NANO DENTISTRY: A REVIEW

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ABSTRACT

Nanotechnology is the manipulation of matter on the molecular and atomic levels. It has the potential to bring enormous changes into the fields of medicine and dentistry. The new era of dentistry will encompass precisely regulated analgesia, tooth renaturalization, complete cure for hypersensitivity and rapid orthodontic treatment. A day may soon come when nanodentistry will succeed in maintaining near-perfect oral health through the aid of Nano robotics, nanomaterials and biotechnology. This review article provides an insight about the importance and possible applications of nanotechnology in the field of dentistry.

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INTRODUCTION

'Nano' is derived from the Greek word, which means 'dwarf'. The concept nanotechnology was set up by physicist Dr Richard Feynman in 1959 and he is known to be Father of nanotechnology. The term nanotechnology was coined by Japanese scientist Dr. Nori Taniguchi in 1974 Nanotechnology can be defined as the science and engineering involved in the design, synthesis, characterization, and application of materials and devices whose smallest functional organization in at least one dimension is on the nanometer scale1 (one-billionth of a meter). It is the control of matter at the nanoscale at dimensions between 1 to 100 nm[1].

'Nanotechnology is widely used in medicine in areas such as drug development, and imaging. Furthermore, the targeted delivery of drugs to diseased cells, such as cancer cells, is an effective, and safer way of treating a disease.[2] The potential applications of nanotechnology are very vast; however, one of the greatest values of nanotechnology will be in the development of new and effective medical treatments. With the application of nanotechnology in dentistry a new stream of nanodentistry is rising. Nanodentistry has a potential to improve oral health by providing the sophisticated preventive, diagnostic, and therapeutic measures using the nanomaterials, biotechnology, and nanorobots.[3] Current research in dentistry includes the use of Nanoparticles, which are being used in resin-based composite (RBC) restorations and in preventive dentistry specifically in control and management of bacterial biofilms. Nanotechnology is also an upcoming tool in the field of implant dentistry. There is a strong belief that nanoscale materials will produce a new generation of implant materials with high efficiency, low cost, and high volume.

Nanostructures used in Dentistry

Commonly explored nanostructures, which can show promising results in dentistry are as follows:

- Nanoparticles
- Nanorods
- Nanospheres
- Nanotubes
- Nanofibers
- Dendrimers
- Nanopores
- Nanoshells

Nanorobotic analgesics

- Nanotechnology uses millions of active analgesic nanometer sized dental nanorobots in colloidal suspension for local anaesthesia.
- Nanorobotic analgesics offer greater patient comfort, reduced anxiety, no-needle, greater selectivity, and control ability of the analgesic effect, fast and completely reversible action and avoidance of most of the side-effects and complications.
- On reaching the dentin nanorobots, within 100 secs, are said to enter dentinal tubules(1 to 4 µm) in diameter.
- Proceed toward the pulp, guided by a combination of chemical gradients, temperature differentials and even position of navigation all under the control of the onboard nanocomputer as directed by the dentist[4].
- 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 sensation, to relinquish control of nerve traffic and to egress from the tooth by similar pathways used for ingress[4,5].

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.

There are many substances which help in teeth repair and regeneration process. These are

I. Hydroxyapatite as a Biomaterial for Dental Restoration

Hydroxyapatite particle (HAp) is a naturally occurring mineral form of calcium apatite, which is predominately obtained in mineralized tissue. It is also one of the major components of dentin. These bioactive nanomaterials can be used as an injectable matrix for periodontal regeneration and bone regrowth.

Overall, HAp-reinforced nanocomposites [Fig.1.] or surface coating improves mechanical stiffness and bioactivity of implants and can be used for dental restoration.

II. Bioinert Zirconia Nanoparticle

Zirconia (or zirconium dioxide)[Fig .2.] is a polycrystalline biocompatible ceramic with low reactivity, high wear resistance and good optical properties. This nano filled zirconia particles promote bone bonding, mineralization and dental tissue repair.

III. Dentin Hypersensitivity

For the treatment of hypersensitivity nano particles of BAG is used.

This technology is known as NovaMin®, Sensodyne [Fig 3.]technically described as an inorganic amorphous calcium sodium phosphosilicate (CSPS) material that was designed based on a class of materials known as bioactive glasses. It comprises 45% SiO2, 24.5% Na2O, 24.5% CaO and 6% P2O[5].

IV. Nanorobotic Dentifrice (dentirobots)

Nanorobotic dentifrice (dentirobots) delivered by mouthwash or toothpaste [Fig.4.]could patrol all supragingival and subgingival surfaces at least once a day metabolizing trapped organic matter into harmless and odourless vapours and performing continuous calculus debridement[8].

Properly configured dentirobots 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.

V. Nano-filled Light Curing Varnish

Application of nanotechnology in GIC is the development of a nano-filled light curing varnish (G-CoatPlus,GC Europe)[Fig .5.], which is applied onto the surface of a highly viscous GIC (Fuji IX GP Extra, GC Europe)[7]. This combination has been commercially branded as EQUIA ('Easy-Quick-Unique-Intelligent-Aesthetic'). The main purpose is to provide surface protection in the early maturation phase of the cement to avoid both water uptake and dehydration. This will lead to improved mechanical properties

VI. IMPRESSION MATERIALS

Nanosilica fillers like Elite HD [Fig.6.] are integrated in vinylpolysiloxanes, producing a unique edition of siloxane impression material.

The material has a

1. Better Flow.

2. Improved Hydrophilic Properties.

3. Tear Strength.

4. Enhanced Detail Precision

The presence of the nanostructure increases the fluidity of the material, especially when pressure is applied.[6]

CONCLUSION

Nanotechnology is such a new, exciting and emerging field with a significant potential to yield new generation of technologically advanced clinical tools and devices for oral health-care. Nano-enabled technologies thus provides an alternative and superior approach to assess the onset or progression of diseases, to identify targets for treatment interventions as well as the ability to design more biocompatible, microbe resistant dental materials, and implants.

For all these things to happen, nanodentistry needs to overcome the various barriers or challenges for its application and yield more effective therapies and preventive properties. Nanotechnology also carries a significant potential for misuse and abuse on a scale and scope never seen before. Nanotechnology might cause adverse effects to human health and environment that are poorly understood. A successful future of nanotechnology will only be achieved through open sharing of ideas, research findings, testing, and forthright discussions.

Research to improve upon existing nanomaterials is still ongoing, with future directions towards more efficient and cost effective in new oral drug delivery systems to disrupt biofilm formation and reduce the incidence of caries and periodontal disease. Although the science behind nanotechnology has lack of long term clinical evidence addressing their clinical performance restricts their wide clinical use.

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