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A STUDY ON CARIOGENICITY OF INFECTIOUS DENTAL PLAQUE BIOFILM: AREVIEW

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ABSTRACT

The following literature review is an available data about dental plaque biofilm which are complex communities of colonizing and acid producing bacteria.Dental biofilm consist of higher organism growing in population and undergoes maturation forming complex microbial community growing on enamel surface resulting in Oral mouth diseases. The slimy extracellular matrix produced by biofilm bacteria encloses the microbial community and protects it from harsh environmental attack. For cariogenisity of plaque many environmental factors are responsible. The change in Phisio-chemical properties of biofilm resulting in oral health issues. *Streptococcus mutans* bacteria was achieved higher in percentage of total positive cultures from plaque sample as compare to other *streptoccoi* group bacteria.Spread of Antibiotic resistence is probably the most common manifestation of the natural Genetic transformation in oral bacteria. Efficency of different antibiotic agents on isolated pathogenic strains from dental plaque.

KEY WORDS: Dental Plaque Biofilm, Oral Streptoccoci, Mouth infection, Cariogenicity, Efficency of Antibiotics.

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INTRODUCTION

Microbial biofilm are complex communities of bacteria and are common in the human body and in the environment. In recent years, dental plaque has been identified as a biofilm. The biofilm undergoes maturation, and the resulting pathogenic bacteria complex can lead to dental caries, gingivitis, and periodontitis. In addition, dental biofilm, especially sub gingival plaque in patients with periodontitis, has been associated with various systemic disease and disorders, including cardiovascular disease, diabetes mellitus, respiratory disease, and adverse pregnancy outcomes [2] . Our mouth consisting of microbial biofilm are complex communities of bacteria. It has been estimated that there are over more than 600 different species prevalent with distinct subsets predominating at different habitats [25]. *Streptococcus mutans* species of oral *streptococci* live in the oral cavity. Each species has developed specific specialized properties for colonizing different oral sites and constantly changing conditions to fight competing bacteria and to withstand external challenges. Imbalances in the microbial biota can initiate oral disease. Under special condition, commensal *streptococci* can switch to opportunistic pathogens, initiating disease and damaging the host. Oral *streptococci* has both harmless and harmful bacteria.*"Mutans streptococci* "Are the most important bacteria associated with tooth decay. *Streptococcus mutans,* the microbial species most strongly associated with carious lesions, is naturally present in the human oral micro biota [6]. Dental caries is a transmissible infectious disease in which *streptococcus mutans* plays the major role. As in many infectious diseases, colonization by pathogens is required before the disease can occur. *Streptococcus mutans* are generally considered to be the principal etiological agent of dental caries [59].There is a range of virulence factors important for the establishment of *Streptococcus mutans* in the complex microbial community of dental biofilm. Studies of the virulence factors of *Streptococcus mutans* and their correlation with species biodiversity are fundamental to understanding the role played by colonization by different genotypes in the same individual, and the expression of characteristics that may or may not influence their virulence capacity and survival ability under different environmental conditions. Studies using phenotyping and/or genotyping methods strongly suggest that the mother is the major primary source of infection for children who carry *S.mutans* and/or *S.sobrinus* strains (2-10) and the saliva is the principal vehicle by which transfer of *Streptococcus mutans* may occur [56].However, detection of genotypes that are not found in children's mothers or other family members indicates that *S.mutans* and *S.sobrinus* may also be acquired from other sources. Furthermore, variability in transmission can be associated with children's individual susceptibilities, including the period defined as the window of infectivity, which was reported to occur earlier in Brazilian children, the number of erupted teeth, the emergence of molars; the presence of enamel hyperplasia sucrose consumption, the action of nonspecific factors of the salivary and mucosal immune systems; and immunological conditions in children [38]. The ability of bacteria to survive and persist in a given environment will depend, in part, on their inherent genetic plasticity, which determines their ability to respond to fluctuating local environmental condition or stresses. The micro biota resident in the oral biofilm is subjected to many variable environmental stresses, including the availability or lack of nutrients, acidic pH., and exposure to organic acids. The proportions of *Streptococcus mutans* and *lactobacilli* were elevated in the biofilm of caries –active subjects, while *Actinomyces naeslundii* isolates formed a significantly greater proportion of the microbiota in samples from caries –free subjects. These observations support the assertion that the biofilm samples from the two subject populations were exposed to different environments and, consequently, to different stresses.In oral streptococci, acid tolerance correlates well with the pH optimum of the FATPase enzyme [48]. In a recent study of young adults, found a maximum of seven genotypes in subjects who had previous caries experience [60]. The pathogenicity of the dental plaque biofilm is enhanced by the fact that in biofilm form, the component bacteria have increased resistence to antibiotics and other chemotherapeutic agents and are less able to be phagocytized by host inflammatory cells. Therefore, control of the dental plaque biofilm is a major objective of dental professionals and critical to the maintenance of optimal oral health [32]. Molecular characterization of strains from plaque isolates is sensitive method for the detection of particular strain, and may also be suitable for carrying out large scale studies on the cariogenicity of isolated strains. Defects in stress-responsive genes have been also associated with biofilm impaired phenotypes [10,42,46] .The search for novel antimicrobial agent is one of the current major concerns in medical research due to increasing cases of antibiotics resistence [17]. Although the basic principle of immune protection from dental caries caused by *Streptococcus mutans* has been established in pre-clinical studies, the effective application of this approach to human needs further refinements.

MICROBIAL SPECIES PRESENT IN ORAL CAVITY

Our mouth consist of multiplex ecosystem of bacteria which contains a extensive variety of microbial species. The mouth is colonized by various different microorganism before teeth erupt, although newborn infants are essentially free from microorganisms. Twenty –five species of oral *streptococci* live in the oral cavity. Each species has developed specific specialized properties for colonizing different oral sites and constantly changing conditions to fight competing bacteria and to with stand external challenge Imbalance in the microbial biota can initiate oral disease. Under special conditions, commensal *streptococci* can switch to opportunistic pathogens, initiating disease and damaging the host. Oral *streptococci* has both harmless and harmful bacteria."*Mutant streptococci*" are the most important bacteria associated with tooth decay. *Streptococcus mutans*, the microbial species most strongly associated with dental caries. *Streptococcus mutans,* the microbial species most strongly associated with carious lesion, is naturally present in the human oral microbial flora.The taxonomy of these bacteria remains tentative [4.] Early plaque consists predominantly of gram –positive organism and that if the plaque is remain un disturbed it undergoes a process of maturation resulting in a more complex and predominantly gram-negative flora [4-5]. These investigators assigned the organism of the subgingival microbiota into groups, or complexes, based on their association with health and various disease severities [4-,5].Color designation were used todenote the association of particular bacterial complexes with periodontal infection. The blue, yellow, green, and purple complexes designate early colonizers of the subgingival flora. Orange and red complexes reflects late colonizers associated with mature subgingival plaque. Certain bacterial complexes are associated with health or disease [5,8]. Large microbial masses develop on the teeth surfaces unless proper oral hygiene measures are taken, whereas, desquamation of epithelial cell does not permit the heavy accumulation on oral irrespective of variation from sample to sample, streptococci, gram positive rods, and veillonellae comprise the majority of the total viable count. In plaque and gingival cervice higher proportion of gram positive and negative rods are observed. More recently, it has been demonstrated that samples obtained from deep periodontal pockets in pateints with advanced periodontitis and periodontosis consist of a significantly higher percentage of gram-negative anaerobic rods [49]. It is to be noted that a limited number of bacterial species in the oral flora can be detected on the tooth surface. The shift in microbial population in developing plaque from a preponderance of *coccal* forms in very early plaque with an increase of rods and filament forms with age was described . However, *streptococci* make up the greater number of the total bacterial population in plaque throughout the period. Most of the *streptococci* can be identified as one of the following species: [14,29,54].

CHARACTERISTICS PROPERTIES OF ORAL STREPTOCOCCI

Oral streptococci posses only characteristic that they inhibit mouth. No member of the *"Pyogenic*" or *Bovis* are included in the oral *streptococci* amoung the other groups of *streptococci, streptococci pneumonia and streptococci thermophilus* are not normally included either. Nor are *streptococci suis* or *streptococcus acidominimus.* All the rest belong to the oral *streptococci,* although only two members of the *"Mutans* Group *"streptococcus mutans* and *streptococcus sorbinus* are found in human mouths. The other are found in various animals. The genus *streptococcus* contains a large number of species which are widely distributed in the animal kingdom. Many species are normally present, forming part of the normal flora but others are the aetiological agents of some serious diseases such as pneumonia, scarlet fever and meningitis, especially neonatal meningitis. They also frequently cause infections of the upper respiratory tract which, although less serious today because of improved control measures, often lead to more life-threatening conditions such as acute glomerulo nephritis and rheumatic fever.the genus *streptococcus i*s defined mainly in terms of the morphology of the cells:gram positive cells mainly in chains with some in pairs [39].The occurrence of *S.mutans* in human carious lesion was confirmed [28]. Extensive taxonomic studies revealed that these organisms formed a fairly homogeneous group of nonmotile, catalase –negative, gram positive streptococci [14]. A number of investigators have also revealed an association between the occurance of *S mutans* and the development of caries. By data available from most *streptococcal s*trains that ferment mannitol and sorbitol in addition to various other sugars, and sysnthesize adherent water-soluble glucan from sucrose, are considered *S.mutans.* They do not usually deaminate arginine to produce ammonia *S mutans* is mostly (alpha) or y hemolytic on sheep blood agar, but a few b-hemolytic strain 621 have been reported a futher characteristic of these b-hemolytic strains is needed before they can be identified as *S. mutans*. *S.mutans* has been sub classified in to several types based on immunological, biological and genetic properties. The natural habitat of*S.mutans* is mouth. The oraganism can be isolated frequently from feces in humans [37,62].

FORMATION OF BIOFILM PLAQUE IN ORAL CAVITY

Biofilms can cover surface throughout oral cavity. The growth and development of biofim are characterized by 4 stages intial adherence, lag phase, rapid growth, and steady state. Biofilm formation begins with the adherence of bacteria to a tooth surface, followed by a lag phase in which changes in genetic expression (phenotypic shifts) occur. A period of rapid growth then occurs, and an expo polysaccharides matrix is produced. During the steady state, the biofilm reaches growth equilibrium. Surface detachement and sloughing occur, and new bacteria are acquired [20]. Initiation adherence and lag phase:The first phase of supragingival biofilm formation in the deposition of salivary compound, known as acquired pellicle, on tooth surfaces. This pellicle makes the surface receptive to colonization by specific bacteria. Salivary glands produce a variety of proteins and peptides that further contribute to biofilm formation. For example, salivary mucins, such as MUC5B and MUC7, contribute to the formation of acquired pellicle, and statherin,[68] a salivary acidic phosphoprotein, and proline-rich protein promote bacterial adhesion to tooth surfaces [28]. Acquired pellicle formation begins within minutes of a professional prophylaxis, within 1 hour, microorganism attach to the pellicle. Usually, gram-positive cocci are the first microorganisms to coclonize the teeth. As bacteria shift from planktonic to sessile life, a phenotopic change in the baceteria occurs requiring significance genetic up-regulation (gene signaling that promotes this shift). As genetic expression shifts, there is a lag in bacterial growth. Rapid Growth:During the rapid growth stage, adherent bacteria secrete large amounts of water –insoluble extracellular [polysaccharides to form the biofilm matrix. The growth of microcolonies within the matrix occurs. With time, additional varities of bacteria adhere to the early colonizers-a process known as coaggregation-and the bacterial complexity of the biofilm increases. These processes involve unique, selective molecular interactions leading to structural stratification within the biofilm. Coaggregation and subsequent cell division also increase the thikness of biofilm [20,72].

Steady State/Detachment

During the steady state phase, bacteria in the interior of biofilm slow their growth or become static. Bacteria deep within the biofilm show signs of death with disrupted bacterial cells and other cells devoid of cytoplasm; bacteria near the surface remain intact. During this phase, crystals can be observed in the interbacterial matrix that may represent initial calculus mineralization [73].

DENTAL PLAQUE BIOFILM AND THEIR ROLE IN ORAL INFECTION

If biofilm kept undisturbed undergoes maturation and the resulting pathogenic bacterial complex can lead to dental caries, gingivitis, and periodonities. Studies on the microbial etiology of various forms of periodonitis support the specific plaque hypothesis, which proposes that only certain microorganisms wthin the plaque complex are pathogenic. Despite the presence of hundreds of species of microorganisms in periodontal pockets, fewer than 20 are routinely found in increased proportions at periodontally diseased sites. These specific virulent bacterial species activate the host's immune and inflammatory responses that then cause bone and soft tissue destruction [43,44,69]. With repect to periodontal disease, dental plaque biofilm demonstrates a succession of microbial colonization with changes in bacterial flora observed from health to disease. Researchers studies over 13,000 plaque samples from 185 patients with conditions ranging from oral health to periodontal disease. Based on their findings, a number of microbial complexes were identified that were associated with various stages of disease initiation and progression [64,65]. Bacterial species contained in the yellow, green, and purple complexes appear to colonize the subgingival sulcus first and predominate in gingival health. In contrast, orange complex bacteria are associated with gingivitis and gingival bleeding. Interestingly, bacteria of the orange complex may also be associated with red complex microorganisms including *Porphyromonas gingivalis*, *Tannerella forsynthesis*, and *Treponema denticola*,organisms found in greater numbers in diseased sites and in more advanced periodontal disease [64,40]. Bacterial communities living in a biofilm possess resourceful survival strategies, including a broader habitat for growth, nutrition, waste elimination, and new colonization; environmental niches for safety; barriers to thwart antimicrobial drug therapy; protection from the host's defence system including phagocytosis; and enhanced pathogenicity [20,69]. These strategies account for the ongoing challenge of successfully controlling periodontal infection and disease progression [31.] As the biofilm matures and proliferates, soluble compounds produced by pathogenic bacteria penetrate the secular epithelium. These compounds stimulate host cells to produce chemical mediators associated with the inflammatory process [32].

MICROBIAL ETIOLOGY OF PLAQUE BIOFILMIN ORAL INFECTION

The understanding of the etiology of oral infection such as dental caries in humans has evolved and changed considerably over the last two decades. It is now widely accepted that dental caries occurs when environmental pressures, primarily in the form of frequent intake of dietary carbo hyadrates and repeated acidification of oral biofilms, lead to change in the proportions of particular bacterial species as a caries lesion is initiated and progresses. A work by Marquis and other focused on the idea that *S.mutans* thrives in cariogenic plaque because it is better able to tolerate, to grow, and to metabolize carbohydrate in a low pH environment [12,48]. For dental caries the concept that certain functions are well-represented in health –associated biofilms, whereas certain other functions, such as acidogenesis and acid tolerance, are better represented in biofilms on or near active caries lesions. Since caries is a disease that does not occur without the production of a low pH environment by oral biofilms, one might predict that activities that help to promote a more neutral pH could have a strong inhibitory effect on caries development. It is known that there are two substrates provided in saliva and the diet that are particularly effective at eliciting an increase in the pH when metabolized by population of oral bacteria: urea and arginine. A more comprehensive review of oral arginine and urea metabolism is provided elsewhere [10,48]. According to recent studies Arginine is metabolized by oral biofilms primarily by a 3-enzyme pathway called the arginine deiminase system (ADS). The net reaction is that arginine is converted to ornitine and 2 molecules of ammonia, which cause the ph rise. the bacteria also gain an ATP in the process [10,48]. By this process ADS is beneficial to the host as it raises biofilm pH, which discourages the outgrowth of cariougenic species and reduces damage to enamel. ADS also helps bacteria to neutralize its cytoplasm, which protects them from acid damage, and the ATP produced can be used for growth or homeostasis. Individuals who had no clinical evidence of past or present caries activity had significantly higher levels of the arginine deiminase enzyme measurable in their plaque and salivary bacterial populations compared with those who had active caries lesions [55].

GENETICS AND MOLECULAR BASIS FOR VIRULENCE IN ORAL DISEASE

The application of 16S r RNA gene sequencing to analysis of the oral microbiome will continue to contribute to our knowledge of the oral microbiome, and with new technologies, the depth and breadth of the information collected should be remarkable. In a study by Griffen and co-workers, species that were previously thought to be associated primarily with health were also elevated in caries-active individuals, leading the authors to conclude that "the relationship of acid-base metabolism to 16S r RNA gene-based species assignments appears to be 'complex'…" [30]. Another reason why the 16S sequence alone appears inadequate to predict association of particular bacetria with oral diseases is related to the concept of phenotypic plasticity. That is, depending on the environment in which the organisms are growing, the phenotypes of the bacteria can be quite different [46]. Enviroment factors, including pH, Oxygen and redox, carbohydrate source and availibilty, population density, and the growthphase of the bacteria, have been shown to have a profound impact on the gene expression profiles of many oral *streptococci* and to influence phenotypes that directly influence cariogenicity .To explore the relationship of Genotype and Cariogenic Potential in *Streptococcus mutans* numerous studies have demonstrated substantial genetic heterogenicity in clinical iisolates of *S.mutans* by [3,13,58,76].

NATURAL GENETIC TRANSFORMATION IN ORAL MICROME

Natural genetic transformation is a process by which bacteria are able to take up and integrate exogenous free DNA from their environment [47]. This process enables the recipient organisms to acquire novel genes or heritable traits, there by promoting the emergence of antibiotic resistance and genetic variation and the rapid evolution of virulence factors [21,23,24]. Therefore, natural genetic transformation can be an important mechanism whereby bacteria adapt to changing environments. Natural transformation in *Streptococcus mutans* was first demonstrated in 1981, when Perry and Kuramitus showed that three strains of *S.mutans* could be transformed to streptomycin resistance . They found that a number of cariogenic properties, including the ability to synthesize water – insoluble glucan and the production of bacteriocins, were conferred by genetic transformation . These early works describing the natural transformation of *S.mutans* have allowed investigators to exploit this property to construct defined mutants and to analyze the functions of many genes in this organism. Induction of genetic competence in these *streptococci i*s mediated by quoram sensing, which depends on a competence stimulating peptide (CSP) signaling system [34,41].

EFFICENCY OF SOME ANTIBACTERIAL AGENTS AGAINST ORAL BACTERIA

The essential factors include the appropriate number and species of bacteria, the type, quantity and frequency of consumption of fermentable carbohydrates and susceptible tooth surfaces. Theoretically, tooth decay can be prevented by eliminating any one of these interacting factors. Water fluoridation for example, has reduced caries by about (50 %) without any additional therapeutic discipline [75]. The great deal of avidence has been accumulated which implicates *Streptococcus mutans* as a major etiological agent in the initiation of enamel caries [33]. Therefore seems reasonable that topical application of chemotherapeutic agents may offer some promise for reducing the number of or completely eliminating *S.mutans* and perhaps other odontopathic bacteria from the infected tooth surface [10,18]. The greatest benefit of topical fluoride has been shown to occur in young persons who have newly erupted teeth and who reside in low fluoride areas [70.] One of the most promising possibilities for the control of tooth decay involves the use of combined agents to increase the resistence of newly erupted teeth, enhance demineralization of hypomineralized enamel, and reduce microorganisms from infected teeth [18,61]. Pomegranate extracts-in especially-fruit crust extract is highly effective on growth of *Streptococcus mutans* in comparison with other extracts and various concentrations of tooth pastes, this fact may reflect efficiency of antibacterial activity of plant extracts, and ability of bacteria to resist other antibacterial agents such as pastes and antibiotics [70].

CONCLUSION

The pathogenicity of the *Streptococci* group bacteria is hugely critical to understand in oral biofilm. Infective plaque and *Streptococci* group bacteria a member of human oral flora- is generally recognized as the vital etiological agent of dental cavities and gum disease in mouth. Oral bacteria, especially *Streptococcus mutans* tolerate rapidly harsh environment fluctuation and exposure to various anti-microbial agent in order to survive or live. There is huge need to know that how these bacteria proliferate in diverse environmental and stress condition in mouth.

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CONFLICT OF INTEREST

There is no conflict of interest.

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