**Nanotechnologies in Oral Surgery**

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**ABSTRACT**:

Diagnostic imaging, surgery, dentistry, and other fields have all undergone numerous dramatic developments with the help of nanotechnology. Monitoring numerous severe diseases, including cancer, genetic anomalies, neurological disorders, cardiovascular diseases, etc., has demonstrated its most significant potential. Medicine can be used for improvised medication therapy, suture material, surgical tools, visualization techniques, and the prevention, diagnosis, and planning of numerous diseases. As a result, it raised the bar for research conducted by scientists and medical professionals in dentistry, clinical trials, the creation of dental equipment, and the management and care of patients. Using nanotechnology in various oral and maxillofacial surgery procedures could have long-term repercussions.

*Keywords*- Nanoparticle, Nanodentistry, Nano-implant, Nanomaterials, Nanomedicine, Photodynamic therapy, Oral leukoplakia, Tumor

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**INTRODUCTION**

In the hard and soft tissues of the maxillofacial region, oral maxillofacial surgery, a subspecialty of dentistry, deals with diagnosing and treating various abnormalities. These facial bone abnormalities must be treated surgically, and bone implants or other bone-forming biocompatible materials must be placed. Materials with poor biocompatibility characteristics can occasionally cause post-operative infection, facial skin discolouration, and discomfort. The superior biocompatibility, human safety, and expertise of modern nanomaterials, which operate at atomic, macromolecular, or micromolecular levels in the range of 1 to 100 nanometers, produce better results. As a result, nanotechnology has enhanced healthcare by offering top-notch techniques for identifying and preventing diseases, as well as a variety of therapies like gene therapy and drug delivery. The lower morbidity and mortality rates for head and neck cancers are among the best illustrations of how nanotechnology has an impact.

**DEFINITION & CLASSIFICATION OF NANOTECHNOLOGY**

Nanotechnology is a young area that uses materials with nanostructures that range in size from 1 to 100 nm. Richard P. Feynman gave a brief overview of nanotechnology in 1959. In a 1974 publication, Norio Taniguchi of Tokyo Science University gave the original definition of nanotechnology: "Nanotechnology" refers to the processing, separation, consolidation, and deformation of materials by a single atom or molecule. K. Eric Drexler made it well-known. The International Organization for Standardization defines nanomaterials as "Materials with any nanoscale dimension or having internal nanoscale surface structure." With the development of technology, there are various classification schemes based on crystalline form origin, particle size, shape, or dimension

 Organic-based, Inorganic-based, carbon-based and ceramic Based.

 **B. Based on dimension, Nanomaterial can be classified as**

1. Nanorods, Nanowires

2. Particles, quantum dots, hollow spheres.

**C. Based on phase composition, nanomaterials are of,**

1. Single-phase solids- Crystalline and amorphous layers.

2. Matrix composites- coated particles

3. Multi-phase systems- colloids aero gels and ferrofluids

**WHAT ARE THE NANOMATERIALS?**

There are Few Examples of Nanomaterial, such as

1. **Nanotubes**: These are carbon rods about half the size of a DNA molecule. These tools are used to pinpoint the precise site of genetic modifications and detect the presence of changed Genes.
2. **Dendrimers**: High-branched macromolecules with regulated three-dimensional structures that enable the attachment of other molecules, such as contrast agents, to the surface of cancer cells, medications, etc.
3. **Nanoscale Cantilevers:** These are the flexible beams which bind to molecules associated with cancer.
4. **Nanoshell**: By varying the thickness of the layers, microscopic beads contain a silica core and a metallic outer layer, often gold. Near-infrared light may be absorbed by beads, producing a powerful heat that kills cancer cells.
5. **Nanopores**: They are little openings that let one strand of DNA at a time pass through. These nanopores increase the efficiency of DNA sequencing.
6. **Digital dental imaging:** Low radiation doses produce high-quality pictures with nano phosphor scintillation.
7. **Quantum dots:** Their ability to attach to proteins specific to cancer cells has been used in the optical detection of gene proteins and cell assays in tumour and lymph node samples, essentially bringing tumours to light. When exposed to ultraviolet light, they can glow brightly.

**Synthesis of Nanoparticles:** There are two main techniques in synthesizing nanoparticles.

1. **Top-down technique:** Microscopic material gets assembled into a compound structure, and these molecules are rearranged to get the desired properties.
2. **Bottom-up technique**: The custom-made molecule can self-replicate by designing and synthesizing. Small structures are created using bigger ones to guide their assembly, as depicted in Fig. 1.



**Figure 1.** Synthesis of nanoparticle

**Application of Nanotechnology in the field of oral and maxillofacial surgery**

One of the most fatal diseases affecting people is oral cancer, which has a high fatality rate. The survival rate for oral squamous cell carcinoma, the sixth most prevalent cancer worldwide, has not yet increased. Early oral cancer detection is essential for increasing survival rates. To detect diseases sooner, clinical diagnostics using nanotechnology has been created. It can deliver highly toxic medications to malignant cells after detecting even one cancerous cell in vivo. Nanoshells, quantum dots, and super-magnetic Materials utilized for cancer detection include nanoparticles (NPs), nanowires, and recently created nanosponges. Individual cancer cells can be located using certain cross-linkers, such as particular antibodies against cancer cells. On the surfaces of individual cancer cells, a unique collection of lipid-coated, targeted quantum dots quantifies a number of distinct indicators. For delivering drugs and genes, investigating DNA structures, and other purposes, various types of NPs are utilized. They comprise therapeutic nanocrystals and polymers such as dendrimers, fullerenes, liposomes, and inorganic NPs.

**Treatment of oral cancer**

Chemotherapy-induced systemic toxicity is one of cancer treatment's most frequent side effects. The effects of treatment include mouth burning and hair loss. By precisely localizing and killing cancer cells with nano-drug delivery, nanotechnology helps lower systemic toxicity by lowering the dosages of anti-cancer medications needed. The most recent development in cancer therapy is nanotechnology, which offers a glimmer of hope for bettering cancer treatments by working at two primary levels, such as giving a pharmaceutical agent new quality and directing the agent directly to the tumour. Thus, treatment through Nanotechnology includes nanomaterials for brachytherapy, nano vectors for gene therapy, nonviral gene delivery systems and drug delivery across the blood-brain barrier. Their localized nanodrug delivery helps preserve surrounding healthy tissues while targeting malignant tissue. Magnetic nanoparticles can also be used for tumour-targeted drug delivery therapy. They are directly injected intravenously to target the tumour site tissue. They require a low dosage of drugs, reducing the systemic toxicity and giving the desired effect of tumour regression only because of their nano size.

 

 Figure 2- Use of gold nanoparticles in identifying the tumour cell



**Figure 3.** Sources of adult stem cells in the oral and maxillofacial region.

**Suture needles:** It incorporates nano-sized stainless-steel crystals RK91 needle developed by Sandvik Bioline, Sweden. Nano-Tweezers are also under development, which will make cell surgery possible shortly.

**Trans-dermal drug delivery system** – This Bypass is the first-pass metabolism and enters directly into the systemic circulation with a more targeted effect, thus resulting in minor toxicity.

**Surface-modified vertical silicon nanowires:** These deliver bio-molecules in mammalian cells without modification of their Chemical structures. Hence, it allows the assessment of phenotypic sequences, small molecules, DNA, RNA, peptides, and proteins.

**Safety dental syringes**: Reduce the risk of accidental needle prick injury by covering the needle with a sheath after removal from the patient's tissue. E.g. Ultra Safety Plus XL syringe, Safety dental syringes

**Nano-encapsulation:** These include Hollow spheres, nanotubes and nano-composite core shells, which are widely explored to provide the best method for controlled drug delivery. E.g. arestin and minocycline

**Computer-controlled local anaesthesia system (CCLAD) (WandTM/ CompuDentTM system)** – These control the flow rate of local anaesthetic solutions through a lightweight handpiece and foot control. Using mechanical force, Jet injection technology creates sufficient pressure to push LA via a small orifice, thus creating a thin column of fluid that can penetrate soft tissues.



**Figure 4.** Electrochemically anodized dental implants with titania nanotubes (TNTs) for enhanced bioactivity and local therapy

**CONCLUSION**

More than many other recent breakthroughs combined, the application of nanotechnology has the potential to alter the dental healthcare system fundamentally. Advanced nanomaterials offer more promising outcomes than traditional ones for techniques used in diagnosis and treatment. Utilizing nanoparticles in oral and maxillofacial surgery can aid in preventing and treating diseases, including oral cancer, orofacial pain management, suture needles, and surface-modified vertical silicon nanowires, among others. By combining the fields of nanomaterials research and biotechnology, nanoparticles have the potential to revolutionize the way we treat and prevent oral diseases by offering both preventative and diagnostic methods. They might help with mending dental tissue that has been damaged.

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