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A Review Of Nanotechnology As A Game Changer In The Field Of Periodontics

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Introduction:

The art and science of creating materials at a scale smaller than 100 nanometres is known as nanotechnology. In a 1974 article, Tokyo Science University's Norio Taniguchi provided the initial definition of nanotechnology, defining it as the manipulation of materials by means of the separation, consolidation, and deformation of individual atoms and molecules. Both natural and manmade nanomaterials are possible. An important development in periodontics is the use of nanotechnology to treat periodontal disorders. About 90% of people worldwide suffer from periodontal disease, with rates as high as 96.3% in poor nations like India. [1]

Untreated inflammatory processes inside periodontal structures, including the gingiva and bone, are the main cause of these disorders. Accessing inflammatory regions is a significant therapy problem. [2]

Another crucial clinical concern is creating more efficient ways to distribute drugs to specific locations. When accompanied by proper postoperative care, traditional therapies such as scaling, root planing, and periodontal flap surgery can be effective.

Due to their scientific significance and commercial potential, regeneration treatments to periodontal abnormalities employing certain agents or procedures have recently attracted more attention. According to the National Nanotechnology Initiative, nanotechnology is the application of phenomena at the nanoscale, which goes beyond the study of tiny particles to include the creation of systems, technologies, and materials with unique chemical, biological, and physical characteristics. [3]

As a result, nanotechnology includes a wide range of technologies with distinct uses and advantages from physics, materials science, engineering, and medicine, among other disciplines.

History:

In 1959, Richard P. Feynman, often referred to as the father of nanotechnology, proposed the idea of using machine tools to create even smaller tools, continuing this process all the way down to the molecular level. He suggested that such nanomachines, nanorobots, and nanodevices could ultimately be used to develop a wide range of atomically precise microscopic instruments and manufacturing tools. [4]

The term "nanotechnology" was coined by Nario Taniguchi in 1975. In 1979, Eric Drexler came across Feynman's 1959 talk titled "There's Plenty of Room at the Bottom." In 1986, Drexler redefined the term "nanotechnology" and wrote "Engines of Creation: The Coming Era of Nanotechnology," which aimed to popularize the potential of molecular nanotechnology. Several pivotal advancements have occurred in the application of nanotechnology to dentistry, including pulp repair, periodontal ligament regeneration, bio-nano surface technology, and implant osseointegration. [5]

The groundbreaking work in nanodentistry represents an exciting new area of study. Nanotechnology has paved the way for further research into the potential benefits of utilizing nanomaterials and techniques in dental treatments. Early research efforts in developing the concept of nanodentistry laid the groundwork for significant advances and further exploration of nanoscale materials and their possible applications. [6]

Properties of Nanomaterials:

When compared to conventional materials, nanomaterials perform better and show improved stiffness and toughness. [7]They also exhibit reduced gas permeability, enhanced resilience to heat, solvents, abrasion, and scratches, and improved transparency.

Furthermore, the chemical, optical, magnetic, and electro-optical properties of nanoparticles are distinctive. These characteristics are very different from those of bulk materials or individual molecules.[7,8]

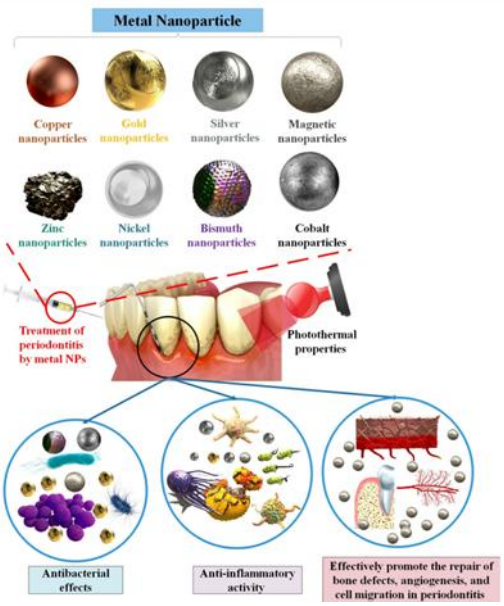
Interestingly, compared to bigger particles, nanoparticles have a higher surface area per unit mass. The ability to self-assemble: One essential feature of nanostructured materials is self-assembly. Without human

assistance, this process entails the autonomous arrangement of constituents into certain patterns or structures. Effective environmental condition adjustment can impact and optimise the entire process.[9]

Mechanism of action:

The use of nanotechnology in dentistry and periodontics, which leads to improved tool and technique efficiency, is based on fundamental principles regulating the behaviour of nanoparticles. Reactivity and surface area are greatly increased by the special qualities of nanoparticles, which include changed physical and chemical properties at the nanoscale. In oral medication delivery systems, this improvement makes it easier to precisely control drug release rates. The use of nanoparticles in periodontics promotes controlled therapeutic drug release, offering a successful therapeutic approach. Additionally, the mechanical qualities of dental composites are enhanced by the use of nanoparticles, increasing the lifetime and durability of restorations. These materials' nanoscale structure is also essential for fostering dental implant durability and osseointegration.

Furthermore, the use of nanotechnology has revolutionised periodontal disease diagnosis and treatment. The ability of nanoscale diagnostic agents to precisely detect bacterial infections and biofilm in periodontal pockets reduces the need for broad-spectrum antibiotics and improves therapy efficacy. With the potential to drastically change clinical practice in patient treatment and diagnostics, the unique qualities of nanoparticles' mode of action in dentistry and periodontics herald a new era of individualised and efficient dental care.[10,12]



Classification:

In the field of nanodentistry, various nanomaterials with distinct characteristics and applications are utilized.[10] Generally, these nanomaterials can be categorized into three main groups:

1. **Nanoparticles**
2. **Nanocomposites**
3. **Nanostructured materials**

A thorough understanding of these classifications is essential to appreciate their roles and potential within the industry.

Nanoparticles are fundamental to the application of nanotechnology in dentistry. They possess sizes ranging from 1 to 100 nanometers, making them exceptionally small and unique entities. Due to their distinctive properties at the nanoscale, nanoparticles are widely used in dentistry as drug delivery systems, diagnostic agents, and for tissue engineering. Their adaptability and versatility significantly enhance the precision and effectiveness of dental treatments.

Nanocompositesare innovative materials that integrate traditional dental substances, such as resins and ceramics, with nanoparticles. By incorporating nanoparticles, these composites offer improved durability, enhanced antimicrobial resistance, and aesthetically pleasing qualities.

Nanostructured materials are increasingly employed in dental implant fabrication, thanks to their contributions to enhanced osseointegration and overall durability. Recognizing the differences among these

categories is crucial for dental professionals when selecting the appropriate nanomaterial for specific applications. [11]

Nanotechnology applications in periodontics:

From non-surgical treatments to implant operations, including regenerative procedures, nanotechnology in periodontics has impacted every facet of treatment. A better treatment process, more effective use of nanotechnology, and ultimately better results all depend on an understanding oftheirmechanism.

Dentifrobots,ornanoroboticdentifrice:

By travelling throughout the supragingival and subgingival surfaces, nanorobots (dentifrobots) produced by mouthwash or toothpaste on the occlusal surfaces of teeth can remove organic residues and continuously stop calculus from building up. When eaten, these nanorobots, which are as small as 1–10 microns and have a maximum speed of 1–10 microns/second, safely deactivate. When properly set up, Denti robots are able to recognise and eliminate harmful bacteria that are present in the plaque.

Nanofibers:

Fibres with a diameter in the nanometre range are called nanofibers. Numerous nanomaterials, including nanofibers such as nanorods, nanoplatelets, nanotubes, nanofibrils, and quantum wires, are being thoroughly studied for a range of uses, with a particular emphasis on their potential for periodontalregeneration.

Tissueengineeringforbonesandcartilage:

Scaffolds are crucial for tissue regeneration because they offer an environment that is conducive to cell differentiation and proliferation. As a framework for alveolar bone and cartilage repair, nanofibers are essential for the targeted administration of medications, growth hormones, and genetic materials[13]. Because nanoparticles are smaller and have a bigger surface area, the scaffold becomes more porous, allowing for improved drug and growth factor infiltration.

Engineering of ligament tissue :

By using conventional techniques or natural tendencies, tissue engineering methods utilising nanofibers have been tried to address the problem of inadequate or inappropriate ligament healing following an injury (Lin et al., 1999). Aligned nanofibers, in particular, improved cell responsiveness and were therefore investigated as scaffolds for ligament tissue engineering.[15]

Graftmaterialandtissueengineering:

To improve integration into vascular tissue and hence boost implant efficiency, a graft with standard PLGA on the inside (boosting endothelial cell function) and nano-structured PLGA-Poly(lactic-co-glycolic acid) on the outside (promoting smooth muscle cell function) could be used .[16]

Dentalhypersensitivitytreatment:

Another condition that can benefit from nanodental therapy is dentin sensitivity. For this prevalent, excruciating illness, many treatment medicines only have a short-term impact. Dental nanorobots, on the other hand, can quickly and permanently cure this disease by sealing particular tubules using natural biomaterials in a matter of minutes. According to Tian and colleagues' theory, excessive dispersion of nanomaterials allows them to readily enter the dentinal tubules, which are 2-3 um in diameter, and block sensation, hence relieving dental hypersensitivity.[16]

Nano-anesthesia:

Anaesthesia is a necessary component of periodontal surgery. In addition to the standard anaesthesia technique, which involves injections, there is a lengthy waiting period and the need for additional injections for treatments that take longer. Nanotechnology makes it feasible to encapsulate different anaesthetic medications.[17]

Local drug delivery:

The term "local drug delivery" describes the application of medications to specific illness sites, which aids in treatment that is more site-specific as opposed to systemic. Triclosan particles were applied to the site of inflammation in a trial, and this helped to reduce the inflammation. Additionally, it discussed the potential applications of nanotechnology, including the Arestin method, which involves administering tetracycline locally by inserting tetracycline-containing microspheresintoperiodontalpockets.[17,18]

Prospects of the future:

The key to the future of nanotechnology in periodontal therapy is computer-controlled nanorobots. In a number of therapeutic and prevention techniques, such as dentifrice, dental hypersensitivity, and local medication release, nanorobots hold great promise.17 These nanorobots have a propensity to approach the intended place of action.

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