

## Evaluation of periodontal health status in patients undergoing fixed orthodontic treatment. A systematic review

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### Abstract

Background: The transmission of orthodontic forces through the stressed tissue matrix onto the local cells within the periodontal ligament and alveolar bone, stimulate the cells to release

proinflammatory, angiogenic and osteogenic agents that activates the process of periodontal ligament and alveolar bone remodelling. Studies have suggested that orthodontic therapy when not fully controlled, may influence the process of inflammation and the destruction of periodontium leading to increased loss of attachment.

**Objective:** To evaluate updated scientific evidence on the relationship between fixed orthodontic therapy and periodontal health.

**Methods:** A systematic literature search was performed using the Pubmed and other databases with keywords “orthodontic” and “periodontal” based on PRISMA 2020 guidelines. Articles published from January 2000 to September 2022 were included. The studies that satisfied the inclusion criteria were evaluated and classified as having low, moderate, or high methodology quality.

**Results:** 12 articles were selected from a total of 864 searched articles after assessing the quality using cochrane ROB 2 assessment tool.

**Conclusions:** The present systematic analysis suggests that there is moderate scientific evidence that a fixed appliance influences periodontal status; no article reported a high score.

**Keywords:** Orthodontic therapy, Periodontal status, Fixed appliance, Systematic review, Orthodontics effects.

## **Introduction:**

The relationship between orthodontic procedures and periodontal status is considered a challenge, especially periodontal health during and after orthodontic treatment. Several studies have addressed the impact of fixed, removable, and myofunctional orthodontic/orthopaedic appliances or retainers in relation to supragingival plaque accumulation and gingivitis (Glans et al., 2003; Skold-Larsson et al., 2003). These supragingival conditions are reversible a few months after appliance removal in patients with a good standard of oral hygiene. Alexander (1991). Multiple studies have suggested that orthodontic treatment not only provides dental esthetics but has a strong psychosocial impact on patients as well. (Gazit-Rappaport et al., 2010) Adult orthodontic patients having severe bone loss presents a continued challenge to clinicians. Healthy periodontium is usually associated with well-aligned dentition than crowded and maloccluded teeth. Studies believe that when orthodontic appliances are applied correctly the forces will not damage the periodontium surrounding it. Orthodontic appliances can also support the periodontal tightening and splinting where oral hygiene is present. (Ristoska et al., 2019)

Gingival inflammation occur when there is a significant accumulation of plaque, thus leading to gingivitis (plaque-induced) which may manifest several patterns with visible signs and symptoms of inflammation that are localized in the gingiva, such as bleeding and edema, if

left untreated it can progress to periodontitis which is characterized by the loss of supporting and surrounding bone (Katancik et al., 2016). Even if the dental plaque biofilm levels decreased, inflammatory infiltrates will still be available within the gingival tissues presented as a part of the physiologic immune system. (Lang and Bartold, 2018) Bacteria present in plaque secrete multiple compounds such as antigens, toxins, and enzymes, which influence the initiation of an inflammatory response that is protective in nature but is also responsible for breakdown of periodontium, increase pocket depth and loss of teeth. (Loesche, 1996). Inadequate and non-consistent oral hygiene activities such as toothbrushing and flossing, influence the accumulation of dental biofilms, which consequently relates for the initiation and progression of periodontal diseases. This indicates the importance of oral hygiene role in the prevention of periodontal diseases. Multiple research projects of experimental and clinical trials have agreed that periodontal health necessitates an efficient removal of dental plaque (Lertpimonchai et al., 2017, Santos et al., 2021). It is very important to maintain high-level of oral hygiene at home and adequate visits for professional cleaning during and after the completion of orthodontic therapy (Meeran and Parveen, 2011).

The transmission of orthodontic forces through the stressed tissue matrix onto the local cells within the periodontal ligament and alveolar bone, stimulate the cells to release proinflammatory, angiogenic and osteogenic agents that activates the process of periodontal ligament and alveolar bone remodelling (Feller et al., 2015). Studies have suggested that orthodontic therapy when not fully controlled, may influence the process of inflammation and the destruction of periodontium leading to increased loss of attachment (Artun and Urbye, 1988). A study explained that the orthodontic movement synergies with periodontal disease in influencing the breakdown through increasing the levels of proinflammatory cytokines (Boas Nogueira et al., 2013). Clear aligner therapy (removable orthodontic treatment) has been introduced into adult orthodontics recently, several advantages have been found including improved aesthetic results (Boyd, 2009). It constitutes clear plastic splints that cover all teeth and the marginal aspects of the gingiva which gradually move the teeth into an ideal arrangement. Multiple studies have also reported that periodontal health is not affected by this treatment modality, mainly due to its removable application not affecting the oral hygiene levels (Boyd, 2009).

The interlinked relationship existing between periodontal tissues and tooth movement processes suggest that orthodontic treatment has an important impact in overcoming associated problems, but if movement became excessive beyond the anatomic boundaries of the alveolar process then it will further contribute in the destruction of the

periodontium(Antoun et al., 2017). This study aims to systematically review available studies in literature that are concerned about the relationship between fixed orthodontic treatment and periodontal health.

**Aim**

To evaluate updated scientific evidence on the relationship between fixed orthodontic therapy and periodontal health.

Criteria	Determinants
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**Materials and Methods**

*Study inclusion and exclusion criteria*

Following the PRISMA 2020 flowchart, articles were first excluded according to the title and abstract; if titles were not written in English language or was irrelevant to the scope of the review. Screening of full texts were done according to eligibility criteria. Studies included were randomized control trial, clinical trial; prospective and retrospective, an observational study; either cohort or case-control study, cross-sectional study, patients needed an orthodontic appliances or have undergone orthodontic treatment; either fixed orthodontic appliance or Invisalign system (removable orthodontic appliance) were outcomes have been compared, clinical findings were correlated with underlying cause if it was due to mechanical or microbiological activity. According to the exclusion criteria, studies of irrelevant topics and that are not related to the review topic either due to use of different orthodontic appliance or that haven't correlated the relationship between orthodontic treatment and periodontal health, studies not written in English language nor full text is available, case reports, case series, systematic reviews, meta-analysis, literature reviews were excluded.

**Search strategies**

Databases have been searched to answer the focus question of this review, “Is the periodontal health of patients who have undergone orthodontic treatment affected by the fixed appliances?”. The electronic databases that were searched included: Medline/PubMed, Cochrane Library, Scielo, Web of Science, and Scopus from January 2000 until 15 September 2022. Keywords used to identify relevant articles included: orthodontics, orthodontic treatment, fixed orthodontic treatment, fixed orthodontic appliance, periodontics, periodontal health, periodontium. PRISMA 2020 statement and flow diagram were used to select the articles. Total of 12 articles were identified after excluding duplicates.

Table 1: *PICO table to determine eligibility of research question*

<b>Population</b>	The patients that have undergone or will undergo orthodontic treatment with fixed appliances.
<b>Intervention</b>	Fixed orthodontic treatment
<b>Comparison</b>	Comparison of orthodontic treatment other than fixed appliance.
<b>Outcome</b>	Periodontal changes associated with fixed orthodontic treatment.

### *Data extraction*

Data from the selected study including author name, year of publication, article aim, demographics, included groups (study and control) mean age and number of participants if applicable, the process of study conduction, study outcomes relating fixed orthodontic appliance and periodontal health and conclusion were retrieved and summarized in table 2.

### *Quality and risk of bias assessment of selected studies*

Risk of bias and quality assessment was done using Cochrane ROB 2 risk of bias assessment tool for the selected articles. Domains assessed included: bias arising from randomization process, bias due to deviations from the intended interventions, bias due to missing outcome data, bias in measurement of the outcome and bias in selection of the reported results. According to the risk of bias tool used, included studies could receive a maximum score of nine which indicates the methodological quality, thus indicates the risk of bias. Studies scored 7–9 points were considered being a low risk of bias article, 5–6 points were considered medium-level risk of bias article and those scored less than five points were considered high risk of bias. Of the included 12 articles in this review, 2 were of high risk, one had some concerns and 9 had low risk of bias (Table 3). The unrandomized control trials, retrospective studies, methodological quality assessment was conducted using the modified Newcastle-Ottawa scale, which covered 3 aspects, patient selection, comparability between study groups and assessment of the outcome.

Table 2: Summarized data of the 12s included studies

Literature	Research Design	Research Purpose	Subject	Result	Conclusions
Sheibaninia et al. (2011)	Case control	To evaluate the correlation between the use of fixed orthodontic appliances and periodontal conditions.	60 female participants. Mean age of 15 years. Two groups: Study group; undergoing orthodontic treatment (n=30) Control group; not undergoing orthodontic treatment (n=30)	Gingival bleeding; 50% in the control group, 76.7% in the study group (P<0.3). Gingival recession; 3.3% in the control group, 0% in the study group (P<0.9). Gingival hyperplasia. 13.3% in the control group, 46.4% in the study group (P<0.005).	Fixed orthodontic appliances rise the probability of experiencing gingival bleeding and Hyperplasia.
Gomes et al. (2007)	Case control	To evaluate periodontal conditions in individuals who had undergone orthodontic treatment with fixed appliances.	54 (23 males, 31 females) participants. Mean age of 23 years Two groups: Study group; underwent orthodontic treatment (n=29) Control group; not undergone orthodontic treatment (n=25)	Visible plaque index, gingival bleeding index, bleeding on probing; Not significant between the groups. Periodontal probing depth; Not significant between the groups. Significant for canines. Clinical attachment loss; Not significant between groups. Significant for canines.	The use of orthodontic appliances is not certainly related to aggravating periodontal problems.
Jiao et al. (2019)	Retrospective cohort study	To evaluate if periodontal status in patients with stage IV/grade C periodontitis was affected after fixed orthodontic treatment.	24 (8 males, 16 females) participants. Age not considered. Individuals included: patients with stage IV/grade C periodontitis	The only clinical parameter with statistically significant improvement was bleeding on probing. Probing depth, bleeding on probing,	Periodontal stability can be obtained for patients with stage IV/grade C periodontitis after orthodontic treatment.

			that received combined periodontal and orthodontic treatments.	percentage of relative bone height; no change was detected after orthodontic treatment.	
Calniceanu et al. (2020)	Clinical trial	To assess specific site-level changes that occurred due to orthodontic forces in adult patients with severe periodontal disease that underwent standard periodontal therapy.	13 (5 males, 8 females) participants. Mean age of 36 years Individuals included: patients previously treated for severe generalized periodontitis were given fixed orthodontic appliances.	Clinical nor microflora parameters showed significant differences in the between baseline and 6 months of orthodontic treatment.	The presence of periopathogens doesn't negatively affect periodontal health during orthodontic treatment in adult patients treated for severe periodontitis.
Salvesena et al. (2021)	Retrospective cohort study	To evaluate the periodontal status in patients undergoing orthodontic retention control and possible risk indicators.	211 (96 males, 115 females) participants. Mean age of 21 years Individuals included: patients who underwent orthodontic retention control between three to ten years after orthodontic treatment	Periodontal parameters were within the limits of healthy periodontium clinically. Fixed retainers and older age are the only variables that were significantly associated with increased calculus.	Long-term fixed retainers have no harmful effect on the periodontium alone. Additional factors may increase the risk of plaque deposits and increased probing pocket depths.

Madariaga et al. (2020)	Clinical trial	To evaluate the periodontal health of orthodontic patients with supportive periodontal therapy in a 3-month follow-up	40 (14 males, 26 females) participants. Mean age of 28 years Two groups: Fixed group: patients ongoing multibracket fixed therapy (n=20) Clear aligners group; patients in treatment with clear aligners (n=20)	Statistically significant decrease in both groups was found for pocket depth, bleeding on probing and plaque index. No significant difference based on type of appliance used.	Patients undergoing orthodontic treatment with fixed appliances and clear aligners did not show differences in gingival health when followed by a dental hygienist.
Levrini et al. (2019)	Clinical trial	To compare the periodontal health and the microbiological changes in patients treated with fixed orthodontic appliances and Invisalign system.	77 (25 males, 52 females) participants. Mean age of 24.3 years Three groups: Invisalign group (n=32) Fixed orthodontic appliances group (n=35) Control group (n=10)	The Invisalign group showed superior results in terms of periodontal health and total biofilm mass compared to the fixed orthodontic appliance group.	Patients undergoing orthodontic treatment with the Invisalign System show better periodontal health when compared to patients in treatment with fixed orthodontic appliances.
Liu et al. (2011)	Clinical trial	To examine periodontal changes and the relative quantity of subgingival Porphyromonas gingivalis during orthodontic treatment.	48 (13 males, 35 females) participants. Mean age of 17 years Two groups: Group A; patients who were at the beginning of orthodontic treatment (n=28) Group B; patients who were at the	There was a significant increase in Plaque and gingival index during the first 3 months of appliance placement but a significant decrease in Plaque index, gingival index, and probing pocket depth during the first 6 months after appliance	Fixed orthodontic treatment is conducive to dental plaque accumulation and gingival inflammation., it may imply a potential risk to periodontal health in certain patients.

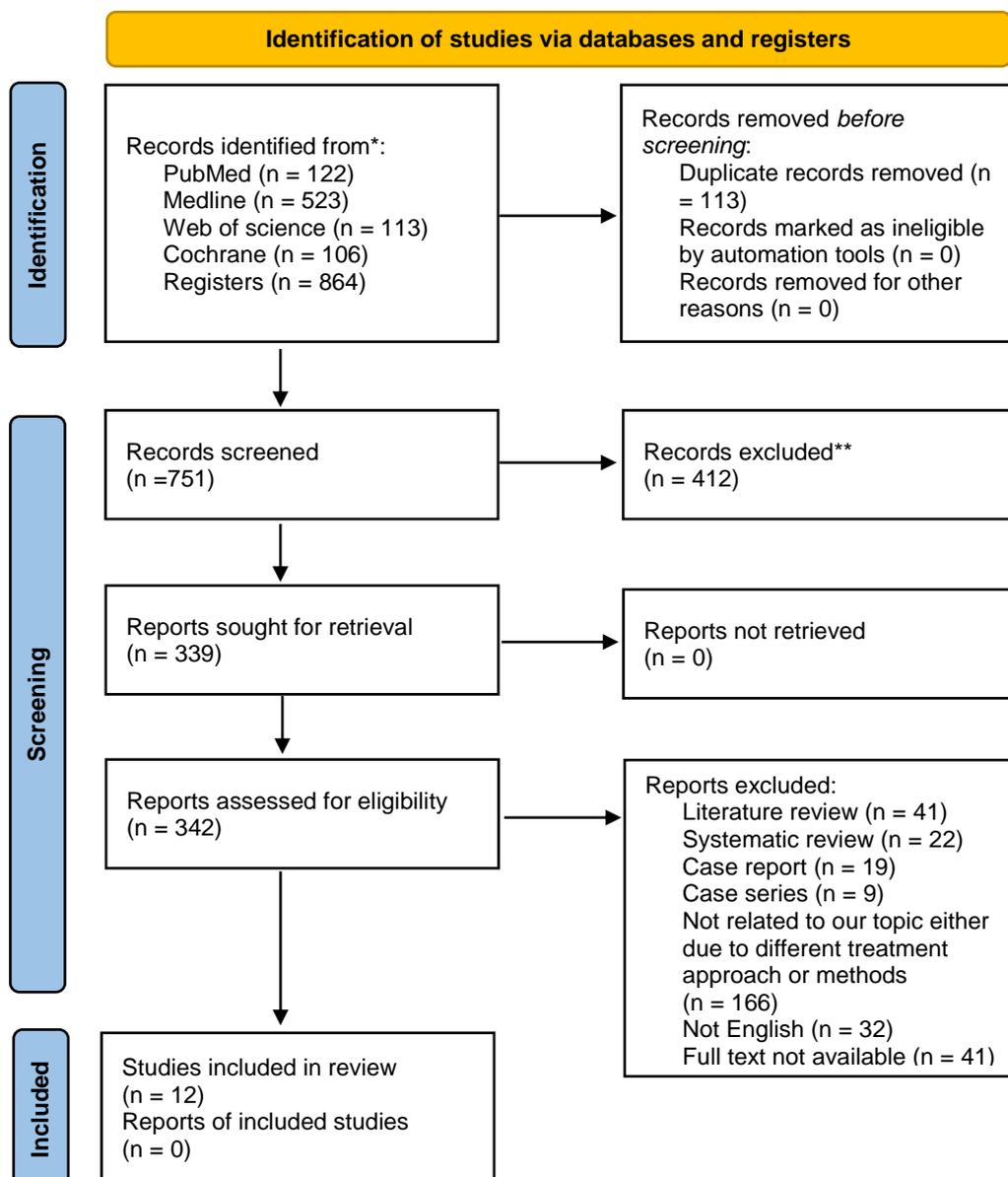
			completion of orthodontic treatment (n=20)	removal. Subgingival P. gingivalis were high at the end of orthodontic treatment, and they decreased significantly after appliance removal.	
Abbate et al. (2015)	Clinical trial	To evaluate and compare the microbiological and periodontal changes occurring in adolescents during orthodontic therapy with removable and fixed appliances.	50 participants. Aged 10-18 years Two groups: Group 1; treated with Invisalign aligners (n=25) Group 2; treated with fixed orthodontic appliances (n=25)	None of the patients was positive for the periodontal anaerobes analyzed. The plaque index, probing depth and bleeding on probing were significantly lower in the group treated with Invisalign than in the group treated with fixed brackets. Compliance with oral hygiene was significantly higher in the group treated with Invisalign than in the group treated with fixed brackets.	Teenagers treated with Invisalign aligners display better compliance with oral hygiene, less plaque, and fewer gingival inflammatory reactions than their patients treated with fixed appliances.
Corbett et al. (2014)	Observational cross-sectional	To compare the periodontal health of maxillary and mandibular anterior teeth retained with two types of fixed retainers.	74 (30 males, 44 females) participants. Mean age of 17 years Two groups: Group 1; treated with a straight twisted wire retainer (n=35) Group 2; treated with a	There was no significant difference between the two retainer groups regarding plaque index, gingival crevicular fluid volume, calculus index, recession, bleeding on probing, and pocket probing	No clinical difference was found in the periodontal health of anterior teeth retained with a SR or WR for a period of 2 to 4 years.

			wave-type retainer (n=39)	depths.	
Al-Moghrabi et al. (2018)	Randomized control trial	To compare the stability of treatment and periodontal health with fixed vs removable orthodontic retainers over a 4-year period	42 (10 males, 32 females) participants. Mean age of 21 years Two groups: FR group; treated with fixed retainers(n=21) VFR group; treated with vacuum-formed retainers (n=21)	Both groups showed similar periodontal outcomes with significant gingival inflammation and plaque levels.	Fixed retention offers the potential benefit of improved preservation of alignment of the mandibular labial segment in the long term. However, both types of retainers were associated with gingival inflammation and elevated plaque scores.
Gastel et al. (2010)	longitudinal, prospective	To monitor patients' microbiological and clinical parameters from bracket placement to 3 months after treatment.	24 (10 males, 14 females) participants. Mean age of 15 years sub- and supragingival microbes periodontal probing depth (PPD), bleeding on probing (BOP), and gingival crevicular fluid (GCF) flow were assessed at baseline (T1), at bracket removal (T2), and 3 months post-treatment (T3).	Sub- and supragingival colony-forming units ratio decreased significantly at T2 compared with T1. Clinical parameters PPD, POB, and GCF flow showed a significant increase between T1 and T2. Between T2 and T3 these variables decreased significantly but remained significantly higher than at T1 [except for BOP values at the bonded sites (P = 0.0646)].	Placement of fixed orthodontic appliances has an influence both on microbial and clinical periodontal parameters, which were only partly normalized, 3 months following the removal of the appliances.

**Results:****Flow Diagram**

In this systematic review authors followed the PRISMA 2020 flow diagram as represented in figure 1. In the identification stage, 864 articles were found in the initial search with 523 articles from medline, 122 articles from pubmed, 113 articles from web of science and 106 from Scopus. Duplicates found simultaneously between multiple databases were removed. In the screening stage, articles were removed according to the titles and abstract summaries, a total of 12 articles remained after elimination. Further removal was done after reading the whole articles and relating them with the inclusion and exclusion criteria. In this systematic review 12 articles were selected, and all were assessed for risk of bias.

Figure 1: PRISMA flowchart



### ***Study Characteristics***

Most studies included in this systematic review were clinical trials, their sample sizes ranged from as low as 13 in the study by Calniceanu et al. (2020) to as high as 77 in study by Levrini et al. (2019). While case control studies had a sample size of about 55 patients.(Sheibaninia et al., 2011, Gomes et al., 2007) Both randomized control trials included about 40 patients.(Abbate et al., 2015, Al-Moghrabi et al., 2018) The Retrospective cohort studies had major differences in sample sizes, ranging from as low as 24(Jiao et al., 2019) to as high as 211.(Salvesen et al., 2021) One of the included study was an observational cross-sectional study and included 74 patients.(Corbett et al., 2015) Another study was a longitudinal prospective study, which included 24 patients.(van Gastel et al., 2011)

Within the twelve studies included, only three studies considered a control group to compare with study group which used fixed orthodontic appliances, where number of participants was comparable between groups.(Sheibaninia et al., 2011, Gomes et al., 2007, Levrini et al., 2015) Five studies compared between two groups such as: a group undergoing fixed orthodontic treatment and a group treated with Invisalign system,(Madariaga et al., 2020, Abbate et al., 2015, Al-Moghrabi et al., 2018) or comparing two types of fixed appliances,(Corbett et al., 2015) or according to the stage of treatment.(Liu et al., 2011) Four studies consisted of studying only one group that have undergone orthodontic treatment.(Jiao et al., 2019, Calniceanu et al., 2020, Salvesen et al., 2021, van Gastel et al., 2011)

In six studies, quantity of male and female participants were comparable.(Gomes et al., 2007, Calniceanu et al., 2020, Salvesen et al., 2021, Madariaga et al., 2020, Corbett et al., 2015, van Gastel et al., 2011) One study only included females.(Sheibaninia et al., 2011) There was no information reported regarding distribution of males and females in one study.(Abbate et al., 2015)

Participants mean age was comparable which mostly included younger individuals ranging from 10 years old(Abbate et al., 2015) to 36 years old.(Calniceanu et al., 2020) In a study conducted by Jiao et al. (2019) age of participants was not considered.(Jiao et al., 2019)

All included studies in this review investigated the relationship between fixed orthodontic treatment and periodontal health. In various aspects. Two studies evaluated its effect on periodontally compromised patients with severe periodontitis.(Jiao et al., 2019, Calniceanu et al., 2020) Two studies correlated the relationship with use of fixed orthodontic appliances compared to healthy individuals.(Sheibaninia et al., 2011, Gomes et al., 2007) Four studies looked into both clinical and microbiological aspects of the relationship existing between

fixed orthodontic treatment and periodontal conditions.(Levrini et al., 2015, Liu et al., 2011, Abbate et al., 2015, van Gastel et al., 2011) One study only compared between removable and fixed retainers.(Al-Moghrabi et al., 2018) One study compared between two types of fixed retainers.(Corbett et al., 2015) One study correlated the relation of fixed orthodontic treatment and periodontal health with oral hygiene level.(Madariaga et al., 2020) And one study reviewed the possible risk factors associated with the proposed relation.(Salvesen et al., 2021)

### Quality Assessment

Table 3: Risk of bias assessment with the recommended approach of Cochrane ROB 2

<u>Authors</u>	<u>D1</u>	<u>D2</u>	<u>D3</u>	<u>D4</u>	<u>D5</u>	<u>Overall</u>
Jiao et al. (2019)	?	+	-	+	?	-
Calniceanu et al. (2020)	+	+	-	+	+	+
Gomes et al. (2007)	-	+	+	?	-	-
Salvesen et al. (2021)	-	+	?	-	+	+
Sheibaninia et al. (2011)	+	+	+	?	+	+
Liu et al. (2011)	?	+	-	+	+	+
Gastel et al. (2010)	?	+	?	?	+	?
Levrini et al. (2019)	+	+	-	+	-	+
Abbate et al. (2015)	+	+	+	+	?	+
Al-Moghrabi et al. (2018)	+	+	+	-	+	+
Madariaga et al. (2020)	+	+	+	?	+	+
Corbett et al. (2014)	+	+	+	?	-	+

Abbreviations; D1: Bias arising from randomization process, D2: Bias due to deviation from intended interventions, D3: Bias due to missing data outcomes, D4: Bias in measurement of the outcome, D5: Bias in selection of the reported results. Red: High risk of bias, Orange: Some concerns, Green: Low risk of bias.

## **Discussion:**

Two of the articles included in this review studied the effect of orthodontic treatment on pathologically involved periodontium, whether patient has periodontitis or previously had periodontitis and have been treated. This topic has been discussed in multiple studies, as for a successful orthodontic treatment the base which the periodontium should be healthy to give such results, so the relationship has an effect both ways. Jiao et al. evaluated periodontal status after orthodontic treatment on patients with stage IV/grade C periodontitis. Study reported that there was no change detected on bleeding on probing, probing depth nor percentage of relative bone height after fixed orthodontic treatment. There were several predisposing factors that led to decrease in bone height including, being a female, excessive horizontal and vertical overlap, crowding, initial probing depth and bone height. The study concluded that periodontal stability in periodontally compromised patients with periodontitis stage IV/grade C, can be obtained after orthodontic treatment.(Jiao et al., 2019) Calniceanu et al. it evaluated the changes that occur at specific sites within the periodontium due to orthodontic treatment in patients who had periodontitis and been treated. The study reported that there were no significant differences in both clinical and microflora parameters between baseline and after 6 months of orthodontic treatment. The study concluded that pathogens associated with periodontal disease doesn't harmfully affect the periodontium that have previously undergone periodontic therapy by the forces exerted by orthodontic treatment.(Calniceanu et al., 2020) Evidence based studies suggest that fixed orthodontic treatment can be safely and satisfactorily executed if adequate oral hygiene is maintained even if previous disease was present. (Willmot, 2008) A recent randomized control trial by Gehlot et al. emphasized that orthodontic treatment doesn't significantly affect the periodontium after periodontal stabilization have been achieved.(Gehlot et al., 2021)

Two articles discussed the relationship between fixed orthodontic treatment on periodontal health. Gomes et al. evaluated the periodontal changes associated with orthodontic treatment. The study reported that plaque and bleeding indices, pocket depth and clinical attachment loss were not significantly different between patients that have undergone orthodontic treatment and who didn't. The study concluded that orthodontic treatment doesn't have an effect jeopardizing the periodontium(Gomes et al., 2007). Salvesena et al, evaluated the periodontal status of patients undergoing orthodontic treatment and any risk indicator associated. The study reported that measured clinical parameters were within the healthy periodontium limits. Some of the risk indicators include, older age and fixed orthodontic appliance were significantly associated with calculus formation, thus increasing probability

of inflammation. The study concluded fixed orthodontic treatment doesn't harmfully affect the periodontium alone, but there are predisposing factors such as increased plaque accumulation and pocket depth(Salvesen et al., 2021). Both studies revealed that there is no association between orthodontic therapy and harmful effect on the periodontium. Previous systematic reviews confirmed that fixed orthodontic treatment generally does not have harmful effects on periodontal tissues when a good oral hygiene is maintained(Bollen, 2008). Three articles discussed the inflammatory impact of fixed orthodontic treatment on the periodontal health. Sheibaninia et al. evaluated the correlation between use of fixed orthodontic appliances and periodontal conditions. The study reported that gingival bleeding and hyperplasia were higher in study group compared to control group, while gingival recession was higher in control group. The study concluded fixed orthodontic therapy will increase the probability of patients experiencing gingival bleeding and hyperplasia.(Sheibaninia et al., 2011) Liu et al. evaluated the periodontal changes and quantity of *P. gingivalis* during orthodontic treatment. The study proposed that there was significant increase in plaque and bleeding index during first 3 months of fixed orthodontic placement. There was significant decrease in plaque and bleeding indices and pocket depth during the first 6 months after removal of fixed orthodontic appliance. As for bacterial count, *P. number of gingivalis* were higher at the end of the treatment and have decreased significantly after orthodontic appliance removal. The study concluded that fixed orthodontic treatment increase dental plaque accumulation and inflammation, thus can be a causative factor compromising gingival health in some patients.(Liu et al., 2011) Gastel et al. evaluated changes that occur due to orthodontic treatment from bracket placement to 3 months within treatment, both clinical and microbiological parameters. The study reported that microbiological colonies decreased after bracket removal compared to beginning of treatment. The various clinical parameters (pocket depth, bleeding on probing, gingival crevicular fluid flow etc.) significantly increased from brackets time of placement to removal. The study concluded that fixed orthodontic treatment have an impact on both microbes and clinical findings, it would minorly become normal after 3 months of removal(van Gastel et al., 2011). Plaque have been reported to be the most provoking factor for initiation, progression, and recurrence of periodontal inflammation and diseases. After placement of a fixed orthodontic appliances most patients experience minimal amount of gingival inflammation(Bimstein and Becker, 2001). The resulted gingival inflammation surrounding the fixed orthodontic bands usually leads to pseudo-pockets, which regress within weeks after the band removal of the brackets(Alfuriji et al., 2014).

Three articles discussed and compared removable and fixed orthodontic appliances and their effect on periodontal health. Levrini et al. evaluated the periodontal health and microbiological changes associated in patients undergoing fixed orthodontic treatment and Invisalign system. The study reported that patients treated with Invisalign system showed better periodontal health and lower quantity of pathological microbes compared to those who have been treated with fixed orthodontic appliances. The study concluded that orthodontic treatment using Invisalign system is better than fixed orthodontic appliances for the periodontal health.(Levrini et al., 2015) Abbate et al. evaluated and compared microbiological and periodontal changes that occur with orthodontic therapy by removable and fixed appliances. The study reported that the plaque index, probing depth and bleeding on probing all were significantly lower in patients treated with Invisalign system compared to patients treated with fixed brackets. Oral hygiene compliance was better in those treated with Invisalign system. The study concluded that teenagers that were treated with Invisalign aligners had better compliance with oral hygiene, less plaque and gingival inflammatory reactions than patients treated with fixed appliances(Abbate et al., 2015). Al-Moghrabi et al. evaluated and compared the stability of orthodontic treatment and periodontal health with fixed and removable retainers for 4 years. The study reported that both fixed and removable retainers showed similar periodontal outcomes with significant gingival inflammation and plaque levels. The study concluded that even though orthodontic appliances provide improved teeth alignment, both types were associated with gingival inflammation and elevated plaque scores(Al-Moghrabi et al., 2018). Multiple studies compared various types of orthodontic treatment and it was collectively proposed that removable appliances such as Invisalign system had better periodontal health, as there was less plaque accumulation thus less inflammation(Azaripour et al., 2015). Another article included in this review discussed the relation of the orthodontic appliances and periodontal health, focusing on oral hygiene as an influencing factor. Madariaga et al. evaluated periodontal health with supportive periodontal therapy on patients undergoing orthodontic treatment. The study reported that there was statistically significant decrease in pocket depth, bleeding on probing and plaque index in patients with fixed and removable appliances. The study concluded that if patients followed up with oral hygienist, both appliance types show similar impact on periodontal health.

Other study compared two types of fixed orthodontic wires and its effect on the periodontium. Corbett et al. evaluated and compared periodontal health of upper and lower anterior teeth retained with two types of fixed wires. The study reported that there was no

significant difference in the various parameters including plaque index, gingival crevicular fluid volume, calculus index, recession, bleeding on probing, and pocket probing depths between both retainers. The study concluded that there was no clinical difference between straight twisted wire retainer and wave-type retainer when followed for 2-4 years (Corbett et al., 2015).

#### Limitations

Only two studies were randomized control trials and only three studies considered a control group, which hinders generalization of review results. There were significant differences in age and sex distribution between compared studies. Aims and intentions of studies included had differences thus meta-analysis was not possible to conduct for this review. Further studies are needed to confirm results and specify the specific factors which are associated with the studied relationship.

#### Conclusion

This systematic review suggests that fixed orthodontic appliances using during orthodontic treatment has moderately affected periodontal health, increasing inflammation perception mainly due to increased plaque accumulation. If good and sufficient oral hygiene measures is maintained by the patient during treatment, then inflammation levels would decrease and become minimal.

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