International Journal of Community Medicine and Public Health
John MK et al. Int J Community Med Public Health. 2015 Feb;2(1):10-14
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040
DOI: 10.5455/2394-6040.ijcmph20150203

Review Article

Incipient caries: an early intervention approach

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Received: 11 December 2014
Accepted: 10 January 2015

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ABSTRACT

Dental caries is an irreversible microbial disease of the calcified tissues of the teeth, characterized by demineralization of the inorganic portion and destruction of the organic substance of the tooth, which often leads to cavitation (Shafer-1993). Organic acids produced as a by-product of fermentable carbohydrate metabolism plays a key role in the disease. The caries process is a continuous, involving various cycles of demineralization and remineralization. Demineralization begins at the atomic level on the crystal surface in enamel or dentine and can continue to cavitation. However currently there are many treatment modalities to intervene this continuing process, to arrest or reverse the progress of the lesion. Remineralization is the natural repair process for non-cavitated or incipient carious lesion.

Keywords: Dental caries, Demineralization, Remineralization

INTRODUCTION

Dental caries is one of the most prevalent diseases affecting mankind. It is a multifactorial disease affecting dentition. Food particles or organic degradable elements should be present on tooth surface for bacteria to act for a substantial period of time for caries to occur (Figure 1).

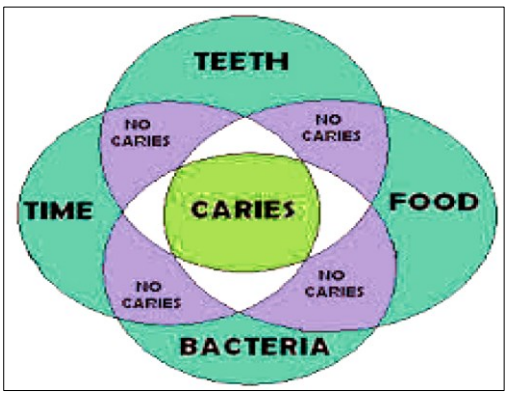

Figure 1: Factors that cause tooth decay.

Many oral microorganisms are capable of forming organic acids that reduce the pH of the dental plaque when exposed to carbohydrates. The essence of the carious process is local demineralization of enamel, causing degradation of hydroxyapatites. This process is initiated within bacterial biofilm - dental plaque that covers a tooth surface. Caries lesions develop where oral biofilms are allowed to mature and remain on teeth for long periods. The environmental acidification of the tooth, affects not only the number and species of bacteria, but also the release rate, viscosity and buffering capacity of saliva. Numerous streptococcus strains, including S. mutans, S. sanguinis, and to a lesser extent, lactobacillus, are considered as prime bacteria's involved in the development of dental caries. These are the bacteria that initially colonize the oral biofilm, acids produced by them as a metabolic by-product induce caries formation.

Dental enamel is composed primarily of hydroxyapatite with smaller amounts of water, protein, and trace elements including fluoride. The enamel can be easily demineralized in presence of these acids causing cavitation, but in presence of remineralizing agents

enamel is capable of maintaining its natural form without undergoing degradation. Oral cavity has a dynamic environment; if conditions are favourable both remineralization and demineralization can occur simultaneously as a see-saw mechanism (Levin's hypothesis).

DISCUSSION

The mineral composition and structure of the enamel surface are partially, products of the dynamic demineralization and remineralization process (Figure 2). This is greatly influenced by the pH of biofilm.[1] Dietary ingestion of fermentable carbohydrates, especially sucrose, provides the substrate for the cariogenic microorganisms in the biofilm to form organic acids. Sucrose is the arch criminal of dental caries .S.mutans is rated as the biggest culprit in caries formation it is both highly aciduric and acidogenic.[2] The enamel demineralization process begins when these acids lower the pH of the biofilm to less than 5.5 (critical pH). The acids result in the loss of calcium and phosphates from the surface and subsurface enamel creating a white spot lesion.[3,4] A white spot lesion (Figure 2) is characterized by low calcium and phosphate content and is the initial detectable evidence of enamel demineralization in the subsurface region of the tooth. The white spot lesion will progress into frank cavitation if the bacterial colony is not timely removed from the tooth surface.

Figure 2: Incipient caries.

The demineralization process is reversible provided that the acidogenic properties of the biofilm are neutralized. The buffering capacity of saliva plays a critical role in helping restore a neutral pH at the tooth surface.[5] Remineralization occurs when the dietary carbohydrate is removed and the pH of the biofilm are raised to approximately 7.0. Once the pH returns to higher than the critical point, demineralization is arrested and minerals can be added back to the partially dissolved enamel crystallites (Figure 3).

Treatment of early caries by remineralization is the non-invasive clinical management of incipient lesion. Calcium and phosphate in the saliva and plaque permit the recovery of some lost mineral content by the enamel. Extremely high calcium and phosphate concentrations in the dental pellicle can actually adversely affect the quality of re mineralization.[6] High concentrations favour formation of calcium-phosphate mineral phases on the surface that occlude the enamel pores and limit remineralization of the subsurface enamel. A more complete remineralization process occurs when the calcium and phosphate are lower. Calcium and phosphate, primarily from saliva, but possibly from other topical sources, diffuses into the tooth and, with the help of fluoride or any remineralizing agent, builds on existing crystal remnants rather than the formation of new crystals (Figure 4). The new crystal surface however, is composed of a veneer of well-formed minerals. The crystal surface is now much less soluble than the original carbonated hydroxyapatite mineral and is more difficult for the acid to dissolve next time there is an acid challenge from the plaque.

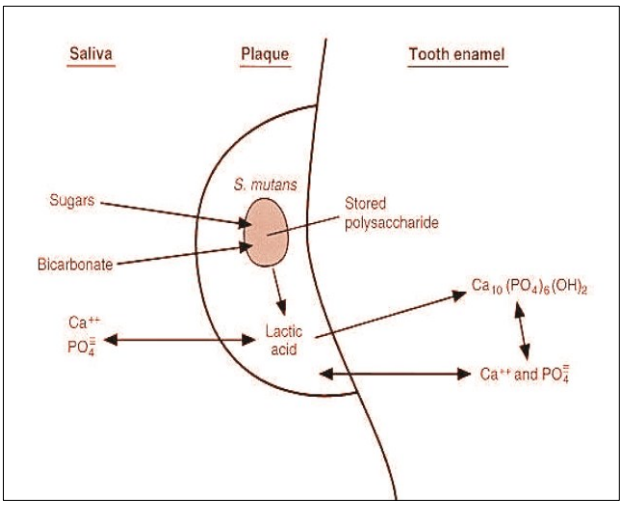

Figure 3: Demineralization process on acid release.

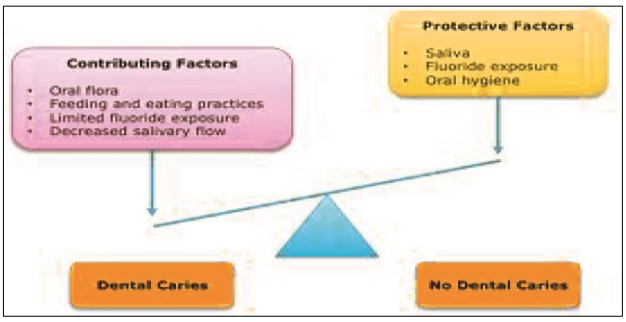

Figure 4: See-saw mechanism of caries progression.

The revised etiopathogenesis models and remineralization concepts have given a forward thrust to the science of cariology .It became imperative to detect these incipient lesions at the earliest to take advantage of the inherent capacity of the body to heal by itself. Dental caries is one of the few diseases in which can be avoided by the use of simple procedures. The treatment approach can be in primary, secondary and tertiary level. In primary level patients is educated or motivated about

proper oral hygiene maintenance and caries preventive measures. In the secondary prevention level initial or incipient lesions are intervened from progressing to an aggressive phase. The goal of tertiary prevention is to reduce or to negate the impact of an already-established disease by restoring function and reducing disease-related complications Tertiary prevention also aims to improve the quality of life for people with disease.

Treatment of early carious lesion

Fluoride

Fluoride is the most reactive element in the periodic table. It is an effective anticariogenic agent and is widely used in the prevention of caries Fluoride ions react with the partially dissolved enamel crystallites and attract calcium and phosphate ions in the saliva to the demineralized dental enamel. This enhances new mineral deposition and crystallite re-growth.[7] In addition, the presence of fluoride favors the formation of enamel fluorapatite by substitution of hydroxyl molecules with fluoride in the hydroxyapatite crystal. Fluorapatite is harder and more resistant to acid dissolution than hydroxyapatite.

Frequent exposure of the teeth to low concentrations of fluoride is thought to produce the optimal remineralization environment. Fluoride is topically applied as tooth pastes, gels, varnishes, foam and mouth rinses. Periodic, professionally-applied topical fluoride agents can also be beneficial. The American Dental Association has approved the use of 1.23% acidulated phosphate fluoride (APF) gel/foam, 8% stannous fluoride solution, and 2% sodium fluoride gel as professionally applied topical agents. European studies of a 5% sodium fluoride varnish have also demonstrated caries preventive benefits similar to APF gel/foam when applied topically to the teeth.

Calcium, phosphate, and fluoride ions in the saliva assist in the remineralization process. Saliva is the vehicle that delivers available fluoride ions to the demineralized enamel and partially dissolved crystallites. The enamel, fluoride reaction products from topical fluoride are CaF_2 and CH (PO_4). Saliva slowly dissolves the CaF_2 and delivers the fluoride ion to the demineralized enamel, without saliva the remineralization process will not occur. Evidence suggests that uptake of fluoride depends on the availability of calcium ions in the mouth. Saliva provides the main source of calcium and phosphate in addition to dissolved tooth structure and crevicular fluid. If salivary level is low the bioavailability of calcium and phosphate ion is compromised inhibiting the remineralization process.

Calcium phosphate

Remineralization is a noninvasive treatment of early carious lesions and hypomineralized enamel negating the need for invasive dental treatment modalities. The development of products to enhance remineralization is a research goal. Currently, few types of remineralization technologies are available.

Amorphous Calcium Phosphate (ACP) is a reactive and soluble calcium phosphate compound that releases calcium and phosphate ions to convert to apatite and remineralize when it comes in contact with saliva[8] ACP provides a reservoir of calcium and phosphate ions in the saliva.

Calcium sodium phosphosilicate (NovaMin) contains calcium, phosphorous, sodium, and silica. It reacts with saliva, releasing Ca^{2+}, P^{5+}, and Na^{+} into the oral environment. First the Na+ buffers the acid and then the charged Ca^{2+} and P^{5} ions saturate saliva precipitating into the demineralized areas to form a new layer of hydroxyapatite crystals sealing demineralized areas.[9]

Casein phosphopeptides (CPP) is a sticky, milk-derived protein that binds to enamel pellicle and bacterial plaque. It stabilizes Amorphous Calcium Phosphate (ACP).[10] Products have recently been introduced containing CPP-ACP caesiated phosphor protein acts as a vehicle to deliver and maintain a super-saturation state of amorphous calcium phosphate at or near the tooth surface. This formulation slows down the progression of demineralization and promotes remineralization of white spot lesions. Some of these products also contain fluoride.[11,12] Gum, lozenges, and topically applied solutions containing CPP-ACP may also remineralize white spots.

Calcium sucrose phosphate is a complex mixture of calcium sucrose phosphate and inorganic calcium orthophosphate. The main advantage of this product is that it quickly breaks down and releases calcium, phosphate and sucrose phosphate ions into saliva.[13] Calcium sucrose phosphate is readily soluble in saliva and it provides high concentration of freely available calcium and phosphate ions. These calcium and phosphate ions are adsorbed onto the tooth surface and it inhibits demineneralization in acid pH and enhance remineralization under neutral pH

Sealants

Sealants are often used to occlude at-risk pits and fissures on teeth. When properly placed, sealants provide a physical barrier between the dental enamel and the oral environment shielding the tooth surface from acid challenge. Sealants are effective in arresting caries progression when properly applied to incipient demineralized lesions. Fluoride-releasing sealants are also on the market. The manufacturers of fluoride-releasing sealants claim that their products promote remineralization by releasing fluoride in the immediate area adjacent to the sealant.

Chewing gum

The importance of saliva's buffering capacity in the remineralization of demineralized hard dental tissues and the maintenance of optimum oral health is well established. Recently there has been renewed interest in the benefits of chewing gum as a means to stimulate saliva flow to prevent dental caries.[14,15] Contraction of the masticator muscles increases the flow of saliva, resulting in an elevated presence of calcium and phosphate ions, and it raises the pH of the biofilm. All of these traits are important to the remineralization process. Numerous studies have demonstrated the caries-preventing qualities of frequent use of chewing gum sweetened by dietary sugar alcohols such as xylitol and sorbitol. Chewing gum, particularly sugar-free gum, may offer a valuable adjunct to a caries prevention and remineralization program.

Future preventive methods

Probiotic therapy - Naturally or artificially grown effector cells are intentionally colonized in the susceptible site. These cells will outnumber pathogens and will compete for niche and nutrition and will itself colonize as indigenous flora in the host.

Genetically altered bacteria - Introduction of genetically altered bacteria will compete with the virulent S. mutans and can kiss them to death

Caries vaccines - The basic principle behind the vaccine is to reduce the indigenous harmful bacteria.

CONCLUSIONS

Dental caries is a major world-wide health problem, which, apart from its effects on oral and dental health, creates a huge impact on economic load.

The caries process is a continuum of many cycles of demineralization and remineralization. Remineralization is the body's natural process for repairing subsurface non-cavitated carious lesions caused by organic acids created by bacterial metabolism of fermentable carbohydrates. Fluoride ions in the presence of calcium and phosphate promote remineralization by building a new surface on existing crystal remnants in subsurface demineralized lesions. This environment also favors the formation of the more favoured fluorapatite crystal in the enamel. Other than fluorides many calcium containing compounds are available in market that enhances remineralization of incipient lesions; these are relatively safer than fluoridated products.

Remineralization of incipient carious lesions is a conservative alternative to conventional caries removal and dental restoration. The development and promotion of a robust caries prevention and remineralization regimen that discourages demineralization and encourages remineralization remains a challenge. Additional research is needed to identify new approaches to stimulate the beneficial effects of the remineralization process, reduce the incidence of dental caries and to optimize health. Newer concepts have broadened our mind set while narrowing our vision to identify the modified, 'miniaturized' presentation of the dental carious lesions. There is a drastic shift in perspective of treatment approach by inculcating a logical approach towards minimal sacrifice and maximal preservation of the natural tooth material. With the advancement in technology we are aiming for a caries free generation.

Key messages

Incipient caries is the beginning stage of demineralization process of teeth. This can be checked from progressing by timely intervention. Patient education and motivation is crucial for this. Routine dental check-up and meticulous oral hygiene practices can prevent the cavitation of this lesion and negate the oral health burden of the patient. Many products are available for the treatment of incipient caries. Huge amounts of money and time is spent in treating denta1 caries. Hence, the prevention and control of dental caries is the main aim of pub1ic hea1th dentistry, eventually the ultimate objective is the elimination of the disease itself.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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DOI: 10.5455/2394-6040.ijcmph20150203
Cite this article as: John MK, Babu A, Gopinathan AS. Incipient caries: an early intervention approach. Int J Community Med Public Health 2015;2:10-4.