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Periodontal impact of orthodontic treatment with clear aligners

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Literature Review presented to the Universidade Fernando Pessoa as part of the requirements for the obtention of Dental Medicine Master's Degree

ABSTRACT

Objective: To compare the periodontal health of patients treated with conventional fixed appliance and patients treated with clear aligner systems, in various malocclusions.

Methods: A systematic literature search comprised three databases: *PubMed*, *B-on* and *Cochrane*. Eligible studies were selected based on the inclusion and exclusion criteria.

Results: Seven studies were selected for data extraction, three randomized controlled trials and four cohort studies. The total number of participants making up this systematic review was 390. The plaque index showed a statistically significant differences between patients with fixed orthodontic appliances and clear aligners while the others indices showed no statistically significant differences.

Conclusion: This review didn't found data that support the existence of significant statistic differences between clear aligners and fixed orthodontic appliances regarding periodontal health impact. More studies are needed to clarify this aspect related with the orthodontic treatment.

Keywords: Periodontal health, Orthodontic treatment, Clear aligners, Fixed orthodontics appliances, Invisalign®.

RESUMO

Objetivo: Comparar o *status* periodontal dos pacientes tratados com aparelhos ortodônticos fixos convencionais e o *status* periodontal dos pacientes tratados com aparelhos removíveis comummente designados alinhadores, em diferentes más oclusões.

Metodologia: Foi realizada uma revisão sistemática da literatura, nas fontes electrónicas de informação seguintes: *PubMed, B-on* e *Cochrane*. Foram definidos critérios de inclusão e de exclusão que permitiram a seleção dos artigos analisados no trabalho.

Resultados: Foram selecionados sete artigos para revisão, dos quais três respeitavam a ensaios clínicos randomizados controlados e quatro a estudos de coorte. O número total de participantes incluídos nesta revisão foi de 390 indivíduos. A análise dos dados relativos aos índices de placa bacteriana dos pacientes revelam diferenças estatisticamente significativas entre os dois grupos estudados, enquanto na análise dos restantes índices periodontais não se detectam diferenças estatisticamente significativas.

Conclusão: Este trabalho não encontrou evidência científica que permita concluir que existem diferenças estatisticamente significativas relativas ao estado de saúde dos tecidos periodontais dos pacientes tratados ortodonticamente, em função do tipo de aparelhos analisados neste estudo. Sugere-se a realização de novas investigações para melhor clarificação deste assunto.

Keywords: Saúde periodontal, Tratamento ortodôntico, Alinhadores, Aparelhos ortodônticos fixos, Invisalign®.

INDEX

ATTACHMENT INDEX

ACRONYMS AND ABBREVIATIONS LIST

CA - Clear aligner

FOA - Fixed orthodontic appliances

PI - Plaque index

SPD - Sulcus probing depth

GI - Gingival index

PBI - Papillary bleeding index

BOP - Bleeding on probing

REC - Gingival recessions

RCT - Randomized clinical trials

Time measures: Letter "T" followed by a number which corresponds to the month. T0 - before treatment; T1 - 1 months; T2 - 2 month; etc.; Tx - non-specified times measure during treatment

I. INTRODUCTION

The main goal of orthodontic treatment is to produce a normal or so-called ideal occlusion that is morphologically stable and esthetically and functionally well adjusted (McNamara Jr et al., 2003). Nevertheless, treatment with fixed orthodontic appliances increases the risk of gingival inflammation, in conjunction with an increase in the plaque index, bleeding and probing depth that can compromise the outcome of treatment (Bollen et al., 2008). The periodontal reaction to an orthodontic appliance depends on several factors, such as host resistance, lifestyle factors, including smoking, the presence of systemic conditions, and the amount and composition of dental plaque (Talic, 2011). Furthermore, Socransky and Haffajee showed that the presence of fixed orthodontic appliances encouraged the growth of periodontopathic bacteria species such as *Porphyromonas gingivalis, Prevotella intermedia, Bacteroides forsythus, Actinobacillus actinomycetemcomitans, Fusobacterium nucleatum and Treponema denticola* (Socransky & Haffajee, 1992). On top of that, this type of treatment has some drawbacks since people wearing traditional braces feel uncomfortable and show some difficulties to perform conventional cleaning. In fact, patients must carefully brush each bracket and floss around the wires to remove all traces of plaque, in order to reduce the risk of demineralization during orthodontic treatment (Bräscher et al., 2016).

In the last decades, orthodontic developments, have been accompanied by a significant increase in the esthetic demands of the patients. Patients often express the need to influence, or even determine, treatment aspects or objectives, along with the orthodontist, driven by the effects that orthodontic appliances have in their appearance (Ziuchkovski et al., 2008). Conventional orthodontic methods have been associated with a general compromise in facial appearance raising a major concern among patients seeking orthodontic treatment (Rosvall et al., 2009). Thus, esthetic materials and techniques have been introduced in clinical practice aiming to overcome these limitations (Gkantidis et al., 2012).

Clear aligner treatment has been introduced in the last decades to satisfy the aesthetic and comfort requirements of adult orthodontic patients. This treatment is based on removable thermoplastic splints covering all the teeth and part of the marginal aspects of the gingiva, which progressively move the teeth into an ideal position. Thanks to the satisfactory mechanical properties of these devices and to the valuable progresses of the aligners technology, nowadays this therapy is suitable for the correction of a wide spectrum of malocclusions (Martina et al., 2019). These aligners should ideally be worn 20–22 h per day and removed only for eating, drinking, and tooth brushing or flossing. Being removable, clear aligners, such as Invisalign®, have the potential of not hindering oral hygiene, since patients encounter none of the obstructions caused by brackets, bands, or archwires (Boyd et al., 2000). For this reason, clear aligner treatment seems to offer several advantages in terms of maintaining oral hygiene (Mampieri e Giancotti 2013).

The aim of this systematic review was to compare the periodontal health of patients treated with conventional fixed appliance and patients treated with clear aligner systems, in various malocclusions.

I.1. MATERIAL AND METHODS:

I.1.1 Focus question

The focus question was formulated based on PICOS guidelines:

1. Population, patient (P): Patients following an orthodontic treatment with clear aligners or with fixed orthodontic appliances.
2. Intervention (I): Periodontal indices during and after treatment.
3. Comparison (C): Comparison of orthodontic treatment with clear aligners and fixed orthodontic appliances.
4. Outcome (O): Better periodontal indices of clear aligners than fixed orthodontic

appliances.

5. Study Design (S): Randomized controlled trial (RTC) or cohort prospective study.

I.1.2 Eligibility criteria and exclusion criteria

Studies were eligible for inclusion based on the following criteria.

1. Primary studies that used an experimental or observational study design (randomized controlled trial, cohort/longitudinal study, case-control study, cross-sectional study).
2. At least one type of contemporary orthodontic appliance was used as either the main sample population or as a comparison/control group with in the study.
3. The study included human subjects of any age, sex and ethnicity.
4. The study measured periodontal health outcome related with the orthodontic appliance, gum bleeding, impact on daily routines performance, or any other orthodontically related outcome.
5. Studies written in English language.

Narrative reviews, case reports and case series studies were excluded from review. Animal studies were also excluded, because the goal of this systematic review was to analyze trends in the use of clear aligners and conventional fixed appliances related with gingival/periodontal tissue inflammation or disease, experienced by human subjects.

I.1.3 Information sources, search strategy, and study selection

A comprehensive electronic search to identify relevant publications was conducted between March 1 and March 30, 2020 in the PubMed/Medline database, B-On and the Cochrane Center Register of Controlled Clinical Trials. The search was developed and

performed by the author, assisted and supported by the supervisor. The search included MeSH terms to locate relevant orthodontic studies. No language restrictions were used. The bibliographies of the included studies were also used to identify additional studies for possible inclusion.

I.1.4 Search terms

The electronic search strategy included terms related to the intervention and used the following combination of keywords: ((clear aligner OR removable aligners OR invisalign) [All Fields] AND (Periodontal health OR adverse OR negative)) [All Fields] AND (fixed orthodontic appliances) [All Fields].

I.1.5 Screening and selection of studies

A protocol was developed and followed the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) statement (http://www.prisma-statement.org). Studies were screened with the previously stated inclusion criteria at the title and abstract level by the author and by the supervisor to reduce bias. A high level of agreement was obtained at the two stages. The studies were reviewed at the full-text level.

I.1.6 Data items and collection

One customized data abstraction form was used to extract data from each study. The following variables were recorded: study authors, origin, study design, sample sizes in the treatment and control groups, age categories at baseline, type of intervention, treatment or observation duration in months, type of orthodontic records, and controls matching criteria.

I.1.7 Assessment of risk of bias

The methodological quality of RCT and prospective cohort studies were assessed guided by the Cochrane Handbook. Each study was classified into the following groups: low risk of bias if all quality criteria were judged as "present," moderate risk of bias if one or more key domains were "unclear," and high risk of bias if one or more key domains were not "present."

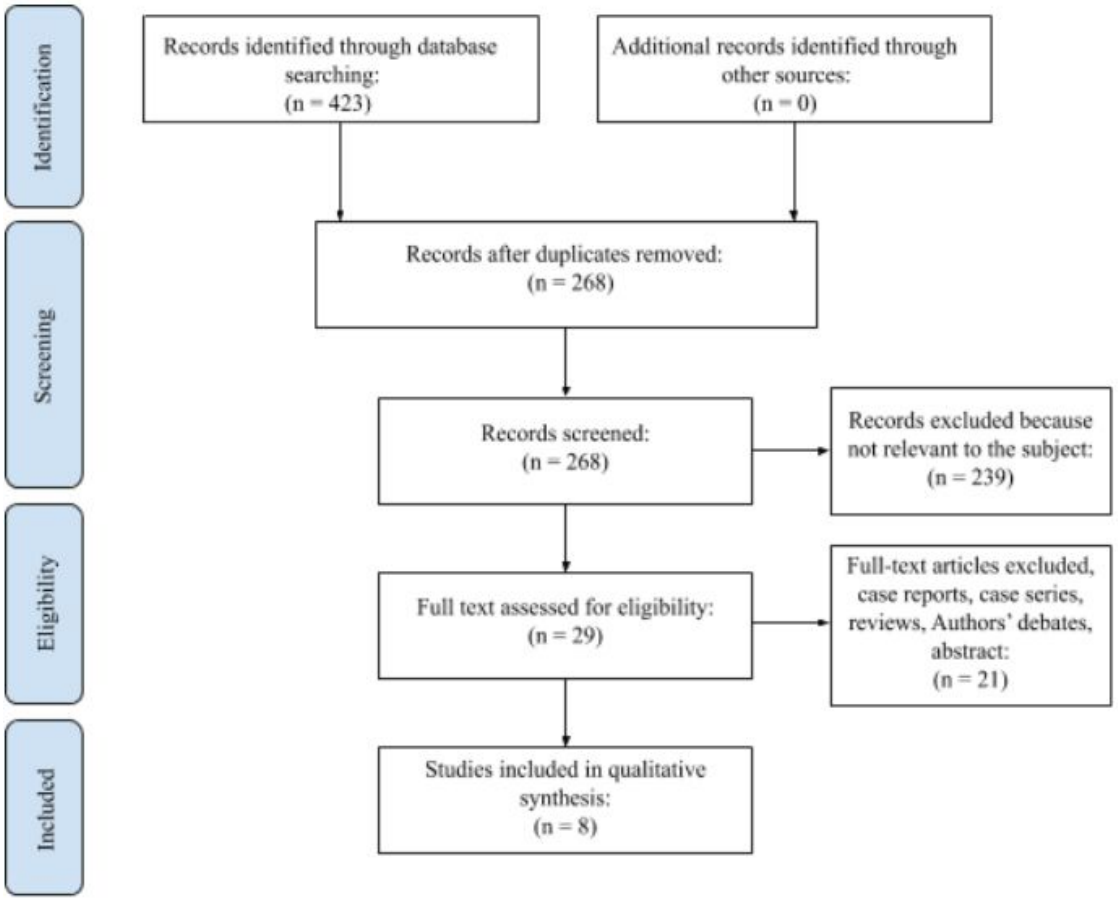

Figure 1. PRISMA flow diagram.

II. RESULTS

II.1 Search results

Figure 1 depicts the flow chart summarizing the results of the search. The electronic search rendered 268 potential references in PubMed, 144 in B-On and 11 in Cochrane. After duplicates discarded, titles and abstracts revision, 29 articles were selected for full-text screening. At the end of the process, 7 articles were selected for data extraction regarding the selection criteria of this literature review.

II.2 Description of selected studies

Among the 7 studies selected, 4 are prospective cohort studies and only 3 are RCTs. The total number of participants making up this systematic review is 390. The sample of studies by Miethke & Vogt (2005) and Karkhanechi et al., (2013) is composed only of adults while that of Chhibber et al., (2017) and Abbate et al., (2015) is, on the contrary, composed of adolescents. The rest of the studies mix the two populations. The only study that includes a control group is the study by Levrini et al., (2013). The duration of patient follow-up varies according to the study. Indeed, the studies of Miethke & Vogt (2005), Azaripour et al., (2015), Levrini et al., (2013) and Pango Madariaga et al., (2020) had a follow-up of 3 months and the other studies had a follow-up at least of 1 year. These informations are gathered in Table 1.

II.3 Risk of bias in individual studies

No single RCT assessed with Cochrane Handbook demonstrated low risk of bias for all the criteria and the majority of studies showed a moderate risk of bias. Blinding of the clinical investigators and participants to the intervention in each group was impossible due to the type of interventions. Most of the studies provided a detailed report about randomization but not regarding other key domains such as allocation concealment and Blinding of outcome assessment, thereby increasing the potential risk of bias (Table 3).

Most of the prospective cohort studies assessed with Cochrane Handbook showed a low risk of bias for the majority of the criterias. Only the study by Karkhanechi et al., (2013) reveals a low risk of bias for the selection of the exposed and non-exposed sample (Table 4).

II.4 Microbiological results

The reports by Abbate et al., (2015) and Levrini et al., (2013) performed a microbiological analysis using the real-time PCR method. The microbiological sample were collected right after recording PI but prior to the other clinical measured. The subjects' microbiological status was determined by investigating the presence or absence of four periodontopathic anaerobes: *Prevotella intermedia, Aggregatibacter Actinomycetemcomitans, Porphyromonas gingivalis* and *Tannerella forsythia*. The results reveal that none of the patients were tested positive for the four anaerobes during the twelve months of therapy (Abbate et al., 2015). Levrini et al., (2013) founded that only one patient, treated with fixed orthodontic appliances, showed the presence of *Aggregatibacter Actinomycetemcomitans* after one and two month of treatment.

The investigation by Karkhanechi et al., (2013) was performed using Hydrolysis of the BANA substrate of plaque samples in order to identify the presence of *Treponema denticola, Porphyromonas gingivalis* and *Tannerella forsythia.*gram-negative anaerobic bacteria strongly associated with chronic adult periodontitis. No difference in BANA scores were found between the fixed buccal appliance and removable aligner groups at baseline or after 6 weeks. However, BANA scores were significantly greater for the fixed buccal appliances group at six months but decreased at twelve months. At this time the odds ratio was still elevated in the fixed buccal appliance group but failed to achieve statistical significance.

II.5 Indices results

Azaripour et al. (2015) found that The GI and SBI indices increase very slightly during treatment for the CA group whereas they strongly increase for the FOA group. They are approximately multiplied by 2. The plaque index, measured according to the API index, also increases for the 2 groups under treatment with 27.8% on average for the CA group

and 37.7% on average for the FOA group. However the authors do not consider this difference to be significant.

Levrini et al. (2013) shows that there are significant differences in favor of the invisalign group for all the PI, SPD, BOP indices and for the total mass of biofilm at T+1 and especially T+3. For the CA group, between T0 and T+3, PI decreases slightly. The other indices remain roughly stable. For the FOA group, between T0 and T+3, the set of indices increases very clearly.

For Karkhanechi et al., (2013) there is no significant difference between the 2 groups for PI GI BOP after six weeks of treatment. At T+1.5, only the SPD index is significantly higher for the FOA group compared to the CA group. At T+6 months, the scores of the PI GI BOP indices improve for the CA group while they deteriorate markedly for the FOA group. At this stage there is therefore a very significant difference. At T+12 months, the scores of the PI GI BOP indices improve for the 2 groups but there remains a significant difference in favor of the CA group. Only the SPD index changes little over time, but it is significantly better for the CA group, whatever the stage of treatment.

In the study by Abbate et al., (2015) there are significant differences, during and at the end of treatment, for all the indices tested, PI, SPD, BOP, full mouth plaque score (FMPS), full mouth bleeding score (FMBS), with significantly better indices for the CA group. PI and BOP improved during treatment for the CA group while these indices deteriorated for the FOA group. Furthemore, the SPD index increased in both groups, slightly for the CA group, markedly for the FOA group. Between the start of treatment, FMPS and FMBS fell slightly for the CA group, while it tripled for FMPS and doubled for FMBS in the FOA group.

Overall, the authors of this four studies reported that clear aligners devices allow better preservation of the periodontal condition of patients. However, Miethke & Vogt (2005) and most recent studies by Chhibber et al., (2018) and Pango Madariaga et al., (2020) do not reach to the same conclusion. The authors believe that there is no clear evidence of better periodontal status in favor of the CA group.

The study by Miethke & Vogt (2005) shows that, during the first control, there is no significant differences between the two groups for GI, PBI and SPD indices. These indices notably improve during the second and the third controls in a similar way in both FOA and CA groups. PI index is significantly better for the CA group during the first check. This index, like the others, improve during the last controls in both groups but much more for FOA, so that the difference is no longer significant. Nevertheless, we can notice that PI index is a better for the CA group. Overall, apart from the plaque index which is significantly higher for the CA group, the other indices are similar. In other respects, no differences were revealed initially and during therapies between the two treatment modalities.

The study by Chhibber et al., (2018) analyzes 3 groups since it distinguishes among patients with fixed appliances, those who have self-ligated brackets (SLB), known to facilitate dental hygiene, and those who have elastomeric ligated brackets (ELB). The results between these 2 subgroups are identical or almost identical for the 3 indices tested, PI, GI, PBI, and for the 3 periods T+0, T+9, T+18. These results were therefore brought together in a single group, FOA. Patients in the CA group performed better regardless of the indices at periods T+9 and T+18 compared to the FOA group. The value of the indices increases clearly so that there is a significant difference at T + 9 for the GI and PBI indices. Between T+9 and T+18 the value of the indices decreases for the FOA group so that the difference is no longer significant at T+18 between the 2 groups.

Pango Madariaga et al., (2020) used PI, SPD, BOP and the gingival recession (REC) indices to determinate the periodontal impact of orthodontic therapies. Between T0 and T+3, the values of the indices PI, BOP, SPD improve very significantly for the 2 groups, so that there is no longer any significant difference at T3 between the two groups for these indices. The linear regression of difference (Δ) models show that the type of device has no influence in improving these indices. At the same time REC increases significantly in the FOA group and slightly for the invisalign group.

Table 1. Relevant data and characteristics of selected studies.

Author	Study design	Population	Country	Groups	Outcomes	Times measures	Oral hygiene instructions
Miethke & Vogt 2005	Prospective cohort study	M: 17 F: 43 Age: 18-51; Mean age: 30,1	Germany	30 FOA 30 Clear aligner Total: 60	PI, SPD, GI, PBI	T+1; T+2; T+3	No specific suggestions Hygiene advices to each check
Karkhanechi et al., 2013	Prospective cohort study	M: 14 F: 28 Age: 18-44	United State of America	22 FOA 20 Clear aligner Total: 42	PI, GI, SPD, BOP, microbiological evaluation	T+1,5; T+6; T+12	Scaling and prophylaxis one week before and complete oral hygiene instructions
Levrini et al., 2013	Randomized clinical trial	M: 9 F: 21 Mean age: 25,1	Italy	10 FOA 10 Clear aligner 10 control group Total: 30	PI, SPD, BOP, microbiological evaluation	T0; T+1; T+3	Standard oral hygiene instructions one month before Hygiene advices to each check
Azaripour et al., 2015	Prospective cohort study	M: 27 F: 63 Age: 11-61	Germany / Netherlands	50 FOA 50 Clear aligner Total: 100	PI, SPD, GI, PBI		Prophylaxis and complete oral hygiene instructions and check up every 6 month
Abbate et al., 2015	Randomized clinical trial	Age: 10- 18	Italy	25 FOA 22 clear aligner Total: 47	PI, SPD, BOP, microbiological evaluation	T0; T+3; T+6; T+12	Standard oral hygiene instructions one month before
Chhibber et al., 2017	Randomized clinical trial	M: 41 F: 30 Mean age: 15,6	Australia	44 FOA 27 Clear aligner Total: 71	PI, GI, PBI	T0; T+9; T+18	Complete oral hygiene instructions
Pango Madariaga et al., 2020	Prospective cohort study	M: 14 F: 26 Mean age: 27,6	Italy	20 FOA 20 Clear aligner Total:40	PI, SPD, BOP, REC	T0; T+3	Individual brushing technique Reminder by a dental hygienist every two weeks

III. DISCUSSION

The present review evaluated the existing literature related to the periodontal effects of clear aligners compared to fixed orthodontic appliances. The results of this systematic review, based on the data extraction of the 7 publications that corresponded to the selection criteria, indicate a high variability in terms of treatment protocols, supportive care, follow-up and on how the outcomes were reported. According to the World Medical Association Declaration of Helsinki, the existing heterogeneity makes it impossible to conduct a meta-analysis of the available reports. Therefore, the results should be interpreted with caution.

Fixed orthodontic appliances create retention areas for plaque accumulation and hinders the attempts of oral hygiene, increasing risk for enamel demineralization, caries, gingival inflammation, and decreased periodontal health (Gorelick et al., 1982 and Derks et al., 2007). Between three and twelve weeks after the beginning of supragingival plaque formation, a distinctive subgingival microflora predominantly made up of gram-negative, anaerobic bacteria and including some motile species, becomes established. In order to establish in a periodontal site, a species must be able to attach to one of several surfaces including the tooth (or retentive surfaces attached to the tooth), the sulcular or pocket epithelium, or other bacterial species that are attached to these surfaces (Ireland et al., 2014). The studies by Abbate et al., (2015) and Levrini et al., (2013) regarding the quality and morphology of the oral biofilm of patients treated with clear aligners stated, that biofilm starts forming on the raised edges or textural surfaces of the aligners and that the types of bacteria included in the biofilm were associated to a low risk of periodontal diseases. They also pointed out that patients undergoing orthodontic treatment with clear aligners prompted a lower total biofilm mass accumulation in the short term when compared with patients in treatment with fixed orthodontic appliances, suggesting the use of clear aligners as a first treatment option in patients who are at risk of developing periodontal diseases.

According to the results of the selected studies most of the author agreed that, from all indices evaluated, only PI index showed significant improvement in patients that were treated with clear aligners in comparison to the patients that were treated with fixed orthodontic appliances. From a clinical point of view, clear aligners seems to be a safe procedure for periodontal tissues with respect to fixed appliance treatment techniques, with particular reference to the amount of possible plaque retention. This seems to be due to the removable nature of clear aligners, facilitating oral hygiene procedures, and to the reduced amount of plaque retentive surfaces (Rossini et al., 2014). Patients undergoing treatment with aligners had to remove them many times during the day, for eating or simply drinking beverages containing sugar. This habit turn them more careful on their oral hygiene procedures before wearing back the aligners and explains their higher compliance during the treatment, also compared to the control group. It is important to remark that patients had to wear removable aligners for 20 hours a day and could therefore perform domiciliary oral hygiene procedures without obstacles (Levrini et al., 2013). For Karkhanechi et al., (2013), Levrini et al., (2013), Azaripour et al., (2015) and Abbate et al., (2015) orthodontic treatment with clear aligners has less periodontal impact than orthodontic treatment with fixed orthodontic appliances.

However, Miethke & Vogt (2005), Chhibber et al. (2018) and Pango madariaga et al. (2020) do not reach to the same observation, although they agree with the different points raised earlier. In fact, the continuous coverage of all surfaces of the teeth including 1 to 2 mm of gingiva by aligners has been shown to prevent the flushing of saliva on dental tissues (Addy et al., 1982). Also, insufficient saliva secretion reduces the self-cleansing mechanisms of the oral cavity and limits the antimicrobial effects of the residual saliva (Lara-Carrillo et al., 2010; Türköz et al., 2012) This can potentially lead to greater accumulation of dental plaque. Furthermore, the margins of aligners are almost never perfectly smooth. This can irritate the marginal gingiva. Bollen et al. (2008) stated the absence of reliable evidence about the effects of orthodontic treatment on periodontal health. Furthermore, van Gastel et al. (2007) and Talic (2011) focused on plaque retention as the main risk factor for periodontal diseases after orthodontic treatment, confirmed that orthodontic treatment itself does not increase the incidence of periodontal pathologies. However, oral hygiene procedures have a great impact on the

periodontal status of orthodontics patients (Talic, 2011). The problem of the lack of adequate microbial plaque removal takes on greater dimensions when undergoing orthodontic treatment (Davis et al., 2014; Sifakakis et al., 2018). Most orthodontic treatments, once initiated, are completed independent of episodes of questionable oral hygiene maintenance; this means treatment is seldom terminated due to unacceptable hygiene (Miethke & Vogt, 2005). Therefore, the orthodontic patient not only requires greater professional assistance, but also precise and individualized instructions for home oral hygiene, which must be continuous and rigorous, given the presence of orthodontic devices that lead to a potential worsening of conditions of the oral cavity until the onset of diseases (Caton et al., 2018).

The analysis of possible sources of bias revealed the deficiency of some methodological features. The lack of subject randomization into fixed buccal appliances or removable aligner groups may have introduced a bias in that those subjects selecting orthodontic treatment with the removable aligner may have been more aesthetically conscious and therefore more willing to perform oral hygiene procedures. In addition, instruction for oral hygiene and follow-up by a dental hygienist, described in table 1, are not similar in all studies. As explained above, this part play a leading role in the success of an orthodontic therapy which can explain the differences in results of studies. Another limitation of most of the studies is the modest sample size and skewed patient distribution. Adults are usually more cooperative than adolescents in regard oral hygiene. It is known that periodontal status varies from adolescent patients to adult patients mainly due to hormonal changes. In addition, adolescents experience more gingival overgrowth due to hormonal changes. Different patients of a wide spectrum of ages have been used in this systematic review, but it was not possible to evaluate the differences in results among them due to the lack of information. We can also notice that the majority of the studies are from European countries, mainly Italy. L. Levrini and G.M. Abbate work in the same university and have each worked in the study of the other. These studies are similar in the methodology and reach to the same conclusion which can reduce the cumulative force of these studies. Furthermore, half of the studies have a short follow-up (3 months) but the results show that most of the indices are increasing until their peak on the 6th month and then normalize periodically. Not all

studies use the same brand of clear aligners which can affect the the results, due to manufacturing differences specific to each brand (gengival covering, material composition, mechanical behavior of the device, others). The role of malocclusion in periodontal health is also important according to Bollen et al., (2008) but is not specified in the current studies and it has not been taken into consideration. Finally, studies do not use the same method for measuring indices (Full Mouth Evaluation, Approximal Plaque Index, Modified Sulcus Bleeding Index, others) and the tools used have never been mentioned.

The following limitations of this review are:

- low number of RCT's currently available;
- heterogeneity in methodologies and treatment modalities among studies and wide variation in terms of follow-up periods;
- small sample size.

V. CONCLUSION

Based on studies with a rather limited statistical power, the present systematic review suggests that:

- Most of the studies have methodological limitations and bias;
- Among all indices studied, only PI was significantly higher in patients with fixed orthodontic appliances therapy than in patients with clear aligners treatment;
- Clear aligners facilitate oral hygiene procedures and reduce the amount of plaque due to their removable nature;
- It seems that there is no evidence that clear aligners have less periodontal impact than fixed orthodontic appliances;

Furthermore, more well designed randomized clinical trials are needed to clearly evidence the differences between clear aligners and fixed orthodontic appliances in terms of periodontal health impact.

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ATTACHMENTS

Table 2. Periodontal indices in selected studies.

		Plaque Index - PI		Gingival Index - GI		Papillary Bleeding Index - PBI		Sulcus Probing Depths - SPD (in mm)	
		CA	FOA	CA	FOA	CA	FOA	CA	FOA
Miethke & Vogt. 2005	T+0 T+1 T+2	0.48 0.41 0.25	0.80 0.56 0.50	0.71 0.61 0.46	1.02 0.72 0.68	0.33 0.31 0.20	0.49 0.31 0.29	2.39 2.29 2.26	2.60 2.52 2.50
Karkhanechi et al., 2013	T+1,5 T+6 T+12	0.70 0.70 0.56	0.86 1.25 1.15	0.87 0.26 0.38	0.98 1.11 0.87	0.34 0.26 0.18	0.34 0.44 0.36	2.65 2.70 2.66	3.05 2.82 3.00
Levrini et al., 2013	T+0 T+1 T+2	0.5 0.35 0.40	0.25 0.95 1.15			0.25 0.40 0.30	0.10 0.60 0.65	2.00 2.50 2.30	2.05 2.50 2.95
Azaripour et al., 2015	T+0 Tx	16.3 27.8	19.6 37.7	0.27 0.35	0.29 0.54	6.6% 7.6%	7.2% 15.8%		
Abbate et al., 2015	T+0 T+3 T+6 T+12	0.91 0.64 0.31 0.36	0.82 1.92 2.32 2.42			3.5% 0% 4.5% 4.5%	0% 36% 58% 74%	2.27 2.23 2.36 2.50	2.26 2.86 3.22 3.42
Chhibber et al., 2017	T+0 T+9 T+18	0.50 0.83 0.92	0.7 1.32 1.32	0.42 0.50 0.75	0.50 0.21 0.32	0.50 0.58 0.46	0.60 1.32 0.84		
Pango Madariaga. et al., 2020	T+0 T+3	41.5 10.5	30.5 14.5			55.5% 13.5%	7.7% 13.5%	13.9% 0.25%	10.4% 0%

Table 3. Risk of bias assessment of the included Randomized Clinical Trials.

	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting
Levrini et al., 2013	Unclear risk	Unclear risk	High risk	Unclear risk	Unclear risk	High risk
Abbate et al., 2015	Low risk	Unclear risk	High risk	Unclear risk	Unclear risk	High risk
Chhibber et al., 2018	Low risk	Low risk	High risk	Low risk	Unclear risk	Low risk

Table 4. Risk of bias assessment of the included Prospective Cohort Studies.

	Was selection of exposed and non-exposed sample drawn from the same population?	Can we be confident in the assessment of exposure?	Can we be confident that the outcome of interest was not present at start of study.	Did the study match exposed and unexposed for all variables that are associated with the outcome of interest or did the statistical analysis adjust for these prognostic variable?	Can we be confident in the assessment of the presence or absence of prognostic factors?	Can we be confident in the assessment of the outcome?	Were co-interventions similar between groups?
Miethke & Vogt, 2005	Definitely no High risk	Probably yes	Definitely yes Low risk	Definitely yes Low risk	Definitely yes Low risk	Probably yes	Probably yes
Karkhanechi et al., 2013	Definitely yes Low risk	Probably yes	Definitely yes Low risk	Definitely yes Low risk	Definitely yes Low risk	Probably yes	Definitely yes Low risk
Azaripour et al., 2015	Definitely no High risk	Probably yes	Definitely yes Low risk	Definitely yes Low risk	Mostly yes	Probably yes	Definitely yes Low risk
Pango Madariaga et al., 2020	Definitely no High risk	Probably yes	Definitely yes Low risk	Definitely yes Low risk	Definitely yes Low risk	Probably yes	Definitely yes Low risk