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NANOTECHNOLOGY IN INTERDISCIPILANRY DENTISTRY

Dental Science

Dr. Hussain Mookhtiar * PG Student, Dept. of Conservative Dentistry & Endodontics, M.A. Rangoonwala College of Dental Sciences and Research Centre, Pune. *Corresponding Author

Dr. Vivek Hegde Professor and HOD, Dept. of Conservative Dentistry & Endodontics, M.A.Rangoonwala College of Dental Sciences and Research Centre, Pune.

Dr. Srilatha Shanmugasundaram Reader, Department of conservative dentistry and endodontics, M.A.Rangoonwala College of Dental Sciences and Research Centre, Pune.

Dr Khatija Memon PG Student, Dept. of Conservative Dentistry & Endodontics, M.A.Rangoonwala College of Dental Sciences and Research Centre, Pune.

ABSTRACT

Nanotechnology is the science of breakdown of a matter into molecular and atomic levels which aids in maintaining the homeostasis of the human body. Its use has gained popularity in the field of dentistry and thus the term," nanodentistry" has come to existence. The aim of this article is to review the different materials and techniques used in nanodentistry in various fields, thus staking its claim as the future of dentistry.

KEYWORDS

Nanotechnology, Nanodentistry, Nano materials, Nanoendodontics

Introduction

What is Nanotechnology?

Nanotechnology or Nanoscience, refers to the research and development of an applied science at the atomic, molecular, or macromolecular levels.1

The concept of nanotechnology was first elaborated in 1959 by Richard Feynman, a Nobel Prize winning physicist, in a lecture titled, "There's plenty of room at the bottom". He concluded that "this is a development which I think cannot be avoided".2-4

Since then, research has evolved towards the various of applications of nanotech in dental diagnosis, material and therapeutics. Soon nano-dentistry and its applications will succeed in maintaining near-perfect oral health through the aid of nanorobotics, nanomaterials and biotechnology. 5

Nanomaterials are those components less than 100 nm in at least one dimension. These may include from the smallest unit i.e. atoms clusters to grains, fibres, films, nanoholes, and composites from these combinations. Nanomaterials in one dimension are termed as sheets, in two dimensions as nanowires and nanotubes, and as quantum dots in three dimensions.6

A. DENTAL NANOMATERIALS –

a) Nano-composites:

Nanocomposites are materials that have revolutionized restorative dentistry by providing nanofillers. They contain very minute filler particles, higher proportions can be achieved resulting in indistinctive physical, mechanical, and optical properties.

Nanocomposites, defined by filler-particle sizes of ≤100 nm, can broadly be divided into nanohybrid and nano filled resin-based composites. Finishing, polishing ability, shade matching, flexural strength and hardness of nano-composites are better than conventional composites. Beun et al. compared the physical properties of nano filled, universal hybrid and micro filled composites, and observed a higher elastic modulus with the nano filled Resin based Composites than most of the hybrids tested. One of the most common nanocomposite systems (Premise, Kerr/ Sybron, Orange, CA) has three different types of fillers: non-agglomerated "discrete" silica nanoparticles, barium glass, and prepolymerized filler. 7

Its clinical advantages are follows 8:
Increased hardness.
Improved flexural strength, toughness and translucency.
Decreased polymerization shrinkage (50%).
Exceptional handling properties.
High polish retention
Higher translucency giving it more lifelike appearance

Nano-solution (Nano-adhesives)

Nano-solutions consists of dispersible nanoparticles, which are then used as a component in bonding agents. They lead to a homogenous and perfectly mixed adhesive consistently.
Clinically the have the following advantages9:
Higher dentine and enamel bond strength
High stress absorption
Longer shelf life
Durable marginal seal
No separate etching required
Fluoride release

Trade name: Adper Single Bond Plus Adhesive Single Bond Nano
Light-curing glass ionomer restorative 10-12
This blends Nanotechnology initially developed for Filtek™ Supreme Universal Restorative with fluoralumino silicate technology.

Advantages:
1. Excellent polish.
2. Superb aesthetics.
3. Enhanced wear resistance

Clinical Indications:
Primary teeth restoration.
Transitional restoration.
Small Class I restoration.
Sandwich restoration.
Class III and V restoration.
Core build-up.

Dentifrices:

Nano-sized hydroxyapatite molecules are a major constituent in these dentifrices. These molecules repair the damage tooth structure by forming a protective shell around the tooth structure. Microbrite dentifrice and hasmicrohydrin (1-5 nanometres) which breaks down the organic food particles. 13

Nanorobotic dentifrice (Dentifrobots):

Nanorobotic dentifrices could contain the dentifrobots which would then survey all gingival surfaces regularly. They would also break down harmful materials into harmless substances and undertake

constant calculus removal.14,15

Nano sterilizing solution:
A new sterilizing solution following nano emulsion concept has been developed by Gandly Enterprises Inc Florida. Nanosized oil droplets attack and destroy the pathogens. 19 E.g.: Eco Tru Disinfectant.
Advantages:16,17
Broad spectrum
Hypoallergic
Does not stain fabric
Require no protective clothing
Environment friendly
Compatible with various impression materials.

B. NANOENDODONTICS
Evaluation of metallic or inorganic nanoparticles such as silver, magnesium and zinc oxide salts against endodontic pathogens have been conducted in many in vitro studies. Amongst these, silver nanoparticles were the most commonly considered in the literature. Due to their known antibacterial properties against gram-positive and gram-negative bacteria, spores and viruses, magnesium containing nanoparticles were also considered in treating endodontic pathogens. 18

Polymeric nanoparticles gained significant interest amongst researchers as a result of their biocompatible and antimicrobial properties. Chitosan nanoparticles (Cs-NPs) obtained from shells of crabs and shrimps, are one of the commonly investigated polymeric nanoparticles in the field of endodontics.

The antimicrobial efficacy of bioactive glass material was shown due to:19
1) release its ions when it came into contact with an aqueous medium,
2) increase the surrounding pH
3) increase the osmotic pressure around the bacterial cell causing inhibition of bacterial growth
4) To precipitate calcium and phosphate ions in the bacterial cell membrane, disturbing its functions. 20

C. REGENERATIVE NANOTECHNOLOGY
Bio- Mimicry Dentition re-naturalization This technique may revolutionize cosmetic dentistry. Initially, old amalgams restorations may be removed and the teeth remodelled with natural materials. This may be followed by complete coronal re-naturalization procedures in which all previous procedures may be undone and all the teeth remanufactured to become identical to natural teeth. 21

Dentition replacement therapy (Major tooth repair)
Nanotechnology may utilize genetic engineering, tissue engineering and tissue regeneration initially, followed by growing whole new teeth in vitro and their installation. There will be a time when production and installation of an autologous tooth may become possible in a single office visit. 22

D. DENTAL NANOROBOTICS
a) Local Nano-anaesthesia:
A million of aesthetic dental nanorobots suspended in colloidal solution would be used to induce local anaesthesia. Deposited on the gingival tissue, the nanorobots would reach the dentin and move toward the pulp via the dentinal tubules, guided by chemical differentials, temperature gradients, and positional steering by a nano computer under the control of the dentist. On reaching the dental pulp, the analgesic nano-robots may shut down all sensation in the tooth. On concluding the treatment procedure, the nanorobots may be ordered to re- establish all sensations and to exit from the tooth. This technique is advantageous as it reduces apprehension and is fast and totally reversible. 23

b) Hypersensitivity cure:
Dentin hypersensitivity which is the most common problem amongst patients is another area where dental nanorobots may find their use.

Nanorobots, using local organic materials, could result in effective occlusion of particular tubules, resulting in rapid and stable treatment. 24

Tooth Repositioning:
All the periodontal tissues, namely the gingiva, periodontal ligament, cementum and alveolar bone, may be directed by orthodontic nanorobots leading to swift and pain-free corrective movements. 25

Challenges faced by Nanotechnology[26,27,28]
Precise positioning and manufacture of nanoscale parts.
Cost-effective nanorobot mass manufacturing methods.
Synchronization of numerous independent nanorobots.
Biocompatibility concern.
Financing and tactical concerns.
Inadequate assimilation of clinical research.
Social issues of public acceptance, ethics, regulation and human safety.

Conclusion:
Nanotechnology in the future times will bring humongous changes into the fields of medicine and dentistry. However, as with all developments, it may also pose a risk for misuse and abuse. Time, newer developments, economic and technical resources, and human needs will determine which of the applications are realized first.

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