

Recent Advancement In Management Of Dental Caries

Tejkanwar Soni¹, Rajni Sidana², Amit Sidana³

Abstract

Dental caries is the most prevalent and widespread chronic oral disease. We as dentist, need to work out patient-centered and personalized treatment planning to regain oral micro-ecological balance, to control caries progression and to restore the structure and function of the carious teeth. This article overviews the latest minimally invasive, nanotechnology and modalities of preventive and therapeutic dental caries management and treatment options. This new information, knowledge, and materials should encourage professionals to implement these methods.

Key words: Anticaries, Remineralisation, Biofilm.

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I. INTRODUCTION

Dental caries is one of the most common chronic infectious, multifactorial disease in the worldwide. It is non self-limiting type disease which if not properly cured, it would lead to destruction of tooth. Imbalance of the demineralization-remineralization process in which demineralization occurs more, that leads to form dental caries. Dental caries is influenced by Acid generating bacteria (mutans streptococci/ present in plaque biofilm as well as dietary and host factors. The prevalence of permanent dental caries ranked first, and the incidence ranked second among 328 diseases in the result of the global burden of diseases study released by Lancet in 2017 [1]. 60-

90% of school children and almost 100% of adult population are affected by Dental caries [2]. dental caries affects person's self-esteem, quality of life and also indirectly reduces nation's productivity hence prevention of dental caries is necessary. [3]

PREVENTIVE TREATMENT

MEASURES TO PREVENT DEMINERALIZATION

Acid is produced when bacteria colonize on the tooth surface and metabolize dietary carbohydrates, these acids diffuse into enamel and dissolve mineral soft tooth structure, mainly calcium and phosphate, this process is known as demineralization. Newer Chemoprophylactic agents, antimicrobial peptides, probiotics, replacement therapy, bacteriophage therapy, photo-dynamic therapy, sugar substitute, immunization are novel approaches to prevent demineralization.

Newer Chemoprophylactic agents

Traditional agents like chlorhexidine, triclosan, xylitol etc. help in caries prevention by reducing the mutans streptococci but these had a very short retention time in oral cavity which is a drawback. Recently binding micellar drug delivery system was developed which not only releases encapsulated drug over a longer period of time but also binds fast with the tooth surface through its carboxy groups. This was accomplished by covalently conjugating the tooth binding moiety to the ends of polyuronic copolymer using 'click chemistry'. [4] Recent advances in novel active plant extracts, includes water soluble component of Labiatae family (Mezine et al); berry juice of Vaccinium plant (Ofek et al), an essential oil composition from Coleus forskohlii (Majeed et al); they all showed significant inhibitory action against S. mutans. [5,6,7]

Probiotics

Probiotics are defined as living microorganisms that are safe for human consumption and considered to provide health benefits when ingested in sufficient quantities. It acts either by production of antimicrobial compound that inhibit oral bacteria such as organic acids or hydrogen peroxide or low molecular weight antimicrobial compound, bacteriocins and adhesion inhibitor produced by lactic acid bacteria; or act by disrupting plaque biofilm formation through competition for binding sites on host tissues and other bacteria, and competition for nutrients. Mollstad et al, discovered new strains of Lactobacil-

lus, including *L. reuteri* CF2-7F (ATCCPTA-4965), MF2-3 (ATCCPTA-4964), FJ—'Prodentis' (ATCCPTA-5289) & FJ3 (ATCCPTA-5290), that have good antimicrobial action on *S. mutans*. [8] Long term consumption of milk containing *L. rhamnosus* GG strain reduces initial caries. Ingestion of *L. reuteri* ATCC55739, *Bifidobacterium* DN-173010 reduces *S. mutans* in saliva.

Antimicrobial Peptides (AMP's)

Robust killing activity of AMP's against a wide spectrum of bacteria's, which includes drug resistant strains has become popular recently. These peptides have overall cationic charge and are amphiphatic mixture of alpha helical & beta sheet. They bind to LPS (negatively charged) of microbial membrane, and then they penetrate inside the cell & kill by intracellular mechanisms. Bobek discovered new AMP's which are more stable & resistant to proteolysis. [9] Leung et al discovered novel AMP which is more stable & easy to synthesize at lower cost. [10] Reynolds et al, recently found AMP's can be derived from milk protein casein. [11] An active agent 1, 25-dihydroxyvitamin D3 (biologically active form of vitamin D) has been recently discovered to be able to induce the expression of the gene encoding LL-37 while cause less toxicity (host inflammatory response). [12]

Bacteriophage Therapy

Viruses that attack bacteria are called bacteriophage. These are target specific, useful for patients allergic to antibiotics, cost effective and contains no side effects. Delise & Rotkowsky have described bacteriophage lytic for *S. mutans*. [13] Recently lytic phage is also discovered for *S. salivarius*. Hence, the isolation and identification of lytic bacteriophage to oral pathogens is considered to be an approach towards phage therapy of dental caries.

Replacement Therapy

Advances in gene engineering and DNA recombination technology that inhibits the pathogens in oral flora is known as replacement therapy. Several mutated strains of *S. mutans* have been developed which lack the ability to metabolize fermentable carbohydrates to organic acid. A non-acid-producing *S. mutans* strain BCS3-L1 has been developed which produces an antibiotic called mutacin 1140, active against other *S. mutans* strains to replace the naturally occurring cariogenic strains in oral cavity. [14-16] This strain was significantly less cariogenic than the parent strain JH1140. In another study, the ability of *S. mutans* to produce extracellular glucans, blocked in a mutation by deleting the GTF-C gene. [17]

Photodynamic Therapy (PDT)

PDT is formation of reactive radical including cell death by utilizing light for activation of photosensitizing agent in presence of oxygen and results in inactivation of microorganism related to caries. Erythrosine is appropriate photosensitizer against *S. mutans* because of its action against gram positive bacteria and hydrophilic nature. There should be light source of 530nm wavelength for erythrosine which may be achieved with low cost LED's. [18]

Vaccines

Vaccine is defined as a suspension of attenuated or killed microorganisms administered for the prevention, amelioration or treatment of infected diseases. Specific antibody production from adaptive immunity against colonization of *S. mutans* provides line of defense to caries. IGA antibodies present in saliva mediate immune defense in dental caries. [19] Recent re-search focus is mainly on the delivery of purified bacterial antigen to mucosal IGA inductive sites. Antigen I/II, GTFs and glucan-binding proteins (GBP) are three main types of *S. mutans* antigens that are involved in pathogenesis of dental caries.

[20] For the accumulation of *S. mutans* and formation of dental biofilm, glucan receptors (GBP) are responsible. A protective immune response has been induced by GBP-B found in *S. mutans* to experimental dental caries. [21] A vaccine is developed from active VIP (virulence-associated immunomodulatory extracellular proteins) (produced by *S. mutans* and *S. sobrinus* which suppress immune response in the host by production of IL-10) which can prevent dental caries by inducing the immunoneutralization of the VIP immunomodulatory effects. [22]

Sugar Substitutes

These are natural or artificial alternative sweeteners. Several clinical studies [23-25] as well as laboratory studies [26-27] have clearly demonstrated that sugar intake plays a major role in the initiation and progression of dental caries. Sugar substitutes exhibit potential anti-caries effect. Takatsuka, et al. [28]

disclosed a sugar substitute **PALATINIT** that can enhance the remineralization. Recently natural sweeteners including **STEVIA** has gained attention, stevia contains rebaudioside A & stevioside which has pharmaceutical properties and possess 100% natural sweetening.

Stevia has following characteristics:-

- It is anticariogenic and anti-periodontopathic.
- It has 0 carb, 0 calories, 0 glycemic index.
- It is 300 times sweeter than sucrose.
- It is non-toxic.
- It is active against *S. mutans*, *S. sorbinus*, *L. acidophilus*, and *C. albicans*.
- It has anti-plaque effect.
- It acts as a healing agent at periodontium level.
- It has numerous systemic effects and its use in pediatric population is still awaited.

MEASURES TO PROMOTE REMINERALISATION

Remineralization is the process of buffering the acid produced by bacteria replacing minerals with the help of saliva. Thereform maintenance of a balance between factors that promote remineralisation and those cause demineralization is essential. Newer remineralizing agents, ozone therapy and recent advances in fluorides are preventive approaches to promote remineralization.

Newer Remineralizing Agents

Non-invasive treatment of early lesions by the means of remineralizing agents are recently focused in management of caries.

(1). CPP-ACP (Casein Phosphopeptide–Amorphous Calcium Phosphate)

The anticariogenic effect of CPP-ACP (Toothmousse, GCo., Japan) has been attributed to the multiphosphoryl-containing sequences of casein. CPP acts as a reservoir of calcium and it deposits high concentrations of ACP in close proximity to the tooth surface. Stable and highly soluble CPP-ACP has been trademarked as Recaldent™ and it is available in a form of chewing gum, mouth rinses, lozenges, topical cream, dentifrices, sprays and energy drinks. Reynolds et al. have reported that the addition of 2% CPP-ACP to the 450 ppm fluoride mouthrinse significantly increases the incorporation of fluoride into plaque. In vitro studies, greater remineralization potential is shown by chicken egg shell powder (CESP) with higher calcium content and calcium sucrose phosphate (ENAFIX). [29, 30]

(2). Pronamel

It is a desensitizing and remineralizing agent which contains 5% potassium nitrate and 1500 PPM sodium fluoride.

(3). TCP: Tri Calcium Phosphate

Greater enamel remineralization is provided with the combination of TCP with fluoride relative to fluoride alone. Using it in toothpaste formulation, a protective barrier is created around the calcium forcing it to co-exist with the fluoride ions but this barrier is dissolved while tooth brushing when it comes in contact with saliva and releases calcium, phosphates and fluorides.

(4). DCPD: Di Calcium Phosphate Dehydrate

DCPD is an abrasive which as shown improving effects of fluoride in mouth. In the presence of fluoride, DCPD which is a precursor for apatite turns into fluorapatite. [31] Researches have shown that free calcium ion are increased in plaque fluid and these remain elevated for up to 12 hrs after brushing compared to conventional silica, if DCPD is included in dentifrices. [32, 33]

(5). NovaMin

Active ingredient of NovaMin is calcium sodium phosphate. It forms hydroxyl carbonate apatite by reactions of bioactive glass material which provides calcium and phosphates.

(6). Enamelon

It is used for treating white spot lesion and repair & remineralization of tooth enamel. It consists of unstabilized calcium and phosphate salts with sodium fluoride.

NanoMaterials in Dental Caries

Any particulate material ranges between 1-100nm are Nano particles. [34] Metallic NPs stimulates biomineralization via facilitating remineralization of demineralized tooth tissues. Metal and metal oxide NPs have been incorporated into dental materials in order to prevent caries development.

Silver Nanoparticles

Antibacterial activity of Ag NPs has been posed to occur via 2 mechanisms: free Ag ion toxicity and oxidativestress.

It inactivates enzymes and inhibits replication of DNA & protein synthesis in bacteria. [35] It is concentration dependent and treating time dependent. [36] A considerable biofilm inhibition rate is seen in the incorporation of Ag NPs into composites. [37] Recently Nano-silver-chitosan has been presented, it has been tested clinically for potential in preventing dental caries. [38]

Zinc Nanoparticles

Plaque formation is reduced by inhibiting *S. mutans* by Zinc NPs. [39] Zinc oxide NPs are more biocompatible compared to zinc nanoparticles. [40] Recently NiTi wires modified with ZnONPs are prepared as an antimicrobial agent [41]

To improve physical properties and antibacterial potential of RMGIC, Malekhoseini et al. developed RMGIC containing ZnONPs into composite resin. [42] Zhan et al. designed a nanocomposite containing Rose Bengal (RB) loaded copper-doped zinc peroxide NPs (ZnO₂-CuNPs), ZnO₂-CuNPs [43] for chemodynamic treatment (acid production of *S. mutans* was weakened).

Titanium Nanoparticles

In a study, 1% w/w and 5% w/w TiO₂ NPs incorporated into orthodontic composite used for bonding metal brackets. [44] Nitrogen doped TiO₂ NPs appear to be a viable antibacterial agent against cariogenic biofilms.

Non Ionised Calcium Fluoride

Pit and fissure sealants containing nano CaF₂ and DMA HDM not show only high fluoride release but also strong antibacterial activity. [45] Ghafaretal. prepared CaF₂ NPs and lignocaine incorporated into a thiolated chitosan-based bioadhesive. [46]

Ozone Therapy

Ozone is a powerful oxidizing & antimicrobial agent. It includes non-invasive treatment of initial caries by eliminating bacteria associated with caries; root caries; as intracanal irrigant; treatment of alveolitis, avascular osteonecrosis of jaw; anti-plaque agent; as adjunct in periodontal surgical & maintenance phase; for disinfection of implant surface; to treat peri-implantitis.

[47] And if it is delivered to tooth surface for 10-40 secs, it can also lead to lesion reversal. Its mechanism of action is by eliminating cariogenic bacteria by decarboxylation of pyruvic acid to acetic acid.

Laser

CO₂ laser irradiation increases acid resistance of enamel, Partial decomposition of the organic matrix or reduction of carbonate content of the enamel surface can result to this resistance. It causes an irregular, rough and melted enamel surface and increases the bonding strength between the resin and enamel surface. Recently novel laser treatment is introduced by Cozeanet al which makes tooth more acid resistant and easier binding to Fions. [48]

Recent advances in fluorides

Copolymer Membrane Device

A membrane-controlled reservoir type designed device containing precise amount of NaF with inner core of HEMA/MMA polymer. It was developed by Cowsarin USA. Rate of fluoride release of device can vary from 0.02 to 1 mgF/day for up to 180 days.

Fluoride Glass Device

Recently new device is shaped in form of disk that is placed within plastic bracket. It releases fluoride by slow dissolution in saliva without affecting device's integrity. It was developed in Leeds, U.K. concentration of fluoride in glass is 13.3 to 21.9%.

Fluoride Releasing Pellet

Jessop et al introduced a dental bracket & associated kit with attached fluoride releasing pellet on tooth to overcome draw-back of slow releasing device. [49] Pellet may be replaced every 6 months to 2 years, bracket can be attached to patient's tooth up to 20 years.

DCPA Nano Composite

For purpose of remineralisation, Xu et al developed DCPA (Dicalcium phosphate anhydrous) nanocomposite as restorative material which slowly releases high levels of calcium phosphate requisites. [50] Novel calcium fluoride nano particles are added recently to develop stress bearing, F releasing nanocomposite (release rate higher than RMGIC). Further polymerizable monomers was disclosed which contain chelating group & F exchanging metal chelates & can "recharge" by taking up of F from aqueous solution containing high F concentration (eg. fluoride mouthwash). [51]

Newer Topical Fluorides

Indiana University developed stannous hexafluoro zirconate which is found to be effective in reducing tooth solubility and in prevention of dental caries. In terms of reducing enamel solubility, Amine fluoride is superior to inorganic fluorides and is also surface active, it holds on to the enamel for longer duration.

Specialized Phosphonate

For enhancement of F incorporation in to tooth, Faller et al recently introduced use of specialised phosphonate containing polymers or telomers. [52]

Effects include –

- Desorption of pellicle proteins associated with undesirable microbial species.
- Hydrophilic tooth surface immediately after treatment.
- Maintaining surface conditioning effects.

THERAPEUTIC TREATMENT

Necessary therapeutic treatment of the diseases should be attempted if dental caries is progressed beyond preventive stage.

Minimal Interventional Dentistry (MID)

The most current strategy for controlling dental caries is an evidence based approach focused on risk assessment and disease prevention. [53] In the field of pediatric dentistry MID has come into focus recently. It has brought revolution of "extension for prevention" to "minimally invasive" in management of caries on microscopic level.

Air Abrasion [microabrasion & kinetic cavity preparation]

It is used in cavity preparations in form of sealants and preventive restorations. Dental hard tissue is removed by an alternative pseudo-mechanical, non-rotary method which involves bombarding tooth surface with high velocity particles carried in stream of air. It results in pain free procedures as compared to dental drill by reducing the problem of heat generation, vibration and other mechanical situation.

Sonoabrasion

Sonic air scalers with high frequency and modified abrasive tips are used for removal of soft carious dentin.

Chemomechanical Caries Removal [CMCR] System

It is softening of carious dentine by chemical agents followed by its gentle excavation. Most recently Carie care gel is introduced which contains active ingredients as papaya extract, an endoprotein, chloramine & dyes. [54]

Enzymes

Streptomyces griseus originated, a specific proteolytic enzyme. Pronase is seen removing carious dentine.

II. CONCLUSION

One of the basic aspects of general health is oral health and Dental caries is the most common oral infectious disease from early childhood to old age. Preventive therapy + Therapeutic therapy can lead to pronounced results. An increased amount of technologies are aimed at promoting tooth remineralisation, they should only be considered as an adjunct to treatment until their anticaries activity is demonstrated in randomized controlled clinical trials.

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