NANOCOMPOSITES IN DENTISTRY: A REVIEW

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ABSTRACT

Nanomaterials offer unique and superior qualities, including a larger surface area and a small nanoscale dimension, which make them extremely sophisticated and important for speedy diagnosis and therapy of a variety of disorders in the health sector. Multidisciplinary collaborations have enabled the growth of sophisticated nanomaterials (NMs) and their application in dentistry. In comparison to their conventional equivalents, these progressive NMs can provide more impressive outcomes in analysis and therapy operations. This review will go through the many NMs that are available and employed in dentistry, as well as the forms and compositions of different nanoparticles (NPs) that are significant to dentistry. NPs in dental restorative materials may help in the anticipation and/or administration of dental tooth decay. NMs and biotechnology are brought together in this research and have the potential to change the world by promoting oral health through preventative and diagnostic services. They may also have an impact on the repair process where dental tissue has been destroyed.

KEYWORDS
Implantology, Nanotechnology, Nanocomposites, Prosthodontics and Vitamin D

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Introduction

Prosthodontics, discipline of dentistry which pacts with teeth. Prosthodontics has become more popular as people's living standards have improved and oral health education has increased garnered a rising amount of media attention. Prosthodontics is the study of teeth mostly for dental abnormalities and post-tooth-loss treatment, like lays, crowns, and dentures, as well as artificial teeth. Periodontal illness prostheses, temporomandibular joint prosthetics disorder, and abnormalities of the maxillofacial tissues[1–4]. The most important dentures are used to improve alveolar function and advent that sustain the wearer's well-being and keep the wearer's look. Denture materials are primarily split into 3 types, resin, ceramics, and metal were the 3 types. They're crucial to remember, construct a dental prosthesis that comes into intimate contact with the teeth oral mucosa, and it has been used in the mouth for a long time. As a result, dental supplies should be thorough to work successfully, it must have certain qualities and a high level of biological activity. Mechanical strength is required in dental composites, better fatigue strength, elevated elastic modulus, reduced hardness, good castability, electrical and thermal conductivity, and therefore less deformation due to shrinkage. Chemical stability is also necessary, like corrosion resistance, the ability to withstand breaking, and the ability to age. Dental materials' hues can be created and have long-term consistency. It ought to be bifunctional and have excellent biocompatibility and security as an oral substance[2–4]. Nevertheless, considering the nature of the material and prolonged use in a damp environment, a variety of issues might arise during denture wear, including pigment adherence, colour change, and ageing fracture.

NMs have received more consideration in current times owing to various their unusual structures and characteristics. In the early 1980s, the term "nanomaterials" (NMs) was used to describe zero-, one-, two-, and three-dimensional materials by a diameter of below 100 nanometers [5, 6]. NMs are categorized into 4 groups: nano-powder, -fiber, -membrane, and -block, with nano powder having the most innovation and software maturity [6]. NMs have a tiny size, a big surface area, a large surface energy, and a larger percentage of surface atoms, as well as 4 distinct impacts: tiny quantum dimensions effect, quantum tunnelling effect, and size influence [7] the surface effect. The advancement of NMs has been enormous which enriched the area of components science research, includes biomaterials. People's comprehension of natural biological processes is growing at the nanoscale, material characteristics and microstructure are important. The importance of NMs in biomedical applications is gradually increasing more emphasis is placed on material science [7, 8]. This review emphases on the use of NMs in diverse divisions of dentistry and complete classification of NMs depends on the dimensions and figure. We also deliberated nanotechnology based probable future tactics of dental substances with extremely progressive features.

Applications in dentistry

Because of their improved bioavailability, effectiveness, and potential to eliminate the necessary amount of morphine, NMs have the possibility aimed at providing better responsibility for the management of a variety of deadly oral disorders. The usage of NPs in dentistry has created a major effect and brought novel avenues for numerous applications due to the emergence of novel procedures (Figure 1).

-Periodontics

Periodontics is a part of the tooth focused only on tooth-supporting structures like gingiva, periodontal ligament, alveolar bone, and sheath, and also disorders that impact them. Tooth decay, bone loss, and dental problems are all symptoms of periodontitis, which damage the hard and soft components around the tooth. Periodontal disorders can be managed using a variety of therapies, some of which require both medical and surgical approaches.

Figure 1. Numerous uses of NMs in Dentistry

Small molecules, that are inherently macro-sized particles, have a difficult time penetrating periodontal pockets in medicinal therapies. Nanoparticles (NPs), on the other hand, are more easily capable of reaching subgingival regions due to their nanoscale diameters. For example, drug delivery using NPs for the therapy of periodontal disease with Triclosan has been demonstrated [9, 10]. Tetracycline (Tet) NPs have also been looked into as a periodontal therapy. Arestin® and Nanogen® were two available commercially tetracycline-loaded microspheres patches. It was applied through putting a patch into the periodontal pocket that delivers the medication over time to the afflicted part [11]. Nanocrystallinehydroxyapatite (HA) was recently tested for the treatment and management of intraosseous periodontal abnormalities, with promising outcomes [12]. In another research, carbonate and apatite crystal NPs were found to effectively seal dentinal tubules, which is regarded to be significant for longer-term therapy of dentinal hypersensitivity [13].

-Oral and Maxillofacial operation

Oral and maxillofacial operation is an area of dentistry, which pacts with wounds and deformities in the harder and softer tissues of the oral and maxillofacial areas. Facial deformities and bone deformities are caused by a variety of dental diseases or trauma, and they necessitate surgery to restore normal facial characteristics. Orally, bone implantations biocompatible components were used to improve the patient's face look. Irritation, infection, and discoloration of the facial skin are all caused by materials having a low biocompatibility. Modern NMs are biocompatible and outperform standard therapeutic options [14]. Due to their potential to stimulate osteogenic differentiation and biomineralization of cells, these could also be employed as scaffolds for novel bone production.
Oral cancer is now one of the deadliest oral diseases, and it is now regarded as a main hazard to human well-being. Chemotherapy-induced systemic toxicity is the most serious consequence for the treatment of cancer. Nevertheless, this therapy causes symptoms such as a burning mouth and hair loss. The precise identification and killing of cancerous cells by nanodrug delivery could also aid to reduce systemic toxicity through lowering the number of antitumor medications needed [15].

Localized nanodrug delivery can also aid to protect healthy tissues whilst destroying cancerous tissue. Magnetic NPs have been shown in numerous trials to be effective for tumor-targeted medication delivery. They can be readily incorporated into tumor site tissue via the intravenous route, and because of their nano size, they only need a little number of medications, which decreases systemic toxicity and achieves the anticipated impact of tumor regression by precision drug delivery [16-18].

-Conservative Dentistry and Endodontics

Endodontics is a field of medicine concerned by the physiology of the standard dental pulp, as well as the genesis and management of illness and lesions to the dental pulp, as well as periradicular disorders. Microbes in the mouth can produce dental caries, which can cause a variety of endodontic operations like root canal therapy, which is the most shared causes of deep dental tooth decay.

Nanotechnology has the potential to show a vital part in the growth of advanced endodontic substances in endodontic therapies. Endodontic procedures involve a variety of materials, including dental amalgum, glass inomer cements (GIC), dental-based composite, gutta-percha, root canal antiseptic, and sealants. The qualities of endodontic substances may be improved by using nanotechnology to include anti-microbial NPs that can help avoid recurrent inflammation and root canal therapy failures [19]. Biopolymeric NPs were identified as higher antibacterial effect in root canal disinfectants, according to a latest report [20]. In another investigation, adding QPEI (quaternary ammonium polyethylenimine) NPs to the root canal sealer increased its antimicrobial activities towards biofilms of (*Enterococcus faecalis*) *E. faecalis* isolates [21].

-Orthodontics and Dentofacial Orthopedics

Orthodontics and dentofacial orthopedics are a division of dentistry that focuses on the detection, preclusion, and dealing of malocclusions. The teeth must be in the best way for the regular functioning of the oral cavity, however malocclusion, overcrowding of teeth, or gap among teeth necessitate orthodontic therapy owing to poor dental health.
The usage of nanotechnology in orthodontic uses is still in its infancy. NMs with improved characteristics are continually being investigated and commercialized by manufacturers [22]. Coating orthodontic wires and brackets with NPs reduces

friction and mechanical resistance. Antimicrobial NPs coated in orthodontic substances may minimize the development of dental plaque around orthodontic uses and tooth cavities linked with orthodontic therapies. Kachoei*et al.*, published their findings in 2006, indication of a decrease in the friction coefficient among arch wires. Self-ligated hooks by a nano covering of spherical metal NPs, as well as self-ligated struts by such a nano covering of spherical metal NPs. The NPs worked as spacers, reducing surface imperfections, and the metal NPs coating functioned as a solid lubricant film, allowing for very lower friction and easy orthodontic wire sliding over brackets in higher-load situations [23].

-Oral Medicine and Radiology

Oral medicine, branch of dentistry, which deals through the mouth. Considering non-surgical organization and diagnostic criteria of oral and facial pathologies that are not caused by tooth decay. Oral illnesses can be caused by poor oral hygiene, maintaining a healthy mouth necessitates prompt and correct diagnosis of oral illness diagnosis. Nanotechnology has provided improved imaging and therapy of oral diseases.

Oral medicinal perspectives based on nanotechnology have a number of advantages over the traditional method. NPs feature a huge surface area and unpaired atoms that has a proclivity for forming stronger chemical or physical connections. Progressive mechanical and physical qualities are generated organic Silica, Zirconia, HA, and inorganic NPs for a long time, titanium dioxide has been utilized in oral medicine [24]. Nano imaging is a relatively recent concept for dental purposes Nano phosphor scintillators, which speedily generate visible light when subjected to even very lower doses of ionizing radiation, are used to test digital imaging. In comparison to traditional approaches, this Nano imaging technology utilizes extremely little radiation to produce higher-quality images, that can be particularly useful in dental uses [25].

-Restorative Dentistry

The field of restorative dentistry is concerned with the management and therapy of dental problems. Many disorders affecting the teeth and the structures that support them structures. Advanced tactics are required to participate in the competition repair and regeneration of tooth structures that have been destroyed, as well as enhanced aesthetics and restoration of dental function [26].

Biocompatible and non-toxicity dental restorative substances like GIC, dental composite, dental implants, and endodontic substances have all benefited from nanotechnology [27]. In recent years, resin-based dental restorations have made significant progress. NPs added to the composite resin resin matrix can improve mechanical qualities such as minimal polymerization shrinkage, abrasion resistance, and surface hardness [28, 29]. The inclusion of fluoro-aluminosilicate glass NPs to GIC increased the mechanical and aesthetic qualities, according to a study conducted [30]. Nanoionomers have previously been reported for therapeutic usage [31].

-Preventive Dentistry

Nanotechnology can aid in the prevention of caries and the protection towards lesion-causing factors in preventive dentistry. Early microbial bio-films on the surface of the tooth cause dental caries, which eventually lead to tooth decay. Dental restorative products including nanoapatite particles can help injured tooth structures remineralizer [32]. Antimicrobial NPs can be included in dental nanocomposite to inhibit harmful germs from adhering to the tooth surface [33]. Biofilm removal and remineralization of enamel defects can be achieved using dentifrices incorporating HA NPs [34, 35]. The use of amorphous calcium phosphate NPs in dental composites can also help with tooth remineralization [36].

-Prosthodontics

Prosthodontics is concerned with the evaluation, diagnostic testing, comprehensive oral rehabilitation, and maintenance of normal oral function in individuals who have medical problems involving teeth missing or oral and maxillofacial tissues, and uses biocompatible alternatives. Natural ageing, oral disorders, and trauma can all alter the normal oral environment, resulting in tooth loss, which requires replacement for appropriate oral function. Newer materials, like acrylic resins and dental implantations, has improved characteristics and were suitable for a wide range of prosthodontic operations. Manufacturing dentures by nanoceramic material displayed higher strength, colour stability, and lower electrical and thermal conductivity [37].

Various metal groupings have been employed for attempting to make a prosthodontic denture to titanium, cobalt chromium and molybdenum alloys [38, 39]. The mixtures display good mechanical characteristics and chemical resistance to stainless steel [40, 41]. Metal NPs like hydroxyapatite NPs and titanium in the manufacturing of prosthodontic dentures, oxide NPs get a greater theoretical affirmation than traditional metals. In prosthodontics, adding nanofillers to polymethylmethacrylate (PMMA) increases transverse strength, improves biological compatibility, increases surface hardness, and lowers water sorption and solubility [42, 43].

Acrylic resin

Acrylic resins' relevance in dentistry is undeniable. Temporary prosthetic foundation components, provisional prosthesis, dentures, and orthodontic detachable devices like retainers and functional uses all are made with them. Methacrylates, particularly poly methyl methacrylate (PMMA), and other copolymers are often used in these resins [44]. The possibility for plaque gathering caused by surface porosities and food retaining arrangement that would in turn increases microbial growth of cariogenic oral flora, is among the key issues that clients and dentists regularly confront when utilizing these disposable acrylic products [45].

Antibacterial characteristics have been induced using titanium dioxide NPs as additions to biomaterials [46, 47]. Recent research has shown that titanium dioxide has antibacterial activities towards candida albicans, staphylococcus aureus and other bacteria [48-51]. Other features like white hue, lower toxicity, great stability and effectiveness, and also availability, go along with the substantial catalytic impact. Titanium dioxide has been found to be an effective antibacterial addition in acrylic resin [52, 53].

Because of its porous assembly and adsorption capabilities, Silica dioxide outperforms other inorganic carriers like apatite, zeolite, and so on. Silica dioxide NPs have a large surface activity and can adsorb a variety of ions and compounds [54]. Because of their tiny size, silver NPs disperse more readily in the PMMA matrix and provide a wider surface region for oxidation [55]. The discharge of silver ions is a key component of silver NPs' antimicrobial function, as it ruptures the cellular wall, producing protein denaturation, limiting cellular respiration, and producing dangerous bacterial decease [56].

Tissue conditioners

Tissue conditioners are frequently employed to improve the appearance of tissues, the recovering of traumatised denture-bearing tissues. In most cases, ill-fitting causes injury or residual ridge resorption dentures. It is possible to keep tissue conditioners clean. Mechanical and chemical procedures are used, although this can produce problems. Silver has led to the destruction to tissue conditioners [57, 58]. It has long been known for its antibacterial properties [59]. Silver NPs are used to resolve this issue. Tissue cleansers are useful because of their modest size, a vast region of surface.

Composites

Dental composite resins were synthetic resins that are utilized as restorative materials in dentistry. Because synthetic resins are insoluble, they have developed as restorative materials, aesthetic, unaffected by dehydration, and simple to alter as well as being fairly priced. Nanofills were dental composites where all of the fillers have been removed and are in the range of 1-100 nm. There are 2 kinds of NPs employed, in order to make nanofill dental-based composite [60]. The 1st one is the utmost frequent and consists of nanomeric particles, were mono-distributed, non-aggregated, and -agglomerated silica sand elements. Nanoclusters are the 2nd form of nanoparticle utilised to make nanofill composites. This is completed to address the shortcomings of the formerly employed nanomeric nanoparticle. Nanoclusters were formed through softly sintering nanomeric oxides to produce clusters with a precise particle dimensions. Nanoclusters have indeed been created from silica sols alone and combined oxides of silica and zirconia [61, 62]. Nanohybrid Composites are a type of composite that is made up of two or more Pre-polymerized organic fillers are introduced to enhance the unfavourable rheological characteristics of composites containing nanomers[63].

Nanocomposite with Alumina NPs - A research carried by Haik *et al.*, found that adding alumina NPs to a nanocomposite boosts its hardness when comparing to other nanocomposites. A lower-power plasma torch is used to manufacture alumina NPs [64]. Zhanhu Guo *et al.*, did a work in that they effectively functionalized alumina NPs by a bi-functional silane surfactant using a simple approach. As a consequence, both modulus and strength increased significantly. The functionalized NPs had no negative impact on the composite's thermal stability, as well as the vinyl ester resin has efficiently endangered the alumina nanoparticle from dissolving in both acidic and basic solutions after curing [65].

-HA-coated implants

The increased sensitivity to bacterial colonization and the covering integrity of HA-coated implants were two important problems. Other important aspects that contribute to implant failures occlusal trauma and microbial infection are two of the most common causes of tooth decay [66-68]. In terms of microbial colonization, there is no difference on Ti implants versus HA-coated implants it was revealed [69, 70]. Furthermore, on Ti, HA, and cementum surfaces, the sequencing and content of bacterial morphotypes in the formation of subgingival dental plaque were identical [71, 72]. As a consequence of the HA surface roughness and hydrophilicity, it had been proposed that HA coverings were more sensitive to microbial invasion than Ti implantations or natural teeth, hence promoting plaque formation and predisposed the implantation to peri-implantitis [71, 73]. Therapeutic efficacy of peri-implant microflora was hindered through HA surface unevenness inside the case of implantation failing at 3 and 12 weeks prone to bacterial infection. When a HA-covered surface is rough to the oral atmosphere, it turns out to be polluted, and cleaning it was possibly more challenging for the individual than cleaning Ti surfaces [74, 75].

Another issue with HA-coated implantations were that the loss of coverings due to dissolution or coating–substrate interface fracture, resulting in implant movement and loss [76]. Coating resorption may occur during the implementation period. Most research, on the other hand, exclusively tested HA coating resorption on stable, static, and unloaded implantation. During the 16-week implantation period, 65 percent of the 50-m-thick HA coating was totally reabsorbed in the proximal during an unstable mechanical scenario, according to an early investigation [77]. The existence of osteoclast-like cells and the breakdown of the HA coatings were blamed for these resorptions. Though bone deposition was most noticeable on the prosthesis's surface, there was occasional foci of bone remodeling across the implantation, such as osteoclast-mediated elimination of the HA covering alongside the neighboring jaw [78].

-Chitosan hydroxyapatite on dental implants

Chitosan's functional groups enables it to react with a variety of materials, including HAp, to produce composites for bone regeneration. Chitosan's cationic character, as a linear polyelectrolyte with such a higher charge, is the foundation of its application areas. Proteins, for example, have a concentration which can react with negatively charged molecules. Because the amino and hydroxyl groups of chitosan are attached to the calcium ions present at the surface of the HAp crystals, the chitosan-hydroxyapatite composite has remarkable mechanical characteristics [79]. There are numerous published reports about chitosan and hydroxyapatite conjugations in many forms. The pastes, coatings, particles, scaffolds, and hydrogels for orthopaedic, tissue engineering and other uses.

Pastes, coatings, particles, scaffolds, hydrogels, and films are all examples of chitosan-HAp composites. The techniques used to make chitosan-HAp composites for orthopaedic and tissue industrial processes are numerous and vary depending on the structure. The simple addition of HAp to a chitosan solution results in the creation of a paste that can be employed for bone regeneration or to transport osteogenic stimulating substances like BMP-2 or cells [80]. Spraying, electrophoretic deposition, electrochemical deposition, or the sol-gel procedure are the most common methods for depositing chitosan-HAp coatings on a titanium or other metallic substrate (simulating prosthetic materials) [81, 82]. Microparticles of chitosan-HAp can be made by spray-drying or nanoparticles can be made through precipitation or in situ hybridization [83]. 3D structures include composite scaffolds, hydrogels, and films/membranes, and there are several production methods documented in the research.

Joint replacement necessitates a assembly by good mechanical capabilities that none of the chitosan-HAp composites mentioned have. A chitosan-HAp composite inside the form of a covering or paste to cover the metallic implantation would be the most suitable for preventing PJI. This composite may be employed as a functional interface here between implant and the patient's bone, with chitosan preventing PJI and HAp improving implant osteoconduction and osteoinduction, encouraging new bone growth.

Vitamin d and physiological viewpoints

Vitamin D, earliest of all hormones, and scientists have found it in the ancient phytoplankton species Emiliani huxleyi1 that makes vitamin D after being exposed to sunlight. 1 Other aquatic life forms use E. huxleii's high calcium concentration for neuromuscular and metabolic functions. Calcium, a key ingredient in the formation of the skeleton and bone mineralization, was conserved as vertebrates developed in places near oceans [84]. On land, vertebrates, on the other hand, needed to sustain vitamin D synthesis in order to absorb calcium. 1 Vitamin D is required by the human body in amounts of 3,000–5,000 IU per day [85]. Dietary sources of vitamin D3 account for a significant portion of the body's recommended intake, particularly fatty fish, eggs, and heartened meals [86, 87]. A current cross-sectional investigation was conducted. A study in the United Kingdom compares meat and fish feeders to vegetarians and vegans, indicating the vegetarians and vegans were healthier than non-veg eaters. Nonvegetarians had significantly greater vitamin D plasma levels than vegetarians [88].

When people consume vitamin D, the body converts it to chylomicrons, according to Hossein-nezhad and Holick [89]. It is then released to the lymphatic system, where it joins the venous bloodstream [89]. Vitamin D is delivered to the liver via attaching to vitamin D-binding proteins and lipoproteins with in venous circulation [89]. The liver then uses 25-hydroxylation to change vitamin D2 and vitamin D3 into vitamin D metabolite, that clinicians and scientists utilize to assess individual’s vitamin D position. The vitamin D metabolite is then hydroxylated once more in the kidneys to create a secosteroid hormone calciferol [89, 90]. Sunlight exposure, on the other side, the primary source of vitamin D. According to another study, after sun contact, the body transforms vitamin D to previtamin D3, and so on, through a procedure called as photoconversion, and that light contact increases isomerization to vitamin D3 through a heat-induced membrane [87]. Vitamin D-binding receptors transport vitamin D3 to the cutaneous capillary bed after it is produced [90, 91]. When consumers are attracted to solar ultraviolet B (UVB) radiation for lengthy periods of time, an existence of tachysterol and lumisterol averts vitamin D overdose [91].

Studies have identified that a number of noticeable effect vitamin D3 synthesis, like skin pigmentation, age, clothes, sunscreen lotion use, time of day, term, latitude, and altitude [90-92]. The sun's broad zenith angle allows solar UVB photons to transportable further into the ozone layer before protects the ground in the winter [92]. This could explain why little, if any, vitamin D3 is generated in the skin throughout the winter above and below around 33° latitude [93]. This could also explain why, in equatorial regions, vitamin D3 fusion happens exclusively among the hours of 10 a.m. and 3 p.m[93]. Figure 2 explains the production and metabolism of vitamin D.

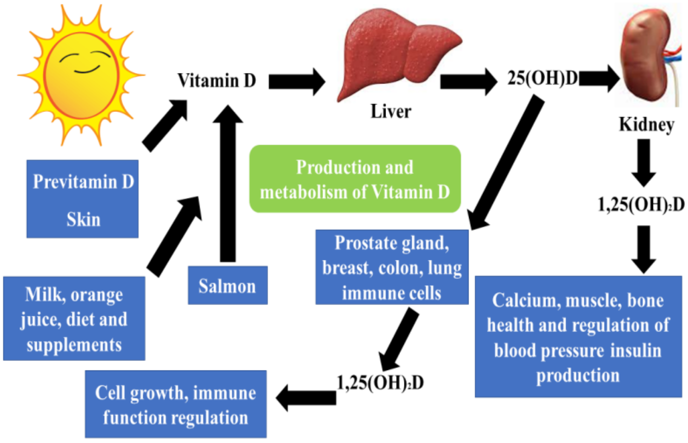

Figure 2. Metabolism of vitamin D.

-Effect of Vitamin D shortage

Vitamin D keeps serum Ca^{2+} and PO^{3-} stages stable that is vital for a variety of physiological activities [93]. Normal bone mineralization, muscle contraction, nerve transmission, and the avoidance of hypocalcemic tetany are among them [90, 94]. Scientists claim that 1,25(OH)2D is required for the body to increase intestinal Ca^{2+} absorption of 40 percent and intestinal phosphorus absorption to 80 percent, both are required for human skeletal health. Sniadecki claimed that rickets, a fatal bone deformity, is caused by a lack of sunshine contact in childhood [92]. The use of a mercury arc lamp to expose youngsters to UVB radiation (290–315 nm) was proved to be an excellent therapy for this problem, and even stopped it from forming [95]. These findings prompted the US media to strengthen parental recommendations supporting the advantages of sunshine exposure for bone growth and rickets prevention in the 1930s [95, 96]. At the same time, the US and European governments sought to enrich milk by 100 IU of vitamin D2 per 8 ounces to combat the prevalent rickets epidemic [96]. Nevertheless, in the 1950s, the UK management was chastised for allowing hypercalcemia to proliferate due to vitamin D supplementation of milk. Because of its upsurge in the occurrence of hypercalcemia, the fortifying of dairy foodstuffs by vitamin D has been prohibited [97].

Vitamin D insufficiency has been related to muscle discomfort and weakness by researchers [98]. Muscle atrophy has been linked to subsequent complications in extreme cases, according to researcher’s hypophosphatemia is caused by hyperparathyroidism [98, 99]. According to a current meta-analysis of ageing persons, taking vitamin D supplements and energetic forms on a daily basis lowered the risk of heart disease. The prevalence decreases by 19% and 23%, respectively [100]. Furthermore, several studies have found that the occurrence of firm kinds of cancer were shown to be more common in populations in those living at greater latitudes had less solar contact [101]. Nevertheless, a randomized, double-blind clinical research evaluating the efficiency of higher vitamin D dosages in enlightening activities involving the low extremities and lowering the risk of falling demonstrated that high dosages of up to 60,000 IU had no effect on the outcome. Neither improved physical functions nor decreased the occurrence of despite increasing the vitamin D range in the blood, the rate of decline continues to a concentration of 30 ng/mL [102].

-Vitamin D and orthodontics

At the alveolar process, bone remodelling involves resorptive and bone production stages once orthodontic forces are applied [103]. There is a link among vitamin D receptor polymorphisms and periodontitis and bone absorption, according to research [104]. Ca^{2+} and phosphorus (P) levels were controlled through vitamin D, parathyroid hormone, and calcitonin, according to study [103, 105]. Vitamin D promoted bone resorption in several experiments by causing osteoclasts to differentiate from their progenitors and boosting the activity of pre-existing osteoclasts [106, 107]. Boyce and Weisbrode examined the impact of Ca^{2+}-rich diets and vitamin D metabolite infusion on bone growth in rats in one of the first efforts [108].

On the first day, treated rats had more osteoclasts than controls. The scientists saw a drop in the number of osteoclasts on days 3 and 4. Days 6, 8, and 10 saw a continuation of this sequela. However, there was a considerable growth in the quantity of osteoblasts in frozen rats associated to the control cluster during the same study time. Calcium and phosphorus levels were elevated, as expected. According to Boyce and Weisbrode, the experimental group had a net upsurge in bone growth [109].

Some researchers believe that, in combination to quicker tooth movement, localised vitamin D injection improves tooth position stability. By enhancing osteoblastic activity, Kawakami and Takano- Yamamoto proposed that calcitriol can increase bone production and periodontal tissue remodelling, that would enhance the stable of the teeth location after orthodontic motion [103]. The researchers split a set of 16 Wistar rats to experimental and control assemblies for this study. Orthodontic elastics were placed bilaterally all-around upper teeth in the experimental class. Calcitriol was infused locally and palatally into the upper molars on the right side every three days. Calcitriol was administered locally in the control group, but no orthodontic elastic was used. After applying an orthodontic force and injecting calcitriol into the submucosal palatal region of the rats who were exposed to tooth crusade, the scientists recognized an elevation in the minerals appositional rates on alveolar bone. Researchers demonstrated that calcitriol has a powerful impact on bone growth in this way. The researchers came to the conclusion that using calcitriol could help the tissue underlying the teeth rebuild following orthodontic treatment [103]. Boyce and Weisbrode discovered a transitory upsurge in bone turnover on the first two days, accompanied through a steady increase in bone production after 14 days of calcitriol administration [103, 110, 111]. According to these lab findings, orthodontic individuals with vitamin D shortage can have a decreased rate of tooth crusade [103, 111]. There was a significant rise in osteoclastic activity at first, accompanied by increases in osteoblastic movement. Vitamin D as well as its metabolites may help with orthodontic therapy, according to this research. More examination is required to confirm the efficacy of vitamin D therapy in orthodontic individuals, and also the best dosage and administration site. Furthermore, given the significant occurrence of vitamin D inadequacy around the world, it was critical that scientists investigate the medical usage of vitamin D. To improve the pace of tooth crusade, vitamin D metabolites are used whilst undergoing orthodontic treatment.

-Vitamin K2 hydroxyapatite on dental implant

With the rising prevalence of bone metastases, the use of targeted drug delivery techniques for cancer therapies has increased dramatically in current decades. Although HA coatings on orthopaedic implants have garnered a lot of attention as load-bearing bone substitutes, orthopaedic surgeons still face a huge issue in repairing tumor-related segmental bone abnormalities. This is owing to the tumor local environment poor bone implant osseointegration and difficulties in new jaw growth.

In addition, insufficient surgical resection leads to tumor recurrence, with bone metastasis occurring in around half of all individuals by bone tumor. As a result, there's a lot of interest in creating local DD based on covered implants that could allow for the controlled release of antitumor and osteogenic biological molecules at the cancer location for better chemoprevention and quicker bone regeneration.35 In the management of osteosarcoma, biologically active HA coverings were employed as a medication delivery system for regulated therapeutic administration of chemopreventive drugs. To attain proper DD in the tumor microenvironment and total implantation success, drug release should be verified at pH 7.4 that mimics in vitro testing conditions and a normal physiological micro - environment, and pH 5.0 that mimics the postsurgical acidic state and extracellular microbiome of cancer cells. In particular, the feasibility of constructing a loadbearplasma-sprayed HA-coated Ti6Al4V implant with the benefits of targeted distribution of biologically active molecules for improved chemo preventive and osteogenic qualities is demonstrated in this study. In vitro release kinetics reveal that the HA coating allows for prolonged release of curcumin and vitamin K2 in both a physiological pH and an acidic milieu. The implants caused severe cytotoxicity in osteosarcoma cells, indicating that they had strong chemo preventive potential *in vitro.*

Whereas the control group had layer-like osteosarcoma cellular part on the implanting surface, the dual issue of vitamin K2 had little to no cellular binding, by 95 percent and 92 percent lesser osteosarcoma cellular viability on days 7 and 11, respectively in comparison with the control group. The reaction of jaw cells was tested using osteoblast cell culture, indicating that the drug-loaded implantations are not harmful to hFOB, and that vitamin K2 actually increased osteoblast viability and multiplication by nearly 9-fold at day 11. After 5 days of femoral epicondyle defect operation in a rat distal femur study, the vitamin K2-incorporated HA-covered Ti6Al4V implants showed improved in vivo osseointegration capacity. Although more study was needed to assess longer-term osseointegration in larger animal studies, this research provides a modest yet efficient creation of a load-bearing jaw implantation for use in jaw defect healing [112, 113, 114].

Conclusion

Nanotechnology's future is interesting, because it has the potential to change dentistry practice. In prosthodontics, advancements in material science will open up new options for further research while maintaining safety, efficacy, and adaptability in mind of these innovative technologies. This review makes an effort to provide information and a brief review of NMs and their applications in the field of prosthodontics and dendistry.

Authors Contribution

Dr Shalini and Dr.Denin: Literature search, data collection,
Dr Revathi Duraisamy: Literature search, manuscript editing

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