



RESEARCH ARTICLE

NANOTECHNOLOGY – NEED FOR NEW PERSPECTIVES IN DENTISTRY

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ARTICLE INFO

Article History:

Received 17th July, 2017
Received in revised form
18th August, 2017
Accepted 26th September, 2017
Published online 31st October, 2017

Key words:

Nanotechnology, Molecule, Nanomedicine,
Nanodentistry, Nanorobots.

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Citation: Dr. Deivanayagi, Dr. Naveenraj, Dr. Lisa Elizabeth, Dr. Anand Krishnan, Dr. Meenakshi and Dr. Anu, 2017. "Nanotechnology – Need for new perspectives in dentistry", *International Journal of Current Research*, 9, (10), 59335-59337.

ABSTRACT

Nano Technology is a potential tool that could help detect the molecular changes and assist in focusing on preventive efforts. Nanodentistry is an emerging field with significant potential to yield new generation of technologically advanced clinical tools and devices for oral healthcare. The growing interest in this field is giving emergence to new field called Nanomedicine, a science & technology of diagnosing, treating and preventing diseases and preserving & improving oral health using nanoscale structured materials.

INTRODUCTION

Nanotechnology is a multidisciplinary field of applied science and technology covering a broad range of topics. A common trend in this ongoing discussion is the capability to operate on a scale small enough to interact with intracellular components including DNA. The word Nano is derived from Greek word "dwarf". The term nanotechnology was coined by Prof. Eric Drexler, a lecturer, researcher and writer of nanotechnology. Nanotechnology is the manipulation of matter on the molecular and atomic levels. It is measured in the billionths of meters or nanometer, roughly the size of two or three atoms. (Sujatha et al., 2010; Preeti Satheesh Kumar and Satheesh Kumar, 2011) "Nanomedicine" is the science of preventing, diagnosing, and treating disease and preserving and improving human health, using Nano sized particles. Nanodentistry will make possible the maintenance of comprehensive oral health by employing nanomaterials, including tissue engineering and, ultimately, dental nanorobots. This review is an attempt to highlight the possible applications of nanotechnology and the use of nanomaterials in dentistry. . (Sujatha et al., 2010; Ravindran, 2011)

Nanorobot

An artificially fabricated object able to freely diffuse in the human body and interact with specific cells at the molecular

level by itself will have a diameter of about 0.5-3 microns. (Yung-four Chen, 2011) Medical nanorobots have been proposed for gerontological applications in pharmaceutical research, clinical diagnosis, dentistry and also for mechanically reversing atherosclerosis, improving respiratory capacity, enabling near-instantaneous homeostasis, supplementing the immune system

Nanomaterials

Nanomaterials are those materials with components less than 100 nm in at least one dimension, including clusters of atoms, grains, fibres, films, nanoholes and composites. Combination of nanomaterials if present in one dimension are called as sheets, if in two dimensions are nanowires and nanotubes, if present in three dimensions are called as quantum dots. (Rosaiah and Aruna, 2011)

The various nanostructures are

1. Nanopores
2. Nanotubes
3. Quantum dots
4. Nanoshells
5. Dendrimers
6. Liposomes
7. Fullerene
8. Nanowires

Field of applications (Chandra Mouli, 2012)

- 1) Protective clothing and Mask (antipathogenic NPs)
- 2) Medical appendages (Biodegradable Nano fibres, Nanocrystalline silver particles)
- 3) Bone targeting Nanocarriers (Calcium phosphate based biomaterial) -supports growth of cartilage & bone cells
- 4) Bone replacement materials-Hydroxyapatite nanoparticles are used (Ostim® (Osartis GmbH, Germany) HA, VITOSSO (Orthovita, Inc, USA)

Quantum dots

“Quantum dot” nanocrystals, are tiny particles measuring only a few Nanometers. Quantum Particles can be excited to fluorescence with white light, can be linked to biomolecules to form long lived sensitive probes to identify specific compounds up to a thousand times brighter than conventional dyes used in many biological tests. “Quantum dots” are useful for studying genes, proteins & drug targets in single cells, tissue specimens & living animals. (Yung-four Chen, 2011; Rosaiah and Aruna, 2011)

These are used as chemical sensors for,

- Cancer cell detection
- Gene expression studies
- Gene mapping
- DNA micro assay analysis
- Immunocytochemical probes
- Intracellular organelle markers
- Live cell labelling
- Medical diagnostic & drug screening
- Vascular imaging

Nanoshells

Nano shells are miniscale beads with metallic outer layers designed to produce intense heat absorbing specific wavelengths of radiations that can be used for selective destruction of cancer cells leaving aside intact, adjacent normal cells. (Rosaiah and Aruna, 2011) Most common methods are Attrition (Macro and Micro Particles are grounded in a ball mill), Pyrolysis (Organic precursors (liquid/gas) forced through orifice at high pressure and burn)

Nanotechnology in medicine

- Drug delivery
- Skin treatment
- Cancer Therapy
- Regenerative Medicine
- Monitoring diabetes
- Gene therapy
- Delivery of antigens for vaccination
- Oxygen emergency reserve

Drug delivery

Nanotechnology to slow the release of asthma medication in the lungs. Nano sensors are used to detect drugs and other substances in exhaled breath and drug abuse like marijuana, concentration of alcohol, testing of athletes for banned substances which replaces urine testing.

Advantages of drug delivery to disease sites with nanotechnology

In addition, the increased vascular permeability coupled with an impaired lymphatic drainage in tumours allows an enhanced permeability and retention effect of the Nano systems in the tumours or inflamed tissues. The tendency of Nano systems to specifically localize in the reticulo endothelial system also presents an excellent opportunity for passive targeting of drugs to the macrophages present in the liver and spleen. Thus, this natural system can be used for targeting drugs for intracellular infections.

Nanodentistry

Possible maintenance of oral health Nanomaterials, biotechnology (tissue engineering) Nanorobotics.

Implantology: The development of material named Nano bone which closely intimates the structure and composition of real bone.

Challenges faced in nanodentistry

- Precise positioning and assembly of molecular scale part
- Economical nanorobot mass production technique
- Biocompatibility
- Simultaneous coordination of activities of large numbers of independent micron-scale robots.
- Social issues of public acceptance, ethics, regulation and human safety.

Nanotechnology in oral medicine and radiology

Oral Squamous Cell Carcinoma is the sixth most common cancer for both sexes. Early diagnosis of individual with high risk of developing HNSCC decrease morbidity and increasing survival

Oral fluid nano sensor test (ofnaset) (Ekta Ingle and Saraswathi, 2011)

The Oral Fluid Nano Sensor Test (OFNASET) technology is used for multiplex detection of salivary biomarkers for oral cancer. It has been demonstrated that the combination of two salivary proteomic biomarkers (thioredoxin and IL-8) and four salivary mRNA biomarkers (SAT, ODZ, IL-8, and IL-1b) can detect oral cancer with high specificity and sensitivity.

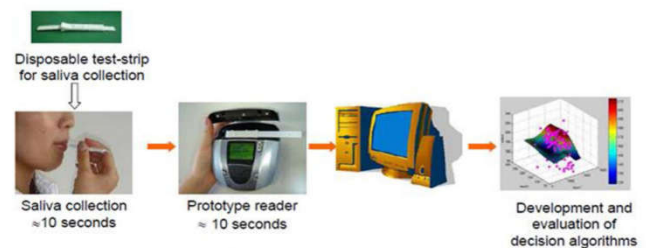


Fig. 1. Oral Fluid Nano Sensor Test

Cancer diagnosis & treatment

- Nano sensors
- Hybrid approaches using Nano tubes and Nano wires

- Nano particles contrast agents
- Gold NPs used as an optical probe for early detection
- Optical Nano biosensor
- Cantilever array sensors

Photo dynamic therapy with nano particles for potentially malignant and carcinoma in-situ lesions

Nanoparticles are placed within the body illuminated with light from outside (laser /light bulb) with some particular nanodots, light can also be used to produce highly energetic oxygen molecules. Those oxygen molecules are very reactive and chemically react with and therefore destroy most organic molecules around them.

Killing cancer with gold bullets and bombs

Thermolysis is a chemical process by which a substance is decomposed into other substances by use of heat. Nanophotothermolysis is the process where nanoparticles, when irradiated by short laser pulses, get hot so quickly that they explode. Gold nanoparticles are the most promising candidates for photothermolysis since they are strong absorbers, photostable, nontoxic, easily conjugated to antibodies or proteins and have adjustable optical properties (Ekta Ingle and Saraswathi, 2011; Current practicality of nanotechnology in dentistry, 2009).

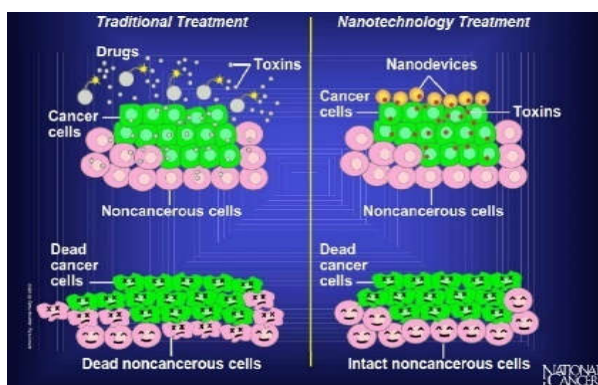


Fig. 2. Traditional Vs Nano Treatment in cancer

Forensic applications of nanotechnology

Nanotechnology contributes to forensic sciences in two ways. Since it can detect and analyse samples in the nanoscale, critical evidence that could not be collected and analysed before due to the detection limits of the instruments can now be analysed and used to support the investigations. Nano finger print Residue visualization using semiconductor CdS semiconductor nanocrystals, GoldNano particles to enhance PCR efficiency, Atomic Force Microscopy to resolve the issues in estimation of time of death. (Nagpal *et al.*, 2011)

Nano health hazards

To properly assess the Health Hazard, the whole life cycle of these particles needs to be evaluated including their fabrication, storage, distribution, application, potential abuse and disposal. Nanostructures can be so small that the body may clear them too rapidly for them to be effective in detection or imaging. Larger nanoparticles may accumulate in vital organs, creating a Toxicity problem.

Nano toxicology (Oberdorster, 2005)

Nanotechnology has great potential to benefit the society; however, those nanomaterials with unknown novel properties can also cause risks to the environment. The seriousness of nanotoxicity has been acknowledged and emphasized in a review by the group of Oberdorster. Additionally, it has been observed that nanoparticles can cross the blood-brain barrier and penetrate into the central nervous system and ganglia, causing even more severe damage to the human body. Nanotoxicology is still a new field of research, but the reduction and eventual removal of toxicity associated with novel nanomaterials, nanostructures and nanodevices is of paramount importance.

Future advances in nanotechnology



Conclusion

Nanotechnology holds the promise to lead to an earlier diagnosis, better therapy and improved follow up care, making the health care more effective and affordable. Current work is focused on the recent developments, particularly of nanoparticles and nanotubes for periodontal management. Nano dentistry still faces many significant challenges in realizing its tremendous potential. There are larger social issues of public acceptance, ethics, regulations and human safety that must be addressed before molecular nanotechnology can enter the modern medical armamentarium.

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