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Effects of conventional orthodontic treatment versus transparent aligners in periodontal health: An integrative review

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como parte dos requisitos para a obtenção do Grau de

Mestre em Medicina Dentária.

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RESUMO

Objetivo: Identificar estudos na literatura científica comparando o fundamental da saúde periodontal em pacientes que usam aparelhos ortodônticos fixos e alinhadores transparentes.

Métodos: Foi realizada uma pesquisa bibliográfica integrativa através de diferentes bases de dados, Pubmed e a Biblioteca Cochrane. Este trabalho foi submetido a uma estratégia de pesquisa seguindo o método PICO.

Resultados: 8 estudos foram elegíveis para esta revisão integrativa. Enumerámos 204 pacientes tratados com alinhadores e 294 com aparelhos ortodônticos fixos - principalmente braquetes elastoméricos ligados. Apenas o Índice de Placas mostrou uma diferença significativa entre os 2 grupos.

Conclusão: São necessários mais estudos para afirmar que os alinhadores são sinónimo de melhores condições gengivais em comparação com os pacientes tratados com aparelhos fixos. Outros actores, tais como instruções de higiene oral, motivação e tratamento de suporte, tendem a ser mais prevalecentes do que o tipo de aparelho em si na avaliação periodontal.

Palavras-chave: «alinhadores»; «tratamento ortodôntico»; «saúde periodontal»

ABSTRACT

Objective: To identify studies in the scientific literature comparing the fundamental of periodontal health in patients wearing fixed orthodontic appliances and transparent aligners.

Methods: An integrative literature search was performed through different databases, Pubmed and the Cochrane Library. This work was submitted to a search strategy following the PICO method.

Results: 8 studies were eligible for this integrative review. We enumerated 204 patients treated with aligners and 294 with fixed orthodontic appliances -mainly elastomeric ligated brackets. Only the Plaque Index displayed a significant difference between the 2 groups.

Conclusion: More studies are necessary to affirm that aligners is synonym of better gingival conditions in comparison with patients treated with fixed appliances. Others actors such as oral hygiene instructions, motivation and supportive treatment tend to be more prevalent than the type of appliance itself in the periodontal evaluation.

Keywords: «aligners»; «orthodontic treatment»; «periodontal health»

SUMMARY

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ABBREVIATIONS

AG	Aligners group
API	Approximative plaque Index
BoP	Bleeding of probing
CCM	Conventional-ceramic brackets
ELB	Elastomeric-ligated brackets
FG	Fixed group
FMBS	Full mouth bleeding score
FMPS	Full mouth plaque score
GI	Gingival Index
MPI	Modified plaque Index
PBE	Periodontal basic examination
PBI	Papillary bleeding Index
PD	Probing depth
PI	Plaque Index
REC	Gingival recession
SBI	Sulcus bleeding Index
SLB	Self-ligated brackets
Tn	Time measure in month

I. INTRODUCTION

Orthodontic treatment ensures proper alignment of the teeth and improves the occlusal and jaw relationship. This not only aids in better mastication, speech, and facial aesthetics, but also contributes to general and oral health, thereby improving the quality of life (Alfuriji *et al.*, 2014).

The demand for orthodontic treatment has increased in both adult and young patients (Bollen *et al.,* 2008; Ren *et al.*, 2014).

Fixed appliances are the most common and traditional treatment method used in contemporary orthodontics (Živković-Sandić *et al.,* 2014). 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).

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 (Martina *et al.,* 2019).

However, like any other treatment orthodontic treatment has complications. Periodontal complications are one of the most observed side effects associated with orthodontics (Dannan, 2010).

In the scientific literature, advantage of clear aligners over fixed appliances on periodontal conditions is still under debate.

The goal of this integrative review is to compare the periodontal health of patients undergoing orthodontic treatment with conventional fixed appliances -brackets and patients with removable appliances -clear aligners.

II. MATERIAL AND METHODS

1. Objective

The problematic of this study was developed through the PICO method illustrated down below in Table 1.

Table 1. Description of the search strategy under PICO method.

Patients undergoing orthodontic treatment with fixed orthodontic appliances and clear aligners.	Population
Periodontal health at the initial phase and prolonged time of treatment (periodontal Indices).	Intervention
Comparison of periodontal status of patients treated with clear aligners and fixed orthodontic appliances.	Comparison
Periodontal health more favorable in short-term with patients wearing clear aligners.	Outcome
Does the chosen orthodontic appliance module significantly the oral hygiene of the patient?	Problematic

We can corroborate that aligners are associated to a better periodontal status than fixed appliances.

2. Study Design

This work included analytical and controlled studies on humans published between 2005 and 2020, establishing a comparison of the periodontal status of patients undergoing orthodontic treatment with clear aligners and fixed orthodontic appliances.

We considered in this work Invisalign Technology as aligners -in a general- term and several types of brackets as elastomeric ligated brackets, conventional ceramic brackets and self-ligating brackets used for orthodontic treatment as a common group of fixed orthodontic appliances (conventional).

3. Population

Human male and female of any age, ethnicity and malocclusion class, undergoing orthodontic treatment with conventional fixed appliances and transparent aligners.

4. Sources

We used several databases in order to collect our articles for this review: PubMed/Medline and the Cochrane Library.

5. Search strategy

An electronic search was undertaken with different combinations of key-words, we presented the details of several expressions used down below:

(Conventional[All Fields] AND orthodontic[All Fields] AND ("therapy"[Subheading] OR "therapy"[All Fields] OR "treatment"[All Fields] OR "therapeutics"[MeSH Terms] OR "therapeutics"[All Fields])) AND Aligners[All Fields] AND (Periodontal[All Fields] AND ("health"[MeSH Terms] OR "health"[All Fields]))

(« orthodontic appliances, fixed"[MeSH Terms] OR ("orthodontic"[All Fields] AND "appliances"[All Fields] AND "fixed"[All Fields]) OR "fixed orthodontic appliances"[All Fields] OR ("fixed"[All Fields] AND "appliances"[All Fields]) OR "fixed appliances"[All Fields]) AND Aligners[All Fields] AND (Orthodontic[All Fields] AND ("therapy"[Subheading] OR "therapy"[All Fields] OR "treatment"[All Fields] OR "therapeutics"[MeSH Terms] OR "therapeutics"[All Fields])) AND (periodontal[All Fields] AND ("health"[MeSH Terms] OR "health"[All Fields]))

Aligners[All Fields] AND (Orthodontic[All Fields] AND ("therapy"[Subheading] OR "therapy"[All Fields] OR "treatment"[All Fields] OR "therapeutics"[MeSH Terms] OR "therapeutics"[All Fields])) AND (Periodontal[All Fields] AND ("health"[MeSH Terms] OR "health"[All Fields]))

6. Study selection and eligibility process

A comprehensive electronic search in February 2020 was conducted to identify relevant publications in order to build this work. PubMed/Medline and Cochrane Library databases were used. The search was performed by the author, assisted and supported by the supervisor.

MeSH terms to target relevant orthodontic studies were used. At the initial phase, no language restrictions were used. The bibliographies of the included studies were also used to identify additional studies for possible inclusion.

The selection and eligibly process are illustrated in the PRISMA Flow Diagram (Figure 1). The author established criteria, approved by the supervisor. Studies were screened at the title and abstract level in accordance with inclusion/exclusion criteria (Table 2). Agreement was obtained at the two stages. Then, studies were reviewed at the full-text level and approved by the supervisor.

Table 2. Inclusion/Exclusion criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
Clinical study on human fitting with the subject	Narrative review
RCT, Prospective or Cohort study comparing Periodontal indexes of patients treated with Fixed Appliance and Aligners with follow-up	Retrospective study
RCT, Prospective or Cohort study comparing Periodontal indexes of patients treated with Fixed Appliance and Aligners without follow-up	Secondary study
	Articles without clinical studies
Articles in english	Not full-text available
Studies fitting with the subject using Invisalign technology	Not relevant title or Abstract
	Patient with antibiotic therapy or periodontitis

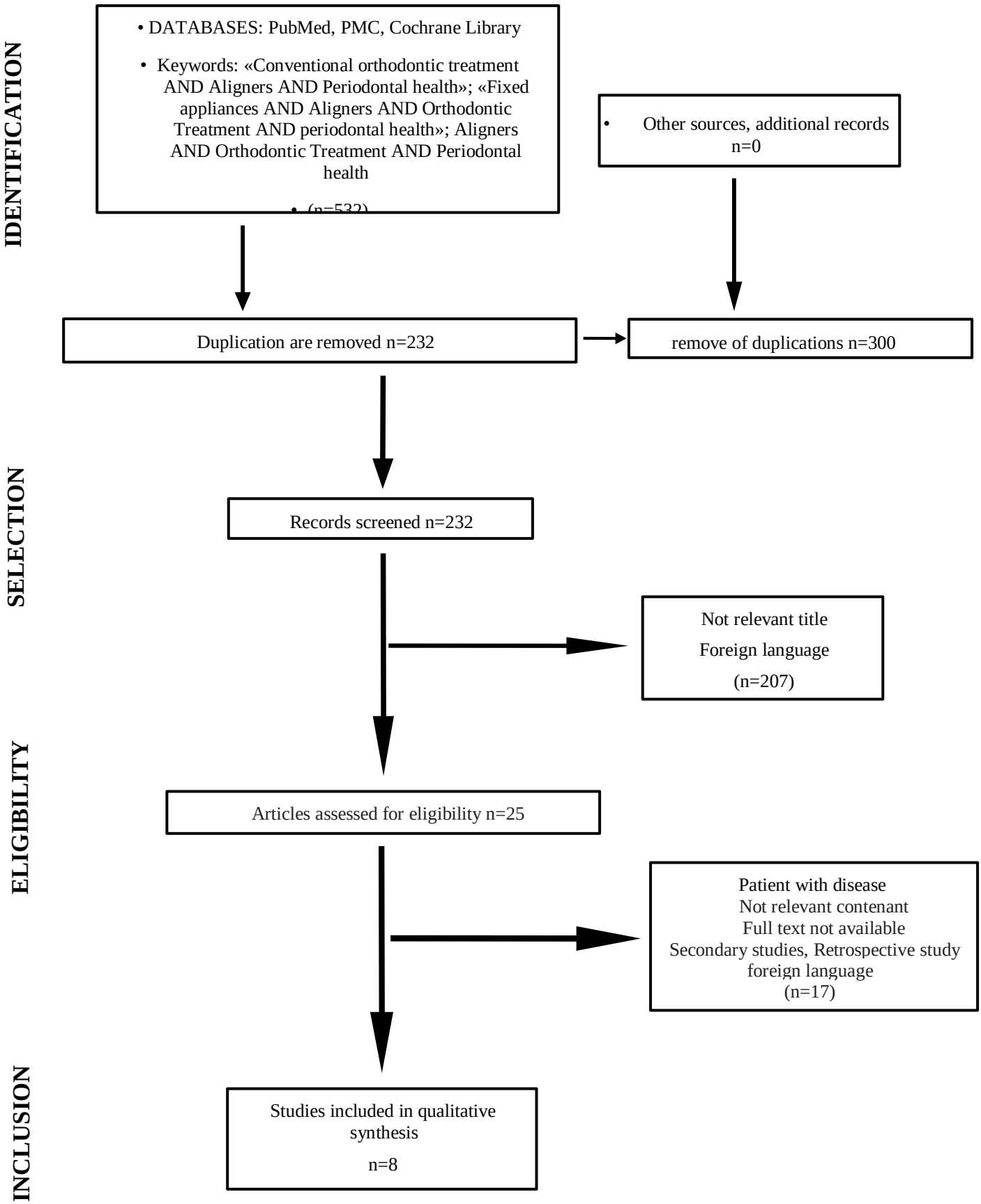

Figure 1. Research PRISMA Flow diagram 2020

7. Data items

One customized data abstraction form was used to extract data from each study. The following variables were recorded: authors (references), gender number, average age, recruitment time, study design, country referred to the clinical trial, outcome measure involved, follow-up in months, sample sizes in relation with the appliance used and control groups.

III. Results

1. Search results

The electronic research displayed 386 articles on PMC, 106 on PubMed and 40 on the Cochrane Library. After duplicates removed, titles and abstract revised, 25 articles were selected for full text-screening. To finish, analyzing full-text and according to the inclusion-exclusion criteria list, 7 secondary studies were excluded, 2 studies involving patients with periodontal disease, 7 articles without interest for this work and only 1 study due to not full-text available. At the end, 8 studies were approved by the author and supervisor for this integrative review (Figure 1).

2. Introduction of the selected studies

Among the 8 studies selected, we can enumerate 7 analytical studies including 4 prospective cohort studies and 2 cross sectional studies and 1 randomized controlled study. We can underline heterogeneous age among studies, some of them considering an adolescent population and others adults only. Also, female gender is dominant. Miethke & Brauner (2007) included a control group of 30 patients wearing aligners from another investigation - also included in this work. Several brackets were used, elastomeric-ligated brackets and conventional ceramic brackets. Chhibber *et al*. (2017) and Issa *et al*. (2020) also considered self-ligated brackets. Only Miethke & Brauner (2007) used fixed lingual appliances. Different follow-up and outcome measures were used. Only Abbate *et al.*, (2015) and Chhibber *et al*. (2017) submitted patients to long-term follow up examination. Characteristics of the eligible studies are regrouped in Table 3.

Table 3. Characteristics of the eligibles studies.

Authors (Refs.)	Female/ Male	Sample number	Average age	Recrutement time	Study design	Country	Outcome measures	Time measures	No. of fixed appliances	No. of clear aligners
Pango Madaraiga *et al.*, 2020	20/20	Total: 40	mean age FG: 20,6 mean age CA: 34,7	Unknown	Prospective clinical study	Naples, Italy	PD PI BoP REC	T0 T3	20	20
Chhibber *et al.*, 2017	30/41	Total: 71	mean age 15,6 +/-4,3	2011-2014	Randomized control trial	Connecticut, Australia	PI GI PerioBl	T0 T9 T18	44 22 ELB 22 SLB	27
Levrini *et al.*, 2015	52/25	Total 77 (33 :Control)	16years old to 30 mean age: 24,3	Unknown	Prospective study	Varese, Italy	PI PD BoP Microbilogical analysis	T0 T1 T3	35	32
Abbate *et al.*, 2015	Unknown	Total 50	10 years old to 18	2012-2013	Prospective study	Varese, Italy	PD PI BoP Microbiological analysis	T0 T3 T6 T12	25	25
Azaripour *et al.*, 2015	73/27	Total: 100	11years old to 62 Mean age FG: 16,3 Mean age CA: 31,9	Unknown	Cross sectional study	Gutenberg, Germany	GI SBI API MPI	T0 T12	50	50
Miethke & Vogt, 2005	43/17	Total:60	18 years old to 51 Mean age: 30,1	2002-2003	Clinical trial (Prospective cohort study)	Berlin, Germany	GI PBI PI SPD	T1 T2 T3 3/4 weeks intervals	30	30
Miethke & Brauner, 2007	Unknown	Total 60	16 years old to 48 Mean age: 39,6	Feb and May of 2005	Prospective study	Berlin, Germany	GI PBI PI SPD	T1 T2 T3 3/4 weeks intervals	30 (lingual group)	30(control group from the previous study)
Issa *et al.*, 2020	40/40	Total:80	Mean age CA 26,85 Mean age FG: 27,05	2015-2016	Cross sectional study	China	PI GI GBI SBI PBI BPE BoP	regular assessments unknown	60 20 ELB 20 CCB 20 SLB	20

3. Data evaluation of the selected studies.

Table 4. Indices evaluation.

Authors (Refs.)	Gingival Index (GI)			Probing Depth (PD)			Plaque Index (PI)			Bleeding of probing (BoP)		
Pango Madaraiga *et al.*, 2020	not mentioned	not mentioned	not mentioned	AG T0=0,1 T3=0	FG T0=0,3 T3=0,14	Mean ∑AG =0,05 ∑FG=0,22	AG T0=0,42 T3=0,11	FG T0=0,31 T3=0,15	Mean ∑AG=0,27 ∑FG=0,23	AG T0=0,55 T3=0,13	FG T0=0,77 T3=0,13	Mean ∑AG =0,34 ∑FG=0,9
Chhibber *et al.*, 2017	AG T0=0,42±0,5 T9=0,50±0,59 T18=0,75±0,53	FG T0=0,05±0,22 T9=1,21±0,79 T18=1,32±0,67	Mean ∑AG=0,55±0,54 ∑FG 1,01±0,56	not mentioned	not mentioned	not mentioned	AG T0=0,50±0,51 T9=0,83±0,48 T18=0,92±0,58	FG T0=0,70±0,73 T9=1,32±0,67 T18=1,32±0,67	Mean ∑AG=0,75±0,52 ∑FG=1,1±0,69	not mentioned	not mentioned	not mentioned
Levrini *et al.*, 2015	not mentioned	not mentioned	not mentioned	AG T0=2,18 T1=2,75 T3=1,6	FG T0=2,18 T1=2,2 T3=1,3	Mean ∑AG=2,17 ∑FG=1,89	not mentioned	not mentioned	not mentioned	not mentioned	not mentioned	not mentioned
Abbate *et al.*, 2015	not mentioned	not mentioned	not mentioned	AG T0=2,28 T3=2,23 T6=2,37 T12=2,5	FG T0=2,26 T3=2,86 T6=3,22 T12=3,42	Mean ∑AG=2,35 ∑FG=2,94	AG T0=0,91 T3=0,64 T6=0,32 T12=0,36	FG T0=0,82 T3=1,92 T6=2,32 T12=2,42	Mean ∑AG=0,56 ∑FG=1,87	AG T0=0,14 T3=0 T6=0,04 T12=0,04	FG T0=0 T3=0,36 T6=0,58 T12=0,74	Mean ∑AG =0,05 ∑FG=0,42
Azaripour *et al.*, 2015	AG T0=0,27±0,25 T12=0,35±0,34	FG T0=0,29±0,24 T12=0,54±0,50	Mean∑AG =0,31±0,29 ∑FG=0,42±0,37	not mentioned	not mentioned	not mentioned	AG T0=0,16±0,1 T12=0,30±0,25	FG T0=0,20±0,1 T12=0,38±0,22	Mean ∑AG=0,23±0,18 ∑FG=0,58±0,16	not mentioned	not mentioned	not mentioned
Miethke & Vogt, 2005	AG T1=0,71±0,39 T2=0,61±0,35 T3=0,46±0,34	FG T1=1,02±0,69 T2=0,73±0,58 T3=0,68±0,66	Mean ∑AG=0,59±0,30 ∑FG=0,81±0,59	AG T1=2,39±0,45 T2=2,29±0,41 T3=2,26±0,48	FG T1=2,60±0,73 T2=2,52±0,65 T3=2,50±0,67	Mean ∑AG=2,31±0,39 ∑FG=2,45±0,65	AG T1=0,48±0,41 T2=0,41±0,37 T3=0,28±0,32	FG T1=0,80±0,58 T2=0,56±0,44 T3=0,50±0,53	Mean ∑AG=0,39±0,31 ∑FG=0,62±0,48	not mentioned	not mentioned	not mentioned
Miethke & Brauner, 2007	AG T1=0,71±0,39 T2=0,61±0,35 T3=0,46±0,34	FG T1=1,02±0,53 T2=1,02±0,43 T3=0,96±0,43	Mean ∑AG=0,59±0,30 ∑FG=1,00±0,43	AG T1=2,39±0,45 T2=2,29±0,41 T3=2,26±0,48	FG T1=2,55±0,38 T2=2,43±0,33 T3=2,50±0,35	Mean ∑AG=2,31±0,39 ∑FG=2,50±0,33	AG T1=0,48±0,41 T2=0,41±0,37 T3=0,28±0,32	FG T1=0,84±0,46 T2=0,95±0,44 T3=0,89±0,45	Mean ∑AG=0,39±0,31 ∑FG=0,89±0,41	not mentioned	not mentioned	not mentioned
Issa *et al.*, 2020	AG Tx=0,008	FG Tx=1,06	—	not mentioned	not mentioned	not mentioned	AG Tx=0,2	FG Tx=1,7	—	AG Tx=0,01	FG Tx=0,37	—

4. Indices comparison

Among the 8 studies, they presented different tools for the comparative evaluation of patients periodontum. Time measure assessment were also different. Only two studies: Miethke & Vogt (2005) and Miethke & Brauner (2007) presented the same indices, respectively GI, PBI, PI, SPD and the same time measure which corresponded to 3 different time with 21/28 days of interval. Following the idea to compare the highest quantity of data available among the different studies, we selected different outcome measures according with their frequency. In this sense, PI used in all the studies has been selected as well as PD (6/8), GI (6/8) and BoP (6/8) in a quantitative analysis. Methods employed to realize indices evaluations are not the same among the studies. GI, PD, BoP indices described no difference between patients undergoing orthodontic treatment with fixed appliances and with clear aligners -even if global outcome describes lower value in favor of aligners. PBI index -not mentioned in Table 4 also showed no significative difference between both appliances. Only the Plaque index is associated to a significative difference. Large spectrum of time treatment was used relatively to the 8 studies selected, which made it difficult to evaluate it. A certain point where most indices had an increase in both appliances, especially in fixed orthodontic appliances was noticeable, designating a period of 3-9 months.

5. Individualization of the authors

Pango Madariaga *et al.* (2020) demonstrated that only BoP significantly increased in fixed appliances as compared with aligners at the baseline evaluation (respectively 0,77 versus 0,55; p=0,006). Those results decreased and turned similar at T3 (0,13 for both appliance). Intra group comparison showed statistically significant decreases between T0 and T3 in both groups for PD, BoP and PI. This study introduced a new index, REC describing higher value in the aligners group. Nevertheless, Authors conclude that the type of appliances did not have any effects on the improvement of periodontal variables -neither aging and number of sited evaluated even if they were significant- giving more credits to other criteria.

In the same courant, Chhibber *et al.* (2017) also contradicted population beliefs that removable appliances compare to fixed one are less subject to undesirable effects on periodontal health. If aligners group described lowest mean values for PI, GI, PBI in comparison with self-ligated and conventional elastomeric brackets, odds ratio at T18 were no

significant -pointing no evidence of differences in term of level of oral hygiene for the 3 types of appliances: this is all the truer for PI index; none of the odd ratios were significantly away from 1 (p>0,05 insignificant) at the 3 time evaluation. In addition, results between SLB and ELB were almost similar. However, odds ratios comparing aligners and conventional brackets for GI (OR=0,14; p=0,015) and PBI (OR=0,10; p=0,012) were statistically significant at T9 suggesting that aligners performed better at short time (those indices were more than twice as high for FG between T0-T9 and almost stable for aligners). They should be 86% less likely than the fixed group to have degree of periodontal inflammation and 90% less likely to have papillary bleeding. Authors concluded by fact that the choice of orthodontic appliance has a little impact on the clinical periodontal parameters.

Levrini *et al.* (2015) described a statistically significant difference between both groups for PI, BoP and PD; aligners patients being associated to lowest mean values. In this prospective study, intra-group comparison painted significative worst periodontal parameters scores regardless the indices -increasing at T3 in the fixed group, as well as the total biofilm mass but statistics were not mentioned. Aligners showed a statistically significant increase only for PI at T3 but again results were not present. Real time PCR analysis revealed a statistically significant difference in the total biofilm mass with a lower score in the 90 days follow-up examination for aligners group. Moreover the microbiological analyses detected the presence *A.actinomycetemcomitans,* in 1 patient subject to fixed appliances at T1 and T3. In this track, the mean bacterial concentration "C" was also significantly lower in aligners, corroborating a bigger plaque accumulation in the fixed group. Authors concluded that removable appliances must be considered as a first treatment option in patients subject to periodontal disease.

Following the same dynamic Abbate *et al.* (2015) also realized a microbiological analysis but, none of the patients tested were subject to any periodonpathic anaerobes after 12 months of treatment. From the baseline until 1 year of treatment, the full mouth plaque (FMPS) value tripled and full mouth bleeding (FMBS) doubled for teenagers treated with fixed appliances; both scores fell softly in the teenagers wearing aligners. According to PI and BoP, we can underline a completely -significant opposite trend in time between the 2 groups: both indexes progressively increased for fixed appliances (PI from 0,82 to 2,42) contrasting with a continuous decrease in patients using aligners (PI 0,91 to 0,36), suggesting less plaque accumulation and gingival inflammation in this case. Moreover, the sulcus probing increased in all the treated patients -specially in fixed group (2,26 to 3,42) while he remained stable in

aligners group (2,28 to 2,5). Authors highlights compliance oral-hygiene evaluation, displaying a favorable significative difference for removable treatment.

Azaripour *et al.* (2015) through API/MPI index described an increase of dental plaque in both appliances, higher in the fixed group (37.7%±21.9) in comparison with aligners (27.8%± 24.6), nevertheless the difference was not significant at T12. Authors displayed significantly a lower gingival inflammation for aligners patients (cf. Chhibber *et al.*,2017). Indeed, if GI and SBI increased in aligners group, those indexes were almost doubled between the initial-ending time of treatment (T12) for the fixed group (GI:0,29±0,24 to 0,54±0,50 and SBI 7,2±4,4 to 15,2±7,6).

In Miethke & Vogt (2005) clinical trial, all indices described a basic improvement from the first to the third screening -regardless the orthodontic appliance. Initially, no statistically significant differences for GI, PBI and SPD were found. The one exception was PI -already significantly different at the first evaluation (fixed group on average 0,32> than aligners). Moreover, scores comparison from all three evaluation time points showed a significantly lower PI for patients treated with aligners. The most superficial improvement concerns SPD. In other terms, Authors concluded they were no differences initially and during treatment between fixed appliances and aligners, crediting the improvement of oral hygiene with other criteria.

In a second study Miethkhe & Brauner (2007) established the same work but bonded the brackets on the lingual/palatine surface. The SPD was slightly increased in both study groups but did not differ significantly; minor changes might be associated to superficial periodontal disease according to the Authors. Without surprises GI and PI scores -at the first screening- were twice as high and PBI half as high in patients wearing brackets. All three indices were significantly worse at the 2nd and 3rd screening, standing in stark contrast with the aligners group and showing how complex oral hygiene is in this case.

Issa *et al.* (2020) also demonstrated the difference in terms of plaque levels, much lower in aligners patients than those undergoing conventional treatment. Moreover, patients treated with aligners showed better scores in all the 7 indices recorded: PI, GI, GBI, SBI, PBI, BPE, BoP. Only BoP index showed no significant differences (p=0,704) -this result might be explained by patient compliance of oral hygiene instructions. Proper to this study, Authors mentioned the Basic Periodontal Examination index in order to evaluate the periodontal

heath. Also results reveled no significant differences between self-ligating brackets and aligners -suggesting a better control of oral hygiene with this type of brackets over conventional or ceramic brackets.

IV. DISCUSSION

Periodontal health is an important factor that may be used to evaluate the success of orthodontic therapy. Periodontal complications are reported to be one of the most common side effects linked to orthodontics. The periodontal complications associated with orthodontic therapy mainly include gingivitis, periodontitis, gingival recession (Alfuriji *et al.*, 2014). However, the risk and complication associated with treatment are reported to be considerably lower compared to other surgical or nonsurgical interventions (Preoteasa, Ionescu e Preoteasa, 2012).

Presence of microbial plaque is reported to be the most important factor in the initiation, progression, and recurrence of periodontal disease (Genco & Borgnakke, 2013). If results -in terms of significancy are contrasted between authors, it is clearly established that fixed orthodontic appliances can promote dental plaque, vector of gingival inflammation. Indeed, orthodontics brackets and elastics might interfere with effective removal of dental plaque, thereby increasing the risk of gingivitis. Few clinical studies also reported poor periodontal health and greater loos of clinical attachment level distally in the dental arches. This could be a result of poor oral hygiene in molar regions and the presence of molar bands, with favors food lodgment (Alexander, 1991). The gingival, distal, and mesial areas, in relation to the brackets, attracted more biofilm than the occlusal areas, which was mostly due to the interference of arch wires and ligating devices on tooth brushing. There is also relatively less self-cleaning from natural chewing in these areas (Garcez *et al.*, 2011). The presence of fixed orthodontic appliances encourages the growth and retention of dental plaque which results in localized gingivitis (van Gastel *et al.*, 2007). The problem of the lack of adequate microbial plaque removal takes greater dimensions when undergoing orthodontic treatment (Davis *et al.*, 2014; Sifakakis *et al.*, 2018). Plaque accumulation can favor the transition of the microbial biofilm to a more aggressive periodontopathogenic flora in sub-gingival periodontal pockets and the production of pro-inflammatory cytokines (Ren & Vissink, 2008).

Abbate *et al.* (2015) and Levrini *et al.* (2015) works painted inferior periodontal health and superior total biofilm mass through microbiological analysis -in short-term (3 months follow-

up) with patients wearing fixed orthodontic appliances, promoting by fact clear aligners as a first treatment option in patients with risks of periodontitis. Furthermore Levrini *et al.* (2015) work displayed only one patient undergoing fixed orthodontic treatment subject to *A.actinomycetemcomitans.* In this sense Ristic *et al*. (2007) prospective study concluded that fixed appliances in adolescents may transitionally increase the values of all periodontal indices -pointed maximum value at 3 months of treatment and stimulate the growth of periodontopathogenic bacteria, but without destructive effects on deep periodontal tissues.

Mummolo *et al.* (2013) displayed a different trend in bacterial colonization of *S. mutans* and Lactobacilli and Plaque Index in both appliances. The maintenance of a better macroscopically (PI) and microscopically (*S. mutans and Lactobacili*) oral hygiene level in patients with removable appliances should be related to the absence of fixed retentive surfaces on the patient's teeth and with the consequent facilitation of oral hygiene procedures. This conclusion is consistent with Levrini *et al.* (2015) work. Increased levels of *S. mutans* and *lactobacillus* species have also been reported to be detected in the oral cavity after bonding orthodontic attachments, and some studies have reported that there is a positive correlation between dental caries and the degree of infection with these bacterial species (Lundström & Krasse, 1987).

In this integrative review, different indices were evaluated: GI, PD, PI, BoP, GBI, SBI, PBI, API/MPI, REC and BPE. The lack of consensus between Authors is obvious, nevertheless most of them agreed that only PI showed a significant difference/improvement in patients treated with clear aligners in comparison with those treated with fixed orthodontic appliances. In Miethke and Vogt (2005), Miethke and Brauner (2007) and Abbate *et al.* (2015) the plaque index decreased in time while Issa *et al.* (2020) displayed a significant difference between both appliances. Several explanations are plausible. On a hand, wearing a traditional brace will make people feel uncomfortable, and it is difficult to conventional cleaning. Patients must carefully brush each bracket and gloss around the wires to remove all traces of plaque, in order to reduce the risk of demineralization during this treatment (Bräscher *et al.,* 2016). This is all the truer for fixed lingual appliances in which the frequent plaque deposition is not surprising, as almost 60% of all patients wearing lingual appliances complain about significant difficulty with tooth brushing (Hohoff *et al.,* 2003). On another hand, unlike fixed dental appliances, removable orthodontic appliances can be taken out and thus enable patients to practice oral hygiene procedures under ideal conditions (Taylor *et al.,* 2003). Another

possibility is that aligners cover the majority of crown, preventing the accumulation of dental plaque on the teeth as well as the transition of supragingival dental plaque to subgingival tissues leading undeniably to potential destructions. A positive relationship between removing the appliance before eating/drinking and compliance with oral hygiene -turning those patients more sensitive to oral care might be mentioned. Also, aligners are more prevalent in the adult population in which oral hygiene education is less complex than adolescents. They are more co-operative in following the instruction from orthodontists (Bagga, 2010). On this track, Abbate *et al.* (2015) work showed a significant difference of compliance with oral hygiene between aligners and fixed orthodontic appliance. To Miethke and Vogt (2007), Abbate *et al.* (2015), Azaripour *et al.* (2015), Levrini *et al.* (2015) and Issa *et al.* (2020) patients treated with clear aligners have a better periodontal health than those treated with fixed appliances.

Miethke & Vogt (2005), Chhibber *et al.,* (2017) and Pango Madariaga *et al.* (2020), results contradicted this affirmation and accredited other explanations. The almost day-long coverage of all tooth surfaces increases the accumulation of soft matter, which in turn could lead to sub-chronic inflammation. Further, the margins of aligners, almost never perfectly smooth, can irritate the marginal gingivae (Mietkhe & Vogt, 2005). Other authors (Addy, Perriam & Sterry, 1982) reported an interference with flushing effect of saliva on dental tissues due to permanent coverage of the surface teeth. Also, insufficient saliva secretion reduces the self-cleansing mechanisms of the oral cavity and limits the antimicrobial effects of the residual saliva -which can lead to greater accumulation of dental plaque (Lara-Carrillo *et al.,* 2010; Türköz *et al.,* 2012). Only Chhibber *et al.,* (2017) suggested that aligners may offer superior gingival conditions in short-term of treatment, however all of them highlighted the crucial role of oral hygiene procedure, leading over the type of appliance chosen. In this sense, Miethke & Vogt (2005) and Pango Madariaga *et al.* (2020) raised no evidence of differences between both appliances when regular check-ups and oral hygiene instructions are performed. Chibber's work extended this conclusion at long-term treatment. To the Authors, great importance should be given to the motivation of the patient including regular check-ups and by personalizing home hygiene technique. Others studies (Acharya *et al.,* 2011; Lalic *et al.,* 2012) reinforced this conclusion.

1. Limitations

Orthodontic treatment time refer to several variables such as age, malocclusion severity, therapeutic choice etc. Among the 8 studies, different time measure was considered. Only 1 study focused on long-term evaluation and 1 study did not mentioned specifically the time evaluation. Results revealed that all the indices increased at 6 months but most of the studies reached their last evaluation at 3 months. Oral hygiene instruction and follow-up by professional were different: in some studies patients were naive from oral hygiene instruction but in other they received instructions and prophylactic treatment before initiating the orthodontic treatment influencing undeniably the results. The role of malocclusion in periodontal health is important (Bollen *et al.*, 2008) but was not present in the studies. Periodontal parameters were assessed differently according to the studies; technic (Ramfjord system, etc.) and material were not the same -considering the probe, number of teeth, number of surfaces involved. Some Authors did not precise their evaluation method. Methods for measuring indices were not similar (FMPS, API, etc.). Ages between patient differed, studies considering adults and others adolescents which reveled heterogeneity. The studies included in this work were mainly prospective cohort studies with only 1 randomized control study. It leads to insufficient amount of information for comparison and bias will appear.

V. CONCLUSION

Patients treated with clear aligners are less subject to plaque accumulation than those undergoing fixed orthodontic appliances. Being removable oral hygiene maintenance is facilitated in comparison with brackets appliances, leading undeniably to more obstacles. However, among all the indices evaluated, only PI differed significantly. Placement of fixed appliances might impact the oral microflora at short-term. Instructions and oral care are important actors during orthodontic treatment and influenced periodontal results, both were different among the studies. If aligners performed better in short-term, we do believe it would be reductive to affirm that aligners guaranty better periodontal heath over fixed appliances, particularly during long time treatment, which is conventionally the period associated to orthodontic treatment. More studies, especially randomized controlled trials, are needed to demonstrate fully that aligners offer better gingival conditions.

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