the use of currently available materials, although rapidly progressing investigations will ensure that developments that seem unbelievable today are possible in the future. The future utilization of the advantages of nanotechnology will facilitate improvements in oral health. Advanced restorative materials, new diagnostic and therapeutic techniques, and pharmacologic approaches will improve dental care. A successful future for nanotechnology will only be achieved through open sharing of ideas and research finding, through testing and frank discussion.

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