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Streptococcus: An orthodontic point of view

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Abstract
Introduction: *Streptococcus mutans* and *S. sobrinus* are the main causative agents of human dental caries. Objective: To analyze the literature on different genera of Streptococcus such as *S. mutans*, *S. gordonii*, *S. sanguis*, *S. sobrinus* and *S. salivarius* in relation to orthodontics.
Methodology: Articles on the subject published through the PubMed, SCOPUS and Google Academic databases were analyzed, with an emphasis on the last 5 years. It was carried out with the words "*Streptococcus mutans*", "*S. gordonii*", "*S. sanguis*", "*S. sobrinus* ", "*S. salivarius*".
Results: *S. mutans*: produces dental caries and demineralization of the enamel. It can be controlled with proper brushing techniques and oral hygiene. *S. gordonii*: predominates in the oral microflora and triggers cariogenic biofilms, is present in the formation of white spots around brackets and its development can be inhibited with fluoride-containing rinses. *S. sanguis*: present in orthodontic appliances, they have adverse effects that help the formation of dental plaque, mouthwash with nanio TiO2 and a good mechanical and chemical cleaning help to eliminate them. *S. sobrinus*: forms white spots, demineralizes enamel and causes dental caries. *S. salivarius*: its acid-base physiology plays an important role, the use of orthodontic appliances can produce an increase in bacteria which is associated with metal alloys.
Conclusion: Streptococcus species are a problem in orthodontics, they can be eliminated by using Enlight composite resin, 0.02% chlorhexidine rinses, mouthwash with nanioTiO2 and a good mechanical and chemical brushing technique.

Keywords: *Streptococcus mutans, S. gordonii, S. sanguis, S. sobrinus, S. salivarius*

1. Introduction
Orthodontic appliances promote the accumulation of supragingival and subgingival biofilms, which alter the oral microbiome and hinder dental hygiene. Orthodontic treatment may be associated with adverse effects such as enamel decalcification, gingivitis and periodontal disease. Studies have reported high levels of *Streptococcus mutans* and periodontal pathogenic bacteria in patients undergoing orthodontic treatment [1].
The streptococcus genus are Gram-positive cocci-shaped, chain-organized bacteria, and are pathogens found in humans and animals [2]. Poor oral hygiene can induce biofilm formation on orthodontic appliances and cause gingivitis and dental caries [3]. Dental caries is a biofilm disease and infection that affects oral and systemic conditions, natural bacteriostatic products are recommended for daily use to prevent this disease [4].
Bacterial colonization in the oral cavity is fundamental for the effective action of probiotics [5].
Dental caries is the disease of calcified tissues of teeth, it is the action of microorganisms on carbohydrates which is characterized by decalcification of a tooth and disintegration of the organic portion [6]. The oral microbiota has been one of the most relevant topics in recent years, they are present in daily clinical practice especially in orthodontic appliances such as bands, in which there is an increased risk of caries and presence of periodontal disease [7,8].
Fixed orthodontics presents a series of adverse effects on dental enamel, this is due to the formation and accumulation of dentobacterial plaque and colonization of microorganisms. However, invisible orthodontics behaves differently in the formation of dentobacterial plaque

and colonization of bacteria, as they presented low results during treatment. Knowledge of salivary films in orthodontic appliances provides a better understanding of microbial adherence [9]. Currently there is no adequate review about Streptococcus in the orthodontic area so in this work the literature about different Streptococcus genera such as *S. mutans*, *S. gordonii*, *S. sanguis*, *S. sobrinus* and *S. salivarius* in relation to orthodontics was evaluated.

2. Materials and methods

Information from articles published in PubMed, Science Direct, Springer and EBSCO was analyzed with emphasis on the last 5 years. The quality of the articles was analyzed based on the PRISMA guidelines, i.e., identification, review, choice, and inclusion. The quality of the review was assessed using the measurement instrument for evaluating systemic reviews (AMSTAR-2). The search was performed using Boolean logical operators AND, OR and NOT. It was realized with the words "Streptococcus", "orthodontics", "epidemiology", "diagnostic methods", "oral manifestations", "treatment", in conjunction with logical Boolean operators OR y AND.

3. Results & Discussion

3.1 *Streptococcus mutans*

3.1.1 Etiology

S. mutans contributes to enamel demineralization [10] and is a major player in the formation of dental caries [11] which affects more than 90% of the world's population [12]. Orthodontic brackets that are made of stainless steel material were introduced in dentistry, although they present less ability to reduce enamel demineralization and are not successful in preventing microbial and biofilm growth [13].

3.1.2 Diagnosis

In a study the hypothesis of the levels of *Streptococcus mutans* occurring in different types of orthodontic ligatures, elastomers, steel ligature crossed over the arch, steel ligature crossed under the arch and steel ligature crossed in eight under the archwire, were tested. ANOVA and Turkey-kramer test were used to compare and evaluate the differences of *S. mutans* between the different groups. After 7 days the ligatures were removed and high levels of *S. mutans* in the different orthodontic ligatures were witnessed [14].

It has been proven that patients who want to keep their teeth straight after orthodontic treatment should use retention, however, the presence of foreign material increases the risk of bacterial colonization and caries formation of which *S. mutans* is the most common [15].

3.1.3 Treatment

The efficacy of photodynamic inactivation (PDI) with hematoporphyrin IX (H) and modified hematoporphyrin IX (MH) was evaluated using an LED light-emitting diode. *In vitro* planktonic cultures with the use of H, MH and LED exerted antimicrobial activity, no effect on *S. mutans* film was observed in any of the types of Brackets with the use of H. MH showed better results, indicating a promising use against dental caries and white spot lesions [16]. A study of 60 patients scheduled for orthodontic treatment was conducted and plaque samples were collected to determine the presence of *S. mutans* before orthodontic placement, at two months and three months after placement using the Dentocult SM kit. The results showed that orthodontic appliances increase colonization of *S. mutans* and Candida albicans in the oral cavity during orthodontic treatment, but can be controlled with proper and timely brushing [17]. In patients with conventional orthodontic appliances compared to self-ligating orthodontics, it was demonstrated that self-ligating orthodontics should be preferred since conventional orthodontics is a latent influencing factor [18].

Streptococcus mutans is one of the main bacteria found in oral cavity that causes dental caries, demineralization of enamel and increases its colonization to the use of orthodontic treatment. It can be controlled with a proper brushing technique and oral hygiene, it is recommended to use orthodontics without elastomers to reduce the formation of *S. mutans*.

3.2 *Streptococcus gordonii*

3.2.1 Etiology

Streptococcus gordonii is a predominant member of the oral microflora and has been isolated from root canals of teeth with refractory apical periodontitis, it participates in the early formation of dental biofilms [19]. L-arginine, an amino acid ubiquitously present in human saliva, serves as a substrate for alkali production by arginolytic bacteria (*S. gordonii*). It has been shown that 1.5% l-arginine is clinically effective in modulating cariogenic biofilms through alkali production by arginolytic bacteria [20].

3.2.2 Diagnosis

Early detection of white spot lesions (WSL) around brackets during orthodontic treatment is important for treatment and prevention. The role of this bacterial coexistence and WSL formation during one year of fixed orthodontic therapy has been evaluated, and the presence of *S. gordonii* and *P. gingivalis* bacteria before and after orthodontic placement is observed, in addition *S. gordonii* could also play a role in enamel demineralization [21]. Saliva detection frequencies and amounts of caries-associated bacteria from patients with orthodontic braces were investigated. PCR indicated that amounts of *Streptococcus gordonii* and *S. mutans* were significantly higher in orthodontic patients than in control-only individuals [22]. Composite brackets were also shown to be more susceptible to adhesion and colonization by *S. gordonii*, while gold brackets were shown to be less prone to colonization [23].

3.2.3 Treatment

Decontamination with adjunctive antiseptic agents, such as chlorhexidine, is often recommended for the treatment of infections [24]. Bacterial activity of bonding agents was investigated to predict the ability to inhibit the development of white spots during orthodontic treatment, standardized and sterilized discs were continuously rinsed for up to 180 days in saline flow. The antibacterial and anti-biofilm activities of *S. gordonii* and other bacteria were evaluated, the decrease in antibacterial activity was 10-60 days in materials with fluoride and slower (90 days) in those containing benzalkonium chloride, chlorhexidine and zinc oxide [25].

Streptococcus gordonii predominates in the oral microflora and triggers cariogenic biofilms, it has been shown that *S. gordonii* is present in the formation of white spots around brackets and its development can be inhibited with fluoride-containing rinses in a shorter time.

3.3 *Streptococcus sanguis*

3.3.1 Etiology

The oral microbiota is extremely diverse and more than 700 different species of bacteria have been detected on the tongue, palate, cheek, teeth and periodontal pockets. Staphylococcus, Streptococcus, of which the most common are *S. sanguis* and *S. mutans*, are present in 90% of cases [26]. It is a common bacterium in the oral cavity, which plays functions in disease and health, in which it has an important role in the formation of oral biofilm. It is also an important etiological agent of infective endocarditis especially with people with previous valvular damage, in recent years S. sanguinis has been shown to be associated with dental caries [27].

3.3.2 Diagnosis

The characteristics of dental plaque microecology can be used as a basis for the construction of a diagnostic algorithm, with the monitoring of patients with dentoalveolar anomalies, for the purpose of the upcoming planning and implementation of effective orthodontic treatment.

The application of Bayes' theorem in medical diagnostics includes such an important step as derivation for each symptom and values of finite probability or a posteriori diagnostic data of germ presence, e.g., *S. sanguis*, in patients receiving orthodontic treatment [28]. The antibacterial properties of a conventional orthodontic adhesive containing three different concentrations of silver/hydroxyapatite nanoparticles were evaluated against *S. sanguis*, *S. mutans*, and *Lactobacillus acidophilus*. The results of the biofilm inhibition test showed that all study groups reduced the viable bacterial count compared to the control group [29].

3.3.3 Treatment

The antibacterial effects of colloidal solutions containing zinc oxide (ZnO), copper oxide (CuO), titanium dioxide ($TiO2$) and silver nanoparticles (Ag) on *S. sanguis* and *S. mutans* were evaluated, and the results were compared with those of chlorhexidine and sodium fluoride mouthwashes. The nanioTiO2-containing mouth rinse proved to be an effective antimicrobial agent which can be considered as an alternative to chlorhexidine or sodium fluoride mouth rinses, provided that it does not exhibit cytotoxic and genotoxic effects on biological tissues [30]. In another study, the antimicrobial and mechanical properties of resins composed of TiO2 nanoparticles (NPs) were evaluated, for *S. sanguis* and *S. mutans* the concentration of TiO2 NPs caused a reduction in colony count [31]. The effectiveness of mechanical and chemical cleaning on the removal of microorganisms from Essix retainers of 3 cleaning methods, brushing with fluoride toothpaste, chlorhexidine gel and immersion in chlorhexidine solution was determined. All 3 cleaning methods effectively removed 99% of microorganisms from Essix retainers [32].

Streptococcus sanguis is present in oral cavity which has an important role in the formation of dental caries. Orthodontic appliances have adverse effects that help the formation of dentobacterial plaque, but it has been shown that mouthwash with nanioTiO2 and good mechanical and chemical cleaning help in the elimination of microorganisms.

3.4 *Streptococcus sobrinus*

3.4.1 Etiology

Streptococcus sobrinus and *Streptococcus mutans* are the main causes of dental caries [33]. They are harmful microorganisms that accelerate caries and produce acid faster. In addition, there is some kind of communication or synergy between these 2 bacteria [34].

3.4.2 Diagnosis

The main problems in the crown of the tooth during orthodontic treatment are white spots, enamel demineralization and dental caries [35].

The number of *S. mutans* and *S. sobrinus* microorganism in stimulated saliva samples does not appear to be significantly different between patients with stainless steel brackets and patients with plastic brackets [36]. Enlight orthodontic composite resin has less adhesion of *S. sobrinus* and *S. mutans* which may reduce enamel demineralization and risk of white spot formation [37].

3.4.3 Treatment

In orthodontics, fixed appliances placed in the oral cavity are colonized by microorganisms. A study was conducted to quantitatively determine the independent bacterial colonization of *S. mutans* and *S. sobrinus* on orthodontic composite resins. Significant differences in bacterial adherence were found between the groups and showed that the orthodontic composite resin evaluated in the GIm and GI obtained the lowest adherence of *S. mutans* and *S. sobrinus*, which may reduce enamel demineralization and the risk of white spot lesion formation [38]. It is suggested that careful hygienic procedures are needed to reduce the risk of dental caries after orthodontic treatment, despite the overall improvement of the patient's oral health [39]. Surface modification of orthodontic brackets with silver nanoparticles can be used to prevent the accumulation of dental plaque and the development of dental caries during orthodontic treatment [40].

Streptococcus sobrinus is the microorganism that accelerates the process of dental caries, it also contributes to the formation of white spots, enamel demineralization and dental caries. Enlight composite resin will help us to reduce enamel demineralization and prevent the formation of white spots because it does not present adhesion of *S. sobrinus*.

3.5 *Streptococcus salivarius*

3.5.1 Etiology

Streptococcus salivarius and *gordonii* produce large amounts of alkali, which plays an important role in the acid-base physiology of the oral cavity [41]. Orthodontic appliances can hinder oral hygiene and promote halitosis. The oral probiotic *S. salivarius* M18 reduced the level of halitosis in patients with orthodontic appliances, but had minimal effects on the flat index, gingival index, and dental biofilm microflora [42]. There are limited data on the beneficial effects of probiotics on gingival health in patients undergoing treatment with fixed orthodontic appliances [43].

3.5.2 Diagnosis

The use of orthodontic appliances can produce a transient increase in the bacterial concentration and isolation rate of oral Streptococcus such as *S. salivarius* after several months [44]. It was found that *S. salivarius* as lactobacillus reuteri, *S. mutans*, *S. sanguis*, *S. mitis*, *S. sobrinus*, sulfate-reducing bacteria, sulfate-oxidizing bacteria, Veilonella, Actinomyces, and *Candida albicans* have a potential association of stainless steel with metallic corrosion, titanium magnets, nickel, cobalt-chromium, neodymium-iron-boron, zirconia, amalgam, copper, aluminum, and precious metal alloys. The included studies inferred an association between oral microorganisms and intraoral dental appliances based on metal alloys, although it is critical to recognize that most of the studies in the review employed an *in vitro* simulation of the intraoral condition [45].

3.5.3 Treatment
It was determined that 0.12% chlorhexidine gluconate mouth rinse can be used to decrease the bacterial density in the oral flora before disunion procedures [46]. In another study, the antimicrobial efficacy of triple and quadruple combinations of *Acacia nilotica*, *Murraya koenigii*, Eucalyptus and Psidiumguajava were analyzed, all triple and quadruple combinations of the plant extracts were found to be of great antimicrobial benefit, superior or comparable to 0.2% chlorhexidine against *S. salivarius*, as well as *S. mutans* and *S. sanguis* [47]. Recently, the use of medicinal herbs and plant extracts as a substitute for chemical drugs has become increasingly common. It was studied that the water extract of *Rhus coriaria* L. had significant antibacterial properties against 5 bacteria, of which *S. salivarius* is found, and was able to inhibit the formation of bacterial biofilms on orthodontic wire [48].

Streptococcus salivarius are present in oral cavity and causes an alkaline environment, the use of orthodontic appliances produces an increase of this bacterium. In the treatment, it indicates that chlorhexidine is of great antimicrobial benefit along with herbal medicine.

4. Conclusions
Streptococcus genus such as *S. mutans*, *S. gordonii*, *S. sanguis*, *S. sobrinus* and *S. salivarius* are present in the oral cavity, which trigger diseases such as dental caries, enamel demineralization, dentobacterial plaque and formation of white spots around the brackets during orthodontic treatment. This is because the presence of foreign material increases the risk of bacterial colonization. However, it has been shown that the use of Enlight composite resin, 0.02% chlorhexidine rinses, nanioTiO2 mouthwash and a good mechanical and chemical brushing technique will help prevent the formation of white spots and dental caries.

References

1. Müller LK, Jungbauer G, Jungbauer R, Wolf M, Deschner J. Biofilm and Orthodontic Therapy. Monogr Oral Sci 2021;29:201-213.
2. Shelyakin PV, Bochkareva OO, Karan AA, Gelfand MS. Micro-evolution of three *Streptococcus* species: selection, antigenic variation, and horizontal gene inflow. BMC Evol Biol. 2019;19(1):83.
3. Xie Y, Zhang M, Zhang W, Liu X, Zheng W, Jiang X. Gold Nanoclusters-Coated Orthodontic Devices Can Inhibit the Formation of *Streptococcus mutans* Biofilm. ACS Biomater Sci Eng 2020;6(2):1239-1246.
4. Ito Y, Ito T, Yamashiro K, Mineshiba F, Hirai K, Omori K, *et al*. Antimicrobial and antibiofilm effects of abietic acid on cariogenic *Streptococcus mutans*. Odontology. 2020;108(1):57-65.
5. Ferrer MD, López-López A, Nicolescu T, Salavert A, Méndez I, Cuñé J, *et al*. A pilot study to assess oral colonization and pH buffering by the probiotic *Streptococcus dentisani* under different dosing regimes. Odontology 2020;108(2):180-187.
6. Sharma R, Singh NN, Sreedhar G. Dermatoglyphic findings in dental caries and their correlation with salivary levels of *Streptococcus mutans* and Lactobacillus in school-going children in and around Moradabad. J Oral Maxillofac Pathol. 2018;22(3):360-366.
7. Lucchese A, Bondemark L, Marcolina M, Manuelli M. Changes in oral microbiota due to orthodontic appliances: a systematic review. J Oral Microbiol. 2018;10(1):1476645.
8. El-Patal MA, Asiry MA, AlShahrani I, El Bayoumy SY, Ahmed Wakwak MA, Mohamed Khalil MA. The effect of fiber-reinforced composite versus band and loop space maintainers on oral *Lactobacillus acidophilus* and *Streptococcus mutans* levels in saliva. J Indian Soc Pedod Prev Dent 2018;36(3):301-307.
9. Sifakakis I, Papaioannou W, Papadimitriou A, Kloukos D, Papageorgiou SN, Eliades T. Salivary levels of cariogenic bacterial species during orthodontic treatment with thermoplastic aligners or fixed appliances: a prospective cohort study. Prog Orthod. 2018;19(1):25.
10. Narmada IB, Cynthia AI, Triwardhani A. A comparison of antibacterial inhibitory effect on *Streptococcus mutans* and tensile strength between chitosan-based bonding adhesives and commercial products. Indian J Dent Res 2019;30(4):553-557.
11. Javed S, Zakirulla M, Baig RU, Asif SM, Meer AB. Development of artificial neural network model for prediction of post-*Streptococcus mutans* in dental caries. Comput Methods Programs Biomed 2020;186:105198.
12. Eriksson L, Lif Holgerson P, Esberg A, Johansson I. Microbial Complexes and Caries in 17-Year-Olds with and without *Streptococcus mutans*. J Dent Res. 2018;97(3):275-282.
13. Fatani EJ, Almutairi HH, Alharbi AO, Alnakhli YO, Divakar DD, Muzaheed *et al*. *In vitro* assessment of stainless steel orthodontic brackets coated with titanium oxide mixed Ag for anti-adherent and antibacterial properties against *Streptococcus mutans* and *Porphyromonas gingivalis*. Microb Pathog. 2017;112:190-194. eri
14. Shirozaki MU, Ferreira JTL, Küchler EC, Matsumoto MAN, Aires CP, Nelson-Filho P, *et al*. Quantification of *Streptococcus mutans* in Different Types of Ligature Wires and Elastomeric Chains. Braz Dent J. 2017;28(4):498-503.
15. Williams DL, Epperson RT, DeGrauw JP, Nielsen MB, Taylor NB, Jolley RD. Effect of silver-loaded PMMA on *Streptococcus mutans* in a drip flow reactor. J Biomed Mater Res A 2017;105(9):2632-2639.
16. Lacerda Rangel Esper MÂ, Junqueira JC, Uchoa AF, Bresciani E, Nara de Souza Rastelli A, Navarro RS, *et al*. Photodynamic inactivation of planktonic cultures and *Streptococcus mutans* biofilms for prevention of white spot lesions during orthodontic treatment: An *in vitro* investigation. Am J Orthod Dentofacial Orthop. 2019;155(2):243-253.
17. Shukla C, Maurya R, Singh V, Tijare M. Evaluation of role of fixed orthodontics in changing oral ecological flora of opportunistic microbes in children and adolescent. J Indian Soc Pedod Prev Dent. 2017;35(1):34-40.
18. Jing D, Hao J, Shen Y, Tang G, Lei L, Zhao Z. Effect of fixed orthodontic treatment on oral microbiota and salivary proteins. Exp Ther Med. 2019;17(5):4237-4243.
19. Kim HY, Kim AR, Seo HS, Baik JE, Ahn KB, Yun CH, *et al*. Lipoproteins in *Streptococcus gordonii* are critical in the infection and inflammatory responses. Mol Immunol. 2018;101:574-584.
20. He J, Hwang G, Liu Y, Gao L, Kilpatrick-Liverman L, Santarpia P, *et al*. l-Arginine Modifies the Exopolysaccharide Matrix and Thwarts *Streptococcus mutans* Outgrowth within Mixed-Species Oral Biofilms. J Bacteriol 2016;198(19):2651-61.

21. Sadeq A, Risk JM, Pender N, Higham SM, Valappil SP. Evaluation of the co-existence of the red fluorescent plaque bacteria *P. gingivalis* with *S. gordonii* and *S. mutans* in white spot lesion formation during orthodontic treatment. Photodiagnosis Photodyn Ther. 2015;12(2):232-7.
22. Al-Melh MA, Bhardwaj RG, Pauline EM, Karched M. Real-time polymerase chain reaction quantification of the salivary levels of cariogenic bacteria in patients with orthodontic fixed appliances. Clin Exp Dent Res. 2020;6(3):328-335.
23. Passariello C, Gigola P. Adhesion and biofilm formation by oral streptococci on different commercial brackets. Eur J Paediatr Dent 2013;14(2):125-30.
24. Ryu HS, Kim YI, Lim BS, Lim YJ, Ahn SJ. Chlorhexidine Uptake and Release From Modified Titanium Surfaces and Its Antimicrobial Activity. J Periodontol 2015;86(11):1268-75.
25. Passariello C, Sannino G, Petti S, Gigola P. Intensity and duration of *in-vitro* antibacterial activity of different adhesives used in orthodontics. Eur J Oral Sci 2014;122(2):154-60.
26. Carinci F, Martinelli M, Contaldo M, Santoro R, Pezzetti F, Lauritano D *et al*. Focus on periodontal disease and development of endocarditis. J Biol Regul Homeost Agents. 2018;32(2 Suppl. 1):143-147.
27. Baker SP, Nulton TJ, Kitten T. Genomic, Phenotypic, and Virulence Analysis of *Streptococcus sanguinis* Oral and Infective-Endocarditis Isolates. Infect Immun 2018;87(1):e00703-18.
28. Chesnokov VA, Chesnokova MG, Mironov AIu, Turchaninov DV, Kriga AS. [The Bayesian framework of detection of cariesgenic Streptoccocus in dental plaque in children with distal occlusion under orthodontic treatment]. Klin Lab Diagn 2013;(8):54-8.
29. Sodagar A, Akhavan A, Hashemi E, Arab S, Pourhajibagher M, Sodagar K Evaluation of the antibacterial activity of a conventional orthodontic composite containing silver/hydroxyapatite nanoparticles. Prog Orthod 2016;17(1):40.
30. Ahrari F, Eslami N, Rajabi O, Ghazvini K, Barati S. The antimicrobial sensitivity of *Streptococcus mutans* and *Streptococcus sangius* to colloidal solutions of different nanoparticles applied as mouthwashes. Dent Res J (Isfahan) 2015;12(1):44-9.
31. Sodagar A, Akhoundi MSA, Bahador A, Jalali YF, Behzadi Z, Elhaminejad F *et al*. Effect of TiO2 nanoparticles incorporation on antibacterial properties and shear bond strength of dental composite used in Orthodontics. Dental Press J Orthod 2017;22(5):67-74.
32. Chang CS, Al-Awadi S, Ready D, Noar J. An assessment of the effectiveness of mechanical and chemical cleaning of Essix orthodontic retainer. J Orthod. 2014;41(2):110-7.
33. Alam MK, Zheng L, Liu R, Papagerakis S, Papagerakis P, Geyer CR. Synthetic antigen-binding fragments (Fabs) against *S. mutans* and *S. sobrinus* inhibit caries formation. Sci Rep. 2018;8(1):10173.
34. Damle SG. Competence and Transformation of Oral *Streptococcus sobrinus* in Dental Caries. Contemp Clin Den 2018;9(2):S195-S196.
35. Pourhajibagher M, Salehi Vaziri A, Takzaree N, Ghorbanzadeh R. Physico-mechanical and antimicrobial properties of an orthodontic adhesive containing cationic curcumin doped zinc oxide nanoparticles subjected to photodynamic therapy. Photodiagnosis Photodyn Ther. 2019;25:239-246.
36. Jurela A, Repic D, Pejda S, Juric H, Vidakovic R, Matic I *et al*. The effect of two different bracket types on the salivary levels of *S. mutans* and *S. sobrinus* in the early phase of orthodontic treatment. Angle Orthod. 2013;83(1):140-5.
37. Velazquez-Enriquez U, Scougall-Vilchis RJ, Contreras-Bulnes R, Flores-Estrada J, Uematsu S, Yamaguchi R. Adhesion of Streptococci to various orthodontic composite resins. Aust Dent J 2013;58(1):101-5.
38. Velazquez-Enriquez U, Scougall-Vilchis RJ, Contreras-Bulnes R, Flores-Estrada J, Uematsu S, Yamaguchi R. Quantitative analysis of *S. mutans* and *S. sobrinus* cultivated independently and adhered to polished orthodontic composite resins. J Appl Oral Sci 2012;20(5):544-9.
39. Jung WS, Kim H, Park SY, Cho EJ, Ahn SJ. Quantitative analysis of changes in salivary *Mutans streptococci* after orthodontic treatment. Am J Orthod Dentofacial Orthop. 2014;145(5):603-9.
40. Jasso-Ruiz I, Velazquez-Enriquez U, Scougall-Vilchis RJ, Morales-Luckie RA, Sawada T, Yamaguchi R. Silver nanoparticles in orthodontics, a new alternative in bacterial inhibition: *in vitro* study. Prog Orthod. 2020;21(1):24.
41. Abranches J, Zeng L, Kajfasz JK, Palmer SR, Chakraborty B, Wen ZT, *et al*. Biology of Oral Streptococci. Microbiol Spectr 2018;6(5):10.
42. Benic GZ, Farella M, Morgan XC, Viswam J, Heng NC, Cannon RD *et al*. Oral probiotics reduce halitosis in patients wearing orthodontic braces: a randomized, triple-blind, placebo-controlled trial. J Breath Res 2019;13(3):036010.
43. Kaklamanos EG, Nassar R, Kalfas S, Al Halabi M, Kowash M, Hannawi H, *et al*. A single-centre investigator-blinded randomised parallel group clinical trial to investigate the effect of probiotic strains *Streptococcus salivarius* M18 and *Lactobacillus acidophilus* on gingival health of paediatric patients undergoing treatment with fixed orthodontic appliances: study protocol. BMJ Open 2019;9(9):e030638
44. Vizitu TC, Giuca MC, Ionescu E. Influence of orthodontic treatment on oral streptococci. Roum Arch Microbiol Immunol 2011;70(3):105-8.
45. Gopalakrishnan U, Felicita AS, Mahendra L, Kanji MA, Varadarajan S, Raj AT *et al*. Assessing the Potential Association Between Microbes and Corrosion of Intra-Oral Metallic Alloy-Based Dental Appliances Through a Systematic Review of the Literature. Front Bioeng Biotechnol 2021;9:631103.
46. Akbulut Y. The effect of different mouthwashes on bacteremia after debonding. Niger J Clin Pract. 2020;23(7):900-905.
47. Chandra Shekar BR, Nagarajappa R, Singh R, Suma S, Thakur R. Antimicrobial efficacy of the combinations of *Acacia nilotica, Murraya koenigii* (Linn.) *Sprengel, Eucalyptus,* and *Psidium guajava* on primary plaque colonizers: An *in vitro* study. Indian J Dent Res. 2016;27(4):415-420.
48. Vahid-Dastjerdi E, Sarmast Z, Abdolazimi Z, Mahboubi A, Amdjadi P, Kamalinejad M. Effect of *Rhus coriaria* L. water extract on five common oral bacteria and bacterial biofilm formation on orthodontic wire. Iran J Microbiol. 2014;6(4):269-75.