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Review

Nanohydroxyapatite in enamel remineralization and tooth hypersensitivity

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ABSTRACT

This study evaluates the advantages of employing nano-hydroxyapatite in dentistry, particularly for preventive treatment applications. Only electronically published papers were searched within this review. Sources: "PubMed" website was the only source used to search for data. 92 most relevant papers to the topic were selected, especially the original articles and review papers, from 1990 till the 1st of April 2022. The morphology of nano-hydroxyapatite, as well as the structure of its crystals, are close to that of dental enamel. As a result, hydroxyapatite can biomimetically replace the natural enamel mineral element.

Keywords: remineralization of enamel, nanotechnology, nanohydroxyapatite, hypersensitivity.

INTRODUCTION

Dental enamel is a calcified tissue that forms the protective outer layer of a tooth's anatomical crown. Enamel cannot be repaired or replaced biologically once it has been produced. The oral cavity goes through cycles of demineralization and remineralization regularly. Demineralization refers to losing minerals from the tooth following an acidic interaction, whereas remineralization refers to restoring these minerals in the tooth structure. The enamel surface becomes rough and rugged when it comes into contact with acid during demineralization. Enamel demineralization/remineralization cycles occur throughout the life of a tooth, determining the degree of mineral balance and tissue integrity or degeneration [1]. Remineralization is the supply and deposition of mineral elements, primarily calcium and phosphate, into the caries lesion lost due to demineralization of the tooth tissue. Remineralization causes hydroxyapatite crystals to grow by apposition, and if fluoride is present in the environment, fluor apatite will form. The treatment for an active early-stage (non-cavitated) caries lesion is remineralization, which aims to reverse the caries lesion or stop it from progressing to the cavitated stages [2]. Carbon dioxide from our breath and water from our saliva combine to form carbonic acid, a mild, unstable acid. The center of the natural remineralization process is carbonic acid. Carbonic acids, like all acids, can dissolve minerals in our saliva (which come from our meals); yet, unlike strong, stable acids, carbonic acid transforms to carbon dioxide and water fast and easily. When this happens, the dissolved mineral ions precipitate out as solid mineral ions once more. The ion is integrated into the tooth enamel if it is near a demineralized area of the hydroxyapatite crystal that requires that ion. Natural remineralization occurs all the time. However, the amount of

activity varies depending on the conditions in the mouth [3]. Remineralization is indicated in high-risk patients as an adjunctive preventive medication to minimize caries, reduce dental erosion in people with GERD or other gastrointestinal problems, in situations of white-spot lesions, restore the enamel, before and after teeth whitening, and desensitize sensitive teeth, orthodontic decalcification or fluorosis [4]. Requirements of an ideal remineralization material are: Does not provide an excessive amount of calcium, does not encourage the creation of calculi, operates at an acidic pH, shows a benefit over fluoride for new materials, diffuses calcium and phosphate into the subsurface or provides calcium and phosphate to the subsurface boosts the remineralizing qualities of saliva in xerostomic patients [5]. Enamel's structure is too complex to be reformed, and the main building components are 20-40 nm hydroxyapatite (H.A. [Ca10 (PO4)6 (OH)2) nanoparticles.
Hydroxyapatite is the major component of enamel that gives the tooth a bright white appearance and reduces diffused reflection of light by filling the small holes of the tooth surface [6]. As a result, remineralization of enamel minerals with synthetic apatite or H.A., which is similar to enamel H.A., could be advantageous [7]. If the H.A. particle size can be lowered to less than a micron, the remineralization effect should be more pronounced. Several researchers have investigated the use of nanoparticles in restorative and preventive dentistry since the development of nanotechnology. Nano-HA is one form of nanoparticle utilized in dentistry. Nano-HA is regarded as promising due to its biocompatibility and bioactivity, as well as its similarities to bone and the mineral structure of teeth. Nano-HA also functions as a filler, fixing minor holes and depressions on the enamel surface, a function aided by the small size of the particles that make up the substance [8].

Method

In the present literature review, a search has been made depending on electronically published peer-reviewed resources using the "PubMed" website. The keywords used were "remineralization of enamel," "nanotechnology" nanohydroxyapatite," and "hypersensitivity," which revealed about 92 relevant papers. Filters applied: Free full text, Full text, Clinical Trial, Meta-Analysis, Randomized Controlled Trial, Review, Systematic Review, Humans, all in English, from 1990/1/1 - 2022/4/1.

Nanotechnology

The control of shape and size at the nanometre scale in the design, characterization, fabrication, and application of structures, devices, and systems is called nanotechnology. The word "nano" is derived from the Greek word "nannos," which means "dwarf." Nanotechnology, according to the National Nanotechnology Initiative, is "the direct manipulation of materials at the nanoscale.". At the nanoscale, a nanoparticle's mechanical, electrical, optical, thermal, and magnetic properties differ from those of its bulk substance. It has a length of one billionth of a meter, measured in nanometers (nm). An atom is approximately 0.1nm in size, and a nanostructure is between 1 and 100 nm in size. Nanotechnology, on the other hand, operates on an atomic and molecular scale [9, 10]. In nano dentistry, nanoparticles are used to improve the durability of dental fillings, prevent oral diseases, and heal injured tooth tissues. The most recent advancements in nanodentistry promise to enter a new era in dentistry. Because of their unique chemical, biological, and physical properties, N.P.s are in high demand in various applications [11]. Because of its high mineral composition, the enamel is the hardest connective tissue in the human body; it comprises 96 percent mineral, 4 percent organic material, and water, with the inorganic material representing hydroxyapatite [12]. The organic component of enamel, despite being less than 1% by weight, had a considerable impact on its mechanical qualities. Hardness decreases as depth increases from the surface to the bottom due to different enamel characteristics in different dental locations. Changes in enamel's chemistry, composition, microstructure, and prism orientation could all play a significant role [13]. Enamel is made up of a large number of hydroxyapatite crystals that are consistently wide, well-aligned and packed within an organic matrix. The hexagonal cross-section of hydroxyapatite crystals appears as a rod with an equilateral hexagon base under SEM, and they are structured to create enamel rods or enamel prisms [14]. Hydroxyapatite is a calcium phosphate compound. In nature, there are other calcium phosphate forms, but hydroxyapatite is the most stable and least soluble. Because pure hydroxyapatite is insoluble, solubility improved considerably per unit time due to the larger specific surface area and low crystallinity of the nano-sized crystals, and more active components can be released [15]. From a technological aspect, nano-hydroxyapatite (nano-HA) manufacture is complicated, involving many steps. The material's hydration is improved due to its broad reaction surface and compact size, resulting in improved physical and chemical properties [16]. Based on its capacity to strongly adsorb to tooth surfaces, nHA has shown in vitro potential to fill enamel interprismatic areas and, hence, perhaps remineralize the enamel [17].

Nano-Hydroxyapatite:

Nano-hydroxyapatite is an artificial material that is widely used in dentistry and medicine. It is made up of nanoparticles that are structurally and morphologically similar to enamel's apatitic crystals but are smaller in size, ranging from 50 to 1000 nm, allowing it to infiltrate enamel pores deep into dentin easily [18, 19]. A variety of methods have been used to make hydroxyapatite nanoparticles. Wet chemical precipitation and hydrothermal processes are the most common fabrication methods. The N-HAp has several advantages over larger crystals, including higher solubility and surface energy, superior bioactivity, and biocompatibility. It can be utilized to improve the tensile strength, density, and toughness of teeth replaced with this material [20, 21]. The ability of hydroxyapatite nanoparticles to chemically bind to bone while also stimulating bone growth without causing toxicity or inflammation is promising [22]. They have a greater surface area and are more hydrophilic than traditional hydroxyapatite crystals. The chemical properties and morphological structure of N-HAp can improve its wettability to form a tough surface layer [23]. It was recently presented as a new remineralizing agent for enhancing demineralized enamel repair [24]. The N-HAp is used in a variety of dental products, including the following: -

It has been used in various endodontic solutions for pulp capping, perforation repair, apical barrier construction, and periapical defect repair [25].

N-HAP toothpastes are superior to conventional fluoridated toothpastes regarding remineralizing effects on enamel deformities. They can also bind to plaque and bacterial components. Furthermore, utilizing N-HAp mouthwash to prevent caries is a good method [21, 22, 26].

Fillers in restorative composite resin and endodontic root canal sealers improve the mechanical properties and biocompatibility of composites, and they were thought to have an impact on apical healing and sealer performance [20].

The mechanical properties of restorative glass ionomer cement have also been reported to be improved by N-Hap [27].

Dentin hypersensitivity (D.H.) is defined as "short, sharp pain emanating from exposed dentin in reaction to stimuli that are often thermal, evaporative, tactile, osmotic, or chemical and that cannot be attributed to any other form of dental defect or pathology ."This dental problem can have a significant impact on a person's dental health and overall quality of life [28, 29]. It can make eating, drinking, and breathing difficult. Dentin hypersensitivity can make it difficult to effectively control plaque, putting your oral health at risk [30]. Dentin hypersensitivity can be caused by root surface denudation as a result of gingival recession or periodontal therapy or by dentin exposure caused by tooth wear during abrasion and erosion. The stimulation of exposed dentin causes dentin hypersensitivity, which is mostly described by Brannstrom's hydrodynamic theory. Dentin activation, according to this idea, causes fluid to flow through the dentinal tubules, which can then be conveyed to nerve fibers at the dentin/pulp junction [31]. Recent research has focused on toothpaste incorporating hydroxyapatite nanocrystals. These bind to enamel and dentine apatite with high reactivity, forming a biomimetic coating on enamel and preventing plaque formation. They also help to prevent tooth decay, restore and renew teeth, and seal dentinal tubules, which reduces hypersensitivity. New items of this type will be a breakthrough in treating dentinal hypersensitivity in the near future [32]. The reason for using n-HAP on D.H. is that it will obliterate the open dentinal tubules and blend in with them because its inorganic composition is identical to that of the tooth. Some researchers believe that the nHA biomimetic function supports remineralization by creating a new layer of synthetic enamel around the tooth or depositing apatite nanoparticles in enamel deficiencies, although the process is unknown. Others, on the other hand, believe that nHA functions as a calcium phosphate reservoir, keeping enamel minerals supersaturated and limiting demineralization while

Effective desensitizing agent: several N-HAp toothpaste and oral rinses have been used to treat dentine hypersensitivity as an alternative to traditional solutions, providing instant and long-lasting relief from symptoms [33].

CONCLUSION

The results for n-HA as a desensitizing agent in situ and in vivo are encouraging. We propose that the mechanism of remineralization is that H.A. functions as a calcium-phosphate reservoir, helping to maintain a condition of supersaturation with regard to enamel minerals, hence lowering enamel demineralization and boosting remineralization. Dental products containing nanohydroxyapatite in the right concentration could thus help promote remineralization when used daily.

Conflict of interest: None

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