

PREVENTIVE ASPECTS OF DENTAL CARIES: A REVIEW

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Abstract

Dental caries is the most prevalent disease and the accent reason for tooth loss, representing a great challenge for oral health care. Diet Counseling aims to help parents to change dietary behaviours and choose diets with low or noncariogenic snacks, limit sweet foods. Use of antagonistic organism to prevent pathogen and control disease is called replacement therapy. The combination of prebiotics and probiotics may have additive and synergistic effect in providing better oral health conditions. Fluoride releasing devices can be used as preventive measure for dental caries.

Key words: Dental Caries, Diet, Fluoride

Introduction

Dental caries is defined as a chemical dissolution of the tooth mineral resulting from metabolic events taking place in the dental bio-film covering the affected area. Dental caries is the most prevalent disease and the accent reason for tooth loss, representing a great challenge for oral health care.¹ Above 80% of the population in India suffer from dental caries. This disease affects the children from a very young age due to neglect of oral hygiene.² Caries of the crown of the tooth initially presents as a white spot in the enamel and on the root as soft areas in the cementum and dentine. As caries progresses, more extensive destruction of the enamel and dentine occurs, followed by inflammation of the pulp and periapical tissues.³ Because of its high prevalence, dental caries is the reason of many interventions targeted toward prevention and control. Patient Education & Patient's motivation are necessary to change behaviors that place patients at increased risk for caries.⁴

Etiology

Three principal factors responsible for this multifactorial disease are

1. Host (teeth and saliva)

Teeth

Deep, narrow occlusal fissures, and lingual & buccal pits tend to trap food debris and bacteria, which can cause caries. The interdental areas are more prone to dental caries. Mal-alignment of the teeth such as crowding, abnormal spacing etc. can increase the susceptibility to caries.

Saliva

Saliva has a cleansing effect on the teeth. Normally, 700–800 ml of saliva is secreted per day. Caries activity increases with increase in viscosity of the saliva. Eating fibrous food and chewing vigorously increases salivation, this improves cleansing of the teeth and aids digestion. Saliva contains enzymes such as lactoperoxidase, lipozyme, lactoferrin and immunoglobulin (Ig) A, which can inhibit plaque bacteria.

2. Microorganisms in the form of dental plaque

Dental plaque is a thin, tenacious microbial film present on the tooth surfaces. Microorganisms in the dental plaque

ferment carbohydrate foodstuffs, especially the disaccharide sucrose to produce acids that cause demineralization of inorganic substances and furnish various proteolytic enzymes to cause disintegration of the organic substances of the teeth, the main processes involved in the initiation and progression of dental caries. The acid produced, is held by dental plaque in close contact with the tooth surfaces and prevents them from contact with the cleansing action of saliva.

3. Substrate (diet)

The refined carbohydrates, mainly the disaccharide sucrose, have a role in etiology of dental caries. The total amount consumed, the physical form and frequency of consumption are important factors in the etiology. Vitamins A, D, K, B complex specially B6, calcium, phosphorus, fluorine, amino acids such as lysine and fats have an inhibitory effect on dental caries.⁵

Preventive aspect of dental caries

I Diet counselling

Caries is considered as nutritional deficiency caused either by sufficient phosphate intake or improper dietary calcium - phosphate ratio. Phosphate salts have the quality to reduce dental caries.

Objectives of Counseling

The main objective of dietary counseling is caries prevention. Diet Counseling aims to help parents to change dietary behaviors and choose diets with low or noncariogenic snacks limit sweet foods to mealtimes and perform tooth brushing after sugar exposures.

The objectives of diet counseling are

1. Correction of diet imbalance, may strike the patients oral health and general health.
2. Modification of dietary habits.
3. Dietary recommendations must be realistic.

Purpose

Educate parents about dental development of the child, dental disease and there prevention.

Create a suitable atmosphere for the child.

Strengthen and develop the child and child's dentition for life.

Content

Parents

Educating parents about dental disease and oral hygiene maintenance.

Parents' motivation about plaque removal program, Changes in mother's oral health, sweets intake & Pregnancy gingivitis.

Myths regarding pregnancy and dentition, Parents dental treatment.

Parents and Child

Parents' education—development of child, Effect of lifestyle on child, sweets intake,

Effect of drugs on child—e.g., tetracyclines, Essential nutrients, Child's needs after birth,

Breast feeding versus bottle feeding, Fluoride supplementation, Teething, Hygiene.

Persons who need counseling must also want information about their potential dental caries problem and must be willing to improve current undesirable food selections and eating habits. The candidates for counseling must give a high priority to preventive dentistry and to maintain their natural dentition in good health for a lifetime.

Dietary advice:

Giving dietary advice successfully, therefore rely on for more than providing knowledge; it requires sensitive understanding of the role of food in society and its significance for the individual patients. Changes in food related behaviour should be accompanied by changes in other aspects of health related behaviour in order to produce healthier person.⁶

II Replacement therapy

The possible use of antagonistic organism to prevent pathogen and control disease is called replacement therapy. This kind of therapy has an advantage of providing lifelong protection, once colonization by the effector strain is established.

Both probiotics and replacement therapy use live bacteria but difference between the two is:

- In replacement therapy, these effector strains are directly applied on site of infection and colonization of site is essential while probiotics are generally used dietary supplements with a beneficial effect without colonizing the site.
- Replacement therapy has minimal immunological impact whereas probiotic therapy has a definite immunological impact.⁷

The basis of replacement therapy is the implantation and persistence within the normal microflora of relatively innocuous 'effector' bacteria that can competitively exclude or prevent the outgrowth of potentially disease causing bacteria, without significantly disturbing the balance of the existing microbial ecosystem.⁸ The human oral cavity harbors a large variety of micro-organisms, but *Streptococcus mutans* as the major cause of dental caries. The principal features of *S. mutans* that predispose it to cause decay are its ability to stick to the tooth surface, its propensity to form large amounts of acid from the metabolism

of dietary sugars and its production from sucrose of extracellular polysaccharides that trap the acid so produced majority of effort in the field of replacement therapy for the prevention of dental caries has centered on isolating effector strains with decreased acidogenic potential. Those receiving the most attention to date include mutants of *S. mutans* defective in intracellular polysaccharide metabolism and mutants lacking the enzyme activity lactate dehydrogenase. Also, a natural variant of *S. salivarius* called TOVE-R has been studied which is non-cariogenic. TOVE-R mainly colonizes tooth surfaces and produces plaque much like *S. mutans*. IPS and LDH mutants and TOVE-R have all been shown to have significantly lower cariogenic potential *in vitro* and in animal models than do wild-type strains of *S. mutans*.

The above studies demonstrate the feasibility of employing carefully selected effector strains for the control of *S. mutans*-initiated dental caries.⁹

III Probiotics and Prebiotics

Probiotic means for life. Lilly and Stillwell in 1965 described it as "substances secreted by one microorganism, which stimulates the growth of another".

According to a WHO/FAO report (2002), probiotics are defined as "live microorganisms which, when administered in adequate amounts, confer a health benefit on the host".¹⁰

Microorganism involved:

Lactobacillus, *Pediococcus*, *Saccharomyces*, *Bifidobacterium*, *Enterococcus*, *Bacillus*, *Aspergillus*.¹¹

Mechanism of action of probiotics in oral cavity

- Involvement in binding of oral micro-organisms to proteins (bio-film formation).
- Action on plaque formation by competing and interfering with bacteria-to-bacteria attachments.
- Metabolism of substrates
- Production of chemicals to inhibit oral bacteria
- Modulating systemic immune function.
- Effect on local immunity.
- Regulation of mucosal permeability.¹²

Probiotics and Dental Caries

The impact of oral administration of probiotics on dental caries has been studied in several experiments utilizing different test strains. *L. casei* and *Lactobacillus rhamnosus GG* have the potential to alter growth of oral streptococci. There is a definite reduction of *S. mutans* count after a 2-week consumption of yoghurt containing *L. reuteri*. A temporary reduce in *S. mutans* was observed in the duration of yogurt intake. Different probiotics such as medical probiotics (microbial preparation) and other probiotics (functional food) are provided in four basic ways.

- Culture concentration added to a beverage or food such as fruit juice.
- The probiotics inoculated into prebiotic fibres.
- Probiotic inoculated into a milk-based food - dairy products like milk, milk drink, yoghurt, yoghurt drink and cheese.

- Concentrated and dried cells packaged as dietary supplements - non-dairy products like powder, capsule, gelatin tablets.¹³

Prebiotics

Prebiotics are “nondigestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon.”¹⁰

They enhance the growth and activity of beneficial organisms and simultaneously suppress the growth and activity of potentially deleterious bacteria.

Some commonly known prebiotics are Lactose, Insulin, Galacto oligosaccharides, Fructo oligosaccharides, and Xylo oligosaccharides. Naturally existing Prebiotics are in fruits like tomato, bananas, asparagus, garlic, and onion wheat.

The combination of prebiotics and probiotics may have additive and synergistic effect in providing better oral health conditions.¹⁴

IV. Remineralising Agents

Remineralization is defined as the process whereby calcium and phosphate ions are supplied from a source external to the tooth to promote ion deposition into crystal voids in demineralized enamel to produce net mineral gain.¹⁴

A. Fluorides

Fluorides are the most effective agent in prevention of dental caries. The mechanism of action of fluorides includes:

- The fluoride ion can exchange with hydroxyl group in the apatite crystal forming fluorapatite which is more stable and less soluble crystal,
- The fluoride can enter void spaces on the apatite crystal and provide stability by additional bonds,
- Fluorides contribute to remineralization of early lesions,
- Fluorides act as an antimicrobial agent against bacteria and
- Reduces bacterial metabolism and growth by inhibiting essential enzymes.

1. Personally used Fluorides

Fluoride Dentifrices and Mouthrinses

- Dentifrices contain 0.1% fluoride and uptake of this fluoride in etched enamel or in incipient lesions enhances remineralization.
- Fluoride mouthrinses are advised in patient with high caries susceptibility and patients with orthodontic and prosthetic appliance.

2. Professionally applied Fluorides

- Fluoride Solutions

The topical solutions of fluoride used are 2% sodium fluoride, 8% stannous fluoride and 1.23% of acidulated phosphate fluoride solutions.

- Fluoride gels

Gels adhere to teeth and eliminate continuous wetting of enamel.

- Fluoride varnish

Topical fluoride reagents cause rapid loss of soluble fluoride formed on teeth. To combat this, waterproof sealant in the form of fluoride varnish was introduced. This procedure improves reaction time between fluoride and enamel providing long term effect. Currently, sodium fluoride based varnish (Duraphat) and polyurethane based varnish (Fluoroprotector) are commonly used.

Fluoride Releasing Restorative Materials

- Glass ionomer cement releases fluoride which is found to be incorporated in enamel, cavity walls and bacteria inhibiting acid production. Fluoride recharge ability of glass ionomer cement helps in long term inhibition of caries.
- Compomers consists of sodium fluoride, silicate glass particles and polyacid-modified monomer without any water.
- Giomers consists of pre-reacted glass ionomer particles and composites, exhibiting properties of fluoride release and recharging with excellent aesthetics.
- Pit-and-fissure sealants contain strontium-fluoride-aluminosilicate glass as filler which undergoes hydrolysis and releases fluoride through external and internal diffusion.

B. Calcium Phosphate Based Remineralization

Calcium phosphate based 4 systems are:

- Enamelon™ is based on technology of unstabilized amorphous calcium phosphate with fluorides. This works on the principle that since calcium and phosphate ions are not stabilized thus allowing the two ions to combine into precipitates which are insoluble. These insoluble precipitates get dissolved in saliva releasing amorphous calcium fluoride phosphate precipitates which in turn transforms to a more thermodynamically stable fluorhydroxyapatite.
- Recaldent™ is derived from a protein casein, present in cow's milk. It is available as casein phosphopeptide stabilized amorphous calcium phosphate. Casein phosphopeptide binds to pellicle and plaques by stabilizing high concentrations of calcium and phosphate ions with fluorides at tooth surface. The ions get freely diffuse to enamel subsurface lesions to promote remineralization.
- Bioactive glass is composed of CaO, Na₂O, SiO₂, and P₂O₅ developed by Professor Larry Hench. It is commercially available as Novamin™ consisting of calcium sodium phosphosilicate. Novamin™ can kill up to 99.9% of pathogens associated with caries.
- Clinpro Tooth Creme™ is a commercially available organically modified tricalcium

phosphate which can coexist with fluoride in aqueous environment. While brushing, this toothpaste contacts saliva and thereby calcium, phosphate and fluoride ions become readily available to tooth thus preventing demineralization.

A. Sugar Substitute

Xylitol is a naturally occurring pentitol which is a sugar substitute incorporated in chewing gums. Manton et al. showed that remineralization can occur with the use of sugar-free gum containing xylitol.

Xylitol acts by:

- Reducing plaque formation
- Making plaque less adhesive
- Neutralize acids in plaque by reducing the production of lactic acid
- Reduces level of *s. mutans*
- Increasing the salivary flow.¹⁵

Sources are fruits, berries, mushroom, lettuce and corns.¹⁴

Sorbitol is another artificial sweetener having anticariogenic effect.¹⁶

B. Ozone

Ozone is a chemical compound which is a powerful oxidizing agent. Ozone acts by attacking thiol groups of cysteine amino acid and destroys the cellular membrane of carious bacteria. Ozone can shift microbial flora from acidogenic and aciduric micro-organisms to normal commensals allowing remineralization to occur.¹⁵

V. Intraoral slow-release fluoride devices

Different types of fluoride releasing devices are described below:

1. Copolymer membrane devices developed in USA,
2. Glass devices that were developed in UK.
3. Hydroxyapatite-Eudragit RS100 diffusion controlled fluoride system
4. Slow fluoride release tablets for intrabuccal use.

Copolymer membrane device: This was developed by Cowsar *et al.* [1976] in the form of a membrane-controlled reservoir. It consists of an acrylic polymer matrix impregnated with granulated sodium fluoride (NaF) that is encased in an acrylic polymer (membrane). Once placed in the mouth, the device becomes hydrated with saliva and its characteristics lead it to release a constant rate of sodium fluoride of 0.02-1.0mg/day for up to 4-6 months, depending on the size of the device. It is usually attached to the first permanent molar that on the buccal surface.

Glass device: The glass device was developed by Curzon in 1984. The fluoride glass device dissolves slowly when it is moist, thus releasing F without affecting the device integrity significantly. The device has been shaped in the form of a disk and placed within plastic bracket to facilitate device attachment, handling and replacement.

Hydroxyapatite - Eudragit RS100 diffusion controlled F-system: This is the newest type of device, that consists of a mixture of NaF, hydroxyapatite and Eudragit RS100. It has about 18 mg of NaF and is intended to release 0.15 mg

F/day. This device is able to increase salivary and urinary F concentrations for at least 1 month.

Slow fluoride release tablets for intrabuccal use: Tablets of 160-200mg were formulated and fixed on a tooth. These tablets have a granular matrix composed of pure hydroxyapatite, Eudragit and ethylcellulose.¹⁷

Effects of devices-

- Increase intra-oral fluoride Concentrations.
- Reduced Caries Prevalence.
- Inhibit caries in medically compromised individuals.
- Reduced caries in Patients undergoing radiation therapy and xerostomia.
- Reduced orthodontic white spot lesions.
- Decreased Dentin sensitivity.

Toxicity and side-effects

- Possibility of de-bonding and subsequent ingestion of device can cause acute toxicity.
- Mucosal irritation, erythema and small ulcers.
- Increased plaque retention on the top of the devices.¹⁸

VI. Caries vaccine

Vaccine is an immunobiological substance produced to promote protection to certain specific disease by stimulating the production of protective antibodies and other mechanisms of the immune system. As dental caries is multifactorial and occurs as a result of the activity of members of a normal commensal oral microbiota, the development of a vaccine against this disease has a high level of complexity.¹⁹

Mechanism of Action of Dental Vaccine

Secretory IgA is the principal immune component of and considered as primary mediator of adaptive immunity apart from other immunoglobulins like IgG and IgM which are derived from the gingival circular fluid. In addition, gingival sulcus also contains various cellular components of the immune system like macrophage, lymphocytes and neutrophils.

Ways by which salivary IgA antibodies act are:

- a. The family of adhesions from *Streptococcus mutans* and *Streptococcus sobrinus* has been shown to be effective antigens. The salivary IgA act as specific agglutinin acting with the bacterial surface receptors and inhibiting colonization and subsequent caries formation.
- b. The second important mechanism involves the migration of antigen-sensitized IgA precursor B cells from Gut-Associated Lymphoid Tissues (GALT) to salivary glands. This GALT covers numerous solitary lymphoid nodules and particularly Peyer's patches, which are source of precursor IgA.
- c. Humoral and cellular components of the systemic immune system are also present at the gingival crevicular level. It is seen that after a subcutaneous *S. mutans* immunisation, the organism is phagocytosed and undergoes antigenic processing by macrophages. B and T lymphocytes get sensitized by macrophages in the lymphoid tissue

preventing the antigen HLA Class complex and releasing IL-1. Induction of CD-8 and CD-4 suppressor cell response takes place. This interaction plays an important part in modulating the formation of IgG, IgA and IgM antibodies and lymphocytes.²⁰

Types of caries vaccines

- Based on active immunization
- Based on passive immunization
- Nucleic acid-based vaccines (DNA)¹⁹

Routes of immunization

4 routes of immunization

1. Oral
2. Systemic (subcutaneous)
3. Active gingivo-salivary
4. Passive dental immunization.²¹

Conclusion

In the above review, various methods of caries prevention have been discussed. Dental caries can be reduced by proper diet manipulation, using various types of fluorides and fluoride releasing devices, using microbes in form of probiotics and prebiotics and last but not the least caries vaccine to reduce dental decay and improving the quality of life or saving the life

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