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Modulating the Oral Microbiome: Probiotics as an Adjunct in OrthodonticBiofilmManagement–AReview

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***Abstract**: The conventional orthodontic treatment modality involves the deployment of various components including brackets,archwires,elastics,andclearaligners.However,thesecomponentscanprovideafavorableenvironmentfor microbial colonization and biofilm formation, which can lead to detrimental effects such as enamel demineralization and gingival inflammation. These effects can significantly compromise the efficacy of orthodontic therapy and have long-term consequences for the patient's oral health. It is therefore imperative to devise strategies that mitigate the risks associated with biofilm accumulation during orthodontics. This review explores the nature of biofilm and probiotics as a method for biofilmcontrolinorthodontics.Continuedresearcheffortsareimperativetodevelopinnovativesolutions,suchasprobiotics that address the challenges associated with biofilm management while ensuring patient safety and oral health throughout orthodontic treatment.*

***Keywords**:biofilms;orthodontics;dentistry;microbiome;microbiota;probiotics;*

INTRODUCTION

The oral cavity ecosystem is incredibly complex, and the oral mucosa and tooth surfaces are just two of the many niches where microorganisms invade.In 1978, Bill Costerton's pioneering work, "How Bacteria Stick," marked the beginning of a new phase in the study of bacterial aggregates, or biofilms.[1]A bacterial biofilm is “a structured community of bacterial cells enclosed in a self-produced polymeric matrix and adherent to an inert or living surface”. Both in the natural environment as well as when colonizing a host, the biofilm phenotype is thought to be the principal means by which bacteria proliferate.To maintain a state of balance, the oral microbiome forms an ecosystem within biofilms that extends throughout the mouth. Any disruption to this delicate balance can create the perfect conditions for disease-causing microbes to emerge.[2] Conventional orthodontic treatment provides retentive areas for microbial colonization and biofilm formation, leading to gingival inflammation and enamel demineralization, due to Streptococcus mutans and Lactobacillus acidophilus. A collaborative approach to prevent biofilm-related issues can ensure that patients receive optimal care during treatment. One such innovative approach is probiotics for maintaining good dental health. Probiotics are available in several forms, including yogurt, tablets, mouthwashes, and lozenges.

Dental biofilm:For bacteria to form a dental biofilm, they need to find a still, sheltered place on the teeth, such as a crevice in the occlusal (biting) surface, about halfway between neighboring teeth, or above the gingiva along the edge. When inadequate dental hygiene techniques go unchecked, a subgingival biofilm may develop from the supragingival biofilm, potentially extending down the tooth root and into the periodontal pocket. While dental caries may develop from biofilms on tooth surfaces, periodontal disorders can be caused by supra and subgingival biofilms located along and beneath the gingival border. The main pathogens associated with periodontitis are Prevotella intermedia, Aggregatibacteractinomycetemcomitans, Porphyromonas gingivalis, Tannerella forsythia, Fusobacterium nucleatum, Treponema denticola, and Eikenellacorredens.[3]If left untreated, this lactic acid spreads to the tooth pulp, resulting in dental abscesses. Periodontitis then follows, causing deep pocket of 3-4 mm to form, receding gums, tooth loss or bone loss. A full displacement of the tooth from its socket is another possible consequence of periodontitis. [4]Long-term neglect of denture hygiene leads to the development of a mature, pathogenic polymicrobial biofilm containing Candida which colonizes the polymethyl acrylate (PMA). Because they are so persistent, these biofilms can only be eliminated by mechanical cleaning. Dental implants typically made from plastic and titanium may experience inflammation and infections around the device. The roughness of the implant's surface is one factor that can contribute to bacterial adherence and biofilm formation which can cause failure of implants.

Changes in microbiota in orthodontic patients:Patients undergoing orthodontic therapy have reported substantial quantitative and qualitative variations in volume and microbiological composition of dental plaque throughout the whole treatment time when compared to those not receiving orthodontic therapy, Pan et al, compared the microbial counts of non-orthodontic and orthodontic subjects were found to differ significantly; the case group showed the largest increase in microbial counts three months following the orthodontic appliance placement, and there was a significantly higher presence of highly pathogenic P. gingivalis specific film closely linked to gingivitis in orthodontic patient.[5]Procedures such as acid etching, priming, and adhesive application modify the tooth’s surface and variations in surface wettability and roughness may also have an impact on biofilm development surrounding the appliances.

A recent meta-analysis by Guo et al, evaluated alterations in microbiota of subgingival plaque comparing case and controls before, during, and following orthodontic therapy with metal-fixed appliances. All the species studied showed a transient increase, six months after the beginning of the treatment, except for T.forsythia, which showed a remarkable rise in three months of orthodontic appliance placement.[6] Additionally, P. intermedia typically increased in the incisors more than the molars.Similarly, in a study conducted by Naranjo et al , clinical parameters and subgingival bacteria were compared before and after bracket insertion.[7] The results showed that orthodontic patients had higher levels of P. intermedia, P. gingivalis, T. forsythia, and Fusobacterium spp. three months after the bracket insertion, compared to the baseline and control group.Kim et al , stated that atleast one of the periodontopathogens such as Treponema denticola, P. gingivalis, Prevotella nigrescens, T. forsythia, Campylobacter rectus, E.corrodens, and A. actinomycetemcomitans, was found in every subject after three months of appliance insertion.[8] Additionally, the study found that T. forsythia took a longer time to colonize, whereas P. nigrescens and C. rectus increased notably following the first week of treatment. These findings suggest that the orthodontic treatment can alter the subgingival microbiota, and thus, careful monitoring of periodontopathogens is necessary to prevent periodontal disease.

Individuals who wear removable orthodontic appliances tend to have better periodontal health compared to those who wear fixed orthodontic appliances.Fixed appliances show a considerably higher bacterial load than the clear aligners group with notably higher concentrations of cariogenic species such as T. forsythia, P. gingivalis, T., and Streptococci.[9] The use of clear aligners showed significantly lower SBI(Sulcus Bleeding Index) and PI(Plaque index) at any observation point but did not exhibit notable differences in SPD and GI when compared to users of fixed appliances.[10]Patients who wore clear aligners had significantly better periodontal indexes and more control over biofilm formations than those with fixed orthodontics supported by multiple studies.[11][12]

It has been demonstrated that elastomeric ligatures as compared to steel ligatures retain more plaque and aggravate bleeding on probing and the plaque index to a greater extent.In contrast, steel ligatures experienced less bleeding at the ligated teeth[13]. Alves de Souzaet al explained that this could be caused by the greater concentrations of P. nigrescens and T. forsythia at elastomeric ligatures.The levels of A. actinomycetemcomitans, P. gingivalis, or P. intermedia differed but were not significant.[14] In many investigations, there was a rise in gram-positive and gram-negative bacteria mostly Lactobacilli and Streptococci, poorer plaque index, and increased bleeding, even if the results did not show statistically important changes when compared to traditional brackets ligated with stainless steel.[15]

On comparison of debonded ceramic and metallic brackets by Anhoury P et al, the mean counts of P. gingivalis taken from anterior and posterior teeth were very similar, as were the amounts of cariogenic bacteria like L. acidophilus and Strep. mutans, Actinomyces naeslundii, P. nigrescens, Actinomyces odontolyticus, Capnocytophagaochracea, T. forsythia, and Actinomyces israelii.[16]However, there were statistical differences between the two types of brackets while counting 8 periodontopathogen species: A. actinomycetemcomitans, T. denticola, F. nucleatum, Eubacterium nodatum, and Streptoccousanginosus were significantly more prevalent in the metallic bracket, while Capnocytophaga, E. corrodens,Selenomonasnoxia were more prevalent in the ceramic ones. Counts of Actinomyces gerencseriae, Streptococcus sanguis, and Streptococcus consnoxiatellatus increased notably in anterior ceramic brackets, while C. rectus was more in posterior metallic brackets.

Within three months of beginning fixed therapy, the populations of plaque-forming bacteria in both bonded molar tube and banded molar tube groups shifted, with a rise in P. nigrescens and T. denticola and a fall in A. actinomycetemcomitans. Heightened levels of periodontal pathogens, including P. gingivalis, T. forsythia, and E. nodatum, were seen in after-treatment plaque linked to both kinds of molar attachments, but Parvimonas Micra, A. odontolyticus, C. rectus, and Veillonella parvula were only abnormally high in bonded molars. The composition of plaque in the banded molar reverted to its initial state a year after the therapy was stopped, whereas the community of microbes in the bonded molars continued to exist in an alternative arrangement.[17]This plaque build up and accumulation of microorganisms due to fixed appliances can be controlled to a large extent with probiotic therapy .This in turn will manifest as a reduction in the occurrence of white spot lesions, which is a recent observation.

The DNA-strip method used in assessment of microorganisms of bonded and banded molar tubes by Martha K et alshowed the presence of F. nucleatum in 92% of samples, E. corrodens in 76% of samples, and Capnocytophaga sp. (C. ochracea, C. gingivalis, and C. sputigena). Rarely were the remaining eight species (E.nodatum, P. micra, C. rectus, T. forsythia, T. gingivalis, P. gingivalis, and A. actinomycetemcomitans) discovered.[18]During therapy, E. nodatum was detected in just two of these patients who had bonded molars. P. micra, T. denticola, T. forsythia, and E. corrodens, on the other hand, remained steady throughout treatment time. In the banded molar group, P. micra ,E. corrodens, T. denticola, and T. forsythia remained consistent throughout treatment time, but two months later, they considerably increased in the bonded group.

Probiotics for biofilm control in orthodontics: Emerging research suggests that probiotics offer a promising new avenue for addressing infectious biofilms. Compared to traditional antibiotics and QS-suppressing agents, probiotics are less likely to exert strong selective pressure on resistant strains and are also less cytotoxic.[19]They additionally possess the capacity to outcompete harmful microorganisms that have adhered to the oral cavity. The two probiotic genera that are often made use of in orthodontic treatment are Lactobacillus and Bifidobacterium.

Different mechanisms of action of probiotics have been proposed,

a. Competitive blocking of the adhesion sites epithelial surfaces.[20]

b. Secretion of various antimicrobial substances such as organic acids, H_2O_2, and Bacteriocin.[21]

c. Immune modulation - modifying the surrounding environment by modulating the pH and/or the oxidation-reduction potential, which may compromise the ability of pathogens to become established.[22]

d. Stimulation of immunoglobulin A production.

e. Downregulation of inflammatory response

Probiotics are available in various forms, including those in yogurt have shown the ability to inhibit certain periodontal pathogens. Probiotic bifidobacteria incorporated fruit yogurt can greatly impact the levels of salivary Strep. Mutans and lactobacilli in people who have fixed orthodontic appliances.Consumption of fruit yogurt that contains bifidobacteriumanimalis subsp. lactis DN-173010 daily during orthodontic treatment with fixed appliances can effectively lower Strep.mutans levels in saliva. These results offer support for the use of probiotics in promoting oral health during orthodontic treatment[23]. Probiotic yogurt exhibited a higher efficacy in reducing Strep.mutans in saliva in the saliva and plaque of children undergoing orthodontic treatment, Additionally, the results indicated that while Indian curd also showed a reduction in Strep. mutans count, the effect was not as significant as probiotic yogurt. However, the ultra-heated yogurt did not demonstrate any favorable impact on the Strep. mutans count in orthodontic patients.[24]

The use of probiotics in toothpastehas shown a similarreduction in the levels of Strep.mutans in the plaque around orthodontic brackets. Probiotic toothpaste and curd significantly decrease Strep. mutans in the bracket-related plaque of orthodontic patients. While the systemic intake of probiotics was less effective than toothpaste, there was no significant statistical difference observed. [25]The differential effects associated with local and systemic use of probiotics on microbial colonization in the saliva of orthodontic patientshave shown that[26]regular probiotic consumption, whether through kefir or toothpaste, could potentially decrease harmful bacteria in the oral cavity and improve buffer capacity.

In addition to regular brushing of teeth, probiotic mouthwash could be administered as an adjuvant to enhance periodontal health while undergoing fixed orthodontic treatment.Probiotic mouthwashes significantly reduced P. gingivalis levelsas estimated by real-time polymerase chain reaction.[27]The efficacy of oral rinses containing probiotics and chlorhexidine was compared in young adults undergoing orthodontic treatment. Both the probiotic and chlorhexidine groups demonstrated significantly lower plaque indices compared to the control group. Furthermore, the probiotic group exhibited a greater improvement in gingival indices compared to the chlorhexidine group. These findings suggest that the use of probiotic mouthwash could potentially lower gingival inflammation and plaque accumulation.[28]These results hold practical implications for orthodontic patients seeking to maintain optimal oral health. The potential efficacy of regular probiotic consumption in the reduction of harmful bacteria in the mouth should be considered while highlighting the importance of considering the efficacy of local versus systemic administration of probiotics. Modern research has shown that probiotic therapy, whether used alone or in conjunction with traditional medicine, may have a significant impact on both overall and dental health. The administration of probiotics is straightforward, cheap, and safe, which are advantages in the treatment of biofilm-associated periodontal disorders.

Conclusion: Orthodontic therapy possesses the potential to enhance both the functionality and aesthetics of teeth. Non-adherence to proper oral hygiene practices during orthodontic treatment may result in negative outcomes, including gingival inflammation and enamel demineralization, which can occur within a few weeks of fixed appliance placement, significantly impacting treatment outcomes and the patient's quality of life. The prevention and control of biofilm in orthodontics entail various measures, including patient education on proper oral hygiene, use of fluoride, antimicrobial dentifrices, and mouth rinses, and modification of orthodontic materials to lessen the likelihood of biofilm development. While antibiotics show efficacy in reducing bacterial adherence in the oral cavity, their use carries the potential of disrupting the natural oral microflora, leading to dysbiosis and drug resistance. The use of oral probiotics is on the rise due to their ability to enhance oral health by targeting harmful bacteria while preserving the balance of the oral microbiota.It is crucial to identify the best probiotic or probiotics that can compete with and disrupt pathogens that produce biofilms in the setting of certain illnesses and bacterial targets. Acknowledging the individual strains efficiency as well as the synergistic effects of probiotic combinations is essential. Consequently, additional systematic investigations and randomized controlled trials are imperative to ascertain the most efficacious probiotic strains and their optimal administration modalities for diverse oral health conditions. Leveraging the rapid advancements in technology and the synergistic integration of biophysics with molecular biology, designer probiotics offer substantial potential for developing natural, non-invasive therapeutic strategies.

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