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Research Article

BIOFILM AND BIOMATERIAL –A TECTONIC RELATIONSHIP IN ORAL CAVITY

C.S.Prabhakar and T. Suganya Harshni

Department of Periodontics, Best Dental Science College, Madurai

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A B S T R A C T

Biomaterial in the body modifies the host in both positive and negative ways. The biomaterials used causes change in the microbiological environment in the oral cavity. This may impair the patient's oral health and sometimes their general health as well. Many factors determine the composition of the microbiota and the formation of biofilm in relation to biomaterials such as, surface roughness, surface energy and chemical composition.

INTRODUCTION

Biomaterials had become as an unavoidable part in dentistry. The dentistry without biomaterial is unimaginable and an oral cavity without biofilms is not possible. Therefore there always exhibit a relationship between biomaterials and biofilms. All surfaces in the oral cavity are covered by a layer of pellicle which contains the glycoproteins from saliva within seconds after cleaning. By inserting foreign bodies like dental restorations, results in new niches for the microorganisms. Such niches will create area which promotes biofilm accumulation with a pathological potential (1). Biofilms formation is a multistage process.

Oral biofilm

Biofilm is described as relatively undefinable microbial community associated with tooth surface or any hard nonshedding material (2). The human oral cavity has hundreds of different species of microorganisms, like bacteria, virus and fungi. There are more than 700 unique bacterial species have been detected. There can be more than 10^{11} microorganisms per mg of dental plaque (1). Bacteria proliferating form the main etiologic factor for the majority of the dental ailments, e.g., caries, gingivitis, periodontitis, and peri-implantitis. Microbial attack has been known to be as the main cause for the dental implant failure (3). Saliva is known to be the main source of nutrients to the bacteria. The acquired pellicle .i.e. thin film covering the tooth surface , is derived from salivary proteins and covers the enamel within seconds after brushing.

Corresponding author:* **C.S.Prabhakar
Department of Periodontics, Best Dental Science College, Madurai

The thickness and structure of the biofilms will be affected by many factors like pH, nutrients, oxygen, time since last cleaning and the type of surface to which it is attached. The biofilm present in the oral cavity will therefore differ in the different locations, such as on the cheek or in between teeth.(1).

Microbiology

The important key pathogens associated with the biofilm are A.actinomycetecomitans, P.gingivalis, P.intermedia, T. forsythia etc.,. Bacteria produces Exopolysaccharides (EPS) in the biofilm and forms the major components making up 50-95% of the dry weight of the biofilm. They play a major role in maintaining the integrity of the biofilm and as well as preventing desiccation and attack by harmful agents. Among those periodontopathogenic bacteria, (*Porphyromonas gingivalis*), a gram-negative anaerobe and which is one of the most important pathogens in the chronic periodontitis, and has the ability for co-aggregation not only with (*Fusobacterium nucleatum*), but also with early colonizers (such as *Streptococcus gordonii*), which explains about its early appearance in the development of the dental plaque biofilms. It is also important to mention about the virulence of *P. gingivalis* which has been attributed to a variety of potential factors which are associated with its cell surface. Attention has also been given to *F. nucleatum*, which is *a* gram-negative anaerobic bacteria, that are commonly found in the subgingival biofilm in periodontal pockets. This organism has found to have an important role in the biofilm maturation, which is acting as a bridge between the early and late colonizers, which guides in the biofilm architecture as only and, consequently, enhances the adherence of more periodontitis-associated bacteria (5).

Ultrastructure of biofilm

Surface adherent bacterial cells form the basic structural unit of biofilms. Colonies are the discrete units of densely packed bacterial cell aggregates. There is a spatial distribution of the bacterial cells of different physiological and metabolic states with in a biofilms are found. A glycocalyx matrix is found to be made up of extra-cellular polymeric substances which surrounds the microcolonies and anchors the bacterial cell to the substrate. The structure and composition of the matured biofilm is known to modify depending on the environmental conditions. Generally, a viable, fully hydrated biofilm appears like a "tower-" or "mushroom" shaped structures, which are adherent to a substrate. The water channels, are regarded as a primitive circulatory system in a biofilm, which intersect the structure of biofilm to establish connections between the microcolonies. (6)

Biomaterials effect on biofilm

Dental restorations affect the composition of the biofilm in many ways. There exists steps, gaps or groves between tooth and restoration. These will complicate the mechanical biofilms removal and alter the chemical balance in the biofilm in that region. Many studies have been performed to establish the relation between biofilms and surface qualities such as surface energy, roughness, topography and chemical composition of the restorative materials.

Dental restorations altering biofilm and their changes on periodontium

Composite are found to show more secondary caries than amalgam fillings. In ceramics fewer problems appear to occur with the secondary caries formation (4). Biomaterials of different types create different junctions between the tooth and restoration. An amalgam filling is not directly attached to the tooth surface. The gap forms a potential area for ingrowth of bacteria which causes results in the secondary caries formation. The resin based fillings are adhesively attached to the tooth substance with no gaps in between them. The filling is placed and cured with a special techniques to avoid the gaps caused by polymerization shrinkage. The cement is used to fix the crown which fills the gap between the tooth and restoration. This will results in irregularities on the surface. The exposed cement is washed out in long duration of time. Secondary caries at the crown margin are caused by the accumulation of biofilm in the crevice between crown and tooth. Hyperplastic gingiva can be formed due to increased plaque accumulation in the connector area of the fixed partial denture. The connector area of the bridge has a bulky design which will complicate to maintain the interdental hygiene. The mercury which is found leaching in very small amounts from fresh amalgam restorations are found to have the bacteriostatic effect (1). Properties of biomaterial affecting the biofilm formation depends on Surface energy, Surface roughness, Chemical composition. There exhibit a close association between restorations placed with overhanging margins which resulted in chronic destructive periodontitis has been known for many years. When there is placement of restorations with overhanging margins, a subgingival flora was detected which closely resembled that flora of chronic periodontitis. Proportions of Gram-negative anaerobic bacteria were found in increased fashion, black-pigmented Bacteroides and an increased anaerobe facultative ratio were also seen. When the placement of the restorations with clinically perfect margins, a microflora with the characteristic feature for gingival health or initial gingivitis was observed. Black-pigmented Bacteroides were detected in very low proportions (1.6-3.8%). Page and Schroeder in 1982 postulated that dental plaque act has a range of effectiveness of about 1.5-2.5 mm. The subgingival restoration act as a source of plaque accumulation will result in bone loss similar to chronic periodontitis.

Biofilm on removable prosthesis

Removable dental prostheses, will create new surfaces for biofilm formation, and thus increase the total amount of biofilms formed in a dramatic fashion. An increase in the total number of microorganisms alters ecology of the oral cavity which results in shift of the balance between harmful and friendly linked microorganisms in oral cavity. The mucosa found in the direct contact with these appliances will be most commonly affected, but the other structures in the mouth will also be involved. Fungal species, like *C. albicans*, starts proliferate when the chemical and physical situations starts altering. The oxygen level drops when the large areas of the oral mucosa are suddenly are covered by denture surface. Proliferations of *Candida* will result in inflammatory response in mucosa under the biofilms like denture stomatitis (1).

Biofilm on implant

The bacterial plaque may play a important and prominent role as an etiologic factor which is responsible for the implant loss after osseointegration, due to the presence of high levels of bacteria in the area of peri-implant sites. Burgers *et al.* had evaluated the initial biofilm formation, in both *in vitro* and *in vivo* experiments on the different titanium surfaces and correlated the findings with different surface properties. The surface roughness and the surface free energy of the samples had been observed that the initial bacterial adhesion to differently textured titanium surfaces were primarily influenced by the surface roughness. This rough surfaces tend to attract more bacteria into micropits, which protects them from washing forces . Those strategies that aims in reducing the bacterial adhesion and biofilm formation on abutment surfaces plays an important role in the clinical practice and used to maintain soft tissue integrity and improve the outcomes of peri-implantitis treatment . The materials like Titanium and zirconia are hydrophobic materials. Gram-positive bacteria present are with hydrophobic characteristics due to the presence of a thick peptidoglycan layer, they will be attracted immediately to these materials. In contrast to gram-negative bacteria, those in direct contact will be repelled (5). Scarano *et al.* studied that zirconia discs which are fixed on a device worn intraorally showed with less plaque accumulation than Titanium discs, both had similar surface roughness. This is due to lower electrical conductivity of zirconia when compared to titanium.(7)

It is also important to discuss about that when the implants are found in contact with plasma or saliva proteins which can direct the attraction or repulsion of bacteria present on external layers since proteins have different degrees of hydrophobic to hydrophilic regions. Salivary protein which is found adsorbed to the titanium surface *in vivo* and *in vitro* is albumin, and the albumin is adsorbed to titanium through the calcium (Ca^{+2} bridges). The negative charge from titanium dioxide start attracting the positive ions like Ca^{+2} and its

presence thus increases the adhesion capacity of some bacteria species.(5)

CONCLUSION

The multiple factors which are involved in the complex biofilm formation, like surface roughness and electrostatic interactions between bacteria and surfaces and interbacterial interactions can make it difficult to characterize and determine the ideal abutment implant surface. However, understanding the influence of materials surfaces on bacterial adhesion will help future development of new materials or surface treatments, in order to reduce or inhibit adhesion of pathogenic microorganisms on them. Addition of therapeutic materials to biomaterials should be aimed to reduce the biofilms formation and thus improve the long shelf life of biomaterials.

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