Republic of Iraq
Ministry of Higher Education
and Scientific Research
University of Baghdad
College of Dentistry

Effect of Orthodontic Appliance on Oral Environment and Microbiome

A Project Submitted to

The College of Dentistry, University of Baghdad, Department Of Orthodontics in Partial Fulfillment for the Bachelor of Dental Surgery

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B.D.S., M.Sc.

April, 2023

Certification of the Supervisor

I certify that this project entitled **"Effect of orthodontic appliance on oral environment and microbome"** was prepared by the fifth-year student **Sabaa Faris Nawaf** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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Date: 2023\5

Dedication

I dedicate this work to my beloved, my strong pillar, my source of inspiration, wisdom, Mam & dad. Thank you for teaching me to believe in myself, in God and in my dreams. Look at me graduating today. It is the fruit of your labor. It's your little daughter...

To my lovely sisters whose loves me, stand behind me, raising me to believe that anything was possible.

To my best and special person who make the world a better place, just by being in it...

Thank you all for being a part of my graduation journey.

(وَآخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ)

Acknowledgment

My faithful thanks and all gratefulness to "**Allah**", almighty for granting me the will and strength to accomplish this project. Allah, praise be to you until you are satisfied, praise be to you when you are satisfied, and praise be to you after you are satisfied.

I would like to thank **Prof. Dr. Raghad Al-Hashimi** the dean of the Collage of Dentistry, University of Baghdad for being so understanding and for upgrading the standards of our college.

My deepest thanks and respect to **Prof. Dr. Dhea AL-Groosh** head of Orthodontics Department.

I would like to thank my supervisor **Lect. Alaa Faleh Albo Hassan** who's helped me through the course of my project. I cannot find enough words to express my thanks for her support, attention, advice, encouragement and valuable instruction.

I would like to thank the mother university, **University Of Baghdad\College Of Dentistry**, which has always been a source of launching the best generations of dentists over the years. Thank you for spending our best moments inside you.

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List of abbreviation

Abbreviation	Meaning
Fig	Figure
Vs.	Versus
Spp.	species
S. Oralis	Streptococcus Oralis
S. Uberis	Streptococcus Uberis
WSL	White Spot Lesion
P. gingivalis	Porphyromonas gingivalis
S. Mutans	Streptococcus Mutans
GOH	Good Oral Hygiene
POH	Bad Oral Hygiene
T. forsythia	Tannerella forsythia
P. nigrescens	Prevotella nigrescens
A.actinomycetemcomitans	Aggregatibacter actinomycetemcomitans
P. intermedia	Prevotella intermedia
T. denticola	Treponema denticola
E. nodatum	Eubacterium nodatum
C. rectus	Campylobacter rectus
A. odontolyticus	Actinomyces odontolyticus
V. parvula	Veillonella parvula
MSB	Mitis salivarius bacitracin
F. nucleatum	Fusobacterium nucleatum
PI	Plaque index
BI	Bleeding index
BOP	Bleeding on probing
CHX	Chlorhexidine

Introduction

Malocclusions are the third most common of oral health problems, and are associated with a number of complications **(Glans *et al*., 2003)**. Orthodontic treatment often can correct these complications or at least prevent them from progressing; but it also holds some potential for harm to teeth and periodontal tissues **(Bollen *et al*., 2008)**.

The Ecological equilibrium maintains the healthy oral status of individuals. When this equilibrium is broken, periodontal diseases and dental caries may occur **(Petti and Renzini, 1994)**. Insertion of orthodontic appliances into the oral cavity greatly inhibits oral hygiene and increases the number of plaque retention areas **(Bollen *et al*., 2008**). These changes in the oral environment are followed by an increase in bacterial concentration, alterations in the buffer capacity, pH acidity and the salivary flow rate **(Chang *et al*., 1999)**.

Orthodontic treatment with oral appliances—either removable or fixed—is a significant disruptor of the oral environment. Through their continual presence to exert the force needed to bring about orthodontic tooth movement and by virtue of remaining in close proximity to the enamel, gingiva and periodontal ligament intraorally over a prolonged period of time, the appliances make a significant biological impact on the paradental tissues, oral environment and oral microbiome, with effects lasting at least until treatment completion which could be anywhere between 1 and 3 years on average **(Pinto *et al*., 2018; Mulimani and Popowics, 2022)**.

A post-procedure communication between the orthodontist and the patients demonstrates that the orthodontist is concerned about patient's well-being, increasing patient's satisfaction, and improving orthodontist-patient relation. Reinforcing reciprocal confidence, the orthodontist will obtain a better adherence to oral hygiene protocol, making patients more aware about the advantages of a correct behavior **(Eppright *et al*., 2014)**.

Aim of Study

1. Exploring the biogenesis and mechanisms of orthodontic appliance-induced modifications of the oral environment and the oral microbiome are the main objective of this review.
2. Detect the best type of orthodontic appliances that have less effect on oral hygiene maintenance.
3. Detect the methods that can aid in preserving oral microbiome and maintain good oral hygiene.

Chapter one
Review of Literature

1.1. The Periodontium and Oral Cavity Environment

The periodontium is a connective tissue consisting of four components: cementum, the periodontal ligament, alveolar bone, and gingival tissue ***(Fig1.1)***. Its functions include supporting the tooth, protecting it against oral microflora, and making the attachment of the tooth to the bone possible **(Melcher, 1976)**.

The gingival epithelium acts as a physical barrier to separate the biofilm from the gingival tissue, providing the first line of defense against bacterial invasion in periodontal disease. Disruption of the gingival epithelial barrier, and the subsequent penetration of exogenous pathogens into the host tissues, triggers an inflammatory response, establishing chronic infection **(Takahashi *et al.*, 2019)**.

The periodontal ligament is a band or sheet of strong fibrous connective tissue that is responsible on the mechanical connection between the alveolar bone and tooth, plays a vital role in force-induced orthodontic tooth movement **(Li Z. *et al*, 2019)**.

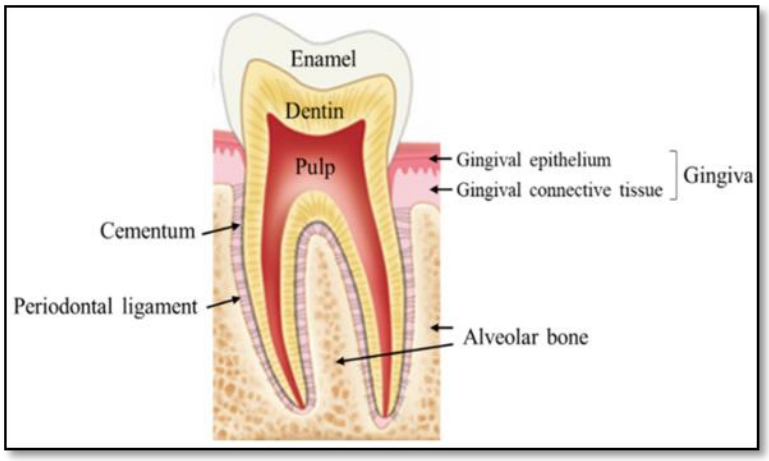

FIGURE (1.1): The structure of periodontium **(Cho *et al*., 2021)**

The human oral cavity provides a habitat for oral microbial communities. The complexity of its anatomical structure, its connectivity to the outside, and its moist environment contribute to the complexity and ecological site specificity of the microbiome colonized there in. Complex endogenous and exogenous factors affect the occurrence and development of the oral microbiota, and maintain it in a dynamic balance **(Li *et al.*, 2022)**.

The oral cavity has the most diverse microbiome in the digestive system. Comprising more than 700 species of bacteria, fungi, viruses, archaea, and protozoans **(Maukonen *et al*., 2008)**, they are part of the natural environment of the oral cavity; they can, however, also become etiological agents of pathology **(Sheiham , 2001; Peterson *et al*., 2013)**.

During orthodontic treatment, maintaining the healthy, symbiotic relationship between the host and oral microbiome, is critical to minimize adverse effects such as enamel demineralization, dental caries and periodontal disease. In combination with additional factors such as increased biofilm formation, change in composition of plaque, difficulty in oral hygiene maintenance and modification of dietary habits, this can cause an imbalance in the native state of the oral microbiome, referred to as dysbiosis **(Kilian *et al*., 2016)**.

The oral cavity is divided into nine niches. The composition of the oral microbiota and the structure of the oral biofilm adapt specifically to these different microecological environments. The communities of oral microorganisms and their interactions with the host maintain the oral microecosystem in a dynamic balance. However, various factors cause the dysbiosis of the oral microbiota, which contributes to oral and even systemic diseases ***(Fig 1.2)*** **(Li *et al*., 2022)**.

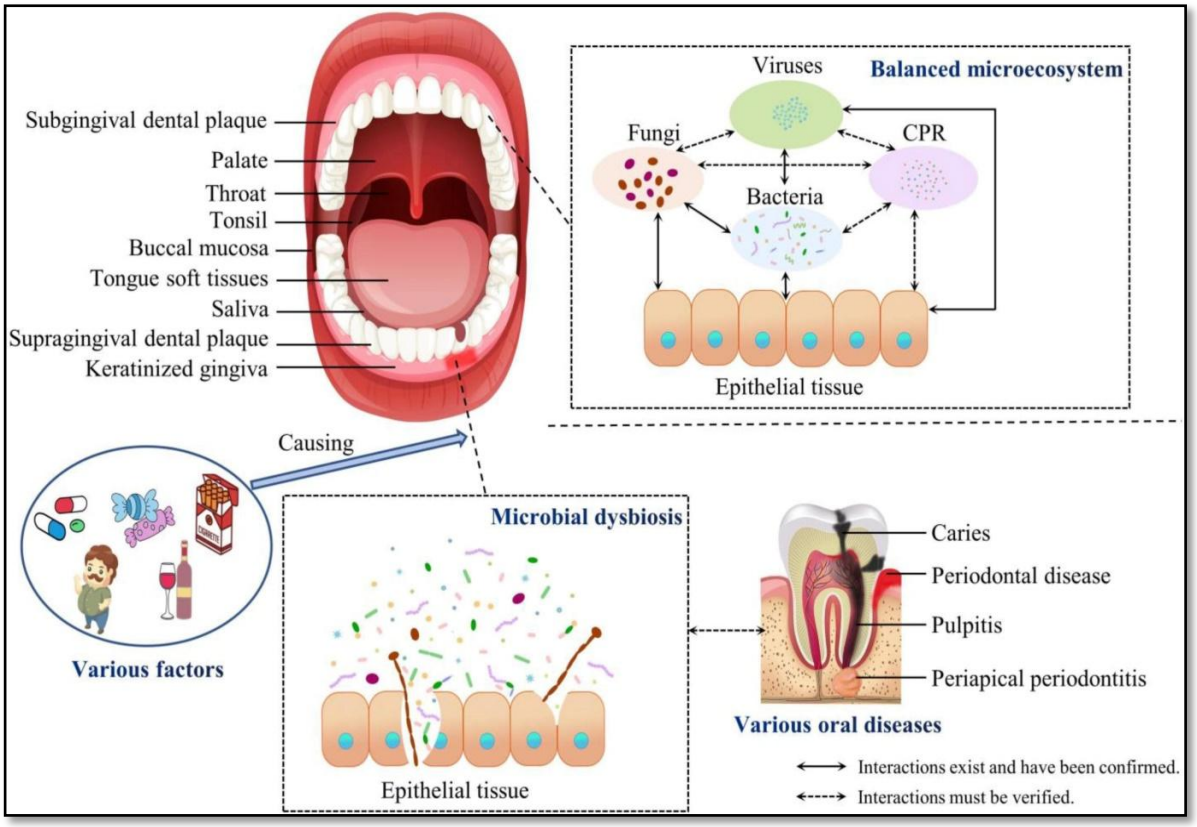

FIGURE (1.2): Compositions of the balanced oral microbiota and during dysbiosis **(Li *et al.*, 2022)**.

1.2. Types of Oral Microorganism

In respect to commensal oral microbes, several aspects support the idea that it may be possible to find bacteria that could be useful in prevention or treatment of oral diseases **(Haukioja *et al.*, 2006; Cosseau *et al.*, 2008; Haukioja *et al.*, 2008)**.

1.2.1. The Useful Microbiota

Probiotics are non-pathogenic living microorganisms that have both preventive and therapeutic effects on oral infectious diseases **(Zaura and Twetman, 2019)**.

Probiotics play a role in creating better oral health through its direct and indirect interactions by: **(Reddy *et al*., 2011)**

1. Probiotics play a role in removing harmful bacteria and stabilizing normal conditions.
2. Interfere with biofilm formation.
3. Compete with oral microorganisms for available substance.
4. Produce chemicals to inhibit oral harmful bacteria that damage the oral hygiene.
5. Probiotics modulation of local and systemic immune functions as well as non-immunologic defense mechanisms.

The useful microbiota include:

- *Candida* is a commensal, harmless form of fungi that can be found in the oral cavity of 53% of the general population; however, if disturbances in the balance of microflora or debilitation of the host occur, it can also become invasive and pathogenic **(Zunt, 2000; Coronado-Castellote and Jiménez-Soriano, 2013)**.
- *Streptococcus Oralis* and *Streptococcus Uberis* have been shown to inhibit the growth of pathogens both in the laboratory and animal models. Presence of *S. Oralis* and *S. Uberis* provided a good indication of health of periodontium. When these bacteria are absent from sites in the periodontal tissues, those sites are more prone to disease **(Elavarasu *et al*., 2012)**.

1.2.2. The Pathogenic Bacteria

Several studies found an increase in the representation of cariogenic bacteria (such as *Streptococcus mutans* and *Lactobacillus spp*.) and of potentially pathogenic gram-negative bacteria in patients undergoing orthodontic treatment **(Maret *et al*., 2014; Klaus *et al*., 2016; Shukla *et al*., 2016; Lucchese *et al*., 2018; Perkowski *et al*., 2019; Grzegocka *et al*., 2020; Contaldo *et al*., 2021)**.

The pathogenic bacteria include:

- *Streptococcus mutans* is a significant contributor to tooth decay **(Loesche, 1996; Ray *et al*., 2004)**.
- Red complex bacteria (including *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Treponema denticola*).
- *Aggregatibacter actinomycetemcomitans*, and several *Bacteroides*, and *Prevotella* species are also regarded as biomarkers of periodontitis **(Abusleme *et al*., 2013; Galimanas *et al*., 2014)**.

1.3. Dental Plaque Characterization

Dental plaque is a polymicrobial biofilm made up of various bacterial complexes, which mutually benefit from coaggregation, adhesion, and metabolic interactions. Dental plaque changes over time and depending on the location, so that early and mature plaques, supragingival and subgingival plaques, differ greatly from each other and are responsible for various and different pathologies, the most prevalent of which are caries and periodontal diseases. This is due to the fact that, by definition **(Kwon *et al*., 2021)**.

Supragingival plaque is generally considered to be the main cause of caries and demineralization of enamel and dentin, as a consequence of the presence of *Streptococcus mutans* and other cariogenic bacteria, such as *Lactobacilli* and *Actinomycetes* species (spp.) as second colonizers **(Freitas *et al*., 2014)** but it also plays a key role in the late coaggregation of periodontopathogen bacteria in the subgingival plaque, consisting mainly of gram-negative anaerobic bacteria strongly associated with periodontal diseases **(Tezal *et al*., 2006)**.

1.4. Orthodontic Appliance

Orthodontic appliances are devices which transmit forces to individual tooth/ group of teeth and /or maxillofacial skeletal units so as create changes within the bone with/ without tooth movement that help in achievement of the orthodontic treatment goals **(Phulari, 2011)**.

1.4.1. Classification of orthodontic appliances

The simplest classification is probably based on the patient's ability to remove the orthodontic appliance. Based on this premise the appliances can be classified as: **(Mitchell, 2013)**

1. Removable **2.** Aligner **3.** Semi-fixed **4.** Fixed

1.4.1.1. Removable orthodontic appliance

As the name suggests, these appliances can be removed from the mouth by the patient. The patient can insert and remove these appliances without the intervention of a clinician. It may be active or passive, depending upon its capability to exert/ generate forces **(Singh, 2007)**.

The removable orthodontic appliances are made up of three components ***(Fig 1.3)*** **(Mitchell, 2013)**:

a. Active components—comprises of springs, screws or elastics.

b. Retentive components—usually include clasps.

c. Acrylic base plate

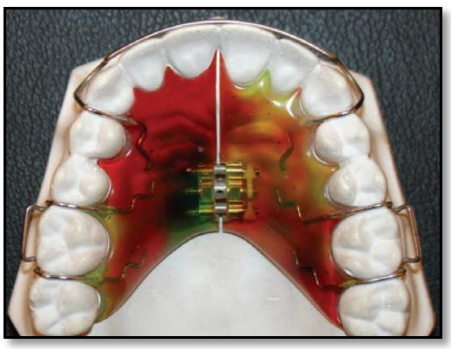

FIGURE (1.3): Removable appliances incorporating screw **(Singh, 2007)**.

1.4.1.2. Clear Aligners

Aligner is a type of removable appliances which is transparent, made from plastic materials. It is used for moderate crowding of the front teeth. In particular it is indicated for "mild to moderate crowding (1–6 mm) and mild to moderate spacing (1–6 mm), in cases where there are no discrepancies of the jawbone. They are also indicated for patients who have experienced a relapse after fixed orthodontic treatment **(Director, 2007; Mitchell, 2013)**. Each aligner is worn for 2 weeks, and is only removed for eating, drinking, brushing and flossing. Each aligner will move the teeth approximately 0.25 mm ***(Fig 1.4)*** (**Mitchell, 2013)**.

FIGURE (1.4): Clear aligner (**Mitchell, 2013)**.

1.4.1.3. Semi-fixed orthodontic appliances

Which some part of the appliance fixed on to the tooth surfaces which the patient cannot remove but the rest of the appliance can be removed, e.g. lip bumper ***(Fig 1.5)*** **(Singh, 2007)**.

FIGURE (1.5): The lip-bumper appliance **(Singh, 2007)**.

1.4.1.4. Fixed orthodontic appliance

An orthodontic devices in which attachments are fixed to the teeth and forces are applied by arch wires or other auxiliaries via these attachments **(Singh, 2007)**.

Phulari (**2011)** listed the component of fixed orthodontic appliance ***(Fig 1.6)***:

a. Active components: which consist of separator, arch wire, Springs, elastics, elastomerics and magnets.

b. Passive components: which consist of bands, brackets, lingual attachemnts , lock pins and ligature wire.

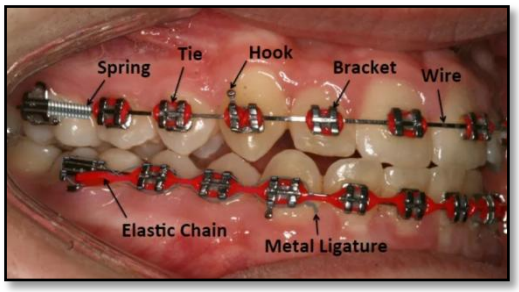

FIGURE (1.6): Components of fixed orthodontic appliance **(Singh, 2007)**.

1.5. Clinical Effects of Orthodontic Treatment on Periodontal Status:

1.5.1. Changes in soft tissue

The placement of orthodontic attachments such as bands and brackets creates new retentive locations, increases plaque accumulation and thereby promotes the inflammatory response **(Alexander, 1991)**.

Gingivitis is a reversible inflammation caused by the accumulation of bacterial plaque in the gingival tissue. The microbiota involved are commensal microbiota, such as *Actinomyces* species, *F. nucleatum*, *Prevotella intermedia*, *Bacteroides*, *Capnocytophaga*, and *Eikenella* **(Huang *et al.*, 2011; Igic *et al.*, 2012)**.

The presence of plaque is the considered as one of the main factors in the development of gingivitis **(Krishnan *et al.*, 2007; Meeran, 2013)**. Orthodontic brackets and elastics might interfere with effective removal of dental plaque, thereby increasing the risk of gingivitis. The cytotoxicity of metal brackets, bands, and auxiliaries causes a localized inflammation; as metal bands are placed subgingivally, gingivitis is commonly seen with them **(Sallum *et al.*, 2004)**. Gingival enlargement due to gingivitis further hinders proper removal of plaque, thereby increasing the bacterial dominance of periodontopathic microbes (*Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis*, and *Bacteroides forsythus*) **(Ainamo and Bay, 1975)**.

Gingival hypertrophy is a very common condition in the orthodontic population that can lead to the appearance of false pocket with or without loss of attachment. It was considered an inflammatory reaction following the accumulation of bacterial plaque or other factors, such as chemical irritation produced by materials used for bonding brackets or other orthodontic devices, food impaction between the teeth, and food persistence between orthodontic devices and gingival tissue **(Eid *et al*, 2014)**, this reaction is characterized clinically by increased signs of inflammation, gingival swelling and pseudo-pocket formation, particularly at the proximal areas which usually disappear with debonding of the brackets. However, this is usually resolved within weeks of debonding ***(Fig 1.7)*** **(Kouraki *et al.*, 2005; Naini and Gill, 2008; Dannan, 2010)**.

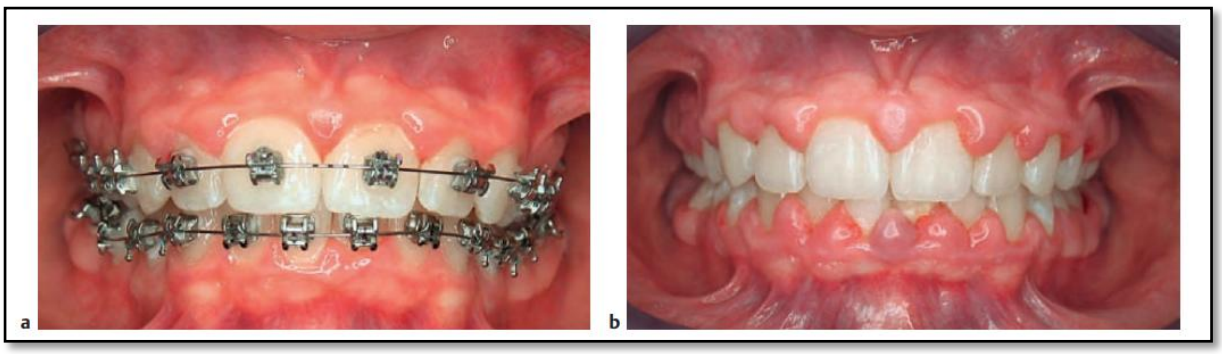

FIGURE (1.7): Gingivitis and Gingival hyperplasia (a) during orthodontic treatment (b) after orthodontic treatment **(Ludwing, 2012)**.

1.5.2. Changes that occur in the bone

Gingivitis may develop into periodontitis, resulting from loss of control. Periodontal disease is a chronic irreversible inflammation caused by the destruction of gingival tissue, alveolar bone, and tooth loss. *P. intermedia*, *F. nucleatum*, *Peptostreptococcus micros* and *Prevotella nigrescens*, defined as microbiota of the "orang complex" as well as the "red complex" composed of *Treponema denticola*, *Porphyromonas gingivalis* and *Tannerella forsythia* are the most commonly associated with periodontitis **(Socransky *et al.*, 1998)**. These complex microorganisms fall or disappear (below the detection limit) after efficient treatment ***(Fig 1.8)***.

Moreover, the presence of fungi, protozoa and viruses, is highly correlated with the severity of chronic periodontitis **(Horz *et al.*, 2015; Zhu *et al.*, 2015; Lauritano *et al.*, 2016; Jabri *et al.*, 2021)**.

FIGURE (1.8): Generalized periodontitis **(Yoshihiro *et al.*, 2018)**.

1.6. Orthodontic Appliances Effects on Oral Microbiota

Several factors influence the oral microbiome in orthodontic patients quantitatively and qualitatively: plaque accumulation, metal corrosion, host immunity, hormone levels and tooth movement **(Uzuner *et al*., 2014)**. In fact, orthodontic appliances, both fixed and removable, promote the retention of food particles and provide retention sites for dental plaque, making it more difficult to maintain oral hygiene and increasing the likelihood of developing gingivitis, periodontitis, white spot lesions (WSL), dental caries and bad breath ***(Fig 1.9)*** **(Zurfluh *et al*., 2013; Cavuoti *et al*., 2016; Contaldo *et al*., 2021)**.

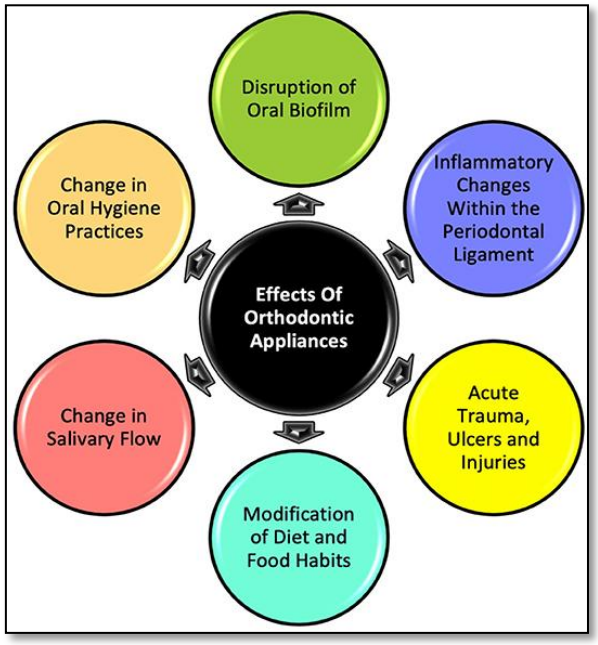

FIGURE (1.9): Impact of orthodontic appliances on intra-oral environment **(Mulimani and Popowics, 2022)**.

As observed by **Klaus *et al*. (2016)** in a study performed to measure the prevalence of *Candida spp*., *S. mutans* and *Lactobacilli* in saliva and plaque, in three groups of subjects undergoing fixed orthodontic treatment —with good oral hygiene (GOH), poor oral hygiene (POH) and poor oral hygiene with white spot lesions (POH/WSL) — a high prevalence of *Candida spp*. was reported in all patients, *S. mutans* and *Lactobacilli* were reported in both saliva and plaque samples, with higher values in the POH and POH/WSL groups than in the GOH group, respectively.

These results were also confirmed by a further study carried out by **Topaloglu-Ak *et al*. (2011)** on a sample of 35 patients with fixed appliances and 34 with removable appliances, reporting a significant increase in *S. mutans*, *Lactobacilli* and *Candida Albicans*, six months after the insertion of fixed/removable appliances with a higher prevalence in the fixed appliance group than in the removable appliance group.

In a study conducted by **Pan *et al*. (2017)** comparing the composition of the oral microbiota in orthodontic patients and in subjects not undergoing orthodontic therapy, it was found that the microbial counts between the two groups of patients showed a significant increase in several periodontopathic bacteria, including *P. gingivalis*, three months after the start of orthodontic therapy **(Naranjio *et al*., 2006; Kim *et al*., 2012; Ferlazzo *et al*., 2017; Guo *et al*., 2017; Sun *et al*., 2018)**. An increase in the presence of *S. mutans* or *Lactobacillus*, which are responsible for the development of caries and white spot lesion, was detected in various clinical studies with both fixed and removable appliances **(Contaldo *et al*., 2021)**.

There are many studies confirming that the insertion of a fixed orthodontic appliance induces changes in the oral microbiota, which persist even after its removal. In fact, according to several controlled studies, the presence of *Aggregatibacter actinomycetemcomitans* in the subgingival crevicular fluid of orthodontic patients increased 3–6 months after the insertion of the fixed appliance compared to untreated patients, with a higher subgingival prevalence of *Aggregatibacter actinomycetemcomitans* and *Tannerella forsythia* in orthodontic patients, up to 6 months after the removal of the appliance compared to untreated patients **(Papageorgiou *et al*., 2018)**.

1.6.1. Conventional orthodontics Vs. Aligners

Aligners had the most favorable effects on oral hygiene and periodontal health. This can be explained by different reasons. First, aligners are removable allowing patients to maintain their oral hygiene without the interference of brackets and wires. Secondly, each pair of aligners are changed almost every two weeks thus, the biofilm lingering for aligners is less than that of fixed appliances. And third, patients treated with aligners display better compliance with oral hygiene ***(Fig 1.10)*** **(Sifakakis, *et al*., 2018; Wang, *et al*., 2019; Mummolo, *et al*. 2020)**.

Despite these benefits, aligner can induce changes in the oral microbiome. These microbial changes could be explained by the fact that Aligners are worn almost all day long, they cover all tooth surfaces and their margins overlap the marginal gingiva thus, they impede the self-cleaning by saliva and may cause plaque accumulation. Also, the use of bonded attachments might provide additional plaque retaining surfaces on the teeth **(Guo, *et al.*, 2018)**.

These results were also confirmed by **Rossini *et al*. (2014)** With regard to the qualitative and quantitative characteristics of the oral microbiota in patients with aligners compared to those with fixed appliances, a significant increase in the total bacterial load during both treatments was reported, with a significant increase in the amounts of those cariogenic species in the saliva of subjects with fixed appliances **(Mummolo *et al.*, 2020)**.

FIGURE (1.10): Clear aligner **(Sword *et al.*, 2020)**.

1.6.2. Effect of Orthodontic brackets and Ligation Methods on Oral Microbiota

Orthodontic appliances lend themselves readily as convenient, new retentive surfaces for plaque and microbiota. The intricate topology of brackets the elastomeric or ligature ties used to secure them, together serve as definitive plaque magnets. However, the role played by physico-chemical properties of bracket materials in biofilm accumulation is not as clear **(Eliades *et al*., 1995)**.

1.6.2.1. Conventional Brackets with Elastomeric Ligatures and Steel Ligatures

Among fixed appliances, metal brackets with elastomeric ligatures have been shown to retain more plaque and worsen bleeding on probing and the plaque index more significantly than steel ligatures ***(Fig 1.11)***.

In detail, **Türkkahraman *et al*. (2005)**, after performing a study on 21 subjects with two different archwire ligation techniques (elastomeric rings and

steel ligatures), reported more bleeding at the teeth ligated with elastomeric rings than those with steel ligatures, this finding was confirmed by **De Souza *et al.* (2008)** which reported significantly higher amounts of *T. forsythia* and *P. nigrescens* at elastomeric ligatures, while *P. gingivalis*, *A. actinomycetemcomitans* and *P. intermedia* did not differ significantly.

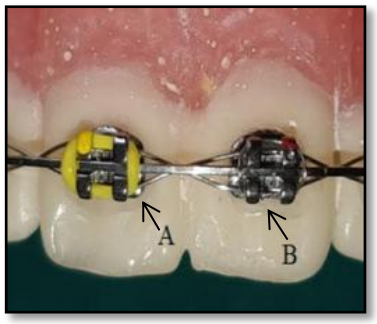

FIGURE (1.11): Types of ligatures (a) Elastic ligature (b) Metal ligature **(Rai *et al*, 2019)**

1.6.2.2. Conventional Brackets Vs. Self-ligating Brackets

Baka *et al*. (2013) and **Uzuner *et al.* (2014)** reported that the self-ligating bracket a system has been variously associated with higher bleeding, worse plaque index and with an increase in gram-negative and gram-positive bacteria (mainly *Streptococci* and *Lactobacilli*) due to the mechanical complexity and surface characteristics of self-ligating brackets, the risk of plaque accumulation around the brackets is increased, despite they did not report statistically significant differences compared to conventional brackets ligated with stainless steel ligatures.

Regarding the risk of caries, **Jing *et al*. (2019)** found a significant increase in *S. mutans* in patients with conventional brackets compared to those with self-ligating brackets over 18 months after starting the treatments.

Self-ligating brackets or steel ligatures are preferred for patients with periodontal involvement, rather than elastomeric rings to retain orthodontic archwires, because patients with elastomeric rings have higher levels of microorganisms in gingival plaque ***(Fig 1.12)*** **(Türkkahraman *et al*., 2005)**.

FIGURE (1.12): Plaque accumulation around self-ligating brackets. **(Ludwig *et al*., 2012)**.

1.6.2.3. Metal Brackets Vs. Ceramic Brackets

In recent decades, the importance of aesthetics has made the use of ceramic brackets very common, which have shown average counts of *P. gingivalis*, *S. mutans* and other periodontal and cariogenic bacteria to be very similar to those found on metal brackets in both posterior and anterior teeth ***(Fig1.13)*** **(Anhoury *et al*., 2002)**.

Do Nascimento *et al*. (**2013)** found that the lowest *S. mutans* colonization was verified with the metallic slot brackets. This was explained by the fact that the ceramic slot bracket is porous with rough areas, and so it had greater potential for accumulating microorganisms compared with the smoother, less porous metallic slot bracket, according to this finding, it could be speculated that ceramic brackets are more inclined to bacterial colonization than metallic ones.

FIGURE (1.13): Patient wearing upper ceramic brackets and lower metal brackets **(Mitchell, 2013)**.

1.6.2.4. Lingual brackets

Studies showed that the most consequent side effects on the oral microbiome and periodontal health have been occasioned by lingual appliances because plaque deposits on the lingual aspects of teeth are more difficult to remove with standard oral hygiene procedures compared to labial and buccal surfaces **(Demling *et al*., 2010; Lombardo *et al*., 2013; Gujar *et al*., 2020)**.

Some studies highlighted a worsening of PI and BOP **(Demling *et al*., 2009; Demling *et al*., 2010; Lombardo *et al*., 2013)**. Two of these studies revealed an increase of *Streptococcus mutans* and *Aggregatibacter actinomycetemcomitans* after 4 weeks ***(Fig 1.14)***.

FIGURE (1.14): Self ligating lingual brackets **(Graber *et al*., 2017)**.

1.6.3. Molar Band Vs. Bonded Molar Tubes

Ireland *et al.* (2014) made a study on 24 orthodontic patients (age range, 11–14 years) to investigate differences in clinical parameters and microbial communities in supra- and subgingival plaque from banded molar vs bonded molar, randomly assigned, during treatment and up to one year after appliance removal. In both groups, the plaque populations changed within three months of starting fixed treatment and was characterized by an increase in *T. denticola* and *P. nigrescens*, and a decrease in *A. actinomycetemcomitans*. Post-treatment plaque associated with both types of molar attachments showed increased levels of periodontal pathogens, such as *P. gingivalis*, *T. forsythia*, and *E. nodatum*, while *C. rectus*, *Parvimonas micra*, *A. odontolyticus* and *V. parvula* were peculiarly elevated only in bonded molars. One year after the cessation of treatment, the banded molar plaque returned to its baseline composition, while a new arrangement of the microbial community persisted in the bonded molars.

From the end of the treatment, the literature agreed in founding a return to the original bacterial flora of the baseline, thus considering all the microbial alterations occurred during orthodontic treatment as transitory **(Guo *et al.*, 2017)**.

a  **b**

FIGURE (1.15): Molar attachment (a) Molar band (b) Molar tube **(Cobourne and DiBiase, 2016)**.

1.7. Effect of Bonding Materials on Oral Microbiota

The bonding material used to maintain the brackets attached to the tooth surface may affect plaque growth and retention of bacteria. This can be due to the surface characteristics of the material used but also by the junction formed between the tooth surface and the bonding material which can provide the initially adhering bacteria and immature plaque biofilm protection from removal forces **(Quirynen *et al*., 1995)**.

Normally, composite resins are used for the bonding of brackets, but glass ionomer cements are also used in fixed orthodontics. Their relationship with the development of white spot and even caries lesion is not hard to envision considering the intimate contact with the hard tooth tissues and the opportunity they offer for bacteria to adhere **(Shannon, 1981; Øgaard *et al*, 1988; Svanberg *et al*., 1990)**.

In a study done by **Örtendahl *et al*. (1997)** the presence of *mutans streptococci* was examined around brackets retained by either a resin-based composite or glass ionomer cement in 11 full-term orthodontic patients. They found lower numbers of *mutans streptococci* around the brackets retained by glass ionomer cement than resin-based composite ***(Fig 1.16)***.

This was illustrated by **Sukontapatipark *et al*. (2001)**, they found that excess composite around brackets harbored a mature plaque biofilm while the surrounding enamel surface had plaque in only the early stages of development. Maturation of the dental plaque makes it easier, and is even a prerequisite, for specific pathogens to appear and multiply.

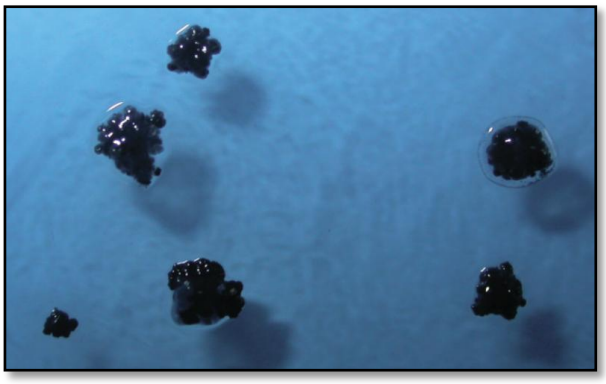

FIGURE (1.16): *Streptococcus mutans* colonies grown on mitis salivarius-bacitracin (MSB) agar **(Eliades, 2009)**.

1.8. Hygiene Approaches for Fixed-Appliance Treatment

1.8.1. Prophylactic Measures

1.8.1.1. Orthodontists Prophylactic Measures

Oral hygiene is more difficult after fixed appliances have been fitted. Efforts to maintain a patient's oral health should therefore start at the bonding appointment.

One way by removing excess composite around the brackets, which may contribute to plaque accumulation **(Ludwing, 2012)**.

Another way to maintain oral hygiene is to use the composite resin adhesives that have chromatic agents that change their color during setting. It has an advantage of easy flash removal thus reducing the amount of plaque accumulation and helping patients to maintain better hygiene ***(Fig 1.17)*** **(Maurya *et al.*, 2011)**.

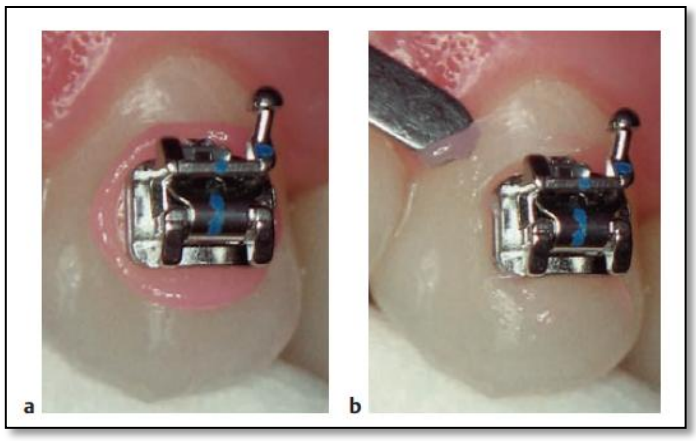

FIGURE (1.17): The bracket has been positioned on the tooth surface with chromatic adhesion (a) the excess adhesive is clearly visible due to the added color (b) removal the excess materials around bracket **(Ludwing, 2012)**.

A new generation of sealants that gradually release fluoride are a promising development. Although they provide only a very thin covering of the tooth surface. The products are reinforced with filler particles and consequently offer good abrasion resistance against everyday wear and tear (such as brushing teeth). According to the manufacturer, the sealing of the surrounding surface area should last for at least 2 years and possibly even longer. Even after 2 years, there is still residual resin on the tooth surface in up to 70% of cases **(Bishara et al., 2005; El Bokle and Munir, 2008)**.

Another prophylactic measures are the application of fluoride-rich varnish ***(Fig 1.18)*** and sealing dental grooves are also recommended.
Eventually, items likely to retain dental plaque such as bands and elastomeric ligatures can also be minimized by better design of orthodontic appliances **(Derks *et al*., 2007; Derks *et al*., 2008; Vital *et al*., 2010)**.

FIGURE (1.18): fluoride varnishes **(Ludwing, 2012)**.

Dentist must preserve the patient's oral health during long orthodontic treatment by monitoring the oral hygiene of the patients during periodic recalls and motivating for oral hygiene to avoid the risk of new caries and periodontal diseases **(Gündüz *et al*., 2008; Vital *et al*., 2010)**.

1.8.1.2. Orthodontic Patients Prophylactic Measures

Dental plaque control can be accomplished in two ways with mechanical and chemical plaque control **(Needleman *et al.*, 2015)**.

Mechanical plaque control done by toothbrushing, besides the use of regular and electric toothbrushes, the use of special orthodontic brushes as well as interdental brushes **(Sälzer *et al.*, 2015)**.

Recommended the patients to brush their teeth immediately after each meal. During orthodontic treatment, tooth brushing with appropriate toothbrushes represents the first line of defense in the removal of food residues and dental plaque. The orthodontic toothbrush is in two levels, in the form of V with longer bristles at the ends and shorter bristles in the middle. This form enables removing the dental plaque of brackets and teeth, that is, the area above and below the brackets ***(Fig 1.19)*** **(Kiliçoğlu *et al.*, 1997; Atanasova *et al*., 2018)**.

The use of the dental floss allows better removal of the dental plaque in the interdental space.

Chemical plaque control done by daily use of fluoride toothpastes as well as the use of mouthwash solutions as additionally affect oral hygiene during orthodontic treatment **(Gunsolley, 2006; Serrano *et al*., 2015)**.

FIGURE (1.19): Various cleaning aids. (a)Various toothbrushes: tufted brushes, interdental brushes. (b) V-shaped toothbrush, with better access around fixed appliances **(Ludwing, 2012).**

1.8.2. Active Measures

When a high incidence of caries has been noted, or a predilection to developing caries or simple gingivitis has been diagnosed, appropriate measures must be considered to prevent exacerbation or development of more serious oral pathology **(Ludwing, 2012)**.

Different concentrations of CHX-containing mouthwashes, varnishes, gel and dentifrices have been tested and confirmed to reduce *S. mutans* levels in orthodontic patients. However, the long-term effects of CHX use on the oral flora and the possible adverse effects exerted on the components of fixed orthodontic appliances have not been reported **(Anhoury *et al*., 2002; Oltramari-Navarro *et al*., 2009)**, at doses higher than 100 ppm, chlorhexidine reduces the number of bacteria. Even low concentrations of 1 ppm or less have a bacteriostatic effect.

Chlorhexidine can be administered at high dosages before the start of orthodontic treatment using a vacuum-formed tray ***(Fig 1.20)***. For this to be successful, all plaque—soft and hard—has to be previously removed, and this should ideally be part of the orthodontic oral hygiene regimen **(Ludwing, 2012)**.

FIGURE (1.20): Clinical use of a vacuum-formed tray containing chlorhexidine gel **(Ludwing, 2012)**

Ideally, patients should receive chairside demonstrations on how to use the soft splints. They are applied after the teeth have been appropriately cleaned, and 2–3 cm of chlorhexidine gel is placed in the tray and distributed evenly. The splint should then be worn for approximately 10 minutes in the evening, after the evening meal and following thorough oral hygiene. This should be continued for at least 14 days, and the treatment outcome should be documented **(Ludwing, 2012)**.

High-quality intraoral photography and regular assessment using oral hygiene indices such as the Plaque Index (PI) and Bleeding Index (BI) make it possible to document treatment progress and help objectify the treatment results. It is important to have policies in place if oral hygiene is insufficient, so that the patient is appropriately warned and informed that the fixed appliances may have to be removed before the completion of treatment if oral hygiene standards deteriorate.

Oral hygiene can be improved by patient education and plaque indicators are often very helpful ***(Fig 1.21)*** **(Ludwing, 2012)**.

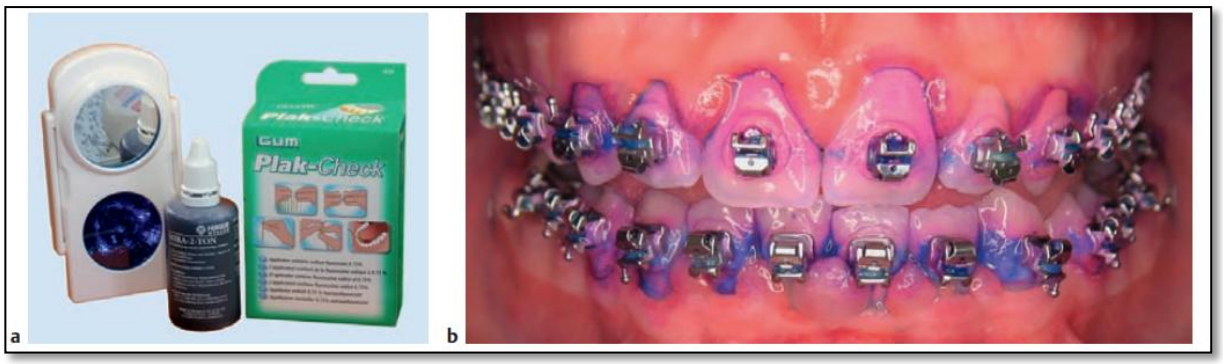

FIGURE (1.21): (a) Plaque indicators: MIRA-2-Tone and Plak Check. Under ultraviolet illumination, Plak-Check reveals plaque with a yellow color. (b) The MIRA-2-Tone indicators differentiate between nature and new plaque. Plaque more than 3 days old appears blue, while pink coloring indicates plaque that is less than 3 days old **(Ludwing, 2012)**.

1.9. Oral Hygiene after Fixed-Appliance Treatment

The retention phase is important for maintaining orthodontic results and adequate oral hygiene continues to be paramount, and depending on the retainers used, may still involve a number of adjuncts. Removable retainers such as Hawley retainers, vacuum-formed retainers, and positioners allow good cleaning, as they can be removed for brushing. However, patients need to be aware that great care has to be taken when fixed retainers are used. Fixed retainer is often used when orthodontic treatment has included extensive tooth movement, in adult patients, and all patients with previous periodontal disease ***(Fig 1.22)*** **(Bock *et al.*, 2005)**.

The advantage of fixed retainer is permanently secured position of the anterior teeth. However, this has the disadvantage that it can create undercuts in areas that are particularly prone to plaque and calculus accumulation and this may consequently put patients at risk for periodontal problems or tooth decay. Appropriate patient information (ideally both written and verbal) and consent to this type of retention is usually advisable. The patient should be instructed to use adjuncts such as interdental brushes , superfloss, and waterpik water flossers to maintain good oral hygiene around fixed retainer **(Ludwing, 2012)**.

FIGURE (1.22): Fixed retainer. The teeth should be professionally cleaned, and the amount of composite around the gingival margin should be reduced to allow for better oral hygiene **(Ludwing, 2012)**.

1.10. Probiotic Therapy

Probiotics are non-pathogenic living microorganisms that have both preventive and therapeutic effects on oral infectious diseases **(Zaura and Twetman, 2019)**.

The bacteriocins released by probiotics effectively antagonize acidic dental plaque, and produce glucanase and urease after their colonization of the oral mucosa, which can counteract plaque formation and saliva acidity, respectively **(Di Pierro *et al.*, 2015)**.

Various vehicles for oral probiotics have been employed, including gums, lozenges, tablets, drops and drinks ***(Fig 1.23)*** **(Alshareef *et al.*, 2020)**.

Probiotics have been shown to play an important role in the treatment of chronic periodontal disease. For example, patients with generalized chronic periodontitis treated with scalling and root planning and probiotic lozenges had significantly reduced levels of periodontal pathogenic red and orange complexes **(Invernici *et al.*, 2018)**.

Twetman *et al.* (2009) reported a reduction of clinical symptoms caused by gingivitis after the use of chewing gum containing *Lactobacillus reuteri* for 2 weeks.

Lactobacillus brevis has also been suggested to be potentially beneficial in view of its anti-inflammatory characteristics. *Bifidobacterium* is another species that has been found to exert a positive impact on periodontal disease **(Burton *et al.*, 2013)**.

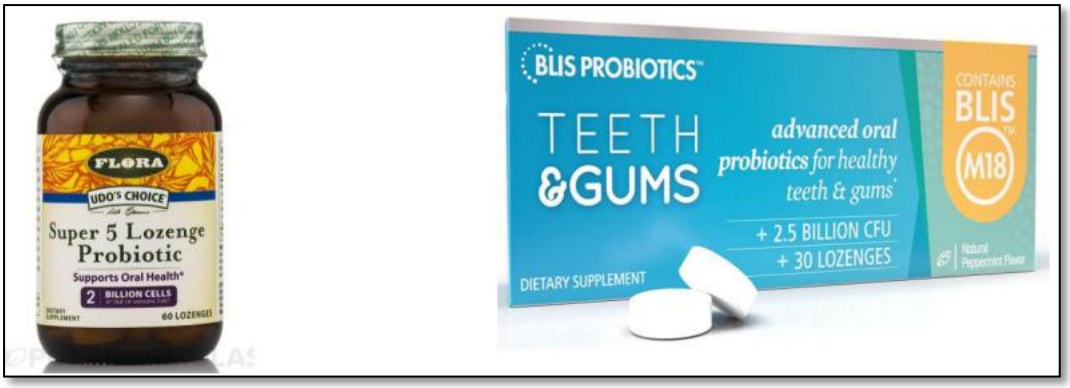

FIGURE (1.23): probiotic lozenges and gums **(Alshareef *et al.*, 2020)**.

Chapter Two
Discussion

Our literature had discussed any specific microbial changes that occur during and after different types of orthodontic treatments.
When compared with subjects without orthodontic treatment, orthodontic patients reported significant qualitative and quantitative differences in the amount and microbial composition of plaque during the entire treatment period.

Removable appliances were less associated with worsening of periodontal indices and caries because, despite being worn nearly 24 hours a day, they can be easily removed to allow for proper oral hygiene.
Furthermore, patients with fixed appliances showed a significant increase in the number of *Streptococci* and *Lactobacilli* and, therefore, a greater risk of caries than patients with clear aligners **(Mummolo *et al*., 2020)**.

A study done by **Jiang *et al.* (2018)**, reporting that patients with clear aligners, compared with those with fixed appliances, appear to benefit from better oral health and periodontal parameters, thus recommending clear aligners as preferential therapeutic option in those patients at high risk of developing gingivitis/periodontitis **(Flores, 2019)**, this disagree with previous study done by **Guo *et al*. (2018)** who showed that aligner can induce changes in the oral microbiome because aligners are worn almost all day long, they cover all tooth surfaces and their margins overlap the marginal gingiva thus, they impede the self-cleaning by saliva and may cause plaque accumulation. Also, the use of bonded attachments might provide additional plaque retaining surfaces on the teeth.

Among the types of brackets and ligatures used in fixed orthodontic therapies, **Jing *et al*. (2019)** found a significant increase in *S. mutans* in patients with conventional brackets compared to those with self-ligating brackets over 18 months after starting the treatments and should be considered at higher risk of developing white spot lesions and caries than patients with self-ligating brackets, this disagree with **Baka *et al*. (2013)** and **Uzuner *et al.* (2014)** whose reported that The self-ligating bracket has been variously associated with higher

bleeding, worse plaque index and with an increase in *Streptococci* and *Lactobacilli* due to the mechanical complexity and surface characteristics of self-ligating brackets, the risk of plaque accumulation around the brackets is increased, despite they did not report statistically significant differences compared to conventional brackets ligated with stainless steel ligatures.

With regard to the ligation methods, **Türkkahraman *et al*. (2005)** reported more plaque and bleeding with elastomeric ligatures than those with steel ligatures for this reason the Self-ligating brackets or steel ligatures are preferred for patients with periodontal involvement, rather than elastomeric rings to retain orthodontic archwires.

A study done by **Jing *et al*. (2019)** found that elastomeric ligatures and ceramic brackets are more associated with poor oral conditions and with a greater amount of periodontopathogen and cariogenic species. Based on these findings, while self-ligating brackets are microbiologically safer, elastomeric ligatures and ceramic brackets must be considered at higher risk of periodontal diseases and caries.

For ceramic brackets **Anhoury *et al*. (2002)** has shown average counts of *P.gingivalis*, *S. mutans* and other periodontal and cariogenic bacteria to be very similar to those found on metal brackets in both posterior and anterior teeth, this diagree with **Do Nascimento *et al*. (2013)** who found that the lowest *S. mutans* colonization was verified with the metallic slot brackets. This was explained by the fact that the ceramic slot bracket is porous with rough areas, and so it had greater potential for accumulating microorganisms compared with the smoother, less porous metallic slot bracket, according to this finding, it could be speculated that ceramic brackets are more inclined to bacterial colonization than metallic ones.

For molar band and molar tube a study done by **Guo *et al.* (2017)** show that band is better than bonded molar, the study show that one year after the cessation of treatment, the banded molar plaque returned to its baseline composition, while a new arrangement of the microbial community persisted in the bonded molars. From the end of the treatment, the literature agreed in founding a return to the original bacterial flora of the baseline, thus considering all the microbial alterations occurred during orthodontic treatment as transitory. This disagree with a pilot study done by **Al-Anezi (2015)** which was in

agreement with several previous clinical trials **(Zachrisson, 1976, Boyd and Baumrind, 1992, Huser *et al*., 1990)**, bands were associated with an increase in BOP in the first three months of treatment and show an increase in the gingival inflammation associated with orthodontic bands which may be explained by **Atack *et al*. (1996)** First, orthodontic bands mechanically irritate gingival tissues. Second, chemical irritation may occur due to the cement used to retain the band, which is in close proximity to the gingival tissues. Third, a greater risk of food impaction and hence posterior gingival and periodontal irritation may occur. Finally, patients may have a tendency to clean their anterior teeth more effectively than their posterior teeth.

For lingual appliance, studies by **Demling *et al*. (2010)**, **Lombardo *et al*. (2013)** and **Gujar *et al.* (2020)** showed that the most consequent side effects on the oral microbiome and periodontal health have been occasioned by lingual appliances because plaque deposits on the lingual aspects of teeth are more difficult to remove with standard oral hygiene procedures compared to labial and buccal surfaces.

Chapter three
Conclusions and Suggestions

3.1. Conclusions

From this study we can conclude the following:

- The Ecological equilibrium maintains the healthy oral status of individuals. Insertion of orthodontic appliances will inhibit oral hygiene, so induces a change in the oral microbiota and increases the number of plaque retention areas.
- Conventional brackets can be used for all types of patients. However, they are not the appliance of choice for treating patients with severe periodontitis.
- Self-ligating brackets are more favorable in patients with previous bone loss. However, the use of elastomeric chains should be avoided as much as possible with this type of brackets because they facilitate plaque accumulation and induce friction.
- Lingual brackets are not recommended in patients with poor oral hygiene. They also might cause tongue irritations so the patient must be informed of this beforehand.
- Patient's motivation for oral hygien is more than enough to counteract or even avoid the microbial imbalance caused by orthodontic treatment.
- If optimal therapeutic results cannot be achieved through removable orthodontic therapy and the use of fixed orthodontics is necessary, it would be essential to reduce the duration of treatment to a minimum and to choose the type of brackets and ligatures in relation to the patient's lower or higher susceptibility to developing pathological conditions. It would also be motivate the patient about the importance of oral hygiene during treatment and to intensify the number of check-ups in order to stop the progression, maturation and disposition of microbiome in the plaque. The dentist must preserve the patient's oral health during long orthodontic treatment by monitoring the oral hygiene of the patients during periodic recalls. Prevention also implies adequate local fluoride administration, notably the application of fluoride-rich varnish, using chlorhexidine varnish and sealing dental grooves are also recommended. Recommended the patients to brush their teeth immediately after each meal, using dental floss to allows better removal of the dental plaque in the interdental space, using mouthwash and fluoride toothpaste and probiotic lozenge

3.2. Suggestions

We suggest for:

1. Further study to know the relationship between different mouthwashes and oral health among orthodontic patients
2. Study the effect of different orthodontic bonding materials on oral health

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