Review Article

Impact Of Forces Acting On Alveolar Bone Due To Orthodontic Therapy In Healthy And Diseased Periodontium: A Systematic Review And Meta Analysis

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Abstract:

Introduction: Orthodontic forces applied on teeth for the correction of malalignment have an impact on the underlying periodontal tissues. This may result in inflammation of the periodontal tissue. Thus, the present systematic review was conducted to study impact of forces acting on alveolar bone due to orthodontic therapy in healthy and diseased periodontium.

Materials and Methods: Electronic databases namely: PubMed, EBSCOhost, Science Direct, Google Scholar and EMBASE were used to search the studies. Randomized controlled trials, experimental studies, case control studies and cohort studies published in peer-reviewed Journals in English language was conducted from the following databases. The following articles were excluded: in-vitro studies, animal model studies, case reports, case series and also studies which were not published.

Results: A total of 12555 records were obtained at initial database search. 10525 records remained on title screening after excluding 1000 records. After removing the duplicates 425 articles remained and after excluding the abstracts 18 full text articles were considered. Out of 18 studies; only 6 studies satisfied the inclusion criteria. These six studies were analyzed.

Discussion: Orthodontic forces can have deleterious as well as beneficial effect on the periodontal tissues. There can be deleterious effects leading to inflammation of the periodontal tissues. Orthodontic forces can have beneficial effect in treating bony defects.

Conclusion: Orthodontic forces applied for correction of malaligned teeth have an impact on underlying periodontal tissues especially the bone. Hence application of excessive orthodontic forces can be detrimental to the periodontal tissues.

Keywords: orthodontic therapy, periodontal disease, periodontitis, alveolar bone, periodontal tissues.

Key messages: There was no association between alveolar bone levels and impact of orthodontic forces in healthy and diseased periodontium. Although there was change in clinical attachment level and probing depth observed in the included studies.

Introduction

Malocclusion has been a major concern affecting the aesthetics of an individual. It also affects the functions of speech and mastication. Orthodontic treatment can be started at different age groups which can affect the periodontium in different ways. It can be started as early as 7yrs of age subsequent to the eruption of first permanent molars. It may interfere with the oral hygiene maintenance of the patient resulting in plaque and calculus accumulation. This will subsequently lead to initiation and progression of the periodontal diseases and destruction of the same.[1]

Inflammation of periodontium is caused by microbes along with inflammation produced due to inflammatory mediators, loss of attachment, formation of periodontal pocket and bone loss. Advanced periodontal disease involves severe attachment loss and reduction of alveolar bone support. In the aesthetically driven world people have become more conscious about their smile and appearance leading to search in the orthodontic treatment and which if not done properly can have adverse effect on the health of the periodontal tissues.[2]

Remodelling of tissue is a physiological process which involves connective tissue and bone forming cells. This tissue remodelling helps in movement of the teeth due to orthodontic therapy. This movement of teeth is faster in the

individuals who are young and have healthy periodontal tissues.The activity of the bone forming cells (Osteoblasts) and bone resorbing cells (Osteoclasts) along with the activity of the cells of periodontal connective tissue result in faster movement of teeth in younger individuals.[3]

Orthodontic forces result in areas of pressure and tension. At the site of pressure there is compression of the tissues and resorptive activities taking place. At the site of tension there is formation of tissue. Excessive orthodontic forces in the compromised periodontium can result is periodontal tissue destruction.[3]

In healthy gingiva forces are incorporated by the tissues and there is minimal or no damage in the underlying periodontal tissues but in the compromised condition the forces cannot be enacted by the diseased periodontium leading to further tissue damage.[3]

It was observed that the cellular turnover rate, bone remodelling and healing is variable in among different individuals. It is faster in young individuals as compared to older individuals. Therefore, in the case of older patients receiving adult orthodontic treatment, the impact of orthodontic pressures on the periodontium is larger. Consequently, throughout orthodontic therapy, effort must be made to reduce the detrimental effects of orthodontic stresses on the periodontal tissues. Hence this systematic review was conducted to study the impact of forces acting on alveolar bone due to orthodontic therapy in healthy and diseased periodontium.[4]

Rationale

Although there are studies analyzing the effect of orthodontic forces on alveolar bone in periodontitis patients, there is limited documentation regarding the impact of forces acting on the periodontium subsequent to orthodontic therapy in healthy and diseased periodontium. Therefore, this systematic review and meta-analysis was carried out to study the impact of forces acting on alveolar bone due to orthodontic therapy in healthy and diseased periodontium.

Focused question?

Is there an impact of forces acting on alveolar bone due to orthodontic therapy in healthy and diseased periodontium?

Primary objective

To assess the impact of forces acting on alveolar bone due to orthodontic therapy in healthy and diseased periodontium.

Secondary objective

To assess the impact of orthodontic forces on gingival tissue.

Protocol and Registration: This systematic review was conducted according to the Preferred Reporting Items of Systematic Reviews (PRISMA) and Meta-analysis guidelines.

Registration number : CRD42023397533

Study design:

The present systematic review and meta-analysis of cohort studies, case-control studies, randomized clinical studies and experimental studies was carried out to assess the impact of forces acting on bone due to orthodontic therapy in healthy and diseased periodontium.

Inclusion criteria

- Randomized clinical trials, cohort studies, experimental studies and case-control studies
- Freely available full text of published articles.
- Articles wherein periodontal parameters namely; Alveolar bone levels, alveolar bone fill, plaque index, gingival index, bleeding on probing, clinical attachment Level and probing pocket depth were evaluated.
- Articles which were published in English.

Exclusion criteria

- In-vitro studies, case report, case series and animal studies
- Unpublished research
- Unavailable full text manuscript
- Articles without assessment of periodontal parameters.
- Information sources & search strategy

The following databases were searched electronically: PubMed, EBSCOhost, Science Direct, EMBASE and Google Scholar. Cohort studies, case control studies, randomized controlled studies, experimental studies which were published in peer-reviewed publications were searched.

The search terms used were Periodontitis AND orthodontic forces, Periodontitis OR orthodontic forces, Healthy periodontium AND orthodontic forces, Healthy periodontium OR orthodontic forces and Periodontitis AND non-periodontitis

Study selection

There were two stages to the study selection process:

i) Evaluation of titles and abstracts

ii) Evaluation of full texts

Data collection process

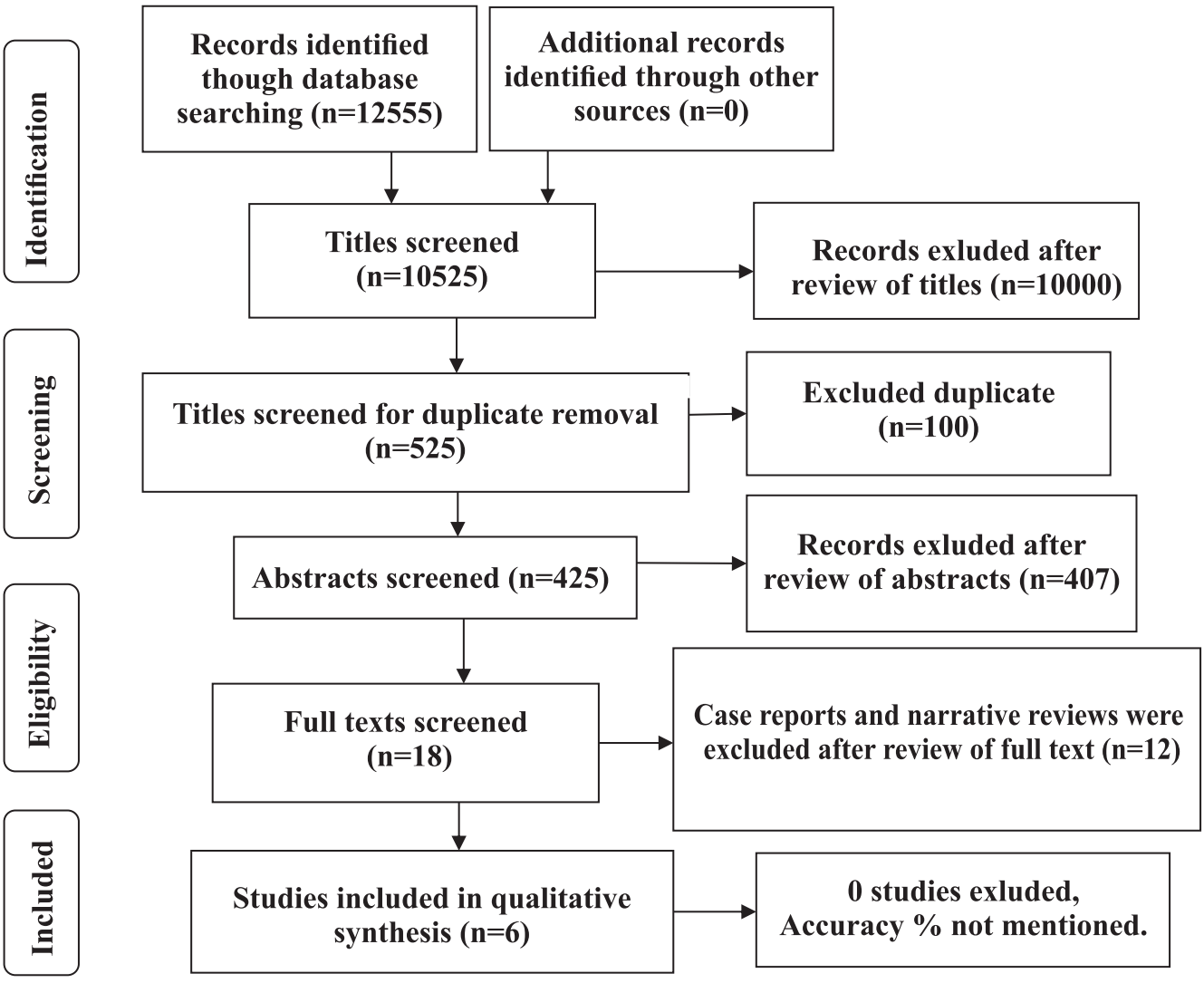
Data was retrieved from articles after they were examined and a data extraction sheet was created based on the factors that were evaluated. The following information was gathered using a data extraction sheet: authors, publication year, nation, purpose, study type, sample size, comparison and control groups, methodology, and conclusion.

Data items:

Variables for which data was sought included Periodontal disease, Orthodontic tooth movement.

Periodontal Disease: Periodontitis is defined as "an inflammatory disease of the supporting tissues of the teeth caused by specific microorganisms or groups of specific microorganisms, resulting in progressive destruction of the periodontal ligament and alveolar bone with increased probing depth formation, recession or both." **Orthodontic tooth movement (OTM):** Orthodontic tooth movement is defined as"a process in which the application of a force induces bone resorption on the pressure side and bone apposition on the tension side. Thus, conventional tooth movement results from biological cascades of resorption and apposition caused by the mechanical forces."[5]

Figure 1: Flow chart of literature search results and study selection



Results

Out of 12555 studies, 10525 records remained after title screening and 10000 records were excluded. After removing the duplicates 425 articles remained and after excluding the only abstracts 18 full text articles were considered. From these only 6 articles which met the inclusion criteria were analyzed

Studies included for the analysis

6 articles included for the quantitative synthesis were randomized clinical trials studies, experimental studies, case control studies and cohort studies. Table 1 shows the details of the studies included for analysis.

Table 1: Characteristics of included studies

Author and year of publication	Country	Aim	Type of study	Sample size, Comparison/ control group	Methodology	Parameters	Conclusion
Aimetti M, Garbo D, Ercoli E, Grigorie MM, Citterio F, Romano F. (2020)[1]	Italy	To evaluate the long term clinical and radiographic changes of a complex treatment including periodontal therapy and orthodontic movements in periodontitis patients with pathologic tooth migration (PTM) of anterior teeth and to investigate reason of tooth loss.	Retrospective case control study	Group 1 (n =25 patients) Group 2 (n=25 patients)	Full-mouth radiographic examination and periodontal charting wasdone at baseline (T0). They received similar active periodontal therapy (APT), which included nonsurgical therapy, extraction of teeth considered irrational to treat.	BD BP PI (Bone defect bleeding on probing plaque index)	Orthodontics tooth movement had no major effects on a healthy but reduced periodontium in patients enrolled in a strict maintenance care program; therefore, it was considered a safe procedure for the management of patients previously affected by severe forms of periodontitis.
Zoizner R, Arbel Y, Yavnai N, Becker T &Birnboim-Blau G. (2018)[2]	Israel	To evaluate the prevalence and severity of interdental alveolar crest height loss during active appliance therapy in a group of consecutively treated adult patients compared with an untreated control group and to identify comorbidity risk factors for bone loss.	Randomised controlled study	Group 1 (n=34 patients) Group 2 (n=34 patients).	The treatment group patient's files were collected from the records of the military orthodontic department. Controls were matched by sex and age from the dental records of the adjacent operative dental clinic	BD	Orthodontic tooth movement did not cause bone defect.
Zasciurinskiene E, NomedaBN (2016)[3]	Sweden	To compare two treatment strategies regarding the effect of orthodontic treatment on periodontal status in patients with plaque-induced periodontitis.	Randomised controlled study	Group 1- 25 patients Group 2 – 25 patients	All patients received supra- and sub-gingival debridement following baseline examination. Control group patients received cause-related periodontal treatment before thestart of orthodontic treatment and which was performed simultaneous to orthodontic treatment for the test group patients.	CAL PD (probing depth)	Orthodontic treatment, simultaneously to the periodontal treatment, could be used in the routine treatment of patients with plaque-induced periodontitis.
Attia MS, Shoreibah EA, Ibrahim SA & Nassar HA (2012)[4]	Spain	To analyze the effects of orthodontic tooth movement (OTM) on clinical attachment level (CAL) changes in treated periodontitis patients with a healthy but reduced periodontium and the efficacy of skeletal anchorage devices compared to conventional systems in terms of orthodontic treatment outcomes compared to non-periodontitis patients	Randomized controlled trial.	26 patients without periodontitis and 69 treated periodontitis patients.	group 1 - orthodontic regenerative therapy combined with immediate application of orthodontic tooth movement group 2- delayed application of orthodontic tooth movement. Control group - regenerative therapy alone.	CAL, PD BD BF At baseline 6months 1yr	Immediate application of orthodontic tooth movement resulted in increase in CAL in treated periodontitis patients
Corrente G, Abdundo R (2003)[5]	Italy	To evaluate the periodontal tissue alterations following periodontal surgery and orthodontic intrusion in migrated upper central incisors with intrabony defects.	Randomised controlled study	10 patients with advanced periodontal disease and an extruded maxillary central incisor infrabony defect at its mesial aspect and its probing depth more than 6mm were included in the study	The vertical and horizontal dimensions of the defects were assessed on standardized radiographs. Seven to 10 days after surgery the active orthodontic treatment started using the segmented arch technique, in order to intrude and move the teeth into the defects.	CAL PD BF At baseline 10days 2-3months	Realignment of extruded teeth with infrabony defects was obtained and a significant probing depth reduction, clinical attachment gain, and radiological bone fill was observed.
Eliasson LK, Hugoson, A, Kurol JR, Siwe H. (1982)[6]	Sweden	To study the influence of orthodontic treatment on the periodontal tissues in patients with advanced periodontal tissue breakdown	Randomised controlled trial	20 patients with advanced periodontal disease.	Oral hygiene, Pocket depth, aveolar bone level were measured and Orthodontic casts were used for assessment of spacing and overjet.	GI PI CAL PD BD (gingival index)	Orthodontic treatment in periodontitis patients resulted in reduction of GI and PI but PD showed no major reduction.

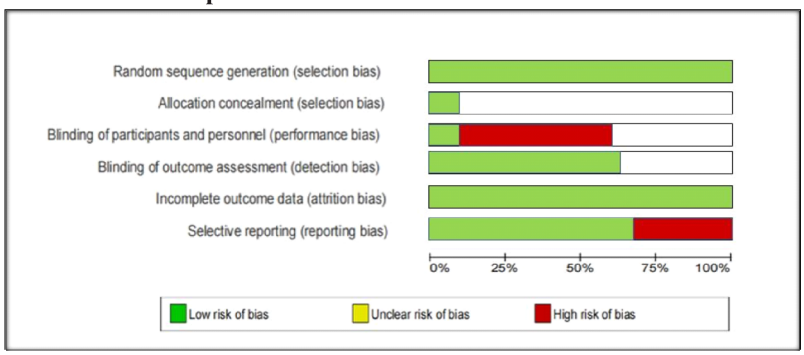
Evaluation of risk of bias in included studies

A numerical score (NOS Score) was allocated after the included studies' quality was assessed using the Newcastle Ottawa Scale. It was desired to assess bias in accordance with participant selection, cross-sectional research group comparability, exposure attained in case-control studies, and cohort study result of interest. A maximum of 4 points were available for selection, 2 points for comparison, and 3 points for the evaluation of the result.The NOS employs a nine-star rating system. The two writers evaluated the included studies' quality and, in case of a disagreement, consulted a third author. Research that receives a score between seven and nine were deemed to be considered. The risk of bias of the included studies is presented in Table 2 and Graph 1, 2

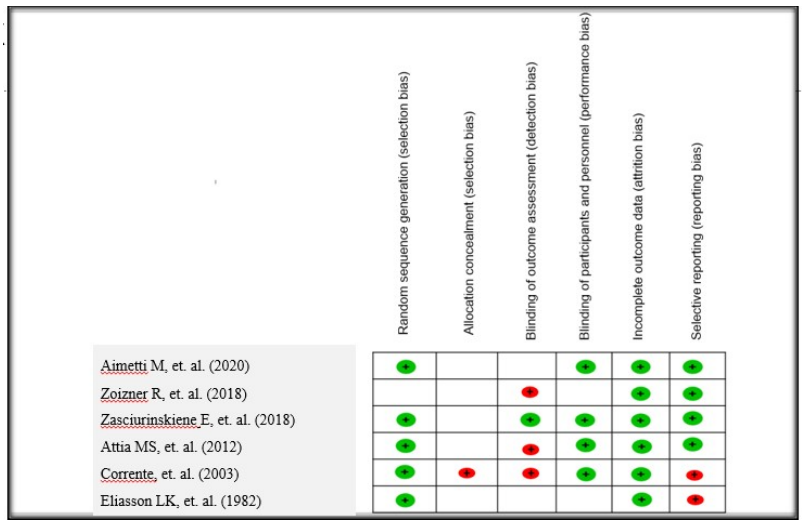
Table 2: Risk of bias assessment in included studies

Sr no.	Authors (Year)	Type of study	Random sequence generation	Allocation concealment	Blinding of participants	Blinding of outcome	Incomplete outcome data	Selective reporting
1	Aimetti M, et. al. (2020)[1]	Retrospective case control study	Low	Unclear	Unclear	Unclear	Low	High
2	Zoizner R, et. al. (2018)[2]	RCT	Low	Unclear	Low	Low	low	Low
3	ZasciurinskienŒ, et. al. (2018)[3]	RCT	Low	High	High	Low	Low	High
4	Attia MS, et. al. (2012)[4]	RCT	Unclear	Unclear	High	Unclear	Low	Low
5	Corrente, et. al. (2003)[5]	RCT	Low	Unclear	Unclear	Low	Low	Low
6	Eliasson LK, et. al. (1982)[6]	RCT	Low	Unclear	Low	Low	Low	Low

Graph 1: Risk of bias of the included studies



Graph 2: Risk of bias summary



Studies excluded for the analysis

4 studies were excluded as they were review articles. The details of the excluded articles are presented in Table 3.

Table 3: Characteristics of excluded studies

Author (year)	Reason for exclusion
Dutra EH, Ahmida A, Lima A, Schneider S, Nanda R, Yadav S (2018)[8]	Animal study
Goyal A, Kalra JPS, Bhatiya P, Singla S, Parul B (2012)[9]	Narrative review
Tsolakis AI, Khaldi L, Rontogianni A (2010)[10]	Animal study
Pizzo G, Licata ME, Guiglia R, Giuliana G(2007)[11]	Literature review

For continuous outcomes, the standardized mean difference (SDM) with 95% confidence interval was computed. If heterogeneity was not there (p >0.05 or I-squared ≤24%), Mantel-Haenszel technique (fixed effects model) was employed; if not, Der Simonian-Laird method (random effects model) was utilized.

The statistical analysis was conducted using RevMan 5.3 (Higgins 2011)[17]. A significance threshold of p<0.05 was maintained.

Evaluation of heterogeneity

Inferential statistics and Cochran's test for heterogeneity was used to assess the significance of any variations in the estimates of the treatment effects of the various trials. This shows the percentage of the total variation across the studies which is due to heterogeneity rather than chance. If P was less than 0.1, heterogeneity was deemed statistically significant. An approximate guide is given in the handbook by Cochrane.

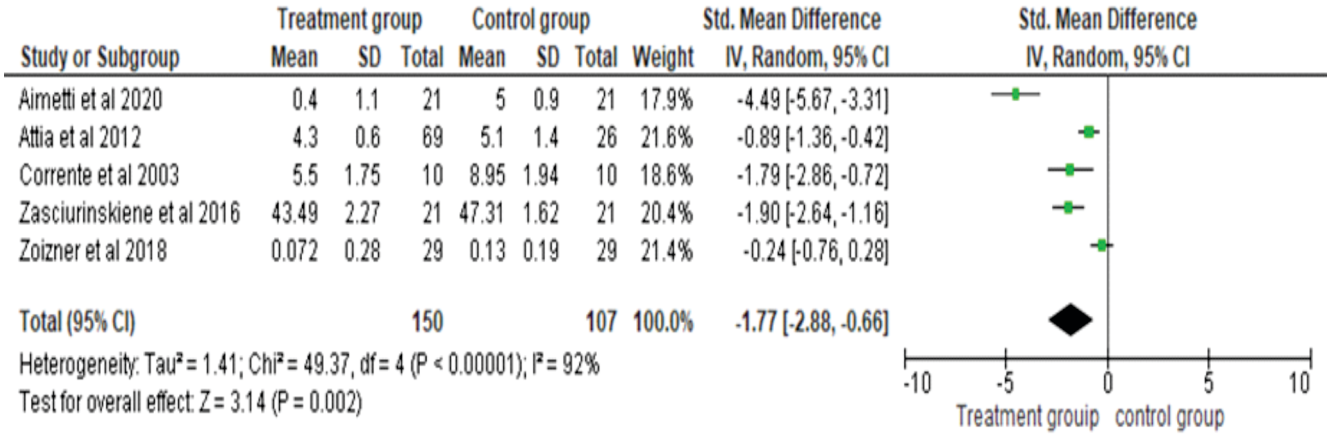
Begg's funnel plot was used to measure the relative symmetry of each study's estimate around the total estimate in order to check for publication bias. Plotting the effect magnitude against the standard error yielded a funnel plot. The funnel plot's asymmetry may be a sign of sample size biases such as publication bias, but it may also be a sign of a real link between trial size and effect size.

Synthesis of result

Clinical Attachment loss:

Data from three investigations totaling 257 (n = 257) participants were analyzed in the therapy group (n = 150), and 107 patients were level (CAL). In a meta-analysis, the standardized mean difference is employed as an overview statistic in cases when studies evaluate the same result using disparate measurement techniques. Consequently, before the study data could be added together to provide an overall pooled estimate, they had to be standardized to a similar scale. As can be seen in Figure 2, the pooled estimates favor the treatment group, and the standard mean difference is 1.77 (-2.88 – 0.66). This indicated that, on average, the treatment group experienced a 1.77-fold greater drop in clinical attachment level (CAL) than the control group, although this difference was significant statistically (p=0.002). In terms of the outcome evaluated, the treatment group outperformed the control group.

Figure 2: Forest plot showing treatment group versus control group with regards to the reduction in clinical attachment level (CAL)



Attia et al. (2012) had the greatest weightage among all the included studies at the overall pooled estimate, whereas Aimetti et al. 2020 had the lowest weightage at the pooled estimate.

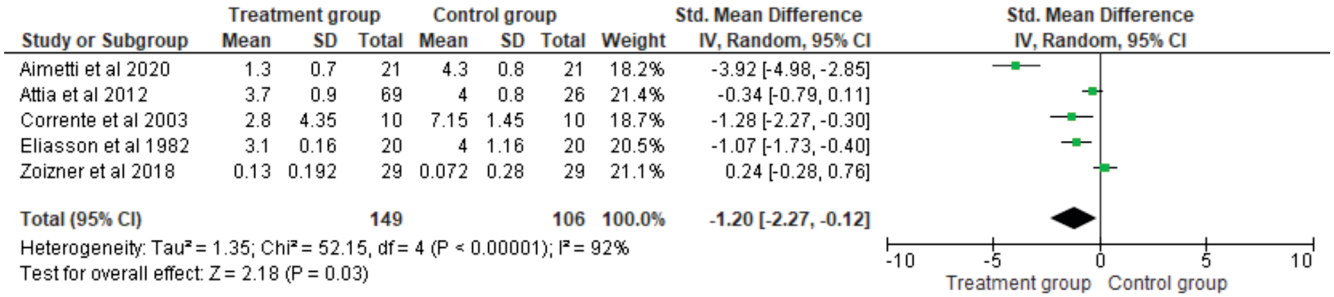
Using the random effect model, the overall effect for Z value was Z = 1.41, the heterogeneity for Tau^2 was 1.41, and the I^2 statistic revealed 92%.

Pocket Depth:

The examination of the reduction in probing depth (PD) was conducted on 255 participants in three different investigations. Of these, 149 participants were examined in the treatment group and 106 patients were tested in the control group.

The pooled evaluation in the control group for the assessment of the reduction in clinical attachment estimations favors the treatment group, as seen in Figure 3, where the Std. Mean Difference is 1.20 (-2.27 – 0.12). This showed that the treatment group saw an average 1.20-fold greater reduction in probing depth (PD) than the control group, and that this difference was significant statistically (p=0.03). When it came to the evaluated result, the treatment group outperformed the control group.

Figure 3: Forest plot showing treatment group versus control group with regards to the reduction in probing depth (PD)



Aimetti et al. 2020 had the lowest weightage at the pooled estimate across all the included studies, whereas Attia et al. (2012) had the greatest weightage overall. The I^2 statistic was 92%, the heterogeneity for Tau^2 was 1.35, the x^2 value was p<0.00001, and the overall effect for Z value was 2.18 (P=0.03) when the random effect model was used.

Discussion

Oral hygiene maintenance is important in maintaining the health of the periodontium. Presence of orthodontic appliances such as orthodontic brackets, bands and wires may interfere with proper maintenance of oral health which causes accumulation of plaque and also lead to periodontitis. Hence orthodontic treatment is considered as one of the factor for increasing the risk for periodontal diseases.

Shift in position of the tooth is because of the physiological action of bone remodelling due to the cells of the alveolar bone. Zachrisson & Alness (1973, 1974) observed that teeth movement accompanied by gingival inflammation may result in the irreversible loss of superficial tissues of the periodontium.

Increased turnover rate of the connective tissue as well as alveolar bone remodelling are required for orthodontic shifting of the tooth. It has been proposed that essential orthodontic tooth movement should occur prior to the conclusion of periodontal therapy, including surgery, in order to capitalize on the cellular activity observed in inflammatory periodontal tissues.

Orthodontic treatment has been reported to have beneficial effect on periodontal tissues. In proclined teeth with thin cortical plates associated with defects; such as fenestration and dehiscence correction of proclination by orthodontic treatment can help in restoring normal contour of the alveolar bone.

This systematic review briefly discusses the observations of the articles that study impact of forces acting on bone due to orthodontic therapy in healthy and diseased periodontium. The studies which evaluated the impact of forces acting on bone due to orthodontic therapy in healthy and diseased periodontium are limited.

This review excluded the articles which did not fulfil the selection criteria. Animal studies, review articles, in-vitro articles did not have higher level of evidence therefore they were put in the exclusion.

The study by Dutra EH, et. al. (2018)[7] studied the impact of bone decortications on tooth movement because of orthodontics and alveolar remodelling in animal model which were rats. Goyal A, et. al. (2012)[8] studied periodontally accelerated osteogenic orthodontics (PAOO) which was a narrative review. Dontas IA, et. al. (2010)[9] had done animal study in aging Wistar rats on malocclusion hence it was excluded. Pizzo G, et. al. (2007)[10] studied root resorption and orthodontic treatment which was a literature review.

Only six studies (randomized controlled trials) fulfilled the selection criteria. Clinical attachment level, periodontal

probing depth, gingival and plaque indices were assessed in few articles and those articles were considered for the review.

Because blinding and randomization of research participants were not done, there was a possibility of bias in the trials. On the other hand, orthodontic forces were shown to have an impact on CAL and PD, but no discernible variations were found with the remaining parameters, according to the examined research like bone loss, bone fill, gingival index and plaque index. Aimetti M, et. al. (2020)[1] evaluated the long term clinical and radiographic changes of a complex treatment including periodontal therapy and orthodontic movements in periodontitis patients with pathologic tooth migration (PTM) of teeth in the anterior region. They also investigated the reason for tooth loss and concluded that the orthodontic tooth movement does not affect the healthy but reduced periodontium which proper oral hygiene in maintained. Hence, even in patients with history of severe periodontitis the orthodontic procedure was considered safe. This article showed high risk of bias in the assessment.

According to research by Zoizner R, et al. (2018)[2], adult patients receiving consecutive orthodontic treatment did not have a bone defect as a result of the orthodontic frequency and extent of interdental alveolar crest height reduction during active appliance therapy. Furthermore, multiple concurrent risk factors associated with bone loss were discovered. The research showed a minimal risk of bias when the danger of bias was evaluated.

In their comparison of the two treatment approaches, Zasciurinskiene E, et al. (2018)[3] examined how orthodontic therapy affected patients' periodontal condition in cases of plaque-induced periodontitis. They noticed that the sites with PD > 4 mm decreased and the CAL increased in both groups. Patients with plaque-induced periodontitis may benefit from routine orthodontic treatment administered along with periodontal therapy. A substantial risk of bias was found in the study when the risk of bias was evaluated.

In their analysis of the impact of orthodontic tooth shifting (OTM) on changes in clinical attachment level (CAL) in patients with treated periodontitis who had a reduced but healthy periodontium, Attia MS, et al. (2012)[4] also examined the effectiveness of skeletal anchorage devices in comparison to conventional methods in terms of the outcomes of orthodontic treatment when compared to patients without periodontitis. They came to the conclusion that individuals with periodontitis who had prompt orthodontic tooth movement had higher CALs. Nonetheless, minimal bias risk was noted once the risk of bias was taken into account.

According to Corrente et al. (2003)[5], realigning extruded teeth with infrabony abnormalities with combined orthodontic and periodontic treatment led to a considerable reduction in radiographic changes, clinical attachment level which is gained and as well as probing depth. Low risk of prejudice was found, however, when the risk of bias was evaluated.

Eliasson LK, et. al. (1982)[6] proved that orthodontic treatment in periodontitis patients resulted in reduction of GI and PI but PD showed no major reduction. However, low risk of bias was observed.

Orthodontic forces can have deleterious as well as beneficial effect on the periodontal tissues. There can be deleterious effect leading to inflammation of the periodontal tissues. Orthodontic forces can have beneficial effect in treating bony defects. Future research on well-planned longitudinal studies with long-term follow-up is still possible.

Limitations

1. Articles of languages other than English were not included.
2. Long term follow-up studies were not available.

Conclusion

Maintaining good oral hygiene is crucial for the wellbeing of periodontal tissues. When orthodontic pressures are used to realign teeth, they affect the alveolar bone and the underlying periodontal tissue. Periodontal tissues are impacted by orthodontic pressures in two ways. It may induce alveolar bone loss or lead to the eradication of alveolar bone abnormalities. Therefore, maintaining the health of periodontal tissues in individuals with and without periodontitis requires a comprehensive assessment of the periodontal tissues and the application of appropriate orthodontic pressures. Even if there has been a noticeable change, there is not much information available about how orthodontic pressures affect alveolar bone in people with & without periodontitis.

Acknowledgements: Nil

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