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REVIEW

Microbial Colonization on Elastomeric Ligatures during Orthodontic Therapeutics: An Overview

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ABSTRACT

The current review focuses on the studies conducted on the colonization of microorganisms on orthodontic ligatures during orthodontic treatment. The fixed orthodontic appliances have long been associated with an increase in plaque accumulation, bacterial colonization, and resultant enamel decalcification. Voluminous research has been carried out on the microbial colonization of even newer orthodontic materials such as elastomeric ligatures with an evidence of variably increased microbial counts during orthodontic treatment. However, conclusive material-based data for minimal microbial colonization to establish acceptance criteria for the use of elastomeric ligatures are hardly available. Thus, there is a need for further studies with dual emphasis on exploring microbial associations based on surface chemistries of different elastomers and their requisite modifications for hampering microbial biofilms to evolve efficacious oral health friendly orthodontic ligatures.

Keywords: Orthodontic ligatures, microbial colonization, biofilm, elastomers

INTRODUCTION

Orthodontic treatment is becoming increasingly popular among adults. It has evolved rapidly over the years with significant advent of newer orthodontic materials. Despite the tremendous advancements in orthodontics, the creation of a favorable substratum for bacterial adherence to orthodontic materials during orthodontic therapy remains an unresolved challenge to the scientific fraternity. The fixed orthodontic appliances have long been associated with an increase in plaque accumulation, bacterial colonization, and resultant enamel decalcification (1-3). These appliances could alter the coronal anatomy of the tooth, thereby leading to an increased number of retentive surfaces and posing a difficulty in controlling the formation and adhesion of plaque (4-9). They might exacerbate preexisting periodontal diseases, cause enamel decalcification, and develop undesirable bacteremia or infections (10). The physiochemical characteristics of the orthodontic appliances are known to determine the effectiveness of the bacterial species in terms of quality and quantity.

Elastomeric ligatures, the components of the fixed appliances that play a crucial role in providing a mechanical connection between the orthodontic arch and the bracket slot that has been developed to speed up ligation procedure have also been found to harbor a number of microorganisms. Researchers have attempted to consistently evaluate the efficacy of these materials. A number of studies have been conducted on these ligatures with respect to their microbial colonization during orthodontic treatment. However, a thorough insight to the current scenario is needed to further plan and execute newer strategies for developing more efficient tools. Thus, the current review attempts to

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highlight the key studies accomplished on different types of elastomeric ligatures and addresses the need for further investigations and comparative interpretations to validate the newer versions of ligatures including colored elastomeric rings for biofilm formation. The findings could be a valuable gateway to evolve materials with minimal or anti-biofilm-forming surface chemistries.

ELASTOMERIC LIGATURES: A BACKGROUND

Elastomers have been quoted as the materials that return to their original configurations. The natural rubber, earlier known as elastomer, had demerits with regard to their water absorption and unfavorable temperature behavior. Earlier, Baker, Case, and Angle advocated the use of rubber; however, its usage increased with the advent of vulcanization by Charles Goodyear in 1839. Later, synthetic rubber polymers made of polyurethane (the thermosetting polymers; -(NH)-(C=O)-O-structural unit) and formed by step reaction polymerization was introduced in the early 1920s due to possible allergic natural rubber latex proteins. The present day elastomeric ligatures are high molecular weight amorphous polymers that exhibit physical properties such as visco-elasticity creep and stress relaxation, and they are manufactured in two basic forms, i.e, cut or injection molded. They are user friendly but tend to deteriorate in the mouth leading to subsequent loss of tooth control. They are said to have a tendency of high level of frictional resistance and are affected by the duration of force and environment (11-16). Elastomers have been the focus of studies pertaining to their force delivery and force degradation (17-21). However, they have also been studied with respect to their microbial colonization on elastomeric ligatures (22-28).

MICROBIAL ADHESION: MECHANISTIC APPROACH

A number of studies citing different mechanistic approaches of microbial adhesion to elastomeric ligatures have been performed. Specific lectin-similar reactions, electrostatic interactions, and Van der Waal's forces have been documented as some of the key factors responsible for the adhesion to the surfaces. A close relationship between microbial colonization and surface free energy, hydrophobicity, and zeta potential of interacting surfaces has also been studies (7, 9, 29). The surfaces with higher free energy have shown a favorable effect on bacterial adhesion (30, 31).

Microbial adhesion in the oral cavity is also influenced by saliva, by masking the overall surface energy of a given material and negating its surface chemistry. It is understood that with surface energies leveled between two materials bacterial adherence would decrease unless receptors for a given bacteria are within the salivary pellicle. The effect of saliva on bacterial adhesion has been reported to be species dependent, based on a binding pattern of the bacterium. Thus, the bacterial composition of the oral cavity along with any factors that could potentially change salivary flow and bacterial concentration is of great importance. The studies have described the increased bacterial counts in saliva during various orthodontic treatments (32-42).

Furthermore, the components of the appliances tend to reduce the physiological mechanism of self-cleansing by the tongue, cheeks, and saliva, thereby leading to increased accumulation of bacterial plaque and the number of retentive sites for the sub layers and cause compression effects damaging the oral mucosa (31). Orthodontic appliances have also been found to increase the stimulated salivary flow rate, buffer capacity, salivary pH, occult blood in saliva, and bacterial levels (43).

Besides, the microbial accumulation due to malocclusion, poor oral hygiene, and a cariogenic diet is compounded by fixed orthodontic appliances, which offer more surface area and mechanical overhangs (9, 31). The introduction of orthodontic appliances increase areas where food debris could collect and increase the number of bacterial niches. Early caries and demineralization along with white spot lesions were often seen in orthodontic patients with poor oral hygiene. It has been evidenced that appliances could aggravate an already compromised situation (1, 2, 44).

MICROBIAL ADHESION: CURRENT PERSPECTIVE

Voluminous research is underway to understand the microbial adhesion and its subsequent effect on the different orthodontic appliances including elastomeric ligatures. In general, the orthodontic appliances have been stated to reduce the efficacy of tooth brushing, reduce the self-clearance by saliva, change the composition of oral flora, and increase the amount of oral biofilm formed and the colonization of oral surfaces by cariogenic and periodontopathogenic bacteria, thereby complicating orthodontic treatment and illustrate the need for oral biofilm control during orthodontic treatment than usual (37). The isolation frequencies of opportunistic bacteria and fungi increase during orthodontic treatment, suggesting the importance of paying special attention to oral hygiene in orthodontic patients to prevent periodontal disease and the aggravation of systemic disease in immune compromised conditions (45). The concentration of the aerobic and anaerobic bacteria had increased during the first 3 months of orthodontic treatment. The oral streptococci and anaerobic bacteria, had also increased in the patients wearing orthodontic appliances (46).

Earlier, it was reported that the ligation with elastomeric rings was associated with increased microbial load compared to ligation using steel wires (31). In another study, stretched elastomers demonstrated a honeycomb pattern of filament detachment corresponding to strained areas. The high protein content of the biofilm organized on the surface of these materials as well as the calcification pattern found were similar to a nonspecific mechanism of film adsorption of biomaterials exposed to body fluids. The results of the study were stated to have clinical implications for the aspects of retraction control through sliding mechanics with the use of elastomeric ligatures, and the potential detrimental effects on dental and periodontal tissues, such as decalcification and gingival inflammation, respectively (38). In a study to assess bacterial plaque accumulation adjacent to orthodontic bracket, it was demonstrated that excess composite around the bracket base is the critical site for plaque accumulation due to its rough surface. However, the method of ligation did not appear to influence the bacterial morphotypes on both composites and enamel surfaces (5).

As a step ahead, the study examined the effect of fluoride-releasing elastomers on the salivary counts of *Streptococcus mutans* and showed a temporary decline in streptococcal counts with the release of fluoride-releasing elastomers (47). Another study on the development of biofilm and *Streptococcus mutans* counts with reference to steel wires and elastomeric rings in orthodontic patients with and without 0.4% stannous fluoride gel led to the conclusion that the topical application of the said gel and the two methods of ligature ties did not prevent dental decalcification, as no significant decline in the streptococcal counts was exhibited in the saliva as well as the biofilm (48). Similarly, a study has quoted the ineffectiveness of fluoridated elastomers in reducing streptococcal or anaerobic bacterial growth in local plaque surrounding an orthodontic bracket after a mean period of 40 days in the mouth (49). Fluoride-releasing elastomeric ligature ties are not advisable to reduce the incidence of enamel decalcification in orthodontic patients as per an *in vivo* study carried out to evaluate the efficacy of fluoride-releasing elastomers in the control of *Streptococcus mutans* levels in the oral cavity (50).

In a bid to compare the efficacy of steel ligatures to elastomeric rings, it was found that the fixed orthodontic appliances are instrumental in creating new retentive sites suitable for colonization of *Streptococcus mutans* and *Lactobacillus* and that teeth ligated with elastomeric rings exhibited slightly greater numbers of microorganisms than teeth ligated with steel ligature wires (40). Elastomeric ligatures have been found to form bacterial plaque on their surface and accumulate greater number of microorganisms on the tooth surface (51). Clinical reports have demonstrated that patients who received orthodontic treatment were more susceptible to enamel white spot formation. Further, no significant difference in *Streptococcus mutans* and *Lactobacillus* counts could be observed on using metallic ligature; however, increased bacterial levels were found with elastomeric ligatures with significant inter-group variation (33). Studies on polymerase chain reaction analysis for the presence of *Porphyromonas gingivalis*, *Tannerella forsythia*, *Actinobacillus actinomycetemcomitans*, *Prevotella intermedia*, and *Prevotella nigrescen,* showed that the elastomeric rings were associated with a higher score for plaque index and bleeding than steel ligatures and concluded that elastomeric rings promoted significant retention of the biofilm with clinical alterations on the plaque index and favored the peridontopathogens with a detrimental effect for the gingival conditions (39). Comparative studies on Super Slick and conventional elastomeric rings showed that the Super Slick type had statistically significant higher *Sreptococcus mutans* contamination than the conventional elastomeric rings. Moreover, scanning electron micrographs exhibited fissures only on the surface of Super Slick elastomeric rings, and the researchers found no clinical evidence that justified the effectiveness of Super Slick elastomers in controlling bacterial biofilm formation during orthodontic therapy (12). An *in situ* pilot study to assess enamel demineralization around orthodontic devices showed an increased pattern of demineralization around brackets ligated with elastomeric rings (52). Brackets ligated with elastomeric rings were found to retain more *Streptococcus mutans* biofilm, whereas this biofilm retention was lesser on steel wire (3). Moreover, the teeth ligated with elastomeric rings exhibited significantly greater number of both aerobic and anaerobic microorganisms compared with those ligated with steel ligatures (53). In another study, the teeth ligated with elastomeric rings; with split mouth technique using Super Slick ties, including TP orthodontics and dumbell ligatures leone on the right side and Aelastixs quick stick ties angulated ties 3M and Aelastixs easy to fit 3M on left side exhibited a greater number of aerobic as well as anaerobic microorganisms (17, 54). It was also observed that the stainless steel ligatures were less prone to adhesion compared with Teflon-coated and elastic ligatures and that the adhesion and growth could be accelerated by saliva (14). A study pointed toward sustained changes in plaque microbiota during orthodontic treatment. The major variation in plaque composition could be seen with self-ligating brackets with an elastomeric ligature (9). Studies also revealed that the fixed orthodontic appliances significantly increased the retention of biofilm regardless of the type of bracket system chosen and that the steel ligature had the least amount of biofilm retention compared to an elastomeric module and self-ligating bracket (21). The presence of fixed appliances influenced the quantity and quality of oral microbiota (26). Further, the plaque accumulation or periodontal problems by slide ligatures, covering the total surface of the bracket were not significantly higher than that by the conventional elastomeric ligatures (55).

Studies have explained differential bacterial adherence to the different orthodontic materials, and the increased level of bacterial adhesion have been attributed to increased incubation time, irrespective of the bacterial strains, and that the effect of saliva coating did not significantly alter the adhesion trend of cariogenic streptococci (24).

MICROBIAL ADHESION: FUTURE PERSPECTIVES

With the constant evolution in orthodontics, orthodontic materials with modified properties, intended to provide efficacious surface bacterial biofilm control are being introduced. A newer version of elastomeric ligature, i.e. Super Slick, TP Orthodontics Incla porte with a covalently bonded metafix coating, which the manufacturers claimed to have decreased bacterial adhesion have been studied with respect to force decay, dimensional change, ligature dimension, and force inter relationship. Few studies have also compared these Super Slick elastomeric ligatures to conventional ligatures with respect to their microbial load (14, 54, 56-58). The presence of Streptococcus mutans and its correlation with colony-forming units in saliva has been reported in biofilms around the elastomeric rings and stainless steel ligatures using scanning electron micrographs (59). Recent studies have shown a progressive increase in the colonization of Streptococcus mutans and Lactobacillus on elastomeric modules during orthodontic treatment (60). Although, there are varying reports on the extent of microbial adherence to Super Slick and conventional ligatures, no uniform conclusive inference could be made yet on a significant difference in microbial colonization of these elastomeric ligatures. Now-a-days, nanotechnology is being explored for the development of materials with a potential for decreased biofilm formation and anticaries properties. Recently, metallic silver nanoparticles using an extract of *Heterotheca inuloides* have been synthesized and their use in coating elastomeric ligatures has demonstrated improved physical properties of these ligatures compared to conventional ligatures. Moreover, this technology is suggested to decrease the incidence of dental enamel demineralization and ensure performance in orthodontic treatment (61).

With the increasing focus on esthetic consciousness, the colored elastomeric rings have also been introduced. However, scientific studies advocating their judicious use with reference to the microbial colonization and its subsequent effect on oral health are still awaited. There seems to be a dearth of the available significant data on these ligatures with respect to microbial adherence, biofilm formation, and their subsequent tendency to deteriorate and develop periodontal infections. Thus, there is a further need to explore the microbial biofilm formation on orthodontic ligatures based on their surface chemistries to re-design conventional and modified elastomeric rings as orthodontic ligation accessories and ascertain their clinical efficacy. Moreover, requisite modifications for hampering microbial biofilms on ligatures need to be explored and executed to evolve efficacious oral health-friendly orthodontic ligatures.

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