NANODENTISTRY - OPENING NEW VISTAS

Guided By:
Dr. Rajeshwari G. Annigeri
Professor & Head

Dr. Sree Vijayabala
Post Graduate Student

Dept. of Oral Medicine, College of Dental Sciences, Davangere.

Nanotechnology is a multidisciplinary field, which covers a vast and diverse array of devices derived from engineering, biology, physics and chemistry.1 Nanotechnology is the science of manipulating matter measured in the billionth of meters or nanometer, roughly the size of two or three atoms. The word nano is the greek word for dwarf.2 Nanomedicine is the process of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using molecular tools and molecular knowledge of the human body by using nanoscale-structured materials and nanodevices including the interaction of nanostructured materials with biological systems.[3] Nanodentistry will give a new visionary to comprehensive oral health care, as now trends of oral health have been changing to more preventive intervention than a curative & restorative procedure.[4]

MEDICAL NANOMATERIALS AND NANODEVICES CURRENTLY IN USE[3]

Currently used materials would include, Nanopores, Molecular Imprinting, Quantum Dots, Nanocrystals, Fullerenes, Nanotubes, Nanoshells, Magnetic Nanoprobes, Targeted Nanoparticles, Dendrimers, Radio-Controlled Biomolecules

APPLICATIONS IN DENTISTRY: Development of nanodentistry will make possible the maintenance of near-perfect oral health through the use of nanomaterials; biotechnology, including tissue engineering; and nanorobotics.[5]

Local Anesthesia: To induce oral anesthesia, dental professionals will instill a colloidal suspension containing millions of active analgesic micrometer-sized dental nanorobot "particles" on the patient's gingivae. After contacting the surface of the crown or mucosa, the ambulating nanorobots reach the dentin by migrating into the gingival sulcus and passing painlessly through the lamina propria or the 1- to 3-μmthick layer of loose tissue at the cementodentinal junction. On reaching the dentin, the nanorobots enter dentinal tubule holes that are 1 to 4 μm in diameter and proceed toward the pulp, guided by a combination of chemical gradients, temperature differentials and even positional navigation, all under the control of the onboard nanocomputer, as directed by the dentist.[5]

Once installed in the pulp and having established control over nerve-impulse traffic, the analgesic dental nanorobots may be commanded by the dentist to shut down all sensitivity in any tooth that requires treatment. After the oral procedures are completed, the dentist orders the nanorobots (via the same acoustic data links) to restore all sensation, to relinquish control of nerve traffic and to egress from the tooth via similar pathways used for ingress; following this, they are aspirated. Nanorobotic analgesics offer greater patient comfort and reduced anxiety, no needles, greater selectivity and controllability of the analgesic effect, fast and completely reversible action, and avoidance of most side effects and complications.[5]

Oral procedures are completed, the dentist orders the nanorobots (via the same acoustic data links) to restore all sensation, to relinquish control of nerve traffic and to egress from the tooth via similar pathways used for ingress; following this, they are aspirated. Nanorobotic analgesics offer greater patient comfort and reduced anxiety, no needles, greater selectivity and controllability of the analgesic effect, fast and completely reversible action, and avoidance of most side effects and complications.[5]

Nanoneedles: Suture needles incorporating nano sized stainless steel crystals have been developed.nanotweezers are under development.it is available under the trade name sandvik bioline.[2]

Dentin hypersensitivity: Dentin hypersensitivity is another pathological phenomenon that may be amenable to nanodental treatment. Many therapeutic agents provide temporary relief for this common painful condition, but reconstructive dental nanorobots, using native biological materials, could selectively and precisely occlude specific tubules within minutes, offering patients a quick and permanent cure.[5]

Nanorobotic dentrifice: Subocclusal Nanorobotic dentrifice delivered by mouthwash or toothpaste could patrol all subgingival and supragingival surfaces atleast once a day metabolizing trapped organic matter into harmless And odourless vapours and performing continuous calculus debridement.[2]

Bone replacement materials: Hydroxyapatite nanoparticles used to treat bone defects are Ostim HA Vitoss HANanoss HA.[2]

Impression materials: Impression material are available with nanotechnology application.nanofillers are integrated in vinyl polysiloxanes producing a unique addition siloxane impression material.it has better flow, improved hydrophilic properties and enhanced detail precision. It is available under the commercial name Nano Tech Elite-H-D+.6

Orthodontic nanorobots: Orthodontic nanorobots could directly manipulate the periodontal tissues, including gingivae, periodontal ligament, cementum and alveolar bone, allowing rapid and painless tooth straightening, rotating and vertical repositioning within minutes to hours. This is in contrast to current molaruprighting techniques, which require weeks or months to complete .[5]

Nanosolutions: Nanosolutions produce unique and dispersible nanoparticles, which can be added to solvents, paints and polymers in which they are dispersed homogeneously. It has higher dentin bond strength and better performance.no bottle shaking required as the nano particles are homogenous, stable and they do not cluster. It is available under the commercial name Adper single bond plus.[6]

Nanocomposites: Nano particles are homogeneously distributed in resins or coatings to produce nanocomposites.the nanofiller used includes aluminosilicate powder having a mean particle size of 80 nm and 1:4 M ratio of alumina to silica. Its advantages includes superior hardness, flexural strength, transparency, handling properties and modulus of elasticity. It is available under the commercial name Filtek supreme universal restorative pure nano.[6]

Tooth durability and esthetics: Tooth durability and appearance may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire or diamond, which have 20 to 100 times the hardness and failure strength of natural enamel or contemporary ceramic veneers, as well as good biocompatibility. Pure sapphire and diamond are brittle and prone to fracture if sufficient shear forces are imposed, but they can be made more fracture resistant as part of a nanostructured composite material that possibly includes embedded carbon nanotubes.[5]

Major tooth repair. The nanorobotic manufacture and installation of a biologically autologous whole tooth replacement that includes both mineral and cellular components, that is, complete dentition replacement therapy shall be performed.[5]

Dentition renaturalization: Dentition renaturalization procedures may become a popular addition to the typical dental practice, providing perfect treatment methods for esthetic dentistry. Full coronal renaturalization procedures in the place of preexisting fillings, crowns with native biological materials may be done.[5]

Cancer diagnostics and therapeutics

Cancer nanotechnology seeks to characterize the interaction of nanoscale devices with cellular and molecular components specifically related to cancer diagnosis and therapy. The potential of cancer nanotechnology lies in the ability to engineer vehicles with unique therapeutic properties because of their small size that can penetrate tumors deeply with a high-level specificity.[7]

Diagnostics: Nano-imaging or molecular imaging includes techniques for the study of molecular events in vivo and for molecule manipulation. The main benefits of molecular imaging for in vivo diagnostics are the early detection of diseases and the monitoring of disease stages (e.g. in cancer metastasis), leading to individualised medicine and real-time assessment of therapeutic and surgical efficacy. A wide range of nanoparticles or molecules are currently used for medical imaging and act as targeting agents or contrast agents in ultrasound, MRI,Nuclear imaging etc.

Some recent developments in optical imaging focus on using nanoparticles as tracers or contrast agents. Fluorescent nanoparticles such as quantum dots and dye-doped silica nanoparticles are systems that, depending on their coating and their physical and chemical properties, can target a specific tissue or cell. Their fluorescence can easily be tuned for specific imaging purposes. They offer a more intense fluorescent light emission, longer fluorescence lifetimes and a much broader spectrum of colours than conventional fluorophores.They are expected to be particularly useful for imaging in living tissues, where scattering can obscure signals.

Therapeutics: Nanoscale devices have led to the development of biodegradable self-assembled nanoparticles, which are being engineered for the targeted delivery of anticancer drugs and imaging contrast agents. Nanoconstructs such as these should serve as customizable, targeted drug delivery vehicles capable of ferrying large doses of chemotherapeutic agents or therapeutic genes into malignant cells while sparing healthy cells. Such "smart" multifunctional bioconjugated nanodevices hold out the possibility of radically changing the practice of oncology, allowing easy detection and then followed by effective targeted therapeutics at the earliest stages of the disease.

TOXICITY OF NANOPARTICLES: The biological impacts of nanoparticles are dependent on size, chemical composition, surface structure, solubility, shape, and aggregation. These parameters can modify cellular uptake, protein binding, translocation from portal of entry to the target site, and the possibility of causing tissue injury. Nanoparticle binding to proteins may generate complexes that are more mobile and can enter tissue sites that are normally inaccessible. Accelerated protein denaturation or degradation on the nanoparticle surface may lead to functional and structural changes, including interference in enzyme function. Nanoparticles also encounter a number of defenses that can eliminate, sequester, or dissolve them.[10]

CONCLUSION: This science might sound like a fiction now, but nanodentistry has strong potential to revolutionize dentisty in future. Nanotechnology will change dentistry, health care and human life more profoundly. In the long run, perhaps 10-20 years from today, the nanorobots may join the medical armamentarium, finally giving physicians the most potent tools imaginable to conquer human disease, ill-health, and aging.

REFERENCES:

1. Ferrari M .Cancer nanotechnology:opportunities and challenges. Nature reviews cancer 2005; 5(3):161-71.
2. Kumar SR, Vijayalakshmi R. Nanotechnology in dentistry. Ind J dent res 2006; 17(2):62-65.
3. Freitas RA. Current status of nanomedicine and medical nanorobotics. Jourl of compl theor nanoscience 2005;2: 125,
4 .http://www.dharwadhubli.com
5. Freitas RA Nanodentistry. J Am dent assoc 2000; 131:1559-65
6. Javeri HM, Balaji PR Nanotechnology, the future of dentistry
7. Cuenca AG, Jiang H, Hochwald N, Delano M, Cance WG. Emerging implications of nanotechnology on cancer diagnostics and therapeutics. Cancer 2006; 107:45966.
8. http://cordis.europa.eu/nanotechnology/nanomedicine.htm
9. Sinha R kim G J , Nie S, Shin DM . Nanotechnology in cancer therapeutics: bioconjugated nanoparticles for drug delivery. Mol cancer ther 2006; 5(8):1909-17.
10. keval.k.jain. The handbook of nanomedicine. Humana press; 1st ed.