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Nanotechnology: An aid in oral cancer detection

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Abstract

An integral aspect of oral pathology is the significance of early detection in the prevention of cancer and the treatment of disease. While traditional treatment approaches have certain drawbacks, they also have significant adverse effects and unfavourable outcomes when used in clinical settings. Researchers' interest in nanoparticles has recently grown due to their potential utility as medical devices and diagnostic probes. The field of nanotechnology is distinct and has transformed the industry. It is leading the way in developing novel treatments for oral cancer, which is why it is being used in oral pathology. It is establishing the current standards for therapy and can aid in a more accurate diagnosis with less dangerous drugs. We provide comprehensive information about nanotechnology and its applications in oral pathology in this review article. The challenges and possible applications of nanoparticles in the diagnosis and therapy of oral cancer are then emphasised.

Keywords: nanotechnology, oral pathology, diagnosis, oral cancer

Introduction

With a 50% 5-time survival rate, oral cancer (OC) ranks sixth in the world's cancer prevalence (Calixto *et al.*, 2014). The most current type of cancer is oral scaled cell lymphomas (OSCC), counting for nearly 90 of all oral malignancies (Warnakulasuriya, 2009). It takes a lot of way and complexity to construct an OC. The oral lichen planus, oral leukoplakia, oral erythroplakia, actinic keratosis, oral submucous fibrosis, and discoid lupus erythematous are the most current oral potentially nasty ails (OPMD) that have the eventuality to develop into cancer (Umapathy *et al.*, 2023). Therefore, the prognostic of ails depends on early identification of oral cancer and OPMD (Warnakulasuriya, 2009). The current standard individual styles used to identify oral lesions that may be nasty or potentially nasty are scalpel vivisection and histological studies (Chen *et al.*, 2018).

Multitudinous effortless individual ways have been developed in the last several decades. Toluidine blue (TB) staining, auto-luminescence (VELscope), and chemiluminescence (ViziLite) are exemplifications of non-invasive visual styles that have been employed alone or in combination as adjuvant testing to identify lesions that may be cancerous (Chainani-Wu *et al.,* 2015). Because imaging styles are noninvasive and may be completed snappily, they're employed as individual supplementary measures to histological evaluations (Keshavarzi *et al.,* 2017). These noninvasive ways do, still, nonetheless have certain downsides. Five new discovery styles need to be delved to bring about clinical benefits

1) directly prognosticating the nasty threat of OPMDs;
2) specifically detecting oral cancer grounded on molecular targeting;
3) the visual tools are largely private and dependent on the investigators' moxie; and
4) offering extremely sensitive nanoscale discovery ways,
5) recommending surgical resection perimeters in real time, and
6) accessibly tracking the prognostic of oral cancer following therapy (Chen *et al.,* 2018)

Over the once many decades, nanotechnologies have been applied in a number of diligence, most specially the medical assiduity to diagnose cancer and track the progress of illness (Gharat *et al.*, 2016)· Nanomedicine is one of the most laboriously delved subfields of nanotechnology, which increases the possibility of specific targeted cancer therapy (Ho *et al.,* 2015). According to the US National Nanotechnology Initiative, nanotechnology is defined as the manipulation of matter with the length scale of 1 – 100 nm in at least one dimension (Ogle OE, Byles N, 2014).

Nanotechnology has been used to identify and diagnose a number of cancers, similar as OC, stomach cancer, nasopharyngeal cancer, lung cancer, bone cancer, and cervical cancer (Zdobnova *et al.,* 2011). We've outlined the several nanotechnologies that have been developed for the opinion and discovery of oral cancer in this review.

The manipulation of matter at the molecular and infinitesimal situations is known as nanotechnology. Richard P. Feynman developed the idea of nanotechnology in 1959. In a 1974 publication, Tokyo Science University's Norio Taniguchi gave the following description of the term" Nanotechnology" primarily refers to the processing, separation, connection, and distortion of accoutrements by one snippet or one patch. K. Eric Drexler made it popular. One billionth of a cadence, or 10 to the power of nine, is one nanometre (Kovvuru *et al.*, 2012).

Nano Materials: In one dimension, they're called wastes; in two confines, they're called nanowires and nanotubes; in three confines, they're called amount blotches. Two factors distinguish their parcels from those of other accoutrements the increase in face area and amount goods. When compared to larger patches, nanomaterials have a significantly advanced face area per unit mass because of their small size. Every property is changed, including the electrical, optic, and glamorous ones (Bhardwaj *et al.*, 2014).

Nanotechnology Generations

First Generation

- Contact and dispersed nanostructures
- Aerosols, colloids, products with nanostructure, coatings, and other materials with passive nanostructure
- Ceramics, polymers, metals with nanostructures, and composites reinforced with nanoparticles

Second Generation

- Health Effect-Targeted, Bioactive Pharmaceuticals
- Dynamic nanostructure: Bio-instruments
- Active physicochemical structures
- Actuators and Amplifiers
- 3D transistor adaptive structures

Third Generation

- Structures are assembled under guidance
- 3D structural networking in nano-systems
- Novel structures with hierarchies
- Automation
- Systems of evolution

Fourth Generation

- Designed molecular devices
- Systems at the molecular level: Atomic Design's molecular devices
- Emerging functions of molecular devices

The Use of Nanotechnology

1) The identification of oral cancer
2) Tumour biomarkers using nanoparticles
3) A medication delivery method based on nanotechnology
4) Molecular nanoparticles based on DNA
5) Molecular imaging in nanoscale
6) Ultrasensitive biomarker detection based on nanotechnology

Oral Cancer Diagnosis and Treatment

1. *Dermis for the diagnosis and treatment of OC*

Dendrimers are multi branched, three-dimensional, tree-like structures. Dendrimers are the three primary components that are usually synthesised using the divergent method are a central core, repeating branches, and terminal functional groups (Cheng *et al.,* 2008). Human telomerase can be silenced by polyamidoamine (PAMAM) dendrimer-mediated shRNAs in OSCC cells and xenograft mice modelsreverse transcriptase (hTERT), demonstrating how well this technology inhibits the growth of tumours and induces cell death (Liu *et al.*, 2011).

2. *Magnetic nanoparticles for treating and diagnosing OC*

MNPs are available in a range of sizes and modifications, and they are all biocompatible and biodegradable in addition to having outstanding magnetic properties and good stability. Because of the RES's absorption capability and aggregation propensity, MNP usage are currently limited. Polymeric coatings function as a barrier to prevent NP aggregation and RES uptake. MNPs are being studied aggressively as MRI contrast agents. They can help with protons. Both med-ton relaxation refinement and proton relaxation refinement can benefit from their use, and they will ultimately develop into useful contrast probes in applications for biological diagnostics (ShabestariKhiabani *et al.,* 2017).

3. *Using quantum dots to diagnose and treat OC*

Semiconductor nanocrystals known as quantum dots (QDs) usually have a diameter of one to ten nanometres. From the ultraviolet to the near-infrared (roughly between 450 and 850 nm), QDs have strong fluorescence intensities, narrow emission spectra, large absorption spectra, and broad excitation spectra. QDs can be employed as probes or drug delivery systems in cancer therapy, but they can also destroy cancer cells by producing heat or reactive oxygen intermediates or species (ROIs/ROS) when exposed to radiation (Viljas, Pauly, 2008).

4. *OC Therapy Using Nanotechnology-Based Carriers*

When the microenvironment is somewhat altered, drug-loaded nanoparticles of the perfect size can guide the precise alteration of drug release behaviours in nano delivery systems, which is utilised for targeted drug delivery therapy. The utilisation of specific OSCC treatment techniques has been made possible by drug carriers based on nanotechnology (Huang *et al.*, 2011).

5. *Particles akin to viruses for OC treatment*

Because of their surface biophysical and chemical properties, VLPs can be easily engineered to have several functions through chemical and genetic engineering. Their effectiveness as oral antigen carriers for vaccination have been well investigated (Chien *et al.*, 2018).

Molecular Nanoparticles based on DNA

Numerous disorders have been treated by DNA nanostructure. Among these with different forms, tetrahedral DNA nanostructures (TDNs) have shown superiority over others for a number of reasons, such as acceptable permeability, low cytotoxicity, and relative stability. Ethyl amine and TDNs were combined by researchers to improve lysosome escape and cell entry while protecting DNA. Multifunctional components with the capacity to load various functional units are referred to as TDNs. Thus, the new TDN complex presents a promising possibility for targeted drug delivery in cancer therapy (Zhao *et al.*, 2015).

Imaging Molecular Nano-Based

Different kinds of nanoparticles have been used as targeted MRI contrast agents for cancer screening as a result of advancements in nanotechnology. Oral malignancies have also been examined with nano-contrast agents. For instance, Asif khan *et al.*, created an MRI contrast agent by combining magnetic poly (lactidecoglycolide) (PLGA) nanoparticles with folate pre conjugated chitosan (Shanavas *et al.*, 2017).

Coherence tomography using optics

An exact replica of ultrasonography is called optical coherence tomography, or OCT. It uses infrared light with a penetration depth of roughly 2 mm to provide cross-sectional architectural images of subsurface tissues, such as basement membranes and epithelial layers, and is appropriate for monitoring oral dysplasia and early oral cancer detection (Green *et al.*, 2016). Photo acoustic imaging It causes transient thermoelastic expansions following optical absorption by generating ultrasonic transients from tissues using a brief laser pulse. After being captured by an ultrasonic transducer, these photo acoustic waves are further converted into photo acoustic pictures based on their arrival times (Xu *et al.*, 2018).

Ultrasensitive biomarker detection using nanotechnology

The investigation of tumour molecular biomarkers, including EGFR, VEGF, TNF-α, and interleukin 6 (IL 6), has significant potential for early cancer diagnosis and detection (Fernandez-Olavarria *et al.*, 2016). The use of nanotechnology in tissue samples or bodily fluids may improve the sensitivity of biomarker identification at low quantities. Salivary proteomics analysis can benefit from the saliva peptide finger print technique, which can identify putative biomarkers that could be important for the diagnosis of cancer (Janissen *et al.*, 2017).

PROS and CONS of different nanotechnology for bioimaging and biomarker detection of oral

Optic Coherence Photography

Advantages: Nano contrast agents have a contrast level that is around 150% higher and are biocompatible.

Cons: Operating methods are complicated, and penetration depth is still limited.

Advantages of MRI: Nano contrast agents have improved relaxitivity and a longer blood circulation half-life.

Cons: expensive

Acoustic Photomagnetics

Advantages: Large acoustic signals might be efficiently provided in micro quantities by nano sensors.

Cons: It's difficult to implement real-time imaging.

Advantages of SERS: utilisation of large aspect ratio nanorods can give high index sensitivity and near-infrared area plasmon wavelength.
Cons: There are few nonmaterial options, and preparing probes is difficult.

Advantages of QD imaging: strong fluorescence, low specific binding, and strong resistance to photobleaching
Cons: More needs to be done to improve the cytotoxicity and biodegradability of quantum dots in vivo.

Advantages of Nano Based Ultra-Sensitive Biomarker Detection include increased sensitivity for the identification of biomarkers in bodily fluids or tissue samples at low concentrations.
Cons: It is not possible to diagnose oral cancer with a single, accurate biomarker.

Many Methods for Creating Nanostructure (Kaur *et al.*, 2016)
Putting together small parts to form complex structures

1) Local anaesthesia
2) Treatment for hypersensitivity
3) Repositioning teeth;
4) Nanorobotic dentistry
5) Dental health and appearance
6) Treatment for orthodontics
7) Diagnostics using nanotechnology
8) Nanotherapeutic medication administration
9) Bionic jaw
10) Skin replacements

Smaller structures are created by utilising larger ones to direct their assembly.

1) Composites made of nanotechnology
2) Materials for nanoimprinting
3) Use of nanotechnology
4) The use of nanocapsules
5) Nano needles
6) Alternatives to bones
7) Greenery
8) Disinfectants for surfaces
9) Tooth resistant to decay
10) Salivary pathology

Nanoparticles as Biomarkers for Tumour

Tumour cell identification in vitro can be done quantitatively or qualitatively using in vitro NPs. By concentrating and shielding a marker from deterioration, they aid in the detection process and increase the sensitivity of the study. An alternative strategy involved encasing inorganic biomarkers in place of luminous organic markers. These chemicals are more appropriate and sensitive for qualitative and particularly quantitative detection because they were more photo stable and unaffected by the intrinsic fluorescence (background signal) released by cells and tissues.

LiveThe NPs' physicochemical properties (particle size, surface charge, surface coating, and stability) enable the marker to be concentrated and redirected at the desired location. Colloidal particles with labels may be employed as radio diagnostic agents. However, certain nonlabeled colloidal systems are still being evaluated as contrast agents for diagnostic procedures such nuclear magnetic resonance imaging and computed tomography, while others are currently in use (Brigger *et al.*, 2002).

Therapy for oral cancer (Poonia *et al.*, 2017)

- Biomaterials for brachytherapy: BrachySilTM
- Gene-therapy nano-vectors
- Non-viral gene delivery technologies
- Blood-brain barrier drug delivery

Conclusion

Nanotechnology has the potential to change human life, dentistry, and healthcare more significantly than many previous technological advancements. Without a doubt, nanotechnology holds the promise of being the most effective and advantageous method of cancer diagnosis and therapy in the future. It will be crucial for early disease detection, diagnostic, and therapeutic treatments in the upcoming years to enhance oral health and the overall well-being of humanity.

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