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NANOTECHNOLOGY IN INTERDISCIPLINARY DENTISTRY

Dental Science

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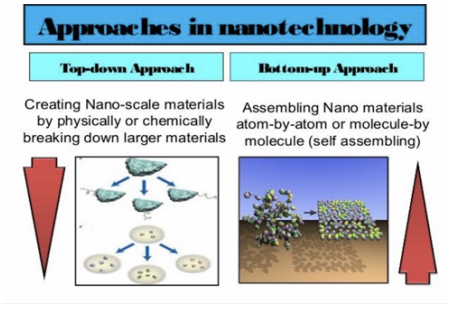
KEYWORDS

INTRODUCTION:-

Renowned scientist Yanxi Li in 2000 said that "If you want to summarize the promise of nanotechnology in one word, that word is "control." For 3,000 years we have been giving drugs to patients, and the drugs go wherever they want and can cause toxicity. They may treat the right things, but we lose control. The promise of nanomedicine and nanotechnology is to allow you to bring back that control.In nanomedicine, you theoretically can program a particular nanomaterial to do what you want it to do using local or remote signals." His words till date give the most precise and apt picturisation of nanotechnology in the filed of health care.

The word "Nanotechnology" Itself was coined first by Richard Feynman in 1959 [1]. The term "Nano" is derived from the Greek word "dwarf". In mathematical terms one nanometer is one-billionth or 10^{-9} of a meter[2]. This technology can be comfortably applied to the fields of medicine and dentistry to yield the terms nanomedicine and nanodentistry respectively.

The various nanomaterials used in nano dentistry are ***nano-pores, nanotubes, quantum dots, nanoshells, dendrimers, liposomes, nanorods, fullerenes, nanospheres, nanowires, nanobelts, nanorings*** and ***nanocapsules***. The formation of these materials follows two major approaches:-

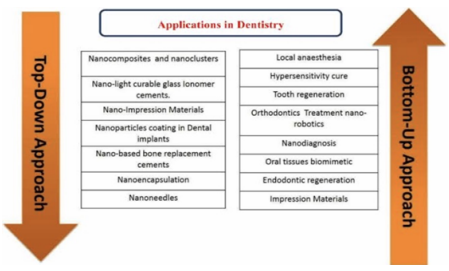


the top down approach and the bottom up approach(figure-1).

Applications Of Nanotechnology In Various Fields Of Dentistry(figure-2):-

This essay, for the first time, aims to classify, the various applications of nanotechnology in dentistry by categorising it into :-

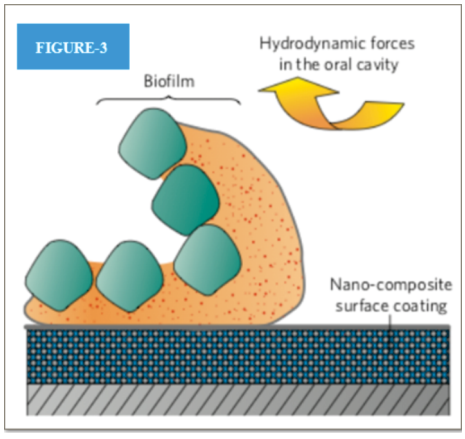
A. DIAGNOSTIC TREATMENT APPLICATIONS.
B. PREVENTIVE TREATMENT APPLICATIONS.
C. RESTORATIVE TREATMENT APPLICATIONS.
D. REGENERATIVE TREATMENT APPLICATIONS.



Diagnostic Treatment Applications Of Nanotechnology:-

1. Nanodiagnostic devices can be used for early disease identification at the cellular and molecular levels. These nanodevices can be used to collect human fluids or tissue samples and to make multiple analyses at the subcellular level.
2. Exosome, a membrane-bound secretory vesicle, is one such marker found in saliva whose level is elevated in malignancy. This marker has been studied by using atomic force microscopy, which employs nanoparticles.
3. The nanoelectromechanical system, oral fluid nanosensor test, and optical nanobiosensor can also be used for diagnosing oral cancer.

Preventive Treatment Applications Of Nanotechnology:-



1. To prevent the intraoral biofilm formation, wear-resistant nano-composite surface coatings have been developed for the modification of the tooth surface in vivo[3]. These surface coatings have a surface free-energy of 20–25 mJ m^{-2} — known as theta surfaces[4] — and facilitate the detachment of adsorbed salivary proteins and adherent bacteria (Fig. 3).
2. Biomimetic carbonate hydroxyl apatite nanoparticles that mimic the size of natural dentinal or enamel apatite are incorporated into mouth rinses and dentifrices and used to repair micrometre-sized tooth-surface defects in vitro[7].
3. Nano-Crystals of Self-assembling anionic β-sheet peptides, based mainly on glutamic acid and glutamine from fibrillar networks, are used to increase remineralization and inhibit demineralization of the enamel.[5]
4. Formation of enamel-like structures was performed in vitro using amelogenin, in slow and precisely controlled crystallization system. Amelogenin aggregates to supramolecular nanospheres and is required for the self-assembly of oriented parallel needle-like apatite bundles. [6]

The major setback in utilising these technologies is the mode of delivery of these biomaterials to their desired areas of need. To overcome this drawback, nanotechnology has come up with the concept of NANOROBOTS. These Dental nanorobots use specific motility mechanisms to penetrate human tissue with navigational precision.[8]

Restorative Treatment Applications Of Nanotechnology:-

1. **Nanoanaesthesia:-** The gingiva of the patient is instilled with a colloidal suspension containing millions of active, analgesic, micron-sized dental robots that respond to input supplied by the dentist.
2. **Nanosolutions:-** Because they produce unique and dispersible nanoparticles, nanosolutions can be used as bonding agents.Nanoparticles have also been used as sterilizing solutions in the form of nanosized emulsified oil droplets that bombard pathogen.
3. **Impression Materials:-**Nanofillers are integrated into vinylpolysiloxanes, producing a unique siloxane impression material that has a better flow, improved hydrophilic properties, and enhanced precision detail.
4. **Bone Replacement Materials:-** Nanocrystals show a loose microstructure, with nanopores situated between the crystals. The surfaces of the pores are modified such that they adsorb protein, due to the addition of silica molecules. Bone defects can be treated by using these hydroxyapatite nanoparticles.
5. **Treatment Of Hypersensitivity:-** Based on the concept of use of nanorobots that selectively and precisely occlude tubules in minutes, by using local, native materials, thus offering patients a quick and permanent cure.
6. **Nano technology In Orthodontics:-** Orthodontic robots allow painless tooth up righting, rotating, and vertical repositioning, as well as rapid tissue repair. A new stainless-steel wire that uses nano technology is being studied that combines ultra-high strength with good deformability, corrosion resistance, and surface finish.
7. **Nano Composites:-** Nano filler technology has enabled the production of nano fill composites(filler size less than 100 nm) by combining the esthetic features of micro fill composites with the mechanical features of hybrid composites.
8. **Nano technology And Antibiotic Therapy:-** This therapy is based on the fact that nano particles are taken up by cells more efficiently than larger micro molecules and therefore can be used as effective transport and delivery systems. Silver, gold, platinum, palladium, and zinc oxide are some specific particles used as antimicrobial agents.

Regenerative Treatment Applications Of Nanotechnology:-

Nanotissue Engineering:-

Replacement of the whole tooth, including the cellular and mineral components, is referred to as *complete dentition replacement*. This therapy is possible through a combination of nanotechnology, genetic engineering, and tissue engineering. Complete dentition replacement was the basis for research by Chan et al., who recreated dental enamel, the hardest tissue in the human body, by using highly organized microarchitectural units of nanorods.

Stem Cells And Nanotechnology:-

The combination of stem cells with sophisticated nano structured materials and scaffolds is increasingly beneficial in all areas of regenerative medicine [10]. Nanoparticles (i.e., 1–100 nm size) can be used both for the diagnosis and targeted therapy through in vivo imaging and drug delivery, and for the creation of biomimetic scaffolds and implants.

Gene, Protein, and Drug Intracellular Delivery

Another attractive concept in manipulating dental stem cell fate is the use of nanomaterials such as polymeric biodegradable nanoparticles, carbon nanotubes, and silicon nanowire arrays for gene and protein delivery.

Artificial Stem Cell Niches: Nano fiber Scaffolds

Dental stem cells anchored to biocompatible and biodegradable nanofiber scaffolds, which are composed by natural or synthetic polymers (e.g., collagen, silk, polylactic acid polymers), could improve their survival, differentiation potential and three- dimensional organization.

Implantology And Nanotechnology:-

The surface properties of dental implants can be modified at the nanolevel, with the ultimate aim of creating a more efficient implant integration in the alveolar bone.It has been demonstrated that interactions between the material and the host tissue are principally governed by nanometric surface cues[9]. Therefore, various strategies have been developed to nanoengineer surfaces that can directly influence the biological functions of implantable metals.

FUTURE :-

Nanotechnology is foreseen to change health care in a fundamental way. The Foresight Institute has offered the $250,000 Feynman Grand Prize to the first researcher or researchers who develop two devices: a basic nanorobot and a nanocomputer. Because the initial nanodevices will be basic, prototypical units, commercial applications will follow years later.

CONCLUSION :-

Nanotechnology will bring enormous 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, economical and technical resources, will determine which of the applications are realized first.

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