Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/15366
DOI URL: http://dx.doi.org/10.21474/IJAR01/15366

RESEARCH ARTICLE

NANOTECHNOLOGY IN DENTISTRY - SOON TO BE CALLED NANODONTICS

Dr. Anaswara S.[1], Dr. Rani Somani[2], Dr. Anu Susan Joy[1], Dr. Serene M.S[1], Dr. Jeetu Yadav[1], Dr. Avani S.[1] and Dr. Deepa P.[1]

1. Post Graduate Student, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research.
2. Professor and Head, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research.

Manuscript Info

Manuscript History
Received: 10 July 2022
Final Accepted: 14 August 2022
Published: September 2022

Key words:-
Nanotechnology, Nano Dentistry, Nanomedicine

Abstract

No field is untouched by nanotechnology, like wise it has also restructured the field of medicine as well as the dentistry. Nano dentistry as an advanced clinical tool with the help of nanomaterials and nano devices will be able to provide comprehensive oral health care. Some of them are Inducing anaesthesia, Hypersensitivity cure, Tooth repair, Nanorobotic dentifrice, Orthodontic nanorobots, Diagnosis of oral cancer, Treatment of oral cancer etc. with ongoing developments in this branch, will offer more sophisticated methods for diagnosis, treatment, and prevention, so that a new era in dentistry is in near future. This review is focused on the recent developments, various approaches. particularly of nanoparticles, materials and its applications in the fi eld of dentistry.

Introduction:-

Human civilization and human science always have a progress and always will progress. If we do not seek new vistas outward, we investigate inward[1]. As we learn more, we realize that sometimes the most intense effects will be achieved by going smaller down to molecular level. So, the science is undergoing yet another change, in helping mankind enter a new era, the era of Nanotechnology.

Theterm ‘nanotechnology’ was introduced in 1974 by Norio Taniguchi, a researcher at theUniversity. However, the baseline motivation towards the field of nanotechnology probably comes fromRichard Feynman for his historical presentation, “There is plenty of room at the bottom” on nanotechnology given by him, in 1959, at the conference of American Physical Society[2,3].The nanomaterial can be considered as a particle with a maximum size of 1×10^{-9}m.At nanoscale the mechanical, electrical, optical, thermal, and magnetic properties of a nanoparticle are different from those of its bulk material[4]. Nanotechnology has been utilized in various research fields including electronics, cosmetics and medicine[5]. There are various nanomaterials that have potential application in the field of medicine and dentistry.

Growing interest in the future medical applications of nanotechnology lead to the emergence of a new field called nanomedicine – the science and technology of diagnosing, treating, preventing disease and traumatic injury, relieving pain, preserving and improving human health using nanoscale-structured materials, biotechnology and genetic engineering with complex molecular machine systems and nanorobots.

Corresponding Author:- Dr. Anaswara S.
Address**:-** Post Graduate Student, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research.

In 2000, the term and the field of nano dentistry were introduced. It is predicted that nanotechnology will affect the fields of diagnosis, materials, restorative dentistry, and surgery. These new branches namely nanorobotics, nano diagnosis, nanomaterials, and nano surgery and nanodrugs would impact clinical dentistry in the future. Soon this science fiction will become reality. The growing interest in the future of dental applications of nanotechnology lead to the emergence of nano dentistry which includes the maintenance of oral health by the use of nanomaterials, biotechnology and dental nanorobotics.

Nano dentistry is the application of nanotechnology in dentistry and is the future of dentistry in which every procedure will be performed using equipment and devices based on nanotechnology.[6]

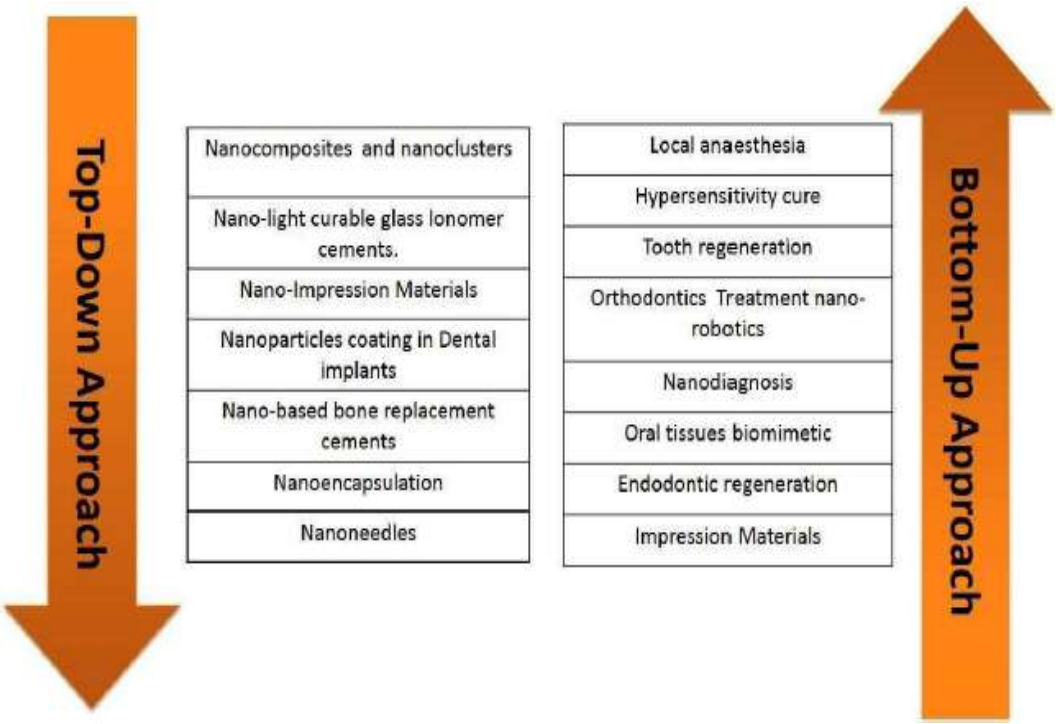
Nanodentistry is defined as the science and technology of diagnosing, treating and preventing oral and dental diseases, relieving pain, preserving and improving dental health using nanostructured material. There are varieties of new dental products available, ranging from implants to oral hygiene products that rely on nanoscale properties.[7]

Application of Nano dentistry:
The various advantages of using Nano dentistry are,
1.Stability- The material incorporated has better stability; hence, its shelf life is increased to incredible amounts.In addition, when thesame material is either dispensed or used in the oral cavity, its stabilityagainst the oral fluidis more.
2.Preparation Techniques- Since, thepreparation is at nano levels, with appropriate armamentarium, it is easyandits large-scale manufacturing is possible.
3.Controlled Release- Corresponding toits function at nano levels, it makes its way quickly to target site,(especially, dentogingival sac), as carriers or vectors, thus maximizing its therapeutic potency[2].

Nanostructures
The enhanced properties of the nanoparticles increase the mechanical properties like enhanced toughness, stiff ness, transparency, increased scratch, abrasion, solvent and heat resistance and decreased gas permeability. The various nanoparticles are nanopores, nanotubes, quantum dots, nanoshells, dendrimers, liposomes, nanorods, fullerenes, nanospheres, nanowires, nano belts, nanorings, nanocapsules[8].

Advantage of nanoscale
1.Nano is the scale at which the basic functions of the biological world operate - and materials of this size display unusual physical, chemical properties and mechanical properties like enhanced toughness, stiff ness, transparency, increased scratch, abrasion, solvent and heat resistance and decreased gas permeability.
2. These profoundly different properties are due to an increase in surface areacompared to volume as particles get smaller [6]

Approaches To Nanotechnology
1. **Bottom-up approach**: This approach arranges smaller components into more complex assemblies. Eg: Inducing anaesthesia, Hypersensitivity cure, Tooth repair, Nanorobotic dentifrice, Orthodontic nanorobots, Dental durability and cosmetics, Nanotech floss, Photosensitizers and carriers, Diagnosis of oral cancer, Treatment of oral cancer[9].
2. **Top- down approach**: This approach creates smaller devices by using larger ones to direct their assemblies: Salivary diagnostics powered by nanotechnologies , Nanocomposites, Nanotechnology for glass ionomer cement ,Nano-ceramic technology ,Nano bond, Nano solutions ,Coating agents, Nanotechnology for impression materials, Nano-composite denture teeth, Implants, Laser plasma application for periodontia, Nano needles, Nano bone replacement materials, Nano bone fibres, Nanoparticles as antimicrobial agents, Nanotechnology based root-end sealant[9].
3. **Functional approach**: This approach develops components of the desired functionality without much importance to their assembly or structure[3].
4. **Speculative approach**: This approach often takes a big picture view of nanotechnology, with more emphasis on its societal implications than the details of how such inventions could actually be created.[3]
5. **Regenerative nanotechnology (**Bio-Mimicry) -Dentition renaturalization, Dentition replacement therapy (major tooth repair)[9]



Break through approaches of nanotechnology and its application in dentistry

Advantages Of Nanotechnology

The various advantages of nanotechnology are as following

1. Better accuracy
2. Better efficiency and speed
3. Non‐invasive technique
4. Computer‐controlled operation with nobs to fine‐tune the amount, frequency, time of release.
5. Use of nanorobot drug delivery systems with increased bioavailability
6. Targeted therapy such as only malignant cells treated
7. Fewer mistakes on account of computer control and automation
8. Reach remote areas of human anatomy, which was not operatable at the surgeon's operating table.
9. As drug molecules are carried by nanorobots and released where needed the advantages of the large interfacial area during mass transfer can be realized
10. Drug inactive in areas where therapy not needed minimizing undesired side effects

Nanomaterials

Nanomaterials are those with components <100 nm in at least one dimension[10]. Their properties vary majorly from other materials due to two reasons:

1. The increase in surface area
2. Quantum effects.

Types of nanotechnologies in nanomedicine

Usually, nanomedicine based on three potent molecular technologies:

1. Nanoscale materials and devices to be applied in advanced diagnostics and biosensors, targeted drug delivery, and smart drugs
2. Molecular medicine through genomics, proteomics, artificial biobotics (microbial robots)
3. Molecular machines and medical nanorobots which helps in immediate microbial diagnosis and treatment, and enhancement of physiological functions. [10]

Examples of nanoscale materials are Nanorobots, Nanosensors, Implantable nanomaterials, Nano phase materials, Nanohydroxyapatite, Nanophase carbon.

Nanorobots
Nanorobots are made of components with size ranges from 1 to 100 nm and diameter of about 0.5–3 μ. Carbon will be the primary component in the form of diamondoid or fullerenes form. Nanorobots would respond to definite programs enabling clinicians to execute accurate procedures with great accuracy, effectiveness, and speed at the cellular and molecular level.

For example, when an Micronanotool atomic force microscope configured to perform nanomanipulation, it can be considered as a nanorobotic instrument. Macroscale robots or microrobots, which can move with nanoscale precision can also be considered nanorobots.

Types of nanorobotic system
The various types of nanorobotic devices that have been developed so far by scientists and engineers are described. These nanorobotic types are very different than the science fiction concept of nanorobots that are usually presented as nano-bugs[9].
a. Biochip
b. Nubots (Nucleic acid robots)
c. Positional nanoassembly
d. Bacteria based
e. Open Technology

Nanosensors
Nanosensors have been used in the military to identify airborne harmful materials, weapons of chemical warfare and drugs, and other substances in expired air.

Implantable nanomaterials
Micro- and nanotechnology-based biomedical implantable devices are collectively known as bionic implants. The term bionic refers to the study of artificial systems that can mimic the biological systems. Implantable devices have demonstrated significant potential for wide applications including biosensing and drug delivery.[11]
These materials can be applied in various fields:
1. Tissue healing and substitution
2. Implant materials
3. Osseous repair
4. Sensory aids
5. Cochlear and retinal implants
6. Tissue regeneration scaffolds
7. Bioresorbable materials
8. Diagnostic and therapeutic devices

Nanophase materials
Nanophase materials are promising materials for various bio- applications like repair of bone defects, as implant materials, etc. It improves both mechanical as well as biological properties[10].

Nanophase hydroxy apatite
Nanophase hydroxyapatite (HA) has increased osteoblastic adhesion and growth compared to traditional HA. In addition, nanophase alumina and titania also show similar features. HA NPs used to treat bone defects are:
1. Ostim HA
2. Vitosso HA + TCP (tricalcium phosphate)
3. NanOSSTM HA.

Nanophase carbon
Carbon nano fibres have extra ordinary conjectural mechanical properties in addition to nanoscale dimensions like natural HA; these features support its proposals a maxillofacial implant material. Extra ordinary mechanical properties and nanoscale dimensions enables carbon nanofibers to use as a maxillofacial implant material.

Applications Of Nanotechnology In Dentistry
Nanodentistry As Bottom-Up Approach.
Nanodiagnostics
Nanodiagnostic devices can be used for early disease identification at the cellular and molecular levels by collecting human fluids or tissue samples and analysing multiple times at the subcellular level. Diagnosis using nanotechnology will overcome drawbacks of biochip technology and conventional technology[9].

Diagnosis of oral cancer
Saliva is used as an inexpensive and noninvasively obtained diagnostic medium that contains proteomic and genomic markers for molecular disease identification. Exosome, a membrane-bound secretory vesicle, is one such marker whose level is elevated in malignancy. This marker has been studied by using atomic force microscopy, which employs nanoparticles[12].

Nano Electromechanical Systems (NEMS)
Oral Fluid NanoSensor Test (OFNASET)
Optical Nanobiosensor

Oral fluid nano sensor test machine (ofnaset)

Local nanoanaesthesia
Ongoing research to induce local anesthesia in the era of nano dentistry, is working on colloidal suspension containing millions of active analgesic dental nano robotic particles that could be instilled on the patient's gingiva. These nano robots, after contacting the surface of the crown or mucosa, reach the dentin by migrating into the gingival sulcus and pass painlessly to the target site. On reaching the dentin, the nano robots enter dentinal tubule and proceed toward the pulp, all under the control of the onboard nano-computer as directed by the dentist. Once installed in the pulp, the analgesic dental robots may be commanded by the dentist to shut down all sensitivity in any particular tooth that requires treatment. After completion of the treatment procedure, the dentist orders the nano robots to restore all sensation, to relinquish control of nerve traffic and to egress from the tooth by similar pathways used for ingress.[13]

Nanorobot for inducing local anaesthesia

Hypersensitive cure:

Researchers at the Chemistry and Biochemistry Department at National Chung Cheng University, Taiwan have published a paper demonstrating the use of gold nanoparticles in occluding dental tubules. These gold nanoparticles (5 nm in diameter), have a low melting point. One of the methods of closing sub-micron sized dentinal tubules explored by Dr. Chris Wang and his team involved the sintering of highly concentrated gold nanoparticles that were brushed into the exposed open ends of dentinal tubules[14]. Laser irradiation also induced the photofusion of gold nanoparticles via photothermal conversion**.**

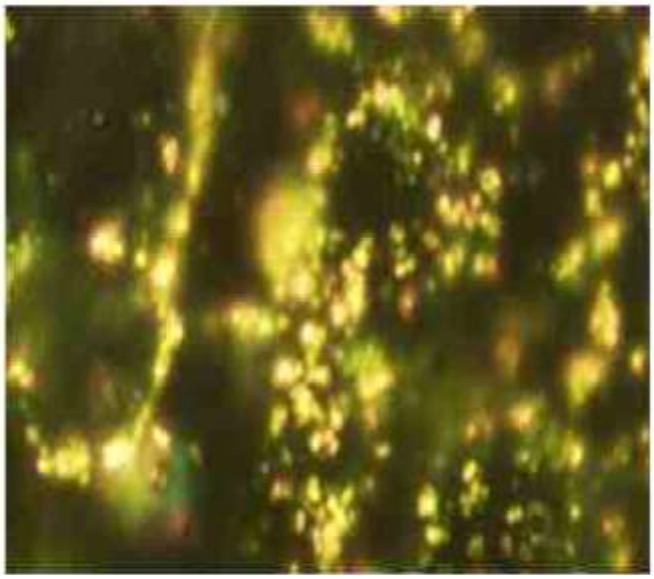
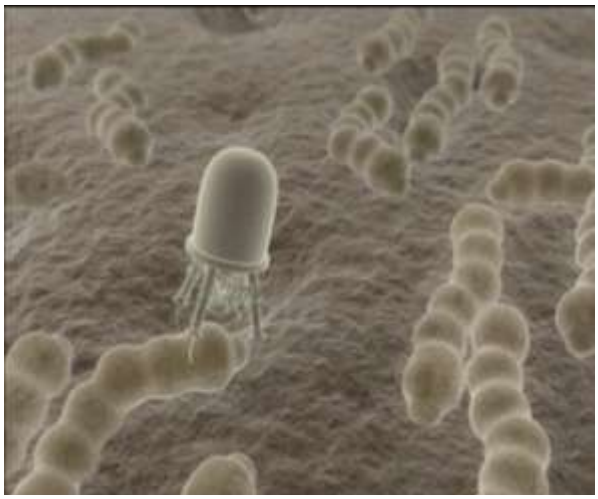


Fig 8:- Gold Nanoparticles.

4.Nanorobotic dentifrices (dentifrobots)

Sub occlusal dwelling nanorobotic dentifrice delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day, metabolising trapped organic matter into harmless and doorless vapours and performing continuous calculus debridement. These invisibly small dentifrobots [1-10 micron], crawling at 1-10 microns/sec, would be inexpensive, purely mechanical devices, that would safely deactivate themselves if swallowed and would be programmed with strict occlusal avoidance protocol[12].



Nanorobotic dentrifice acting on oral microflora

Tooth durability and appearance

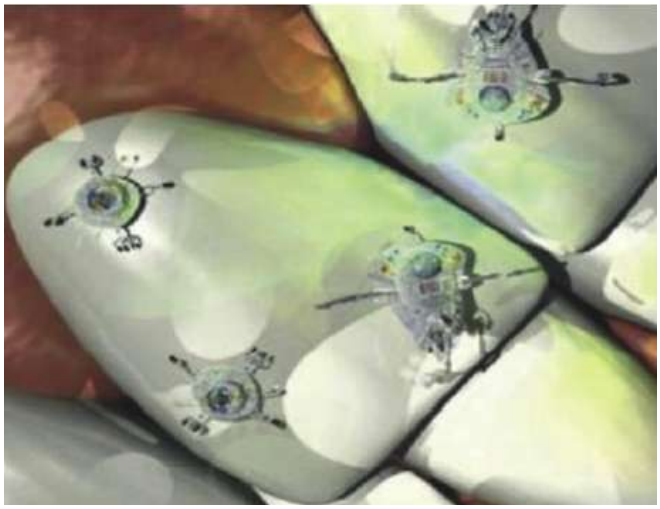
Durability and appearance of the tooth may be improved by replacing upper enamel layers with covalently bonded artificial materials such as sapphire or diamond.Nanotechnology has improved the properties of various kinds of fibres. Poly nanofibers and carbon fibres with nanometre dimensions possess larger surface area per unit mass, which permit an easier addition of surface functionalities and also increase in osteoblast adhesion necessary for successful orthopaedic/dental implant applications respectively. Nanofibers are also integrated in vinyl siloxanes, producing a unique addition Siloxane impression material. Better flow improved hydrophilic properties, hence fewer voids at the margin and better model pouring, enhanced detail precision are some of the advantages of this impression material[15].

Orthodontic treatment

A new stainless-steel wire that uses nanotechnology is being studied that combines ultra-high strength with good deformability, corrosion resistance, and surface finish in contrast to current molar up righting techniques, which require weeks or months to complete[12].

Halitosis

Dentifrobots may prevent the oral malodor by interfering with the metabolism of bacteria.Nanorobots are being incorporated in mouthwash so that they can identify and destroy pathogenic bacteria leaving behind harmless oral flora to flourish in the oral ecosystem. It would also identify food particles, tartar and plaque lift them from the teeth to be rinsed away. [16]



Nanorobotic oral prophylaxis

Nanotech floss
Ultra-thin, ultra-glide, completely non-shredding with excellent tensile strength. The unique nano-structure of dental tape allows for the addition of flavours, and delivery of medications.

Photosensitizers and carriers
These reside on the surface of the target cell, when activated by UV light, they produce free oxygen radicals, which are harmful to the target cells**.**

Nanodentistry As Top-Down Approach:-
This includes carving and fabricating small materials and components by using larger objects.

Nano Aluminium Oxide:
This is available in powder form or as nano Al_2 O_3fibres. The powder form (60-100 nm) has high purity, large specific surface area & high surface activity. Nanoceram(nano aluminium oxide powder incorporated in dental ceramics) - the sintering temperature is decreased. Studies have shown that nano aluminium oxide when incorporated in dental cements have high hardness, high modulus, very high dielectric properties, good oxidation-resistant property, low thermal expansion efficient and superior surface finishing & polishing.[14]

Nanocomposites
Nanofiller incorporated into resin matrix are of 2 types- nanomers and nanoclusters.

Nanomers (NM) are mono-dispersed, nonaggregated and non-agglomerated silica nanoparticles treated with 3 methacryloxypropyltrimethoxysilaneMPTS . MPTS also allows chemical bonding of the NM filler to the resin, matrix during curing[10].

Nanoclusters (NCs) particles- the primary particle size of this NC filler ranges from 2 to 20 nm, while the spheroidal agglomerated particles have a broad size distribution, with an average particle size of 0.6 μm.

Trade name: Filtek Supreme universal restorative pure nano, Ceram X mono(Densply)

Advantages
1. Increased hardness.
2. Improved flexural strength, toughness andtranslucency.
3. Decreased polymerization shrinkage (50%).
4. Exceptional handling properties.
5. High polish retention
6. Higher translucency giving it more lifelike appearance

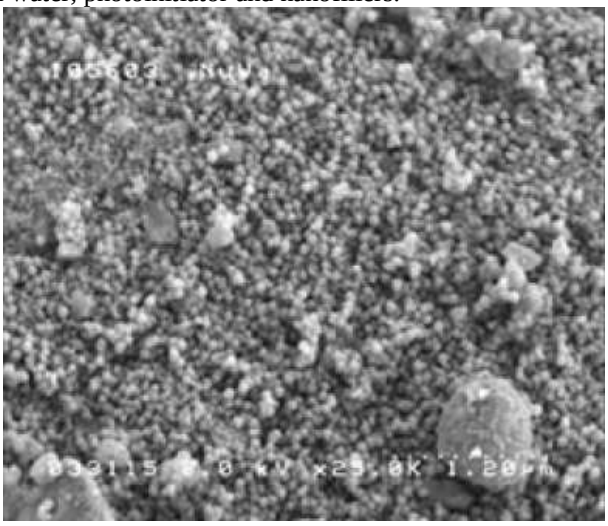
Nanosolution (Nanoadhesives)
Nanosolutions are constituted by dispersible nanoparticles, which are then used as a component in bonding agents. They lead toa homogenous and perfectly mixed adhesive consistently.

Advantages:
1. Higher dentine and enamel bond strength
2. High stress absorption
3. Longer shelf life&Fluoride release
4. Durable marginal seal
5. No separate etching required

Nano glass ionomer restorative
Nanotechnology provides superior properties to glass ionomer restoratives by using bonded nanofillers and nanoclusters, with FAS (Fluoroaluminiosilicate) glass in a newer type of GIC with fluoride releasing property**[10]**.

Commercially available as Ketac N100 light curing nano ionomer restorative (3M ESPE).
Nano light curing GIC is comprised of two paste system:

1. Paste 1 – Non-Aqueous paste –contains FAS glass matrix that is prepared by fusing together SiO2, AlF3, ZnO, SrO, cryolite, NH4F, MgO and P2O5, reactive resins HEMA and filler components- Nanomers, nanoclusters of varying sizes.
2. Paste 2 - Aqueous paste-polyalkenoic acid component-modified polyacrylic acid with pendant methacrylate groups, HEMA, deionized water, photoinitiator and nanofillers.



SEM image of nanofillers in nano GIC matrix

Nanoceramic technology-based composites:
The Nano – Ceramic particles can be described as inorganic – organic hybrid particles (Methacrylate functionalised silicon dioxide nano filler) where the inorganic siloxane part provides strength and the organic methacrylic part makes the particles compatible and polymerizable with the resin matrix. The good resistance to microcrack propagation might be related to the strengthening[14].

Bone Replacement Materials:
Nano hydroxyapatite is used to treat bone defects are,
1. Ostim ® (osartis GmbH Germany) HA.
2. VITOSS ® (orthovita Inc, USA) HA+ TCP
3. NanOssTM (Angstrom Medica ,USA) HA

Impression materials:
Nano fillers are integrated in vinylpolysiloxanes, producing a unique addition of siloxane impression materials. The material has better flow, improved hydrophilic properties and enhanced detail precision[13].

Trade name:
Nano Tech Elite H-D+

Advantages:
1. Increased fluidit
2. Hydrophilic properties
3. Resistance to distortion and heat resistance
4. Snap set that consequently reduces errors caused by micro movements
5. Better working and setting time.
6. Low contact angle of approximately 30^0 for accurate, reliable impressions in the oral environment.
7. Outstanding tear strength ensures reliable impressions.
8. Minimized out-gassing time for immediate pour of models.

Nano-composite denture teeth
Nanocomposite denture teeth are made of Polymethylmethacrylate (PMMA) and homogeneously distributed nanofillers[10].

Advantages:
1. Excellent polishing ability and stain-resistant
2. Superb esthetics
3. Enhanced wear resistance and surface hardness

Nanoencapsulation
It is a controlled drug release system using nanomaterials like hollow spherical or core- shell structured nanotubes and nanocomposites. Have been widely explored for controlled drug release.South West Research Institute developed specifically targeted release system in the form of nanocapsules for the delivery of vaccines, antibiotics, and various drugs with fewer adverse effects.They also developed protecting outfit and mask, incorporating anti- pathogenic nano- emulsions and nano- particles, medical appendage dressings for immediate cure and bone targeting nanocarriers which integrate with natural bone easily[17].

Dentifrices
Nano-sized hydroxyapatite molecules are a major constituent in these dentifrices. These molecules repair the damage tooth structure by forming a protective shell around the tooth structure. Microbrite dentifrice and has microhydrin (1-5 nanometres) which breaks down theorganic food particles[9].

Prosthetic Implants
Albrektssonet al., in 2008 and Goeneet al., in 2007 demonstrated that the addition of nanoscale deposits of hydroxyapatite and calcium phosphate creates a more complex implant surface forsuccessful osteoblast formation.Bone growth and osseointegration can be effectively attained with implants by using nanotechnology because they enhance the integration of nanocoatings resembling biological materials to the tissues[9].

Orthodontic wires:
Sandvik Materials Technology has developed a new stainless steel with exceptional properties; called Sandvik Nanoflex, the new steel allows ultra-high strength to be combined with good formability, corrosion resistance and a good surface finish[16].

Nano sterilizing solution (Eco Tru Disinfectant)
A new sterilizing solution following nanoemulsion concept has been developed by Gandly Enterprises Inc Florida. Nanosized oil droplets attackand destroy the pathogens.
E.g.: Eco Tru Disinfectant.

Advantages:
• Broad spectrum,Hypoallergic,Noncoroding,Does not stain fabric,Require no protective clothing, Environment friendly,Compatible with various impression materials.

Nano surgical devices, nanoneedles and nanotweezers
Nanosized stainless-steel crystals incorporated into suture needles have been developed with an advantage of giving sharper incisions and lower penetration pressure. Cell surgery may be possible in the near future with nano tweezers, which are now under development. Nanoneedles were manufactured from nanosized stainless steel crystals (Sandvik Bioline RK 91 needles, Sweden). Nano tweezers are also under the way of development, which may enable cell surgery feasible in near future.

Trade name: Sandvik Bioline, RK 91 TM needles.

Nanodentistry As Regenetrative Approach (Bio Mimicry): -
Dentition renaturalization
This technique may revolutionize cosmetic dentistry. Initially, old amalgams restorations may be removed, and the teeth remodelled with natural materials. This may be followed by complete coronal renaturalization procedures in which all previous procedures may be undone and all the teeth remanufactured to become identical to natural teeth[18].

Dentition replacement therapy (major tooth repair)
Nanotechnology may utilize genetic engineering, tissue engineering, and tissue regeneration, initially followed by growing whole new teeth in vitro and their installation. Mainly nanorobotics manufacture and install biologically

autologous whole replacement tooth that includes both mineral and cellular components which leads to complete dentition replacement therapy[35]. So Nanodentistry for major tooth repair may consist of growing the whole new teeth in vitro using genetic and tissue engineering and embedding them into the socket.

Disadvantages of nanotechnology

Even though nanorobots may prove to be a boon to emerging medical technology, there are certain disadvantages/risks associated with it.

1. The initial design cost is very high
2. The design of the nanorobot is a very complicated one
3. Electrical systems can create stray fields which may activate bioelectric-based molecularrecognition systems in biology.
4. Electrical nanorobots are susceptible to electrical interference from external sources such as RF or electric fields, electromagnetic pulse, and stray fields from other in vivo electrical devices.
5. Shielding these devices from electromagnetic fields may prove to be difficult leading to their malfunctioning.
6. Hard to interface and customize
7. Nanorobots can cause a brutal risk in the field of terrorism.
8. The terrorism and anti-groups can make use of nanorobots as a new form of torturing their communities as nanotechnology also have the capability of destructing the human body at the molecular level.
9. Privacy involved with Nanorobots.
10. As Nanorobots deals with the designing of compact and minute devices, there are chances for more eavesdropping than that already exists.
11. Require customization for specialized functions.

Challenges faced by nanodentistry

There is no doubt that nanoparticles have interesting and useful properties. But challenge has to be faced regarding nanodentistry are Engineering challenges, biological challenges, socialchallenges[19].

Engineering challenge

• Precise positioning and assembly of molecular scale part

• Manipulating and coordinating activities of large numbers of independent microscale robots simultaneously

•Feasibility of mass production technique.

Biological challenges

• Synthesized with biocompatible materials to avoid foreign body reaction and rejection by host tissue.

• Should be non-replicating and capable of self-destruction once it achieved its function to avoid the risk of self-replication

• Developing biofriendly nanomaterial

• Ensuring compatibility with all intricate of human body.

Social challenges

- Public acceptance

-Regulation and human safety

-Ethics

- Financing and tactical concerns.

- Inadequate assimilation of clinical research

Hazards of using nanoparticles

Since nanotechnology is a very recent discovery and is only just being put in to use, there are issues that need to be addressed. Nanomaterials released in the environment can be further modified by, Temperature, pH, different biological conditions, and presence of other pollutants. In this interaction, nanomaterials can alter atmosphere, soil and water and prove to be harmful to human health and the environment. With its numerous advantages, the use of nanoparticles in day-to-day dentistry has some drawbacks. The substantial administration of nanomaterials in dental materials and treatment Plan has a potential effect on human cell toxicity.

The three most important factors that cause toxicity are the size, charge, and shape of the nanoparticle used. Along with which the mechanism of action, by which it causes damageinvolved in cell lysis and cell apoptosis.

Conclusion:-

This review is focused on the recent developments, various approaches. particularly of nanoparticles nanocomposites, and other materials will play a growing role in materials development for the dental industry. Nanomedicine needs to overcome the challenges for its application, to improve the understanding of pathophysiologic basis of disease, bring more sophisticated diagnostic opportunities, and yield more effective therapies and preventive properties. Despite the several ongoing global developments in nanomedicine several countries in the Asian and African continents remain far off in terms of nanotechnological developments. This has been primarily fuelled by factors such as poor funding, inability to retain trained nanotechnology manpower/experts, poor technological transfer principles, slow strategic decisions at relevant levels of governance and research, absence of private enterprises participation and collaborations. Overcoming these challenges would facilitate further advancements in Nano dentistry in these regions, and indeed worldwide. Although this rapidly advancing field of medicine offers a promising future, it may also pose a risk for misuse and abuse. Further researches, testing, and frank discussions with open sharing of ideas should be required to make this promising technology a reality.

References:-

1. Aeran H, Kumar V, Uniyal S, Tanwer P. Nanodentistry: Is just a fiction or future. Journal of Oral Biology and Craniofacial Research. 2015 Sep 1;5(3):207-11.
2. Calisir M. Nanotechnology in dentistry: past, present, and future. InNanomaterials for Regenerative Medicine 2019 (pp. 197-216). Humana, Cham.
3. Jandt KD, Watts DC. Nanotechnology in dentistry: Present and future perspectives on dental nanomaterials. Dental Materials. 2020 Nov 1;36(11):1365-78.
4. Senocak E, Sarıkaya I, Hatırlı H, Coşgun A. Dental Students' Emotions, Knowledge, Awareness And Learning Intention On The Applications of Nanotechnology In Dentistry.
5. Sheetz T, Vidal J, Pearson TD, Lozano K. Nanotechnology: Awareness and societal concerns. Technology in Society. 2005 Aug 1;27(3):329-45.
6. Selvaraj S, Jayachandran D. Nanodontics-A New Horizon in Dentistry. Issues and Development in Health Research Vol. 3. 2021 Aug 18:134-40.
7. Mantri SS, Mantri SP. The nano era in dentistry. Journal of natural science, biology, and medicine. 2013 Jan;4(1):39.
8. Sasalawad SS, Sathyajith NN, Shashibhushan KK, Poornima P, Hugar SM, Roshan NM. "Nanodentistry"-The Next Big Thing Is Small. International Journal of Contemporary Dental & Medical Reviews. 2014;2014.
9. Nandagopal N, Usha M, Sreejith S, Rajan S. A clinical review of nanotechnology in maxillofacial practice. Journal of Oral Research and Review. 2021 Jul 1;13(2):149.
10. Bhardwaj A, Bhardwaj A, Misuriya A, Maroli S, Manjula S, Singh AK. Nanotechnology in dentistry: Present and future. J Int Oral Health 2014;6:121-6.
11. Bisht R, Mandal A, Mitra AK. Micro-and Nanotechnology-Based Implantable Devices and Bionics. InEmerging Nanotechnologies for Diagnostics, Drug Delivery and Medical Devices 2017 Jan 1 (pp. 249-290). Elsevier.
12. Vora MS, Ramya BJ. NANODENTISTRY–A DENTAL BOON.
13. Upadhyay Y. 'NANODENTISTRY': Exploring the beauty of miniature. Indian Journal of Public Health. 2015 Jan;6(1):2.
14. Malathi Suresh DV, Mahalaxmi S. Nanotechnology–an asset to dentistry!!!. Int J Comm Dent. 2014;5(1):27-31.
15. Gambhir RS, Sogi GM, Nirola A, Brar R, Sekhon T, Kakar H. Nanotechnology in dentistry: Current achievements and prospects. Journal of Orofacial Sciences. 2013 Jan 1;5(1):9.
16. Desai K, Somasundaram J. Nanodentistry-An Overview. European Journal of Molecular & Clinical Medicine. 2020 Dec 1;7(1):2879-87.
17. Chandki R, Kala M, Kumar KN, Brigit B, Banthia P, Banthia R. 'Nanodentistry': Exploring the beauty of miniature. Journal of Clinical and Experimental Dentistry. 2012 Apr;4(2):e119.
18. Hegde V, Memon K. INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH.
19. Mahalaxmi S. NANODENTISTRY–PROBLE. Journal of Current Research. 2017 Aug 10;9(10):58855-8.