

Preventive Techniques & Remineralization Of Dental Caries For Public Health: A Review

Abstract

Dental caries is an infectious disease that may result in an oral infection. The impact of a high rate of dental caries and its consequences as a public health problem was recognized in the 1940's. As dental clinicians are primary providers of preventive services, they develop an array of types of preventive plans for patients. Because of its high prevalence, dental caries is the focus of many interventions targeted towards prevention and control. The use of fluoridated toothpastes, other topically applied fluorides, fluoridated municipal water and pit and fissure sealants, along with dietary improvement, remain mainstays of caries management. Disease control concerns influencing biofilm formation and growth, or modifying the dissolution kinetics of the apatite, or both. Fluoride and CPP-ACP are currently the most effective ingredients for achieving tooth remineralization without resorting to invasive procedures. The use of regular fluoride dentifrice is still the best and most feasible choice to be used to control caries lesions progression in enamel.

Key Words

Dental caries, preventive techniques, remineralization, fluoride, CPPACP

Introduction

Dental caries is an infectious disease that may result in an oral infection. The impact of a high rate of dental caries and its consequences as a public health problem was recognized in the 1940's^[1]. As dental clinicians are primary providers of preventive services, they develop an array of types of preventive plans for patients. The disease process of hidden and incipient caries is dynamic: hidden and small carious lesions oscillate between demineralization and remineralization, making it improbable that a preventive plan alone would suffice for the patient if it is a need-driven plan^[2].

Because of its high prevalence, dental caries is the focus of many interventions targeted toward prevention and control. The use of fluoridated toothpastes, other topically applied fluorides, fluoridated municipal water and pit and fissure sealants, along with dietary improvement, remain mainstays of caries management. These modalities, which are based on high-quality evidence, are the first choice for prevention and control of dental caries^[3].

Patient Education & Patient's motivation are necessary to change behaviors that place patients at increased risk for caries^{[4],[5]}.

Disease control concerns influencing biofilm formation and growth or modifying the dissolution kinetics of the apatite or both. The following may have a role to play:

- Mechanical/ chemical removal of plaque.
- Chemical (antimicrobial) modification of plaque.
- Use of fluorides.
- Role of Dietary control/ composition.
- Salivary composition and stimulation^[6].

Mechanical Removal Of Plaque Dentifrices/Toothpaste

Although the mechanical action of brushing is the primary means of plaque removal, a dentifrice (i.e. a toothpowder, toothpaste or a gel) facilitates the oral hygiene process^[7].

The high fluoride toothpastes can promote remineralization and inhibit demineralization more effectively, than the 1450 ppm F, the non-fluoridated and the calcium sodium phosphosilicate toothpastes^[8].

High fluoride toothpaste has a greater impact on adolescents who do not use toothpaste regularly or do not brush twice daily. The 5000ppm toothpaste appears to be an important vehicle for the treatment & prevention of caries in patients with high caries risk. However when it comes

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to preventing caries in adolescents with a higher caries risk, one challenge is motivating them to use toothpaste regularly, at least twice a day^[9].

Many behavioral factors could influence efficacy of toothpaste in caries prevention. H Sonbul et al showed fluoridated toothpaste of 1cm size brushed for 2 minutes followed by swishing the slurry around the teeth for about half a minute before spitting it out & no post brushing water rinsing & no eating/ drinking for 2 hours had a preventive effect on buccal or lingual enamel caries but not on the progression^[10].

Dentifrices are also fulfilling the cosmetic demands of the general population. In this world of prevention, dentifrices are helping dentists in maintaining their patient's oral hygiene^[7].

Pit & Fissure Sealants

School-based sealant programs (SBSPs) increase sealant use and reduce caries. Programs target schools that serve children from low-income families and focus on sealing newly erupted permanent molars. The evidence supports recommendations to seal sound surfaces and noncavitated lesions, to use visual assessment to detect surface cavitation to use a toothbrush or handpiece prophylaxis to clean tooth surfaces, and to provide sealants to children even if follow-up can not be ensured. These recommendations are consistent with the current state of the science and provide appropriate guidance for sealant use in SBSPs. This report also may increase practitioner's awareness of the SBSP as an important and effective public health approach that complements clinical care. SBSP's work with partners, such as local dental practices to help students without a source of dental care, receive comprehensive dental services^[11]. A systematic review found that pit-and-fissure sealants are effective in reducing the percentage of noncavitated carious lesions that progressed to cavitation in children, adolescents and young adults^[12]. Mean caries increment & its dynamics are lower in children with sealed teeth. The degree of caries reduction depends upon number of posterior teeth sealed & on tooth type^[13].

Use Of Polymeric Coatings

A new technology currently under development for increasing tooth resistance to decay is the fabrication of thin polymeric coatings over tooth crowns and accessible root surfaces^[14].

Laser Light

The ability of laser light to alter the surface of enamel and increase its resistance to acid challenge has been known for 30 years. A recent study has shown that use of carbon dioxide i.e. CO₂ laser light is efficiently absorbed by tooth minerals, is transformed rapidly into heat and forms a ceramic like surface that is highly resistant to acid attack, as well as to the initiation of caries as demonstrated in an in vitro model system^[15].

Chemical Removal Of Plaque:

Mouth rinse

The use of mouthrinses to deliver chemotherapeutic agents is well accepted by the public, both by self administration

and under supervision, mainly in school fluoride rinsing programs. Mouthrinse formulations are generally much simpler than dentifrices and compatibility problems are not as large an issue as they are with dentifrice products.

Following agents can be used for chemical plaque control

- a) Cationic Agents: Chlorhexidine, Cetylpyridinium chloride, Delmopinol, Hexitidine
- b) Anionic Agents: Sodium dodecyl sulfate
- c) Non-ionic Agents: - Triclosan
- d) Other Agents: - Enzymes^[16]

The supervised use of fluoride mouthrinse by children is associated with a clear reduction (preventive fraction of 26%) in caries increment (Marinho et al., 2003). Both daily rinsing with 0.05% sodium fluoride i.e. NaF (226 ppm F) and once a week/once every two weeks rinsing programs with 0.2% NaF (900 ppm F) were found to be effective. From a mechanistic perspective, fluoride mouthrinses can lead to higher levels of oral fluoride retention than fluoride dentifrice, depending on behavioral practices after toothbrushing. The FDA classifies mouthrinses as either cosmetic (as mouth fresheners) or therapeutic (as antiplaque/antigingivitis and anticaries drug products) or a combination of the two. The dental profession needs to help find incentives for the oral health care industry to develop more effective products that give consumers what they need as well as what they want. We also need to raise the level of social consciousness to support the development of cost effective and culturally effective caries management strategies targeted at high caries risk individuals^[17].

The combination treatment of a dentifrice containing 1450ppm F with the 450ppm F mouthrinse elicited significant enhancements in rehardening of incipient enamel erosive lesions, and significantly increased their subsequent resistance to a second erosive challenge^[18].

Chlorhexidine Varnish

The rationale for using Chlorhexidine to prevent caries is based on its ability to effectively suppress *S. mutans* (MS). The duration of suppression of MS is variable & may be influenced by the Chlorhexidine concentration of the varnish [Ribeiro et al., 2007]. Although

suppression of MS has been shown to be more effective with higher concentration varnishes such as 40 % Chlorhexidine [Schenken et al., 1989, Scheken et al., 1991., Attin et al., 2003], no pattern in relation to concentration & caries preventive effect can be observed. The frequency of application may also influence the duration of MS suppression [Le & Scheken et al, 1993], but among this trials that showed a significant effect, the frequency of application varied^[19].

Chemical Modification Of Plaque Role of antimicrobials

The mutans streptococci and the lactobacilli, either separately or together, are the primary causative agents of dental caries. Unlike classical infectious diseases, caries is caused by resident oral microflora. This flora has a function that is beneficial to the host. The goal is therefore not to eliminate the flora, but to control it to levels compatible with oral health, with minimum adverse effects.

Chemical agents can reduce plaque levels through one or more of the following principles:

1. Inhibition of microbial colonization.
2. Inhibition of microbial growth and / or metabolism.
3. Disruption of mature plaque.
4. Modification of plaque biochemistry and ecology.

Antiplaque agents can be delivered to the oral cavity by various delivery agents (vehicles), i.e. mouthrinses, sprays dentifrices, gels, chewing gum/ lozenges or sustained release vehicles such as varnishes. The choice of vehicles depends first on compatibility between the active agent and the constituents of the vehicle.

These chemical agents are advocated for individuals with high caries activity and incidence such as physically or mentally handicapped individuals or subjects who suffer from hyposalivation due to systemic diseases or medication. In all cases, expected benefit should be weighed against potential adverse effects and treatment length, mode of application and dose should be made on an individual basis^[16].

Targeted Antimicrobials

The basic idea of targeted antimicrobials is to develop an inexpensive targeting molecule that will reliably attach only to

the organism of interest such as *S. mutans* and *S. sorbinus*. Once the targeting molecule is perfected, a killer molecule is optimized and chained to the targeting molecule. The combined unit selectively eliminates the infection of interest^[20].

Probiotics

The concept of probiotics casts a new light on the connection between diet and health. Probiotics which literally mean “for life” are microbial preparations which exert

health promoting influences on humans^[20]. Probiotics are bacterial cultures or micro organisms which upon ingestion in certain numbers, exert health benefits and support a good and healthy microbial flora. Considerably less novel is the idea of exploiting ‘good’ bacteria, probiotics, to promote health. The concept to enrich the oral microbiota with health-associated species follows the paradigm that maintaining a healthy flora might be more successful than eliminating pathogenic microbiota^[21].

Replacement Therapy

Genetically modified *Streptococcus mutans* organisms that no longer produce acid are introduced to compete for ecological niche with wild type *S. mutans*, thus entirely displacing it. Not only does this stop the disease process, but also prevents the re-emergence of disease causing organism and eliminates reinfection because the ecological niche is full. Yoghurt with *Bifidobacterium* DN173 010 acts on salivary *S. mutans* and *Lactobacillus*. Introducing *Streptococcus gordonii* prior to the establishment of *S. mutans* may help to reduce the incidence of dental caries in children.

Use of Fluorides

The mechanism by which fluoride increases caries resistance may arise from both systemic and topical applications of fluoride and can broadly be grouped as follows:

- Increased enamel resistance.
- Increased rate of maturation.
- Remineralization of incipient lesions.
- Interference with micro-organisms.
- Improved tooth morphology^[22]

National institute of health has determined that topical application of acidulated phosphate fluoride once or twice a year and the placement and

maintenance of the integrity of pit and fissure sealants are two of the best methods for the primary prevention of dental caries throughout the life^[23].

Topical fluorides provide an additional benefit when used with fluoridated dentifrices. Acidulated phosphate fluoride is contraindicated for the use on patients who have composites, porcelain or sealants restorations as it can etch these materials^[24].

Following are overall recommendations for the use of fluoride toothpaste

- Use accredited fluoride toothpaste and brush twice daily, before going to bed and at one other time during the day, preferably after a mealtime. Use a small amount of water to remove the waste toothpaste slurry.
- Consider the appropriate fluoride concentration in toothpaste for an individual after assessing potential caries risk and overall fluoride exposure. Consider the use of low fluoride toothpastes for children at low caries risk or multiple fluoride exposures.
- For young children, brushing should be supervised and it is important that toothpaste is out of reach to minimize risk of children eating toothpastes. When brushing, children should use a pea sized amount of paste^[25].

Combinations of strontium and fluoride at specific concentrations induced a synergistic remineralization enhancement. Further in vitro studies are needed to determine the precise concentrations at which both strontium and fluoride should be used in combination to obtain optimal anticariogenic effects^[26].

Fluoride Varnish

Application of 5 % sodium fluoride varnish can be recommended as a public health measure for reducing caries prevalence in high caries risk population. Arruda AO et al found the use of 5% NaF varnish [Cavit shield] as a safe & effective topical agent in preventing early childhood caries & progression of decayed & filled tooth surfaces i.e. DFS increments in permanent dentition among high caries risk children. The results demonstrated a tendency in the fluoride varnish group toward reduction in new DFS lesions & with minimal increase in secondary DFS

lesions. Zeimmers et al showed 37% reduction in DFS increments in permanent dentition with binnial application of Duraphat (Colgate Oral Pharmaceuticals, New York, NY, USA). Two fluoride applications per year are more efficacious than one application^[27].

The Role Of Dietary Control

In conjunction with oral hygiene and other preventive measures such as widespread use of fluoride, dietary control makes an important contribution to the multifaceted strategy for caries prevention. The diet-caries relationship therefore needs to be evaluated not only against the quantity and type of fermentable carbohydrate consumed, but also against several background factors including intake pattern, total food intake, salivary secretion rate, plaque composition and use of fluoride^[28].

Salivary Composition And Stimulation

Chewing Gum

Saliva can be stimulated by any food or drink, but the most practical way of stimulating saliva is by chewing ORBIT sugarfree gum. The concentration of ions (calcium and phosphate) which make up the lattice structure of hydroxyapatite are higher in stimulated than in unstimulated saliva. Consequently, stimulated saliva is more effective at remineralising enamel crystals damaged by initial caries attack. The other benefits of sugar-free gum are:

- Neutralization and buffering of plaque acid.
- Oral clearance of sugars, acids and food debris from the mouth.

The use of sugar-free gum after eating meals and snacks promotes the in vivo remineralization of enamel lesions, and has been shown to reduce clinical caries development- in one study by up to 40%.

Xylitol

It is a nonfermentable sweetener and may possess some properties that promote remineralization. Xylitol is a naturally occurring polyol which is taken up by streptococci but not fermentable. Habitual consumption of xylitol in the diet appears to select for *mutans streptococci* with impaired adhesion properties, i.e. they bind poorly to teeth and shed easily from plaque to saliva. Thus, it can be speculated that the streptococci of mothers in xylitol group had impaired adhesion property leading

to reduced mother- child transmission of mutans streptococci^[29]. Use of xylitol chewing gum can retard return of oral mutans streptococci after suppression of these cariogenic organisms^[30].

Xylitol is a safe dental caries-preventive incorporated into chewing gum or confections. Many health organizations worldwide already support the habitual use of sucrose-free xylitol or polyol combinations in chewing gum or lozenges for at-risk populations (Fontana and Gonzalez- Cabezas, 2012). New modes of xylitol delivery, such as xylitol wipes, have been found to reduce the development of new caries in very young children (Zhan et al.,2012)^[21].

Recaldent Gum containing Xylitol and CPP-ACP has enhanced enamel remineralization considerably, compared to sugar-free chewing gum due to incorporation of CPP-ACP complexes^[31].

Remineralization of Dental Caries: Casein Derivatives

Casein is the predominant phosphoprotein in bovine milk and accounts for almost 80 % of its total protein, primarily as calcium phosphate stabilized micellular complexes . CPP-ACP i.e. Casein phosphopeptide amorphous calcium phosphate binds readily to the surface of the tooth as well as to the bacteria in the plaque surrounding the tooth. In this way, CPP-ACP deposits a high concentration of ACP in close proximity to the tooth surface. Under acidic conditions, this localized CPP-ACP buffers the free calcium and phosphate ions, substantially increases the level of calcium phosphate in plaque and, therefore, maintains a state of supersaturation that inhibits enamel demineralization and enhances remineralization. Clinical studies of mouthrinses and dentifrices containing CPP-ACP and fluoride have provided interesting insights into the synergy between these. For example, addition of CPP-ACP to a fluoride mouthrinse increases the incorporation of fluoride into dental plaque biofilm. A dentifrice containing CPP-ACP with fluoride provides remineralization which is superior to both CPP-ACP alone and to conventional and high fluoride dentifrices. The presence of agent CPP-ACP on dentine surfaces provoked lower demineralization and higher

remineralization^[32]. CPP-ACP and fluoride (APF)are both able to reduce the enamel wear caused by the combination of abrasion and erosion. Moreover, their concurrent use is more effective than using either of them alone^[33]. Fluoride and CPP-ACP are currently the most effective ingredients for achieving tooth remineralisation without resorting to invasive procedures^[34].

Tricalcium phosphate (TCP)

Chewing gums are considered to be potential anticaries agents, because, as a consequence of their effect on salivary flow, they can induce increases in plaque and salivary pH. This higher pH can increase tooth mineral saturation during a challenge and thus decrease demineralization. Increased calcium and phosphate concentrations in the oral environment can also increase tooth mineral saturation in oral fluids. Unfortunately, studies of candies or gums fortified with dicalcium phosphate dihydrate have not demonstrated their clinical efficacy. This failure has been ascribed to the low solubility of this mineral at neutral

pH and the correlated difficulty of inducing a calcium phosphate plaque reservoir from an insoluble source. An acidic gum can be used to increase the solubility of a calcium phosphate additive (alpha-tricalcium phosphate).

Pronamel

Despite its name, Pronamel™ is not considered a remineralizing agent per se and it does not contain any calcium compounds. It is a relatively new addition to the Sensodyne™ family of fluoride dentifrices, and is targeted to help with the problem of dental erosion. It contains 5% potassium nitrate to help relieve tooth sensitivity, has a neutral pH and a low abrasivity, and lacks the detergent sodium lauryl sulfate formally found in dentifrices. The fluoride component is sodium fluoride, giving 0.15% w/v fluoride ion, or 1500 ppm, an increase of 50% above conventional dentifrices.

NovaMin

A class of compounds called bioactive glass has been available since the late 1960s a materials designed to help repair damaged bone. The key components - SiO₂, Na₂O, CaO, and P₂O₅ - are mixed to be highly reactive to aqueous media. It

provides calcium and phosphate upon reaction. In the case of products with NovaMin, the active ingredient is a calcium sodium phosphosilicate that reacts when exposed to aqueous media and provides calcium and phosphate ions that form a hydroxycarbonate apatite (HCA) with time. If NovaMin® is able to fill in small surface defects in tooth enamel and thereby help stop erosion from acidic foods and beverages, it may also enhance tooth esthetics, such as gloss, by this mechanism. Thus, the ability to provide calcium and phosphate to an eroded surface may decrease mineral loss as well as allow remineralization to occur in the surface defects.

Enamelon

Enamelon consists of unstabilized calcium and phosphate salts with sodium fluoride. The manufacturer of this product claims that its Liquid Calcium(TM) Formula delivers fluoride along with soluble calcium and phosphate, the building blocks of enamel. Enamelon toothpaste is beneficial in the reduction of white spot lesions and the repair and remineralization of tooth enamel compromised by acidic beverages.

Dicalcium phosphate dihydrate (DCPD) DCPD abrasive is unique for fluoride stability. It is suggested that DCPD slurries were more effective than silica in preventing plaque pH drop when compared to silica. Toothpaste containing monofluorophosphate (MFP) and DCPD was significantly more effective than MFP/silica toothpaste. The MFP/DCPD dentifrice was superior to MFP/silica. More active calcium and a higher degree of saturation with respect to enamel exist for an extended period of time after use of a MFP/DCPD dentifrice^[35].

Caries Arrestment Agents

Different topical agents, such as silver nitrate, stannous fluoride, sodium fluoride, silver fluoride and silver diamine fluoride (SDF) have been applied clinically at high concentrations with the intent of arresting active caries lesions and/or to prevent further caries progression. Clinical protocols have included their use with and without prior removal of caries tissues, and with and without the subsequent placement of restorative material. Of greatest interest

is the use of these agents in non-traditional approaches for treating caries lesions, commonly referred to as Atraumatic Restorative Treatment (ART). This approach typically involves minimal removal of caries tissues by excavation with hand. Annual application of SDF is more effective in arresting dentin caries than application of fluoride varnish every 3 months. Furthermore, the removal of caries tissue does not improve the effectiveness of SDF or fluoride varnish to arrest dentin caries. The apparent effectiveness of SDF in arresting dentin caries without the necessity of prior caries removal may have advantages in certain community oral health programs where access by trained dental professionals is limited or not available^[17].

Remineralization during Orthodontic Treatment

MI Paste Plus (GC America, Alsip, Ill), can prevent the development of new white spot lesions during orthodontic treatment and decrease the number of white spot lesions already present^[36]. Both light-cured filled resin (Pro-seal) and fluoride varnish (Vanish) can prevent enamel demineralization next to orthodontic brackets exposed to cariogenic conditions^[37].

Conclusion

Dental caries is a dynamic process comprising of alternating periods of demineralization & remineralization^[38]. Fluoride dentifrices remain the most widely used method of delivering topical fluoride. The efficacy of this approach in preventing dental caries is beyond dispute. However, the vast majorities of currently marketed dentifrice products have not been clinically tested and have met only the minimal requirements of the FDA monograph using mainly laboratory testing and animal caries testing. Daily use of fluoride dental rinses as an adjunct to fluoride dentifrice has been shown to be clinically effective as has biweekly use of higher concentration fluoride rinses. The use of remineralizing agents (other than fluoride), directed at reversing or arresting non-cavitated lesions, remains a promising yet largely unproven strategy. Most of the recent innovations in oral care products have been directed toward making cosmetic marketing claims. There continues to be a need for innovation and collaboration with other scientific disciplines to fully

understand and prevent dental caries. As part of the evidence based approach to care, these clinical recommendations should be integrated with the practitioner's professional judgment and the patient's needs and preferences. The use of regular fluoride dentifrice is still the best and most feasible choice to be used to control caries lesions progression in enamel. The agents based on calcium and phosphate compounds could be useful to control the progression of carious lesions, but the results will need to be confirmed by clinical studies^[39].

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