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ADVANCEMENT IN NANOTECHNOLOGY FOR RESTORATIVE DENTISTRY

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Abstract:

Nanotechnology is considered to be an upcoming technology. Nanotechnology in the field of dentistry helps in diagnosis, prevention and treatment. Nanotechnology incorporates the usage of nanoparticles less than 100 nm. The usage of nanoparticles in restorative materials has increased the quality and life of dental restorations resulting in better oral care and hygiene. The technology helps in modifying the existing restorative material in terms of physical, chemical and biological aspects to improve their quality. Nanotechnology uses nanoparticles which are synthesized naturally from plants and chemically. The usage of specific nanoparticles is based on the properties and cytotoxic actions. Conventional GIC (Glass Ionomer Cement) and composites have been modified and improved in numerous ways by the addition of different nanoparticles. The restorative materials with nanoparticles currently used are nanocomposites, nano glass ionomers, nano adhesives and endodontic sealers. Nanotechnology is paving the way for recent advances in nanomaterials innovations. The advances of nanoparticles are helping the future of dentistry and production of new developments of materials with high quality. The main drawback faced in using nanoparticles is the toxicity produced by the nanoparticles but the demand for nano based dental material preparation has increased so there is a need for new nanomaterials. The review article provides an overview of the advancement of nanotechnology in restorative dentistry.

Keywords:

Nanotechnology, restorative dentistry, oral care, nanomaterials, cytotoxic action, diagnosis

INTRODUCTION:

Nanotechnology incorporates the usage of nanoparticles less than 100nm. The particles are divided into categories on basis of their size, morphology and chemical properties. Due to their chemical, physical and mechanical properties they are used in medicine and dentistry [1]. The materials tend to possess different properties in nanoscale according to conductivity, colour ,strength and toxicity [2]. The plasmonic nanoparticles are a novel group with unique properties currently used in the field of biomedicine [3]. The usage of nanoparticles is according to their characterization, size and shape. Characterization of nanoparticles is done using the X-ray diffusion method [4]. Commonly used silver nanoparticles are synthesized using the grape seed and acts as a good capping and reducing agent [5].

Nanoparticles help in dental diagnosis, dental prevention, improvising dental materials, nano-biosensing and chemical substance analysis [6]. Adding nanoparticles to the existing group improves the quality of the nanoparticles[7]. Nanostructures used in dental application include nanorods, nanospheres, nanotubes, nanofibers, dendrimer and dendritic copolymers [8]. Nanotechnology can also help the reduction of the postoperative pain after the usage of endodontic sealer and endoactivator because of the increased drug delivery mechanism of the nanoparticles [9]. The cone beam technique is used in evaluating the remaining dentin

thickness of the after the cleaning and shaping process [10], and after removing the calcified enamel [11], nanobased sealers can be added for more stability.

The nanomaterials are smaller materials that are in the form of nanoclusters. The nanoparticles are used for the diagnosis, controlled delivery and drug targeting [12]. In the preparation of nanomaterials the silver nanoparticles possess good properties followed by the iron oxide and carbon [13]. The nanosized structures in restorative material can enhance the mechanical property and make the material dimensionally stable [14]. Chlorhexidine acts as a very good antibacterial agent hence using chlorhexidine along with nanoparticles has a high drug delivery mechanism [15,16]. The usage of nanoparticles as intracanal medicament has good ability as an antimicrobial agent [17]. The technology shows the involvement of natural extract along with nanoparticles helps in the maintenance of the antimicrobial susceptibility after the replantation of the avulsed tooth [18]. The matrix metallo protease helps in the control of the release of nanoparticles from the biomaterials [19]. Nanoparticles have good electrical conductivity hence can be used in the electric pulp tester for the examination of pulp vitality in future studies [20]. In the ellis class 2 fracture the patient feels hypersensitivity which cne be treated using nanoparticles [21]. The nanoparticles have the capacity to penetrate into small structures hence the without optimal space also the teeth can be treated [22].

The main nanomaterial used in the restorative dentistry is the nanocomposites and the nano-ionomer cement. The nanomaterials possess good properties when compared to that of the conventional composites and glass ionomer cement. The usage of nanotechnology in the field of dentistry promotes the material stability and possesses antimicrobial properties according to the concentrations given. The future nanoparticle and the advance are to produce and enhance the application of the nanoparticles in the field of dentistry

NANOTECHNOLOGY IN DENTISTRY:

Nanotechnology plays an important role in all fields of dentistry. The new emerging nano-sized equipment in dentistry include nanomaterials, nanorobots and biotechnology. The nanomaterials include the restorative material, adhesives and primers, bonding agents and fluoride releasing agents.

Carbontube nanoparticles possess unique chemical, mechanical properties, thermal and electrical properties [23]. Graphene nanoparticles have the capacity to remove the biofilm of streptococcus mutans and prevent caries. This nanoparticle acts as an antibacterial agent [24]. The nano-hydroxyapatite crystals have the capacity to enter the dentinal tubules [25]. There are 2 forms of iron oxide nanoparticles magnetite and maghemite which are non toxic and biocompatible. These iron-oxide nanoparticles are utilized to remove the biofilms [26, 27]. Zirconia nanoproducts have similar color and metallic properties as teeth [28]. Nano zirconia and alumina material possess the physical and chemical properties of ceramic material. Silica nanoparticles are used as dental fillers [29]. Silver nanoparticles possess

antibacterial activity [30]. Because of their minute structure they have the capacity to penetrate the bacterial cell membrane resulting in the production of bactericidal activity [31].

APPROACHES IN DENTISTRY:

The 2 approaches used in dentistry for producing nanoparticles include top down and bottom up approach. The top down approach such as monolithic processing, chemical vapor deposition, plasma etching and wet are used to produce structures in micro and nanoscale[32]. The bottom up approach fabricates the material by harvesting atomic elements. The bottom up approach depends on the chemical synthesis and the growth of the material [33][34].

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The nanomaterials are divided into 4 types as polymers, metals, composites and ceramics [35].

Nanocomposites:

The evolution of nanocomposites is based on the issues faced on strength, polymerization shrinkage and wear resistance [36]. The nanocomposites consist of matrix material and nanoscale particles. The properties of this material depends on the method of synthesis. The matrix of the nanocomposite can be ceramic, metallic or polymeric [37, 38]. The properties of nanocomposites help in reducing the polymerization shrinkage [39]. Composites along with silver and zinc oxide nanoparticles have proved to have good antimicrobial effects against lactobacilli and streptococcus mutans[40]. The nanocomposite particles contain carbon based nanofillers, layered nanoclay, porous and hollow nanoparticles, nanocellulose and nanoparticles of metallic ions. The carbon based nanofillers include nanotubes and graphene. The polymer nanocomposites are produced by three methods that include in situ polymerization, melt blending and solution [41]. Nanohybrids contain larger particles ranging from 0.4-5 micrometer [42]. Nanohybrid composites with nanoparticles can be used in ceramic laminates as they produce good strength and stability [43, 44]. The advantages of nanocomposites include its reduced weight, good thermal, electrical properties, antibacterial activity and remineralization of the tooth lesions [45, 46].

Adhesives:

The dental adhesives are resin monomers in solution form that makes the residential substrate interaction [47]. The failure of a restoration takes place in case of secondary bacteria invasion, the antibacterial effect of the adhesives help in reducing the bacterial effects [48]. The nanoparticles increase the surface tension of adhesives [49]. The use of nanoparticles of silver and amorphous calcium phosphate in the adhesives showed good antibacterial effect

and enhanced the bond strength of the material [48]. The aluminium oxide added to the adhesives showed microshear bond strength [50]. The magnetic nanoparticle containing adhesives had good microshear bond strength and improved the penetration of the adhesive into the dentin [51].

Glass Ionomer Cement:

The glass ionomers with nanoparticles are called nanoionomers. The glass ionomer cement is widely used on the basis of their chemical binding to the tooth surface. Nanomers and nanoclusters are added to fluoroaluminosilicate glass [52]. The nanoionomer produces aesthetics and fluoride releasing properties. The nano glass ionomer has high translucency and optical properties compared to the conventional GIC [53]. The nanoparticles are directly mixed with the cement with hand mixing and hence reduces the porosity by filling the spaces between the glass particles in the cement [54]. The pre-reacted glass ionomer technology using GIC and composite 'Giomer' was prepared and using hydroxyapatite with glass powder 'Mainomer' was prepared. New advances in GIC include bioactive glass, CPP-ACP, Reinforced GIC, zirconomer, chlorhexidine GIC, Nano Bioceramic impregnated GIC, ceramirand Giomer[55]. The bioactive glass shows remineralization potential on the enamel surface [56]. The resin modified glass ionomer can be modified by adding bioactive glass nanoparticles [57]. The advantage of nanoionomers is they are chemically stable, improved bond strength and insoluble [58].

Endodontic Sealer:

Endodontic sealers have a solid core material that helps in three dimensional sealing of the root canal. These sealers help in filling the voids, irregularities of the canal and adapt to the root canal [59]. The properties of sealer includes the antibacterial activity, periapical healing and the formation of the hard tissue [60]. Based on the properties, composition and setting reaction type they are classified and used as glass ionomers, zinc oxide eugenol, salicylate, epoxy resin, methacrylate resin and tricalcium sealers. The tricalcium silicate shows low microleakage compared to AH Plus [61]. A bioceramic based nanoparticle (Endosequence BC sealer) [62] has been developed recently. Nano materials containing nanoparticles have delivery of material from 0.012 capillary needles which helps in adapting to the dentin surface which are irregular [63]. The advantage of using nano endodontic sealers is they seal better compared to the conventional sealers [64] and the usage of nanoparticles serves as a good antimicrobial agent [65]. Nanoseal plus root canal sealer is a new nano based endodontic sealer that helps in filling the spaces in the root canal. It is made of calcium phosphate hydroxyapatite nanoparticles ranging from 40-60 nm that are rod shaped and can penetrate into the void spaces easily[59].

Newer findings have been done using nanoparticles for future studies on amalgam, primer adhesive to improve the property for proper usage of the materials clinically.

ADVANTAGES OF NANOPARTICLES:

The nanoparticles like silver, copper and zinc produce antibacterial properties in bulk form but metals like iron are not antibacterial in huge form but they possess antibacterial activity in nanoform. Antibacterial nanoparticles possess multiple mechanisms by releasing metal ions, penetrating into cell walls and producing membrane damage [66]. The nanoparticles possess a good delivery system for the release of micronutrients, protection and encapsulation. The smaller size of the nanoparticles shows advantages like improved bioavailability, high optical clarity, gravitational separation and stability to aggregate [67]. The nanoparticles have the ability to cross the blood brain barrier. Hence the usage of nanoparticles produces the enhancement of the property of conventional material by adding on with properties. In the ellis class 2 fracture the patient feels hypersensitivity which cne be treated using nanoparticles.

DISADVANTAGES OF NANOPARTICLES:

The main disadvantage of nanoparticles is cytotoxicity. The cytotoxicity is seen only in higher concentration. The cytotoxicity depends on the size selective difference. The biological behaviour of nanomaterials depends on the particle size [68]. Targeting the higher disadvantage compared to cost and regulations [69]. Nanotoxicology is the exposure to the dangerous nanoparticles through the entry of the nanomaterials in a biotic and abiotic environment [70].

CONCLUSION:

Nanotechnology plays an important role in the field of dentistry. The nanoparticles possess antimicrobial, anti inflammatory and anticancer activity. The nanoparticles have a wide range of usage in implants, adhesive, nano-composites and primer-adhesives. In restorative dentistry nanocomposites have a wide range of applications with very good properties and strength. In case of usage of GIC with nanocomposites promotes the overcoming of the slow setting reaction, weak bond strength and decreased or compromised mechanical properties. The demand and preparation of nano based dental materials has increased owing to its potential applications and benefits. The usage of nanorobots is a new evolution which helps in fighting against bacteria. The discussed review article states nanotechnology in dentistry as an emerging field. The upgrading of the nanomaterials will be occurring in the future and new nano based restorative materials can replace the existing conventional materials.

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Conception or design of the work: N.E.Kaviya

Data collection: N.E.Kaviya
Data analysis and interpretation: N.E.Kaviya
Drafting the article: N.E.Kaviya
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CONFLICT OF INTEREST:

Nil

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