Influence Of Nanotechnology as Next Generation Periodontics. Is Small the Beginning in Periodontology?

[1]Dr .Mallanagouda B Patil, [2]Dr.Girija V Arishinagodi, [3]Dr. Shobha prakash.

[1]Professor, [2]Postgraduate student, [3]Professor and Head of the Department.
Department of Periodontics, College Of Dental Sciences, Davangere, India

ABSTRACT: Small is the beginning of new big? Nanotechnology is at front roads now and it has emerged to show as rapidly growing technology in all the fields including medicine and Periodontics/dentistry. Emergence of a new field nanomedicine/nano dentistry has shown more interest in the future applications of using nanotechnology to different research areas. Inside of this, many nanoproducts are on the way and new treatment modalities are proposed. Nanotechnology is the roadmap for innovations and improvement in prevention, diagnosis ,treatment of oral and periodontal diseases. It is estimated that 90% of world population suffers from periodontal disease and hence nanoinventions may be helpful in future for the diagnosis and treatment of the same. This review article provides insight about role of nanotechnology as a whole in the field of periodontology.

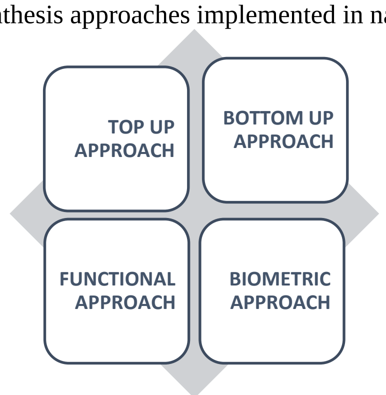
Index Terms: Nanotechnology, Nanoperiodontics, Nanomaterials.

I.INTRODUCTION

Nanotechnology is science and engineering involved in the design, synthesis, characterization, application of materials and devices whose smallest functional organization in at least one dimension is on the nanometer scale or one billionth of a meter[1]. **"Nano**" is the greek word for dwarf[2][3][4]. As Winfred Phillips, DSc, said, "You have to be able to fabricate things, you have to be able to analyze things, you have to be able to handle things smaller than ever imagined in ways not done before"[5] [6]. The world began without man, and it will complete itself without him. As Cloude Levi Strauss said once. "Nano-technology" first employed in 1974-by Japanese scientist **Norio Taniguchi** of the Tokyo University of Science and then K. Eric Drexler in 1980 popularised the word 'nanotechnology'.

II.Classification : Classified according to approach, materials , origin,dimensions of particles, composition etc.

Various synthesis approaches implemented in nanodentisty:



The fabrication techniques of these nanoproducts can be divided into two approaches "top –down" and "bottom-up". In the TOP-DOWN techniques produce very small structure from larger pieces of material. These are mostly extensions of methods already employed in small-scale assembly at the micron scale. By further miniaturization, the nanodimension is entered. "BOTTOM –UP'' approach first described by Drexler (atom by atom) to manufacture large scale materials using nanobots capable of self –replication [7][2] .

Functional approach: (Niche-approach) Targeting root issues rather than symptoms, Antimicrobial medicines, Nutrient supplements, stress management etc.

Biometric approach: (Biognosis, or biomimicry) creating new material by mimicking natural processes and natural matter.

According to materials used: ***Natural*** -Common origins in nature are oil, sea waves, sand storms, volcanoes, forest fires, living organisms, crystalline structures, and space (Dolez, 2015). **Incidental nanoparticles**—are emitted as ultra-fine particles as unintended by-products of human controlled processes such as power generation, engine exhaust, material welding,etc. **Engineered nanoparticles** are now engineered artificially in order to provide enhancement to targeted characteristics.

Based on dimension:[8]

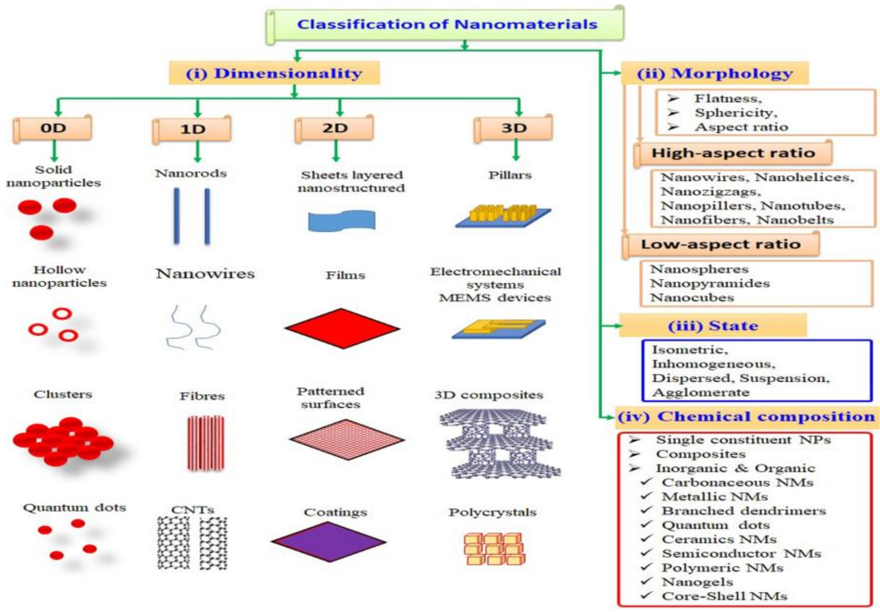


Figure 1:Schematic illustration of the classification of nanomaterials based on different criteria.[9]

Figure2:Classification of nanoparticles based on composition [10]

III. Nanotechnology in dental sciences[2].

Nanotechnogy AS bottom –up approach	Nanotechnology as top-down approach
Inducing anesthesia	**Nanoporous silica filled composites**
Hypersensitivity cure	**Nanoadhesive –POSS4**
Tooth repair	**Nanoceramics**
Nanorobotic dentifrices	**Nanoneedles,dental composites**
Orthodontic nanorobots	**Bone replacement materials ,GIC .**
	Nano-ceramic technology ,impression making ,drug delivery.

IV. Nanotechnology in Periodontology.

1. Nanorobotic Anesthesia : To induce oral anaesthesia in the era of nanotechnology, a colloidal suspension containing millions of active analgesic micron sized dental nanorobots will be installed on the patients gingiva. The nanorobots reach the dentin by migrating into the gingival sulcus and passing painlessly through the lamina propria or the 1-3 micron thick layer of loose tissue at the cemento-dentinal-junction. Once after reaching dentin, the nanorobots enter the 1-4 micron diameter dentinal tubule holes and proceed towards the pulp, guided by a combination of chemical gradients, temperature differentials and even positional navigation, all under onboard nanocomputer control. They have greater patient comfort and reduced anxiety, no needles, greater selectivity and controllability of analgesic effect, fast and completely reversible switchable action, and avoidance of most side effects and complications[2].

2. Nanoneedles and tweezer : Suture needles incorporating nano sized stainless steel crystals have been developed. They are commercially available as Sandvik Bioline,RK 91™ needles [11],nanotweezers are still under development.

3. Oral fluid Nano Sensor Test(OFNASET)

The OFNASET is a handheld, automated. easy-to-use integrated system that will enable simultaneous and rapid detection of multiple salivary protein and nucleic acid . This salivary biomarker detector can be used in the dental office for disease screening[12].

University of California Los Angele's Oral Fluid NanoSensor Test.

4. Subgingival Irrigation: Hayakumo et al has described the use of ozone nanobubble water produced by nanobubble technology in subgingival irrigation. The results of their study demonstrated that it can be used as an adjunct to periodontal therapy because of their enhanced antibacterial activity [13].

5. Nanomembranes: Nanoguide, which has silk fibroin nanomembrane, used in guided bone regeneration[13][14][15].

6. Chronic periodontitis: Applying nano-HA in addition to scaling and root planing increases clinical attachment gain,(ojge et al). Kadam et al hypothesized that adjunctive use of silver nano-particle gel with scaling and root planning has superior effect in comparison to tetracycline gel in management of chronic periodontitis.[11]]Nanoproresolving lipid mediators because of their increased ability to penetrate into periodontitis affected tissue may be an effective method to manage chronic periodontitis.

7. Nanovectors: A calcium phosphate nanoparticle was found to potentially serve as a good vehicle (nanovectors) to deliver target genes to fibroblasts for periodontal regenerative purposes *in vitro* [11].

8. Nanorobotic Dentifrice(Dentifrobots) : Subocclusal-dwelling nanorobotic dentifrice delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day, metabolizing trapped organic matter into harmless and odorless vapours and performing continuous calculus debridement.

9. Biofilm management: Biofilms incorporate wide array of microorganisms that results in increased antimicrobial resistance and pathogenicity. Till today, effective technique for biofilm management has not been devised. Nanoscale materials including zinc oxide,titanium dioxide, copper oxide, carbon nanotubes, chitosan, gold and quaternary ammonium compounds are shown to exhibit antibiofilm activity through the disruption of bacterial cell membrane by generating reactive oxygen species[17].

10. Host Immunomodulation Therapy: Cafferata et al stated the multitasking efficiency of nanocarriers for treating periodontal disease[2], In this study he highlighted the immunomodulatory effects of host modulating agents delivered through nanotechnology based system. They were shown to decrease the level of proinflammatory and bone resorbing T-cell namely Th-1,Th-22 and Th-17. They also increase the differentiation of TH-2 and Treg cells[16].

11. Dentin hypersensitivity: Reconstructive dental nanorobots,using native biological materials, could selectively and precisely occlude specific tubules within minutes, offering a quick and better cure. On reaching dentin the nanorobots enter dentinal tubular holes that are 1 to 4 um in diameter and proceed towards the pulp, guided by a combination of chemicals gradients, temperature differentials and even position of navigation, all under control of the on board nanocomputers as directed by the dentist. The clinical studies proved nano-hydroxy formulations provided relief from dentin hypersensitivity pain they also render durable results[18].

12. Nanomaterials for Local Drug Delivery: Pinon Segundo et al, produced and characterized triclosan-loaded nanoparticles by emulsification-diffusion process, in an attempt to obtain a novel delivery system adequate for the treatment of periodontal disease. [21]In the study by Karol steckiewicz et al, they designed and synthesized silver nanoparticles(AgNPs)conjugated with chlorhexidine(AgNPs-CHL)or metronidazole(AgNPs-PEG-MET) to see whether they had effect on periodontal diseases. Result of the study showed nanomaterilas act as antimicrobial and anti-inflammatory.

Nanomaterials including hollow sphere, core-shell structure, nanotubes and nanocomposite have been widely explored for controlled drug release.

13. Tissue engineering: Tissue engineering concepts for periodontal regeneration are focused on the utilization of synthetic scaffolds for cell delivery purposes. The clinical utility of these nano-constructed self-assembling materials is their capacity to be developed into nanodomains or nanophases, leading to unique nanobuilding blocks with inbuilt nanocontrol and nanodelivery capabilities. Polymer based scaffold for cell seeding, growth factor delivery and tissue engineering via the nanoparticles embedded in site of tissue damage can also be constructed. Through tissue engineering the use of nanoscale perspectives is spellbinding, their use in clinical scenarios still remains fictious. In the future these processes may be well manipulated via nanodevices implanted to sites of tissue damage [19].

14. Bone replacement materials: Hydroxyapatite nanoparticles used to treat bone defects are

a) Ostim^R(Oartis GmbH,Germany)-HA

It is completely synthetically manufactured pure, nanocrystalline hydroxyapatite. The crystals are needle-shaped with a mean crystallite size of 18mm.It is fully degradable after implantation. It can be used in traumatology,orthopaedics,spine surgery and maxio-facial surgery.

b) VITOSS ^{R}(Orthovita,Inc.,USA)

It is an improved form of B-Tricalcium Phosphate(B-TCP)

It is highly porous structure, and is similar to major mineral components in natural bone, approximately 39% calcium and 20% phosphorus, compared with 35% and 15% in the normal bone mineral, it is more readily soluble than synthetic hydroxyaapatite, it is nonimmunogenic in animal studies. It is appropriate as a substitute for calcellous bone in orthopaedic surgery.

c) NanOss TM (Angstrom Media,USA)
It is highly osteoconductive and remodels over time into human bone, with applications in the sports medicine, trauma, spine and general orthopaedic market[3] .

15. DENTAL IMPLANTS AND NANOTECHNOLOGY

a) Nanoporous ceramic implant coatings

A different approach to improve implant properties is anodisation of aluminium. It is widely used for producing corrosion resistant aluminium parts(Thompson,1997). Helical rosette nanotubes are new class of organic nanomaterials featuring two basic DNA components, i.e guanine and cytosine (Fenniri et al., 2001).The result of the study showed helical rosette nanotubes enhanced osteoblast function.

b) Implant surface roughness modification

There was increased in vitro osteoblast function and osteoclastic(bone-resorbing cells) response was correlated with nanometre surface roughness(ranging from -20-300nm)for nanophase alumina and poly-lactic-co-glycolic acid(PLGA) cast of carbon nanofibers[20].

c) Self assembling implants: C.X. Li et al investigated the effectiveness of nano structured self-assembling dental implants in type-II diabetes patients and stated that they exhibited decreased marginal bone loss and better osseointegration than the conventional dental implants used.

16. Periimplantitis: Clot stability can be increased by using nanohydroxyapatite on citric acid conditioned surface. Elangovan et al in their study demonstrated enhanced fibroblast proliferation with the use of platelet derived growth factor-BB delivered using calcium-phosphate nanoparticle[28].

17. Nanoantibiotics: These are the antibiotics that are delivered through nanocarriers with specialized antibiotic coating on their surface. They manifest broad spectrum of activity and decrease the probability of secondary infections[13].

18. Nanoencapsulation: SWRI [South West Research Institute] has developed targeted release systems that encompass nanocapsules including novel vaccines, antibiotics and drug delivery with reduced side effects. At present, targeted delivery of genes and drugs to human liver has been developed by Osaka University in Japan 2003

19. Medical appendages for instantaneous healing:

- Biodegradable nanofibres - delivery platform for haemostasis
- Wound dressings with silk nanofibres in development
- Nanocrystalline silver particles with antimicrobial properties on wound dressings [ActicoatTM, Uk , It is broad spectrum and act against methicillin-resistant strains.

20. Laser and nanoparticles: Laser irradiation on nanotitanium particles coated surface are shown to increase collagen production. Using this principle, gingival depigmentation and other periodontal procedures can be carried out. Sadony and Abozaidillucidated that nanoparticles along with diode laser has the potential to decontaminate dentin surface.[13]

FUTURE OF NANOPERIODONTICS.

Research into nanotechnology is currently taking place in both developing and developed nations around the world. Nanotechnology in Periodontology is applicable in many fields from the prevention of the disease like in dentifrices, mouth rinses which inhibit the growth of the microorganisms, on going in vivo studies need to provide success for nanomaterials for hypersensitivity and other therapies. Numerous untreatable diseases may be treated using nanotechnology. Nanotechnology based diagnosis and treatment of periodontal diseases is the present focus of research and will be made possible in near future.

Conclusion

Nanotechnology is the "The next technological revolution"and has been transforming in the field of medicine and dentistry for few years now. Detecting diseases at an early stage, diagnosing and even treating cancer cells directly. Innovations are happening in this world on hourly basis and growing at very fast rate ,nanotechnology is also in the race. Despite the number of problems with nanotechnology, the new era of nanotechnology in dentistry could change many people view on this field .The public and clinicians should be educated in the area of nanotechnology so they understand the development in the treatment they are receiving. This review has briefly described in the classification and application in Periodontics of nanoscale particles.Although the field of nanoperiodontics is fascinating, data on long term in-vivo effect of nanoscale particles are essential for clinical application.

REFERENCE:

1. A Silva Gabriel; Introduction to Nanotechnology and its applications to Medicine; Surg Neurol2004; 61: 216-220
2. Kumar Saravana , Vijaylakshmi ; Nanotechnology in Dentistry ;Ind J Dent Res 2006 ; 17(2); 62-65.
3. Ingle Ekta, Gopal K Saraswathi; Nanodentistry: A Hype or Hope ;J Oral Health Comm Dent 2011; 5(2): 64-67.
4. Satyanarayana TS, Rai R. Nanotechnology: the future. Journal of interdisciplinary dentistry. 2011 Jul 1;1(2):93.
5. Mallanagouda patil,Dhoom singh Mehta,sowjanya guvva;Future impact of nanotechnology on medicine and dentistry; J Indian Soc Periodontol. 2008 May-Aug; 12(2): 34–40
6. 2.Rocco Castoro U F expects big things from the science of small, nanotechnology. Think Small. The POST 02-2005
7. Pavan Kumar Pavagada Sreenivasalu , Chander Parkash Dora , Rajan Swami , VeeriahChowdary Jasthi ,Predeepkumar Narayanappa Shiroorkar , Sreeharsha Nagaraja , Syed Mohammed Basheeruddin Asdaqand Md. Khalid Anwer; Nanomaterials in Dentistry: Current Applications and Future Scope;Nanomaterials **2022**, 12, 1676
8. Tawfik A. Saleh ; Nanomaterials:classification ,properties,and environmental toxicities;Environmental technology and innovation volume20 nov 2020 .
9. Saleh TA. Nanomaterials: Classification, properties, and environmental toxicities.Environmental Technology & Innovation. 2020 Jul 24:101067.
10. Prajitha N, Athira SS, Mohanan PV. Bio-interactions and risks of engineered nanoparticles. Environmental research. 2019 May 1;172:98-108.

11. Baheti MJ, Toshniwal NG. Nanotechnology: a boon to dentistry. J Dent Sci Oral Rehabil. 2014;5:78–88
12. Wong DT; Salivary diagnostic powered by nanotechnologies,proteomics and genomics .J Am Dent Assoc 2006;137;313-321
13. Parvathi Thenappan CB, Vijayalakshmi R, Mahendra J, Ramakrishnan T. Nanotechnolgy in periodontics: An overview. Medico Legal Update 2020;20:2272-7
14. Hayakumo S, Arakawa S, Mano Y, Izumi Y. Clinical and microbiological effects of ozone nano-bubble water irrigation as an adjunct to mechanical subgingival debridement in periodontitis patients in a randomized controlled trial. Clin Oral Investig 2013;17:379-88.
15. Han D, Hong K, Chung C, Yim S. A comparative study for guided bone regeneration of silk fibroin nanomembrane (NanoGuide-S (TM)). J Koraen Acad Periodontol 2008;38:475-82.
16. Kennedy S, Srinivasan S, Jayavel K, Sundaram R. Nanotechnology in periodontal management. Int J Orofac Biol 2019;3:8-
17. Gopinadh A, Prakash M, Lohitha K, Kishore KK, Chowdary AS, Dev JR. The changing phase of prosthodontics: nanotechnology. Journal of Dental and Allied Sciences. 2015 Jul 1;4(2):78.
18. Schleyer T L.Nanodentistry fact or fiction?; J am Dent Assoc 2000;131;no 11;1567-1568.
19. Bayne SC .dental biomaterials: Where are we and Where are we going?J Dent educ ;2005:69:571-585.
20. Shibata Y, Tanimoto Y. A review of improved fixation methods for dental implants. Part I: Surface optimization for rapid osseointegration. Journal of prosthodontic research. 2015;59(1):20-33.
21. Pinon-segundo E ,Ganem-Quintarnar A,Alonso –Perez V,Quintanar-GUERRERO D.Preparation ana Characterization of triclosan nanoparticles for periodontal treatment.INT J Pharm 2005 :294:217-232