Volume 2, 2021, 874973

GUHES

Journal of Gazi University Health Sciences Institute

journal homepage*:* https://dergipark.org.tr/tr/pub/guhes

Remineralization Materials Used in Dentistry

Emre Bakır [1], Nurhan Öztas Kırmızı [1]

[1] Gazi University, Faculty of Dentistry, Department of Pediatric Dentistry, Ankara, Turkey

Article info:

Received: 05.02.2021

Accepted: 18.02.2021

Keywords:

Remineralization, Materials, İnitial caries lesions

Abstract

Ceasing caries in pediatric patients before it progresses reduces the social and economic problems of dental caries in the future. Therefore, the effectiveness and ease of preventive and inhibitory treatments against caries have great importance.

For many years, the thought that dental caries could only be treated as restorative, has limited the diagnosis to cavitated caries lesions. It is possible to reverse the destruction without cavitation and to provide remineralization of the demineralized areas with the early diagnosis of dental caries. Today, it is aimed to prevent destruction, protect and cure, and diagnosis is carried out with this in mind in the treatment of dental caries. Many new alternative materials are being investigated in order to prevent dental caries and to provide remineralization, there are some limitations such as possible toxic effects and not being used safely in all age groups although successful results are obtained with the use of these agents. Therefore, the properties of remineralizing agents will be mentioned in this article.

1. Introduction

Dental caries, which is a multifactorial disease, is caused by the deterioration of the balance between pathological and protective factors; It is the most common chronic childhood disease that can result in destruction, localized dissolution of calcified tissues, and tooth loss in advanced stages (Roberson, 2006).Today, studies in the field of dentistry are focused on preventive treatments and reversing this process by diagnosing at early stages rather than treating dental caries (Guerrieri, Gaucher, Bonte, & Lasafargues, 2012).

1. Caries

1.1. Etiology of Caries

Dental caries is defined as a multifactorial disease involving the interaction of host factors, dental plaque and diet. Caries occurs when the minerals in the hard tissues of the teeth dissolve as the organic acid formed by the cariogenic microorganisms using fermentable carbohydrates causes the demineralization of the balance between the microflora in the mouth and the host biology. It is an active environment where the oral cavity, demineralization and remineralization cycle continues (Rao, & Malhotra, 2011).

In the etiology of dental caries; 4 main factors play a role and these are host (tooth), microflora with acidogenic potential, suitable substrate for pathogenic bacteria (carbohydrate) and time, and these four factors must be present at the same time for the formation of dental caries (Tanzer, 1995).

Protective and pathological factors are important in determining why people have caries and why they are at risk of developing caries in the future. While protective factors from caries are stated as the presence of saliva components and saliva flow, antibacterial agents, fluoride, calcium and phosphate ions; pathological factors have been reported as the presence of cariogenic bacteria, fermentable carbohydrates and salivary dysfunction. (Featherstone, 2006).

2. Demineralization

Demineralization is the case of the dissolution or ionization of especially Ca and P minerals in dental hard tissues with the decrease of the pH of the oral environment due to the effect of acids produced by microorganisms in the bacterial plaque. The critical pH value at which demineralization starts is between 5.2 and 5.5, although it differs by individual. When the critical pH value is reached, organic acids are diffused to the enamel surface through the acquired pellicle structure (Zero, 1999).

At the atomic level, organic acid molecules are diffused to sensitive areas in the crystal structure and cause calcium, phosphate and carbonate loss in selected areas. This process continues until a balance is achieved between enamel and oral environment (Margolis, & Moreno, 1990).

3. Remineralization

Remineralization is defined as the storage of minerals lost in the demineralization process on the tooth surface and is a part of the dynamic caries formation process. When the pH of the oral environment is higher than 5.5, the demineralization process can be replaced by the remineralization of

***Corresponding author: Emre Bakır**
e-mail address: dt.emrebakir@gmail.com

the damaged enamel crystal structure with the help of the presence of Ca and P, F in the saliva structure. This new structuring includes fluoride HA and fluorapatite, which are more resistant to acid attacks than the original structure (Selwitz, Ismail, & Pitts, 2007).

Under physiological conditions, saliva and biofilm fluid contain Ca and P in saturated concentrations according to the mineral content of enamel. As a natural defense mechanism supported by saliva to preserve the mineral structure of enamel, these ions constantly re-accumulate on the enamel surface and lost enamel areas. The oversaturation of saliva from Ca and P ions provides a permanent opportunity for enamel remineralization and helps cariogenic resistance to protect the tooth (Roberson, 2010).

4. Remineralization Agents

Remineralization treatment should be preferred in cases where there is a chance of success with preventive methods. Agents containing anticaries properties that are capable of initiating many remineralisations are available on the market. (Farooq, Moheet, Imran, & Farooq, 2013).

4.1. Fluoride

Fluoride ions present in saliva in a certain amount have been proven to have clinical effectiveness in reversing initial enamel lesions and the balance between demineralization and remineralization in favor of remineralization (Yın , Hu, & Li, 2013).

Fluoride ions present in the mouth compensate the mineral losses caused by the acids produced in the biofilm by inducing the precipitation of fluorapatites which is less soluble mineral phase (Hicks, Garcia-Godoy, & Flaitz, 2004b).

4.1.1. Usage Types of Fluoride

Prophylaxis methods such as fluoride treatments are evaluated in two main groups as systemic and topical applications for the protection of teeth both during the development process and after teeth eruption.

4.1.1.1. Systemic Application of Fluoride

As a result of the use of fluoride in various forms by swallowing, the systemic use of fluoride, which occurs in the blood serum, is occurred by precipitation on the developing teeth in children. Systemic use of fluoride is carried out in the form of fluoridation of school and drinking water, fluoridation of salt and milk, F supplements in the diet, giving pastilles, drops and F tablet preparations. The most widely used of these methods today is the fluoridation of drinking water.

These systemic application methods of F are thought to be effective in preventing caries in two ways.

These are exposure of the tooth enamel that is developing in the pre-eruption period to fluoride,

In the form of topical use of F, which is used systemically, as a result of the increase in saliva concentration as a result of passing into saliva. (Sampaio, & Levy, 2011).

4.1.1.2. Topical Fluoride Applications

The systemic activity of F on teeth ends with the eruption of teeth, after that the fluoride has only a topical effect. Topical F agents currently used store soluble F as calcium fluoride on enamel or lesion.

***Corresponding author: Emre Bakır**
e-mail address: dt.emrebakir@gmail.com

Calcium fluoride acts as an F source for FHAP formation. (Qgaard, Seppa, & Rolla, 1994).

The agents used for topical F applications are divided into individual and professional applications (by the dentist). Individual applications have been developed as agents containing F in low concentrations such as toothpaste, mouthwash, dental floss, toothpicks, chewing gum. Professional applications have been developed as solution, gel, polish and slow release systems. These agents contain high doses of fluoride and are applied only by the dentist every 3, 6, 12 months, depending on the caries activity level of the person (AAPD, 2012).

4.2. Bioactive Glass

Bioactive glass is a multi-element inorganic component composed of silica, calcium, sodium and phosphate. All these elements are found naturally in the body. In addition to their biocompatibility, bioactive glasses tend to be bonded chemically to tissues (Cheng, Li, Hao, & Zhou, 2009).

Bioactive glasses are known to have osteoconductive properties and chemically bond to bone tissue by forming an appetite layer on the surface through ion release. For this reason, studies are carried out on the use of bioactive glasses as mineralization agents in dentistry (Valinoti, Da Silva, Pierro, Da Silva, & Maia, 2011).

4.3. Nano-Hydroxyapatite

Since 60% of human bones and 97% of tooth enamel are made up of hydroxyapatite, hydroxyapatite is the primary ingredient of bones and teeth in the human body. Hydroxyapatite is produced naturally or synthetically. Hydroxyapatite, naturally obtained from seashells, is a non-toxic bio-ceramic material that is highly compatible with human bone. (Jeong, Lee, Baek, Choi, Park, & Song, 2013).

The fact that synthetically produced nanohydroxyapatite materials are materials with high biocompatibility and having chemical properties similar to tooth enamel, which are mainly composed of 20-40 mm hydroxyapatite particles, have caused them to take place in remineralization studies. Compared to other calcium phosphate compounds, nanohydroxyapatites are less soluble. For this reason, nanohydroxyapatites have been developed in order to increase the ratio of calcium and phosphate ions released by increasing the solubility of hydroxyapatite and make it more biocompatible with enamel tissue. Synthetically produced nanohydroxyapatite particles have the same formulation as the hydroxyapatite structure of the enamel tissue. After the production of nanohydroxyapatites, the remineralization studies have intensified in this direction (Görken, Erdem, İkikarakayalı, & Sepet, 2013).

4.4. Ozone

It exists as a light blue gas at room temperature, has a specific odor and is quite abundant in the upper layers of the atmosphere.

In recent years, its usage area has been expanding day by day with the increasing data indicating that ozone is a useful therapeutic agent in the field of medicine and dentistry and it is accepted as an alternative treatment procedure in many countries (Nagayoshi, Kitamura, Fukuizumi, Nishibara, & Terashita, 2004b).

***Corresponding author: Emre Bakır**
e-mail address: dt.emrebakir@gmail.com

Use of Ozone Gas in Dentistry

The usage areas of ozone gas in dentistry can be listed as follows:

- In initial caries lesions,

- In canal disinfection in root canal treatment,

- In the disinfection of the cavity opened before restoration,

- Before fissure sealant is placed,

- In teeth whitening,

- In gingivitis, periodontal inactivation of destructive sulfur compounds,

- In the destruction of the biofilm layer and sterilization of dental unit water distribution systems,

-In eliminating all microorganisms responsible for caries formation at a rate of 99% (Nagayoshi, Kitamura, Fukuizumi, Nishibara, & Terashita, 2004b).

Ozone has the ability to oxidize caries-causing bacteria, that is, acid-producing bacteria, and it has been reported that it removes the protein layer that protects the caries lesion thanks to its strong oxidizing feature. It provides the metabolic balance to shift towards remineralization by decreasing the bacterial population of the caries lesion and increasing the pH level. Thus, the penetration of cariogenic bacteria into the lesion after remineralization is prevented and provides a destructive effect on the bacterial population in the carious lesion (Huth, Jakob, Saugel, Cappello, Paschos, Hollweek, 2006).

4.5. Silver Ion

In the field of dentistry, silver nitrate was started to be used in order to decrease the incidence of caries in milk teeth in the early 1840s. In the 1960s, it was started to be used together with fluoride to support the beneficial properties of silver ion. However, its ability to cause discoloration on teeth stands out as a factor that limits its usage. (Peng,Boelho, & Maillinna, 2012).

As a result of the application of fluoride and silver ions applied topically to the demineralized tooth surface; it has been reported that both ions provide mineral deposition on the surface, and they have no significant effect on tooth remineralization when applied together. (Zhi, Lo, & Kwok, 2013).

4.6. Xylitol

It is not possible to eliminate sugar in the modern diet approach. Different substances that can be used instead of sugar have been developed to reduce the risk of caries. Xylitol is one of the products that can be used instead of the sugar. The use of chewing gum containing xylitol both increases the amount of saliva flow and consequently strengthens the protective factors of saliva (Makinen, 2010).

Xylitol has an anticariogenic effect. This anticariogenic situation prevents the binding of sucrose molecules and the metabolism of Streptococus Mutans, as a result, the demineralization process is reduced. It also decreases the number and ability of mutans to bind (Lee, Baek, Choi, & Jeong, 2013).

***Corresponding author: Emre Bakır**
e-mail address: dt.emrebakir@gmail.com

4.7. Chitosan

Chitosan is a biopolymer obtained as a result of deacetylation of chitin found in nature and it is used in studies to prevent dental caries due to its bacteriostatic and bactericidal properties. Chitosan is also a biocompatible and biodegradable material. In addition, products resulting from the breakdown of chitosan are largely non-toxic (Petri, Donega, Benassi, & Bocangel, 2007).

One of the important properties of chitosan is its pH value of 6.3, which is suitable for buffering. In this way, it can buffer the effects of organic acids that reduce pH values in the mouth (Petri, Donega, Benassi, & Bocangel, 2007).

4.8. Propolis

Propolis is a resin-containing composition obtained from plant exudates by honey bees (Apis Mellifera) that used to fill the gaps in their combs. The current main chemical structure class of propolis consists of flavonoids, phenolic and various aromatic compounds. (Marcucci, Ferres, Viaguera, Bankovavs, Castro, & Dantas, 2013).

Propolis is known to have other positive properties in addition to its antibacterial effects on oral health. Various studies show that it has many effects as antioxidant, antifungal, antiviral and anti-inflammatory agents (Özalp, & Tulunoğlu, 2014).

In dentistry, propolis is used as a prophylactic for caries and periodontal diseases by adding to toothpastes, mouthwashes, dental floss and chewing gums. It is important to control dental caries with propolis in the oral cavity environment because of its bacteriostatic, bactericidal and anti-adherent activities on microorganisms associated with dental caries. Propolis has antibacterial activity especially against gram-positive bacteria. Despite these benefits in the field of dentistry, propolis has an allergy risk (Özalp, & Tulunoğlu 20014).

4.9. CPP-ACP and CPP-ACPF

Although it is known that milk and dairy products have anticaries properties, they must be consumed in large quantities to have this effect when used naturally. For this reason, researchers have focused on efforts to separate the protective factors in milk and use them in personal products in order to prevent caries. As a result, it has been reported that casein phosphopeptide (CPP), which is the protective factor in milk, was obtained as a result of degradation of casein by trypsin enzyme by using selective precipitation method. (Reynolds, Riley, & Adamsonn, 1994)

Anticaries effect of the CPP-ACP nanocomplex is explained by 3 different mechanisms;

1. It significantly increases the calcium and phosphate ion levels of the plaque by participating in the structure of dental plaque. This mechanism is the ideal mechanism to prevent demineralization. Because there is an inverse relationship between the level of plaque calcium and phosphate and demineralization.

2. It supersaturates tooth surface by binding free calcium and phosphate in the CPP-ACP plaque, which is localized on the tooth surface. Thus, it prevents demineralization and increases remineralization.

***Corresponding author: Emre Bakır**
e-mail address: dt.emrebakir@gmail.com

3. It also prevents the bacterial cells in the plaque from being colonized on the tooth by binding to its surface (Azarpazhooh, & Limeback, 2008a).

4.10. Theobromine

Although the relationship between chocolate and dental caries is known, various studies have reported that there are a few caries inhibitory substances in chocolate.

Theobromine contains theophylline and caffeine-like compounds and is abundant in chocolate. It is structurally very similar to caffeine. Its name comes from the Latin name of the cocoa plant 'theobromine cacao'. After its effects on the mineralization of dental hard tissues were discovered, its anticaries effect has been investigated in various studies (Syafire, Permatasari, & Wardani, 2012).

References

American Academy Of Pediatric Dentistry (AAPD) (2012). Guideline on fluoride therapy, 34, 12-13.

Cheng, L., Li, J., Hao, Y., Zhou, X. (2009). Effect of compounds of Galla chinensis and their combined effects with fluoride on remineralization of initial enamel lesion in vitro. *Journal of Dentistry, 36* (5), 369-73.

Farooq, I., Moheet, I.A., Imran, Z., Farooq, U. (2013). A rewiev of novel dental caries prevetive material: Casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) complex. *King Saud University Journal od Dental Science, 4*, 47-51.

Featherstone J.D. (2006). Caries prevention and reversal based on the caries balance. *Pediatric Dentistry, 28*(2), 128-132.

Garcia-Godoy, F., Hickc, M.J. (2008). Maintaining the integrity of the enamel surface: The role of dental biofilm, saliva and preventive agents in enamel demineralization and remineralization. *Journal of American Dental Association, 139* Suppl;25- 34.

Görken, F.N., Erdem, A.P, İkikarakayalı, G., Sepet, E. (2013). Nano-hidroksipatitli diş macunlarının mine remineralizasyonu üzerine etkileri. *İstanbul Üniversitesi Diş Hekimliği Fakültesi Dergisi; 47*(2): 81-88.

Guerrieri, A., Gaucher, C., Bonte, E., Lasafargues, J.J. (2012). Minimal intevention dentistry: part 4. Detection and diagnosis of initial caries lesions. *British Dental Journal. 213* (11), 551-557.

Hicks, J., Garcia-Godoy, F., Flaitz, C. (2004). Biological factors in dental canes role of reimineralization and fluonde in the dyhamic prooess of demineralization and remineralization (part 3). *Journal of Pediatric Dentistry, 28* (3), 203-214.

Huth, K.C., Jakob, F.M., Saugel, B., Cappello, C., Paschos, E., Hollweck, R. (2006). Effect of ozone on oral cells compared with established antimicrobials. European *Journal of Oral Science, 114*(5), 435-440.

Jeong S.H., Lee, Y.E., Baek H.J., Choi Y.H., Park Y.D., Song, K.B. (2013). Comparison of remineralization effect of three topical iluende reginens on enamel initial catiou lesions. *Journal of Dentistry, 38* (2), 166-171.

Lee, Y.E., Baek H.J., Choi Y.H., Jeong S.H., Park Y.D.. Song, K.B. (2013). Comparison of remineralization effect of three topical iluende reginens on enamel initial catiou lesions. *Journal of Dentistry, 38* (2), 166-171.

Makinen K.K. (2010). Sugar alcohols, carics incidence and remineralization of caries lesions a lite-rature review. *International Journal of Dentistry, 24*(3), 1-23.

Marcucci M.C., Ferres, P., Viaguera, C.G., Bankovavs, F., De Castro, S.L., Dantas, A.P., (2013) Phenolic compounds from Brazlian propolis with pharhmacological activitics, *Journal of Pharmacology 74*, 105-112.

Margolis, H.C., Moreno, E.C. (1990). Physicochemical perspectives on the cariostatic mechanisms of systemic and topical fluorides. *Journal of Dental Research, 69* Spec No: 606-613.

Nagayoshi, M., Kitamura, C,. Fukuizumi, T., Nishihara, T., Terashita, M. (2004). Antimicrobial effect of ozonated water on bacteria invading dentinal tubules. *Journal of Endodontics, 30*(11), 778-781.

Özalp S., Tulunoğlu, O. (2014). SEM-EDX analysis of brushing abrasion of chitosan and propolis based toothpastes on sound and artificial carious primary enamel surfaces. *Journal of Pediatric Dentistry, 24*, 349-357.

Qgaard, B., Seppa, L., Rolla, G. (1994). Professional topical fluoride applications Clinical efficacy and mechanism of action. *Advences Dental Research, 8*, 190-201.

Peng, E.E., Boelho, M.G., Mailinna, I.P. (2012). Sitver compousds used in sdenitiste for ares managesent: a review. *Journal of Dentistry, 40*, 531-534.

Petri, D.F., Donega, J., Benassi, A.M., Bocangel, J.A. (2007). Preliminary study on chitosam modified glass lonomer restoratives. *Dental Materials, 23*, 1004-1010.

Rao, A., Malhotra, N. (2011). The role of remineralizing agents in dentistry: A review. *Compendium, 32*(6), 26-33.

Reynolds, E.C., Riley P.F., Adamsonn, J.A. (1994). Selective Precipitation Purification Procedure for Multiple Phosphoseryl-Containing Peptides and Methods for Their Identification. *Analytic Biochem. 217*(2), 277-284.

Roberson T.M. (2006). Cariology: The Lesion, Etiology,

***Corresponding author: Emre Bakır**
e-mail address: dt.emrebakir@gmail.com

Prevention, and Control. Sturdevant's Art and Science of Operative Dentistry. In Roberson TM, Heymann HO, Swift EJ editors. Art and science of operative dentistry. 5th ed. Ankara: Güneş kitabevi, 65-135.

Sampaio, F.C., Levy, S.M. (2011). Systemic floride. *Monographs in Oral Science, 22*, 133-145.

Selwitz, R.H., Ismail, A.I., Pitts, N.B. (2007) Dental caries. *Lancet*, *369*(9555), 51-59.

Syafire, A.G., Permatasari, R., Wardani, N. (2012). Theobromine eflects on cnamel surface mikrohardness: In vitro. *Journal of Dentistry, 19* (2), 32-36.

Tanzer J.M. (1995). Dental caries is a transmissible infectious disease: the Keyes and Fitzgerald revolution. Journal of Dental Research, 74(9), 1536-1542.

Ten Cate, J.M., van Loveren, C. (1999). Fluoride mechanisms. *Dental Clinics of North America, 43*(4), 713-742.

Valinoti, A.C., Da Silva, Pierro V.S., Da Silva, E.M., Maia, L.C. (2011). In vitro alterations in dental enamel exposed to acidic medicines. *International Journal of Paediatric Dentistry; 21 (1)*, 141-150.

Yın, W., Hu, D.Y., Li, X. (2013). The anti-caries efficacy of a dentifrice containing 1.5% arginine and 1450 ppm floride as sodium monoflorophosphate assessed using Quantitative Light-induced Florescence (QLF), *Journal of Dentistry, 41*(2), 22-28.

Zero, D.T. (1999). Dental Caries Process. *Dental Clinics of North America*, *43*(4), 635-664.

Zhi, Q.H., Lo, E.C., Kwok, A.C.Y. (2013). An in vitro study of silver and fluoride ions on remineralization of demineralized enamel and dentine. *Australian Dental Journal, 58* (1), 50-56

Wikén Albertsson, K., Persson, A., & Van Dijken, J. W. (2013). Effect of essential oils containing and alcohol-free chlorhexidine mouthrinses on cariogenic micro-organisms in human saliva. Acta *Odontologica Scandinavica, 71*(3-4), 883-891.

***Corresponding author: Emre Bakır**
e-mail address: dt.emrebakir@gmail.com