Journal of Applied Dental and Medical Sciences
NLM ID: 101671413 ISSN:2454-2288
Volume 2 Issue 2 April - June 2016

Review Article

Nanotechnology- Prosthodontic Aspect

Babita Yeshwante[1],Nazish Baig[2] , Swati Bhandari[3], Sonali Gaikwad [4], SnehaMaknikar[5], Supriya Deshpande[6]

[1] HOD, Dept of Prosthodontics, CSMSS Dental college,Aurangabad,Maharastra
[2] Professor, Dept of Prosthodontics, CSMSS Dental college,Aurangabad,Maharastra
[3, 4,5,6] Post Graduate student, Dept of Prosthodontics, CSMSS Dental college,Aurangabad,Maharastra

A R T I C L E I N F O

Keywords:
Nanotechnology, Nanodentistry, Prosthodontic, Nanoceramic, Nanofiller

A B S T R A C T

Science makes difference in our lives. Scientific discovery changes our perception, our way of thinking and our attitude about today and tomorrow. Nanotechnology utilizes nanoparticle which are less then 100nm in size for various application. dentistry has seen many era of revolution in past, making things more comfortable and reliable for patient. Development of Nanodentistry will make possible the maintenance of near perfect oral health through use of nanomaterial biotechnology including tissue engineering and nanorobotics. This review describe nanotechnology and its Prosthodontic aspect.

Introduction

"Nano" is derived from the Greek word for 'dwarf. Nanotechnology is the science of manipulating matter measured in the billionths of meters or manometer, roughly the size of 2 or 3 atoms.[1]

The late Nobel prize winning physicist Richard P. Feynman in 1959 speculated the potential of nanosize devices as early as 1959. In his historic lecture in 1959, he concluded saying, "this is a development which I think cannot be avoided"[1]he also presented a talk entitled "There's plenty of room at the bottom" at the annual meeting of the American Physical Society at the California Institute of Technology, Pasadena, CA.[2]

one nanometer is one-billionth or 10-9 of a meter. To put that scale in context, the comparative size of a nanometer to a meter is the same as that of a marble to the size of the earth. Or the other way of putting it is that a nanometer is the amount a man's beard grows in the time it takes him to raise the razor to his face.[3-6]

The only thing that is constant in life is change. Two pivotal changes have transformed scientific medicine from a merely rational basis to a molecular basis. The first pivotal event was the drug revolution; the second pivotal event was the genetics revolution, starting with the discovery in 1953 of the information-carrying double-helix structure of DNA by Francis Crick and John B Watson. In the mid-1980s the Human Genome Project was launched, with the objective of fully sequencing every gene in the human genome. The first phase of this project neared completion as the 20th century drew to a close. Thus, the late 20th century is

* Corresponding author: ***Dr.Swati Bhandari J-64 sector-4 Airoli,Navimumbai-400708,Maharashtra. Email:Bhandariswati25@gmail.com, Phone number: 9545973883.***

best regarded as the molecular age of basic biological science. The molecular influence pervades all the traditional disciplines underlying clinical medicine.[2]

Rieview Of Literature

Robert A Freitas (2000)[7]Discussed about the the vision of nanotechnology and future applications of nanotechnology and the emergence of a new field called nanomedicine. This is the science and technology of diagnosing, treating and preventing disease and traumatic injury; of relieving pain; and of preserving and improving human health, through the use of nanoscale structured materials, biotechnology and genetic engineering, and eventually complex molecular machine systems and nanorobots.

George M White Sides, J Christopher Love (2001)[8] Stated about the Nanofabrication and Nanofabrication methods. Nanofabrication methods can be divided into two categories: Top Down methods which carve out or add aggregates of molecules to a surface and bottom up methods, which assemble atoms or molecules to nanostructures. Bottom up methods produce quantum dots which serve as biological dyes.

ShiroSuzuki(2004)[9] Evaluated the relative wear resistance of several types of denture teeth using an in vitro wear testing device.He used Four different types of denture teeth and flattened buccal surface of each denture tooth was subjected to the evaluation of Knoop hardness (n = 5) and localized wear for 100,000 cycles (n = 10). Wear values were determined in micrometers using a profilometer. The data for the hardness, weardepth, and worn surface areas were individually analyzed. He concluded that The nanocomposite tooth was harder and more wear resistant than the acrylic teeth.

Luiz Meirelles, Fredrick Currie, Magnus Jacobson(2008)[10] Investigated the effect of chemically modified implants with similar microtopographies but different nanotopographies, they concluded that the chemical modification used were capable of producing particular nanotopography and together with the ions present at the implant surface explained the increased removal torque values after certain healing period.

JiaHusheng, HouWensheng, Wei Liqiao et al (2008)[11] Studied the structures and antibacterial properties of two kinds of sterilizing nano-SiO2 specimens and concluded that SLS(Silver –Loading nano SiO2 Specimen) and SLZS(Zinc silver loading nanoSiO2 specimen) can be effectively incorporated in dental resin-based materials to provide antibacterial activity against bacteria.

Chih Yao Chiang, Shih Hwa Chiou, Wei En Yang (2009)[12] Discussed about the methods to improve human cell growth on titanium (Ti) used for dental implants through formation of a nano-network surface oxide layer created by an electrochemical anodization treatment and concluded that a multilayer TiO2 nano-network was producedrapidly on Ti surface using a simple electrochemical anodization treatment. The TiO2nano-network layer on the anodized Ti surfaces significantly improved in vitro and invivo human bone marrow mesenchymal stem cells (hMSC) growth.

Antoni P. Tomsia, Maximilien E. Launey, Janice S. Lee et al (2011)[13] discussed about the role of nanoscale materials and stated that nanoscale materials will produce a new generation of implant materials with high efficiency, low cost, and high volume. Metallic dental implants have been used successfully for decades, but they have serious shortcomings related to their osseointegration and the fact that their mechanical properties do not match

those of bone. They discussed about the fabrication of novel coatings and nanopatterning of dental implants and also summerized the state of the art in.dental implant science and described possible advantages of nanotechnology for future improvements.

NANODENTISTRY

Nanodentistry will make possible the maintenance of near-perfect oral health through the use of nanornaterials, biotechnology including tissue engineering and nanorobotics. Oral health and disease trends may change the focus on specific diagnostic and treatment modalities.[14]

Nanodentistry as bottom up approach[15]

1. Local anesthesia
2. Hypersensitivity cure
3. Nanorobotics dentifrice (dentifrobots)
4. Dental durability and cosmetics
5. Orthodontic treatment
6. Photosensitizer and carrier
7. Diagnosis of oral cancer
8. Treatment of oral cancer

Nanodentistry as top up approch[16]

1. Nanocomposite
2. Nanosolution
3. Impression material
4. Nanoencapsulation
5. Other product manufactured by SWRI
6. Nanoneedle
7. Bone replacement material

PROSTHODONTIC ASPECT

1.DENTAL DURABILITY AND COSMETIC:

Tooth durability and appearance may be improved by replacing upper enamel layers with pure sapphire and diamond which can be made more fracture resistant as nanostructured composites, possibly including embedded carbon nanotubes[15]

2.NANOCOMPOSITES

Nanoproducts Corporation has successfully manufactured nonagglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce nanocomposites. The nanofiller used includes an aluminosilicate powder having a mean particle size of 80 ran and a 1:4 M ratio of alumina to silica and a refractive index of 1.508.

Advantages

1.Superior hardness

2.Superior flexural strength, modulus of elasticity and translucency

3. 50% reduction in filling shrinkage

4.Excellent handling properties

Trade name: Filtek O Supreme Universal Restorative P Lire Nano O.[16]

The resin composites were introduced for the first time in dentistry in the mid 1960s, for the restoration of anterior teeth, because of the necessity to eliminate the shortcomings of the restorative materials existing at that time. Because of their aesthetic aspect, adhesion to hard dental tissues, high values of the physico-mechanical properties, they play an important role in modern dental practice.[17]

Basic composition of composite resins include:

1. Resin matrix
2. Fillers
3. Coupling agent
4. Activator –initiator system
5. Inhibitors
6. Optical modifiers and coloring agents

Nano composites - When inorganic phases in an organic/inorganic composite become nanosize, they are called nanocomposites.

Main types of nano filler –

1. Nanomers
2. Nanoclusters

Advantage of nanofillers:

1. Better optical property
2. Increased surface area of filler particle
3. Reduced polymerization shrinkage

Recent advances in Nanofiller technology:

1. Reinforced fillers- nanofibers
2. Short E Glass fibers
3. TiO2Nanoparticles
4. Caries prevention fillers

3.NANO CERAMIC

The Organically Modified Ceramic nano-particles comprise a polysiloxane backbone. The chemical nature of the siloxane backbone is similar to that of glass and ceramics. Meth acrylic groups are attached to the backbone via silicon-carbon-bonds. These Nano-Ceramic particles can be best described as inorganic-organic hybrid particles where the inorganic siloxane part provides strength and the organic methacrylic part makes the particles compatible and polymerizablewith the resin matrix. The good resistance to micro-crack propagation might be related to the strengthening effect of the nano-ceramic particles. Propagating cracks are either more often reflected or absorbed by the nano-ceramic particles.[18]

Nano aluminium oxide fibers - Nanoceram3

Nanostructural aluminium oxide fibers provide added strength and improved performance to metals, plastics, polymers and composite materials.[19]

4.IMPRESSION MATERIAL

Impression materials are available with nanotechnology application. Nanofillers are integrated in vinyl polysiloxanes, producing a unique addition of siloxane impression materials. The material has better flow, improved hydrophilic properties and enhanced detail precision.[16]

Trade name: Nanotech Elite H-D[16]

Benefits:

1. 1 minute working time, 2 minute oral set time
2. Low contact angle of ˜30° for accurate, reliable impressions in the oral environment
3. Outstanding tear strength ensures reliable impressions
4. Minimized out gassing time for immediate pour of models

Impression materials Nanotech Elite H-D from the company Zhermack is available with nanotechnology application. Here nanofillers are integrated in the vinyl polysiloxanes, producing a unique addition siloxane impression material having added advantages of:

- Better flow
- Improved hydrophilic properties hence fewer voids at margin and bettermodel pouring
- Enhanced detail precision.

Zhermack Elite H-D + silicone impressions formulation incorporates a combination of organic polymers, inorganic particles and nano fillers. The result is an A Silicone with increased fluidity, high tear resistance, hydrophilic properties, resistance to distortion and heat resistance. The inclusion of nano particles has enabled Elite H-D+ to obtain a degree of fluidity completely different from the initial viscosity. When pressure is exerted during impression taking an excellent reproduction of infinitely small details is obtained. Elite H-D +has also been design to produce a

snap set that consequently reduces errors caused by micro movements. Elite H-D + is available in light fast, light regular set, medium and heavy viscosities and is delivered in the new safety cartridges.[19]

5.IMPLANT

Titanium (Ti) and its alloys are widely used to manufacture dental implants, maxillofacial, and orthopaedic prostheses. Replacement of missing tooth structure and restoration of oral function with surface-modified titanium implants is the ultimate goal in implant dentistry.[20]

Implantable materials.[21]

This technology can be used in the following areas:

- Tissue repair and replacement
- Implant coatings
- Tissue regeneration scaffolds
- Structural implant materials
- Bone repair
- Bioresorbable materials
- Smart materials
- Assessment and treatment devices
- Sensory aids
- Retinal and cochlear implants.

Nanotechnology can alter the implant surface at an atomic level[22] and may influence the chemical composition of these surfaces[23.]different chemical elements can be added to the implant surface and biomolecules such as BMP2 or FGF can be applied and covalently bonded to the Ti implant surface[24].

Various surface modification technique includes:

1.Morphological Modification of Titanium Surface

2. Physicochemical Modification of Titanium Surface

3. Biochemical Modification of Titanium Surface

Brånemark et al.described the osseointegration as a direct structural and functional boneto implant contact under load. For instance, surfaces that promote contact osteogenesis rather than distance osteogenesis would be desired in bony site while intimate fibrous tissue healing in gingival tissue. In order to enhance this intimate contact between tissues and implant, surface treatments at the nanometer scale has to be performed on metal implants[25]

CHALLENGES FACED BY NANOTECHNOLOGY ARE:

- 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

PROBLEMS OF RESEARCH IN NANOTECHNOLOGY IN INDIA

- Painfully slow strategic decisions
- Sub-optimal funding
- Lack of engagement of private enterprises
- Problem of retention of trained manpower

FUTURE OF NANOTECHNOLOGY

Nanotechnology is foreseen to change health care in a fundamental way:

- Novel methods for disease diagnosis and prevention
- Therapeutic selection tailored to the patient's profile
- Drug delivery and gene therapy

CONCLUSION

This science might sound like a fiction now, but Nanodentistry has a strong potential to revolutionize dentistry as to diagnosing and treating dental diseases in future as it opens up new avenues for vast &

abundant research. In Prosthodontic nanotechnology builded up its place by improving strength in resin to impression material. Improving esthetic in composite resin to ceramic. Improving osseointegration of implant, providing a strong base for prosthesis.Nanotechnology will change dentistry, health care and human life more profoundly than other development.

REFERENCES:

1. Saravanak ,Vijaylakshmi . Nanotechnology in Dentistry .Ind J Dent Res 2006 ;17(2) : 62-65
2. RosiahK ,Aruna K . The Changing Face of Dentistry. Nanotechnology: International Journal of Nanomedicine 2011;6: 2799-2804
3. Taniguchi N. On the basic concept of 'nano-technology'. Proceeding of the International. Conference on Production Engineering; 1974
4. Schleyer TL. Nanodentistry: fact or fiction? J Am Dent Assoc. 2000;131: 1567–1568
5. Feyman R. There is Plenty of Room at the Bottom: Miniaturization. New York: Reinhold; 1961:282–296
6. Kahn J. Nano's big future: nanotechnology. National Geographic. 2006:98–119.
7. Robert A F.Cover Story. J Am Dent Assoc 2000; Vol 131 : 1559-1565
8. George M W, Christopher L . The art of building small . Scientific AmericanJournal 2001: 33-41
9. ShiroS . In Vitro Wear of Nano Composite Denture Teeth. Journal of Prosthodontics 2004; Vol 13 (4) : 238-243.
10. Luiz M ,Fredrik C ,Magnus J et al . The effect of Chemical and Nanotopographical Modifications on the Early Stages of Osseointegration. IntJOralMaxillofac Implants 2008;23: 641-647
11. JiaH ,Hou W , Liqiao Wei et al. The Structures and Antibacterial properties ofNano Sio2 supported silver/zinc silver materials. Dent Mater 2008;24:244-249

12. Chih Y C , Shih H C , Yang E W et al . Formation of titanium nano network ontitanium surface increases the human cell growth .Dent Mater 2009;25:1022-1029
13. Antoni P ,Maximilien L E , Janice L S et al . Nanotechnology approaches toimprove dental implants .Int J Oral Maxillofac Implants 2011;26 : 25-44
14. Freitas RA Jr: Nanodentistry, Journal of the American Dental Association, 131(11):15591565,2000.
15. Whitesides GM and Love JC: The Art of Building Small, Scientific American, 285[3]: 33-41, 2001
16. Jhaver HM and Balaji: Nanotechnology: The future of dentistry, 5:15-17, 2005.
17. Baran S, Jinming G. Theronostic nanomedicine for cancer.Nanomedicine 2008;3(2): 1377-140
18. IndrajitR ,Tymish Y O , Dhruba J B et al . Optical tracking of organicallymodified Silica nanoparticles as DNA carriers. A non viral Nanomedicineapproach for gene delivery. PNAS 2005;Vol 102(2) : 279-284
19. Volker W ,AnwynD,Anne K et al.The Emerging NanomedicineLandscape.Nature Biotechnology 2006;Vol 24 :1211-1217
20. EktaI ,Saraswathi G K . Nanodentistry A Hype or Hope . J Oral Health CommDent 2011; 5(2): 64-67
21. Gordon N, Sagman U, Borm P, et al. The Potential Risks of Nanomaterials: A Review Carried Out Canadian Nano Business Alliance, Nanotechnology Research and Development in Canada, February 2008 and 2009
22. Oh SH,Finones RR, Daraio C, Chen LH, Jin S Growth of nanoscale hydroxyapatite using chemically treated titanium oxide nanotube. Biomaterial 2005;26:4938-43
23. Guo J Padilla RJ, AmbroseW, De kok IJ, Copper LE Modification of TiO_2 grit blastedtitanium implant by hydrofluoric acid treatment alter adherent osteoblast gene expression in vitro and vivo biomaterial 2007;28:478-55
24. ScotchfordCA,Gilmore CP, Copper E, Legett GJ, Downers S. Protein adsorption and human osteoblast-like cell attachment and growth on alkylthiol on gold self-assembled monolayers. J Biomed mater Res 2002;59:84-99
25. Hemant A ,Nanodentistry and Its Application.JIDA 2011; Vol 5(1) :164-165

Source of support: Nil Conflict of Interest: None
Online available at: www.joadms.org