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Remineralizing Agents for White Spot Lesions

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Abstract

White spot lesions (WSLs) are early signs of dental caries that appear as opaque white areas on the enamel surface due to demineralization. Remineralizing agents aim to restore the mineral content in these lesions, enhancing their aesthetic and structural integrity. Common remineralizing agents include Fluoride, Casein Phospho-peptide Amorphous Calcium Phosphate (CPP-ACP), Tri-calcium Phosphate (TCP), Self-assembling Peptide P11-4, Amorphous calcium phosphate, Calcium carbonate carrier-sensistat. These agents are available in various forms, such as toothpaste, gels, varnishes, and professional treatments, and are essential in managing and reversing WSLs effectively. Combining these strategies with regular dental check-ups and proper oral hygiene practices can significantly improve the management and reversal of white spot lesions.

Keywords: White spot lesions, Remineralization, Incipient carious lesion.

Introduction

The term "white spot" lesions, which indicate that there is a subsurface area with most of the mineral loss behind a comparatively undamaged enamel surface, refers to the first carious lesions. The features of carious enamel can be seen in a cross-section of the white opaque spot.[2]. Many physicians refer to them as early lesions since they are the first noticeable symptoms in the genesis of caries. It is important to keep in mind, nevertheless, because demineralization cannot be seen until it is at least 300–500 μm below the surface.[5] This dynamic process begins when acidogenic bacteria in dental plaque—primarily Streptococcus sobrinus, Lactobacillus acidophilus, and Streptococcus mutans—ferment carbohydrates from food. This fermentation produces organic acids such as lactic, propionic, pyruvic, butyric, and acetic acids. These acids act on hydroxyapatite crystals, liberating calcium and phosphate minerals and initiating cavity formation. The critical pH for net mineral loss from dental enamel is 5.5, and for dentin, it is 6.2. When the pH drops below these levels, demineralization occurs.[1] Examining the lesion visually and with a probe after air drying is crucial. White spot lesions appear translucent when the surface is wet, but they turn opaque white when air sprayed on them.[9] Radiographs and clinical and visual examinations are two outdated techniques for finding early lesions. These techniques, however, may produce false-negative results and are inaccurate in assessing early carious lesions. Because 30% to 40% of the mineral must be lost for the lesion to be seen on a radiograph, radiographs are unable to identify early carious lesions. These days, a lot of innovative diagnostic modalities including fiber-optic illumination for digital imaging, optical coherence tomography, laser fluorescence, electronic caries meter, Raman spectroscopy, and Terahertz imaging have been implemented.[4]The three major approaches to managing enamel white spot lesions are surface modification, non-invasive infiltration and inhibition, and intervention using remineralization procedures.[2] Remineralization can be brought on by treatments or it might happen naturally. The majority of populations believe that the widespread use of fluorides is the primary cause of the decline in dental caries, and fluoride (F)-based therapies have the strongest level of supporting evidence among the current treatments. Remineralization of carious lesions and white spot lesions may be achievable with a range of currently available medicines that contain casein phospho-peptide in amorphous calcium phosphate, self-assembling peptide, fluoride, and bioavailable calcium and phosphate.[1]

This review article discuss the use of herbal remineralizing agents, nanomaterials, self-assembling peptides, fluoridated and non-fluoridated agents, bio memetic materials and other remineralizing enhancers in the treatment and prevention of white spot lesions.

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Management of White Spot Lesions

1. Motivation and Education of Patient

Encouraging patients to practice proper oral hygiene by brushing and flossing their teeth is the most efficient way to modify the composition of bacteria in plaque and, in turn, alter the creation of white spot lesions.[5]

2. Dietary Regulations

Anaerobic metabolism of dietary fermentable carbohydrates results in the production of organic acids that demineralize dentin and enamel, increasing the local risk of dental caries. Proteins that are high in

polyphenols, such as those found in cheese, milk, and unprocessed cereals, as well as minerals and chemical building blocks of foods like cocoa and tea, are known to have bacteriostatic properties, which hinder the metabolism of harmful microbes.[9]

Certain foods with a fibrous and rough texture can aid in mechanical cleaning, while others have an anti-carcinogenic impact by increasing salivary flow and volume due to their flavour and aroma.[5]

3. Use of Antimicrobial Agents

It is advised to use mouthwash containing chlorhexidine for 30 seconds right before bed since the lower salivary flow rate throughout the night facilitates the mouthwash's easier attachment to oral tissues. It quickens the remineralization process and lowers the number of Streptococcus mutans.[5]This method of using chlorhexidine mouthwash lowers the amount of Streptococcus mutans below the threshold that could lead to the formation of caries, and the effect of this reduction lasts for two weeks.[5]

4. Remineralising Agents Based on Flouride

- **Flouride Application**

Fluoride varnish, often used commercially, typically contains 5% NaF (22,600 ppm fluoride), allowing it to adhere to teeth in the presence of saliva. The application of fluoride varnish is quick and easy, sticking to tooth surfaces rapidly and reducing the risk of gagging and swallowing.[6]Fluoridated dental products are believed to be the most effective means of preventing enamel demineralization. Although toothpaste with 1,000 ppm fluoride has been shown to be helpful in numerous trials, toothpaste with 5,000 ppm fluoride may be able to further minimize demineralization and promote remineralization.[7]

The many kinds of topical fluorides used in dentistry are stannous fluorides, sodium fluoride (NaF), sodium mono-fluorophosphate, and acidulated phosphate fluoride (APF). These inorganic fluorides can be found in many forms such as solutions, varnishes, foams, gels, and dentifrices.[1]

- **Systemic Application**

Systemic applications are useful techniques, particularly for people who are at a high risk of developing dental cavities and for populations with minimal fluoride utilization. Water fluoridation is one systemic administration method that exhibits both systemic and topical effects. According to the World Health Organization (WHO), taking one milligram of fluoride daily is good for your health. Fluoridating drinking water, salts, milk, and adding fluorinated tablets or drops to food are examples of systemic applications of fluoride.[5]

5. Non Flouride Remineralisation

- **Biomimetic Remineralisation**

A. Dentine Phosphoprotein-Derived 8d55 Peptides

In the mediation of physiologically guided mineral deposition, 8DSS peptides seem to have two different mechanisms. In demineralized dentine, they first prevent Ca2+ and PO4 3-ions from dissolving, and then they encourage the ions' absorption to build new mineral deposits on demineralized enamel.[1]The most prevalent non-collagenous extracellular matrix component in dentin, dentin phosphoprotein (DPP), is recognized to be essential to tooth mineralization. Numerous repeated aspartate-serine-serine (DSS) nucleotide sequences have been found in human DPP, and studies have demonstrated that DPP can produce hydroxyapatite (HA) crystals in calcium phosphate solutions, which is thought to encourage the development of HA.[6]

B. Self-Assembling P11-4 peptides

A biomimetic peptide like P114 has the extra advantage of promoting "natural" repair by refilling the mineral itself. P11-4 may cause the initial surface lesions on the proximal and occlusal surfaces to reverse. The radiopacity and aesthetics of P11–4 treated carious lesions were unchanged even six to twelve months after therapy.[8]SAP P11-4 is more effective than other remineralizing agents like fluoride, CPP-ACP, and SDF. However, its standalone efficacy is still considered inferior. Combining SAP P11-4 with fluoride may have a synergistic effect, but further research is needed to confirm this.[13]

- **Calcium And Phosphate Delivery Agents To The Tooth Surface**

A. Calcium Phosphate Compounds

Beta TCP: It is a component of products like Biovision, Cerasorb®, and Bio-Resorb®.[1] To enable β-TCP to serve as a targeted low-dose delivery system when administered to teeth via dentifrices or mouthwashes, barriers inhibiting early fluoride-calcium interactions were created through functionalization [Karlinsey and Pfarrer, 2012].[6]Tricalcium phosphate alpha: Tricalcium phosphate (TCP) has also been proposed as a potential strategy to raise the calcium content of saliva and plaque. When chewing an experimental gum containing 2.5% beta-TCP by weight, there were some minor changes observed in the levels of free calcium and phosphate in saliva and plaque fluid, in comparison to a control gum that did not contain any additional TCP.[3]It has been demonstrated in laboratory and clinical studies that adding the functionalized TCP component to NaF formulations results in stronger, more acid-resistant minerals than fluoride alone.[7]

B. Casein Phosphopeptides And Amorphous Calcium Phosphate (Cpp-Acp)

CPP-ACP is marketed under the trademark Recaldent and can be found in mouthwash, chewing gum, and candy. Additionally, a water-based, sugar-free cream with RECALDENT TM (CPP-ACP) is offered on the market. (GC Tooth Mousse/ Prospec MI Paste).[7] When CPP-ACP comes into touch with an enamel lesion, the CPP stabilizes the calcium and phosphate in a metastable solution, allowing for large concentrations of Ca 2+ and PO4 3− to diffuse in the lesion. The weakly bound calcium and phosphate ions would be released by the CPP-ACP once it was present in the enamel subsurface lesion and would then settle into crystal gaps. Due to their strong affinity for apatite, the CPPs would attach to the more thermodynamically preferred surface of an apatite crystal face as soon as they entered the lesion. Therefore, it is possible that the CPPs play a significant role in controlling anisotropic crystal development and preventing crystal.[6]Research revealed that while treatments like fluorides and CPP–ACP can effectively halt the advancement of dental caries, they fall short when it comes to improving aesthetics, as per the ICDAS. [5]

C. Amorphous Calcium Phosphate

Dr. Ming S. Tung developed the ACP technique. ACP was first added to toothpaste in 1999 under the brand name Enamelon. Church & Dwight then reintroduced it in 2004 under the brand name Enamel Care toothpaste. Additionally, it is offered as Premier Dental's Enamel Pro Polishing Paste and Nite White Bleaching Gel by Discuss Dental. It's also a part of the Bosworth-produced Aegis product series, which includes Aegis Pit and Fissure Sealant.[3]ACP toothpaste is a dual chamber fluoride toothpaste that applies calcium phosphate in an unstabilized system that provides Ca2+ and PO43-ions

to the oral cavity in different doses. It causes intraoral Ca2+ and PO43-mixing when brushing. ACP, or amorphous calcium fluoride phosphate, is then rapidly deposited after this. Since these precipitated compounds have been shown to be unstable, they quickly transform into fluorohydroxyapatite, or HA, a more stable form.[1] Bio-actively active composites filled with ACP: ACP is a filler that is encased in a polymer binder and contained in these composites. It is comparable to the HAP that naturally occurs in teeth in that it releases calcium and phosphate ions into saliva and deposits as an apatite mineral into tooth structures.[1]

D. Sodium Calcium phosphosilicate (Bioactive Glass)

Drs. Gary Hack and Len Litkowski created the Nova Min Technology. Soothe Rx, Den Shield, Nu Care-Root Conditioner with Nova Min, Nu Care-Prophylaxis Paste with Nova Min, and Oravive are the products that are currently on the market that use Nova Min.[3] Saliva containing sodium, calcium, and phosphorus ions that can be used to remineralize the tooth surface is quickly released when bioactive glass comes into contact with saliva. In addition, they adhere to the tooth's surface, release ions continuously, and promote remineralization even after the first application. It has been noted that for up to two weeks, these particles release ions and change into HCA.[3]Novamin - This technology is based on bioactive glass. It quickly releases sodium ions upon coming into contact with saliva, raising the local pH and causing the release of Ca and P.[4]

E. Calcium Carbonate Carrier-Sensistat

The SensiStat technology, developed by Dr. Israel Kleinberg, uses arginine bicarbonate and calcium carbonate particles to remineralize teeth. Initially in Ortek's Proclude and later in Denclude, the arginine complex binds calcium carbonate to teeth, allowing slow dissolution for calcium release.[3]

F. Nanomaterials

Nanohydroxyapatite has also been the subject of recent research. Nanohydroxyapatite particles were regularly deposited on the cellular structure of the demineralized enamel surface, which appeared to form new surface layers, according to a scanning electron microscope analysis conducted in a study by Zang et al. that examined the role of nanohydroxyapatite alone on remineralization.[2]With shape, structure, and crystallinity similar to the apatite crystal found in enamel, synthetic nanohydroxyapatite is regarded as one of the most biocompatible and bioactive materials.[6]The different approaches used are

Calcium Fluoride Nanoparticles

Calcium Phosphate - based Nanomaterials Nano HAP Particles.[1]

- **Agents Engaged In Biofilm Modification**

An amino acid called arginine bicarbonate contains calcium carbonate particles that can stick to the surface of minerals. While the release of carbonate may cause a small local pH increase, the dissolved calcium accessible to remineralize the mineral.[1]

6. Natural Products

A. Xylitol

Naturally occurring fruits, vegetables, and berries contain xylitol, a five carbon sugar polyol (pentilol). It is mostly extracted from plant sources high in xylan, such beech and birch wood. It serves as a sugar replacement.[11]By inactivating S. mutans and preventing plaque from producing acids and polysaccharides, it has anticariogenic properties.[1]Additionally, xylitol promotes increased salivary flow, which lowers the risk of dental cavities and encourages remineralization.[4] slow down

demineralization by stabilizing the remaining organic matrix, which blocks the ion diffusion channels.[6]

B. Grape Seed Extract

Proanthocyanidin (PA), a particular class of polyphenol, is present in grapeseed extract. Plant-derived with anti-inflammatory and antioxidant qualities are called polyphenols. The conversion of soluble collagen to insoluble collagen is accelerated by proanthocyanidin.[8] Hameed et al. found that grape seed extract and sodium fluoride are equally effective at remineralizing both surface and subsurface artificial enamel lesions.[10]

C. Hesperidine

Hesperidine stabilizes the collagen matrix and encourages remineralization because the collagen matrix serves as a scaffold for the mineral deposition process.[1]

7. Laser Treatment

Alqahtani et al. shown that, in comparison to no treatment and fluoride treatment alone, diode laser irradiation plus topical fluoride application considerably raised the hardness and improved the aesthetic appearance of WSLs.[5] The surface qualities of the enamel are impacted when a laser is applied to the enamel surface because a micro-gap is created that keeps vital ions locked rather than releasing them when the enamel is subjected to acid attacks . Saliva contains Ca+2, PO4, and F ions, which precipitate into these micro-gaps and strengthen enamel's resistance to demineralization. Moreover, they enhance salivary mineral absorption.[9]

8. Resin Infiltration Technique

Using a light curable resin, resin infiltration, also known as caries infiltration, is an innovative technique used largely to halt the progression of non-cavitated white spot lesions, non-cavitated interproximal caries lesions, or incipient proximal lesions. The chameleon-producing penetrating resin has a high refractive index, doesn't need shade matching, and blends in rather well with the surrounding natural[14]

The dental industry is currently seeing developments in cosmetics and aesthetics as more and more patients want minimally invasive cosmetic enhancements that don't require anesthesia, drilling, or costly restorations. This method permits the restoration of the normal tooth appearance and can be regarded as a minimally invasive therapy for smooth-surface white spot lesions. Consequently, Icon Resin is a novel microinvasive technology that will cover up the enamel white spot lesions and fill, fortify, and halt the spread of caries.[12]

Conclusion

In conclusion, remineralizing agents play a pivotal role in the management and reversal of white spot lesions, a common early manifestation of dental caries. The integration of remineralizing agents and adjunctive therapies into routine dental practices not only improves the aesthetic and structural integrity of teeth but also promotes long-term oral health. Continuous research and development in this field are crucial to refining these treatments and discovering new, more effective methods.

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