Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2023; 23:e220116
https://doi.org/10.1590/pboci.2023.029
ISSN 1519-0501 / eISSN 1983-4632

SYSTEMATIC REVIEW

The Effects of Orthodontic Tooth Movement on Clinical Attachment Level Changes in Treated Periodontitis Adult Patients with Malocclusion: A Systematic Review and Meta-analysis

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Academic Editor: Myroslav Goncharuk-Khomyn

Received: 02 July 2022 / **Review:** 09 October 2022 / **Accepted:** 22 October 2022

How to cite: Moravej A, Pornamazeh T, Hatamzade Z, Soltanian M, Amiri A. The effects of orthodontic tooth movement on clinical attachment level changes in treated periodontitis adult patients with malocclusion: a systematic review and meta-analysis. Pesqui Bras Odontopediatria Clín Integr. 2023; 23:e220116. https://doi.org/10.1590/pboci.2023.029

ABSTRACT

Objective: To investigate the effects of orthodontic tooth movement on clinical attachment level (CAL) changes in treated periodontitis in adult patients with malocclusion. **Material and Methods:** Present study is based on PRISMA guidelines; all articles published in international databases such as PubMed, Scopus, Science Direct, and Embase between 2012 to May 2022 are included. 95% confidence interval (CI) for mean difference with fixed effect modal and inverse-variance were calculated. Data analysis was performed using STATA.V16 software. **Results:** In the initial review, duplicate studies were eliminated, abstracts of 175 studies were reviewed, two authors reviewed the full text of 21 studies, and finally, eleven studies were selected. The mean of CAL gain was 2.29 mm (MD, 95% CI -2.47 mm, -2.12 mm; p=0.00) (I^2=91.81%; p=0.00; high heterogeneity). The mean difference of PPD changes was −1.93 mm (MD, 95% CI -2.07 mm, -1.80 mm; p=0.00) (I^2=98.52%; p=0.00; high heterogeneity). **Conclusion:** Due to the limitations of the study and based on the meta-analysis, it is observed that orthodontic treatment is performed with higher success after reconstructive surgery with periodontal improvement.

Keywords: Malocclusion; Meta-analysis; Periodontitis; Tooth Movement Techniques.

Introduction

When bone defects, loss of interdental adhesions, and the formation of envelopes are observed in a person, it is called stage IV periodontitis. Very complex and multidisciplinary rehabilitation must be performed in this situation because chewing disorder, tooth loss, and secondary occlusive trauma are seen [1]. One of the effective treatments to prevent the movement of teeth and maintain the condition of the interdental space is the use of orthodontic treatments [1]. Of course, the important point is that periodontal inflammation should be treated during orthodontic treatment; otherwise, there will be more loss of adhesion [2].

A study conducted in 2018 by Papageorgiou et al. [3] showed that the use of orthodontic treatment with fixed appliances has no significant effect on clinical attachment levels (CAL). However, after about three months of orthodontic treatment, periodontal parameters return to normal. Other findings have shown that using fixed orthodontic retainers is directly related to periodontal health and does not cause side effects [4].

According to the searches, previous studies have evaluated the effects of fixed orthodontic retainers on periodontal health and the effect of orthodontic treatment on periodontal clinical adhesion. In the present study, an attempt was made to investigate their effect on CAL in periodontitis patients during orthodontic treatment to provide stronger evidence based on the consensus of study results; the findings of the present study can help the orthodontist to plan treatment. Therefore, the present study investigated the effects of orthodontic tooth movement on clinical attachment level changes in treated periodontitis in adult patients with malocclusion.

Material and Methods

Search Strategy

The present study is a systematic review and meta-analysis based on PRISMA guidelines [5]. All articles were published in international databases such as PubMed, Scopus, Science Direct, and Embase between March 2012 and May 2022; the Google Scholar search engine was used. Table 1 shows the response to PICO.

Table1. PICO strategy.

PICO Strategy	Description
P	Population: Adult patients with malocclusion
I	Intervention: orthodontic treatment
C	Comparison: before and after treatment
O	Outcome: clinical attachment level (CAL), Probing pocket depth (PPD), and bleeding on probing (BOP)

The following keywords were used to search: (("Index of Orthodontic Treatment Need"[Mesh] OR "Orthodontic Anchorage Procedures"[Mesh] OR "Orthodontic Retainers"[Mesh] OR "Orthodontic Brackets"[Mesh] OR "Orthodontic Appliances, Removable"[Mesh] OR "Orthodontic Appliances"[Mesh] OR "Orthodontic Appliances, Fixed"[Mesh] OR "Orthodontic Appliances, Functional"[Mesh] OR "Orthodontic Appliance Design"[Mesh] OR "Tooth Movement Techniques"[Mesh]) AND ("Malocclusion"[Mesh] OR "Malocclusion, Angle Class III"[Mesh] OR "Malocclusion, Angle Class II"[Mesh] OR "Malocclusion, Angle Class I"[Mesh])) AND "Periodontitis"[Mesh].

Study Selection and Data Extraction

The data from the selected studies were extracted using a checklist. In this checklist, the first author's name, years, study design, the number of participants, mean age, and the number of smokers were extracted from the full text of the studies.

Quality of Studies

The quality of the randomized control trial studies included was assessed using the Cochrane Collaboration's tool [6]. Scale scores range from 0 to 6. The scale score for low risk was 1, and for high and unclear risk was 0; a higher score means higher quality. Non-randomized Studies (ROBINS-I) tool [7] was used to the assessed quality of the cohort studies and Clinical controlled trials. Newcastle-Ottawa Scale (NOS) [8] was used to the assessed quality of the cohort and cross-sectional studies, case-control, and case series studies; this scale measures three dimensions (selection, comparability of cohorts, and outcome) with a total of 9 items. Any studies with NOS scores of 1-3, 4-6, and 7-9 were defined as low, medium, and high quality, respectively.

Method of Analysis

Data analysis was performed using STATA.V16 software. The I^2 index test was used to evaluate the level of heterogeneity ($I^2 < 50\%$ = low levels, $50 < I^2 < 75\%$ = moderate, and $I^2 > 75\%$ = high levels). In addition, 95% confidence interval (CI) for mean difference with fixed effect modal and inverse-variance were calculated.

Results

In the review of the existing literature using the studied keywords, 218 studies were found. In the initial review, duplicate studies were eliminated, and abstracts of 175 studies were reviewed. At this stage, 154 studies did not meet the inclusion criteria, so they were excluded, and in the second stage, the full text of 21 studies was reviewed by two authors. At this stage, ten studies were excluded from the study due to incomplete data, inconsistency of results in a study, poor studies, lack of access to full text, and inconsistent data with the purpose of the study. Finally, eleven studies were selected (Figure 1).

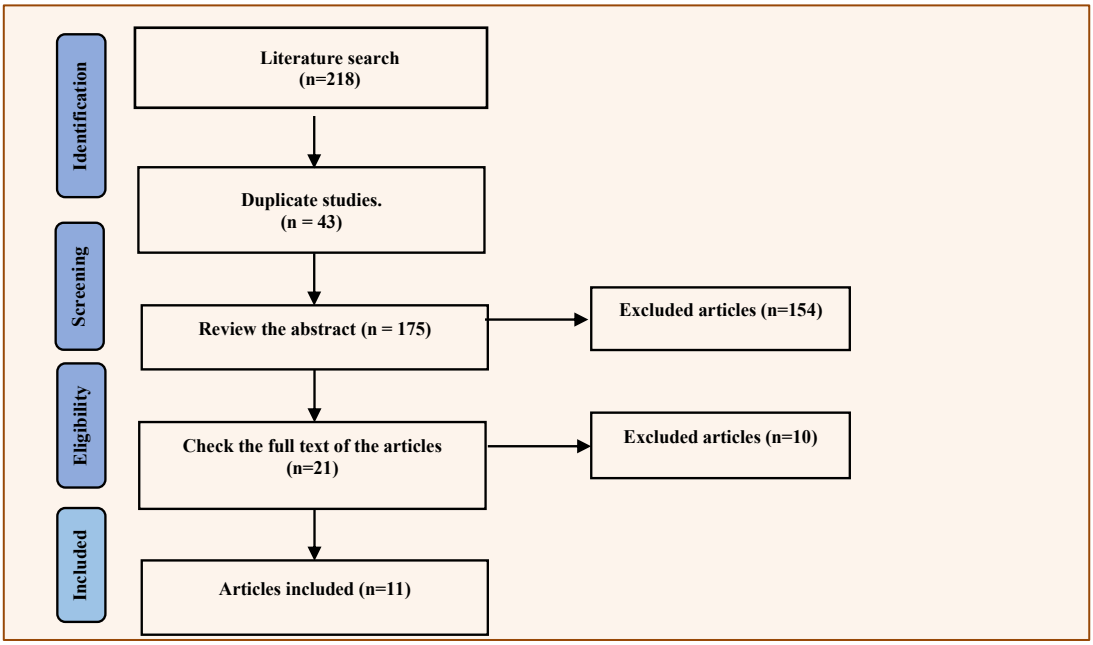

Figure 1. PRISMA flowcharts.

Characteristics

The total number of patients was 266 (male=103 and female=163). Other important data are summarized in Table 2.

Table 2. Summary of demographic and outcomes extracted from selected studies.

No.	Study	Study Design	Number of Patients		Mean of Age (years)	Orthodontic Baseline Malocclusion	Type of Appliances	Study Duration (mean)
			Male	Female				
1	Tu et al. [9]	Retrospective cohort study	10	11	40	Intrusion and alignment	Fixed appliances	NR
2	Tietmann et al. [10]	Retrospective cohort study	20	28	32	Intrusion and alignment	Fixed appliances	48
3	Aimetti et al. [11]	Randomized controlled trial	5	16	52	Intrusion and alignment	Fixed appliances Cantilever	18
4	Attia et al. [12]	Randomized controlled trial	3	11	34	Intrusion and alignment	Fixed appliances sectional arch	9
5	Zasčiurinskienė et al. [13]	Randomized controlled clinical trial	9	16	47.3	Intrusion and alignment	Fixed appliances	21
6	Carvalho et al. [14]	Prospective	2	8	22.3	Intrusion and alignment	Edgewise brackets	18
7	Zhang et al. [15]	Randomized controlled clinical trial	38	21	36	Intrusion and alignment	Functional Fixed appliances	36
8	Ogihara et al. [16]	Randomized controlled clinical trial	6	19	52	Extrusion	Fixed appliance occlusal metal bar	37
9	Cao et al. [17]	Prospective	3	11	38	Intrusion and alignment	Fixed appliances Utility arch	19
10	Lee et al. [18]	Prospective	2	12	42	Intrusion	Partially fixed edgewise appliance	35
11	Attia et al. [19]	Controlled clinical trial	5	10	27.9	Intrusion and alignment	Fixed appliances sectional arch	12

Bias Assessment

According to the National Institute of Health's quality assessment tool, three studies had Fair, and one had a poor risk of bias (Table 3).

Table 3. Bias assessment (National Institute of Health's quality assessment tool).

Criteria	Aimetti et al. [11]	Carvalho et al. [14]	Cao et al. [17]	Lee et al. [18]
1. Study question/objective	Yes	Yes	Yes	Yes
2. Eligibility criteria and study population	Yes	Yes	No	Yes
3. Study participants representative of clinical populations of interest	No	No	Yes	No
4. All eligible participants enrolled	Yes	NR	Yes	NR
5. Sample size	No	No	No	No
6. Intervention clearly described	Yes	Yes	Yes	Yes
7. Outcome measures clearly described, valid, and reliable	No	No	Yes	No
8. Blinding of outcome assessors	No	Yes	NR	Yes
9. Follow-up rate	NA	Yes	Yes	Yes
10. Statistical analysis	Yes	Yes	Yes	Yes

11. Multiple outcome measures	No	No	No	No
12. Group-level interventions and individual-level outcome efforts	NA	NA	NA	NA
Overall Appraisal	Poor	Fair	Fair	Fair

According to NOS tools, two studies had a low risk of bias (high quality), and one study had a moderate risk of bias (moderate quality) (Table 4).

Table 4. Bias assessment (Newcastle-Ottawa scale (NOS)).

Study	Risk of Bias Cohort Studies									
	Selection (0. 0 stars; 1. 1 star)				Comparability (0. 0 stars; 1. 1 star; 2. 2 stars)	Exposure/Outcome (0. 0 stars; 1. 1 star)			Assessment	Quality
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that the outcome of interest was not present at the start of the study	Comparability of cohorts based on the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur (> 6 months)	Adequacy of follow-up of cohorts (complete follow-up of all subjects y/n)		
Tu et al.[9]	*	*	*	-	**	*	*	*	8	High
Tietmann et al. [10]	*	*	*	-	**	*	*	*	8	High
Carvalho et al. [14]	*	*	*	-	*	-	*	*	6	Moderate

According to the ROB2 tool, two studies had a low risk of bias, and two had a moderate-low risk of bias (Table 5).

Table 5. Bias assessment (ROB2 tool).

Authors	Randomization Process	Deviations from Intended Interventions	Missing Outcome Data	Measurement of the Outcome	Selection of the Reported Result	Overall Bias
Attia et al. [12]	Low	Low	Low	Some concerns	Low	Some concerns
Zasčiurinskienė et al. [13]	Low	Low	Low	Some concerns	Low	Some concerns
Zhang et al. [15]	Low	Low	Low	Low	Low	Low
Ogihara et al. [16]	Low	Low	Low	Low	Low	Low
Attia et al. [19]	Low	Low	Low	Some concerns	Low	Some concerns

Clinical Attachment Level (CAL) Changes (mm)

The mean of CAL gain was 2.29 mm (MD, 95% CI -2.47 mm, -2.12 mm; p=0.00) (I^2=91.81%; p=0.00; high heterogeneity). Furthermore, based on the meta-analysis findings that the mean difference was calculated using the fixed-effect model and inverse-variance method before and after treatment, a Significant increase in CAL was observed (p=0.00) (Figure 2).

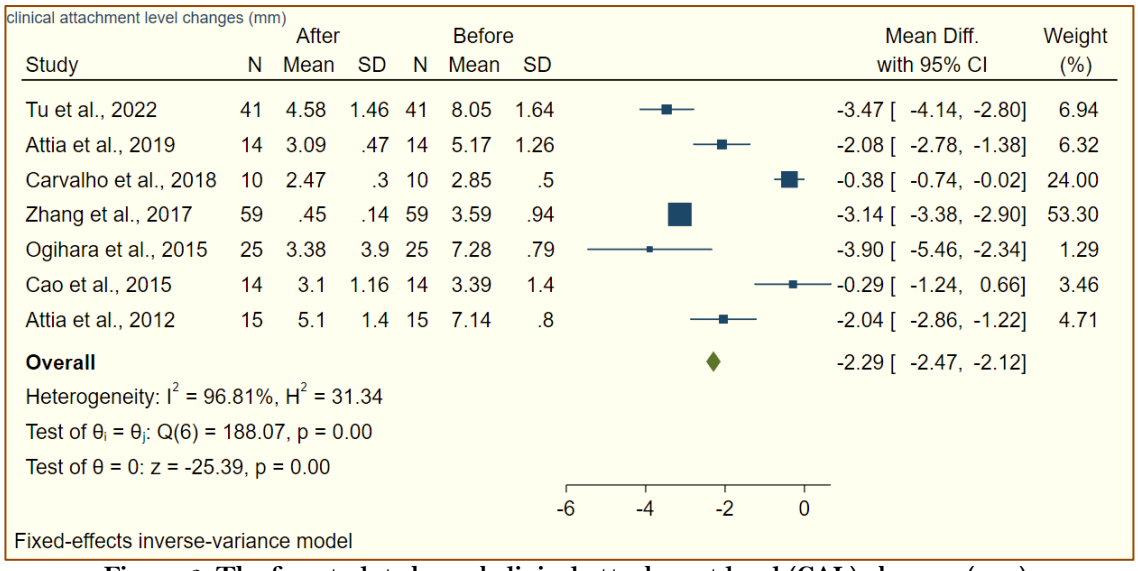

Figure 2. The forest plot showed clinical attachment level (CAL) changes (mm).

Probing Pocket Depth (PPD) Changes (mm)

The mean difference of PPD changes was -1.93 mm (MD, 95% CI -2.07 mm, -1.80 mm; p=0.00) (I^2=98.52%; p=0.00; high heterogeneity). Based on the meta-analysis findings that the mean difference was calculated using the fixed-effect model and Inverse-variance method, before and after treatment, a statistically significant difference was observed in terms of PPD, so after orthodontic treatment, the mean decreased (p=0.00) (Figure 3).

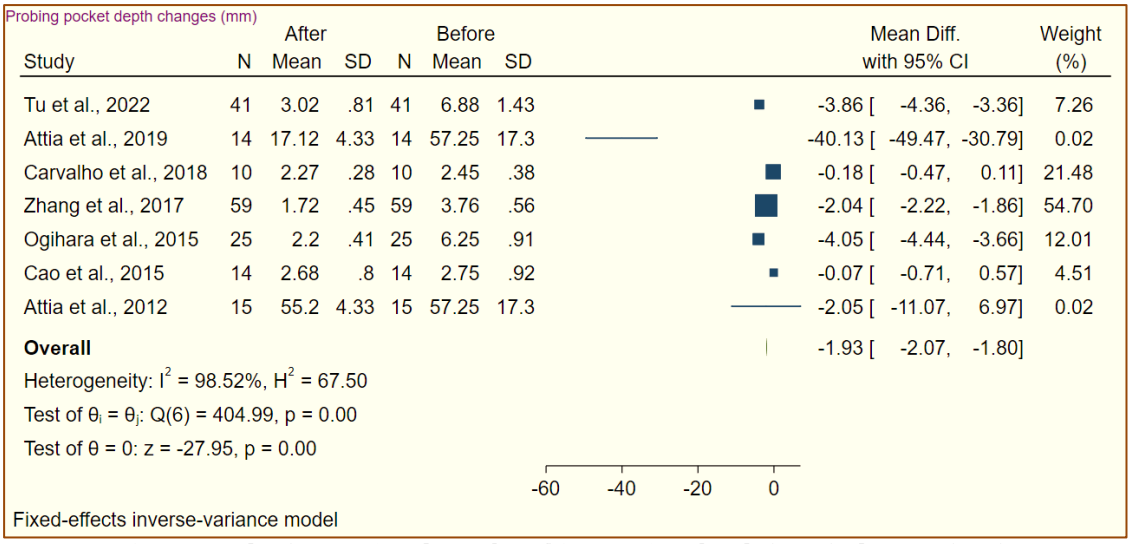

Figure 3. The forest plot showed probing pocket depth (PPD) changes (mm).

Bleeding on Probing (BOP) Changes (mm)

The mean difference of BOP changes was -5.40 mm (MD, 95% CI −6.80 mm, -4.00 mm; p=0.00) (I^2=28.44%; p=0.25; low heterogeneity). Based on the meta-analysis findings that the mean difference was calculated using the fixed-effect model and Inverse-variance method, before and after treatment, a statistically significant difference was observed in terms of BOP, so after orthodontic treatment, the mean decreased (p=0.00) (Figure 4).

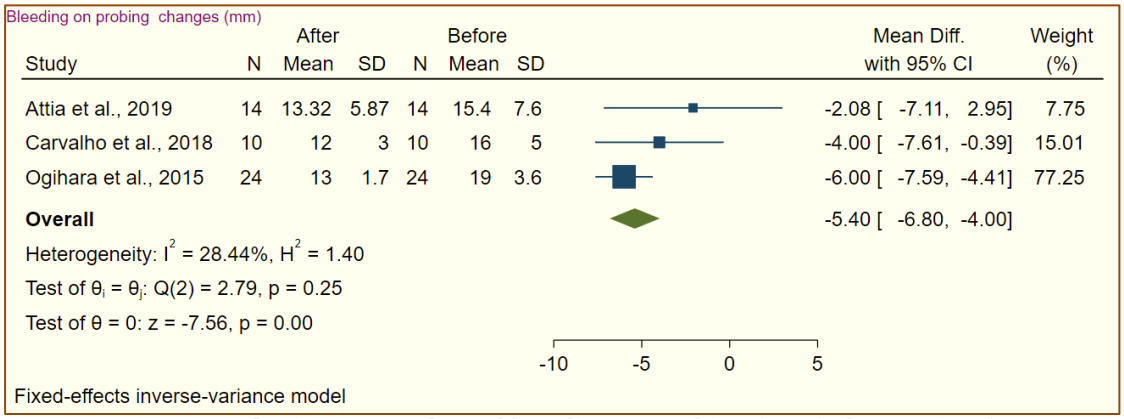

Figure 4. The forest plot showed bleeding on probing (BOP) changes (mm).

Discussion

Based on the existing literature, it is observed that there is very little evidence regarding orthodontic treatment in patients with severe periodontitis, the quality of studies in this field is low, and the risk of bias is high. Based on meta-analysis findings before and after orthodontic treatment, an increase in CAL and a decrease in PPD were observed in patients with periodontitis. Based on the research, few studies were found to be of high quality or almost high quality. However, most studies in this field were of low quality. Therefore, studies were selected for meta-analysis, but due to the high heterogeneity between methodological studies, citation studies with the present study's findings should be done with caution.

Further studies are needed to confirm the evidence with the same methodological method. In addition, other RCT studies with the same treatment duration and a higher sample size are required. In the present study, 266 patients were evaluated, including patients with non-periodontitis and periodontitis whose periodontal outcomes were measured after orthodontic treatment. According to the available evidence, the best time to apply orthodontic force in patients with periodontitis is less than a week, one to two months, or more than three months after periodontal surgery.

A study showed that if periodontal reconstruction treatment is performed, a better basis for orthodontic movement is provided [16]. Another study also showed that interdisciplinary treatments significantly affect orthodontic tooth movement [12]. Research by Tu et al. [9] found that if orthodontic treatment were given earlier, we would see a more significant increase in CAL than in late orthodontics. As a result, early orthodontic movement of the tooth may not compromise the restorative effect; conversely, it may help orthodontists make the most of the regional accelerator phenomenon and improve the overall effectiveness of periodontal reconstruction [9].

According to Tietmann et al. [10], combining regenerative treatment with subsequent orthodontic tooth movements showed excellent results for up to 4 years. In addition, Aimetti et al. [11] showed that clinical attachment levels and residual probing depths improved after treatment and were stable throughout the follow-

up. Also, orthodontic treatment combined with periodontal treatment in periodontal patients results in external apical root resorption in 81% of all single-rooted teeth [13].

The present study had some limitations, including very few RCT studies. Most of the studies were retrospective with small sample sizes, the course of treatment was very different in the studies, and the methodology of the studies was not the same, so high heterogeneity was observed between the studies. Moreover, the very poor design of the studies was the most important factor that made the need for more studies to confirm the evidence, in addition to the small number of studies. Future studies in the form of RCT are suggested, a procedure similar to other studies. It is recommended to perform studies that report the results before periodontal and orthodontic treatment and then report the results and interpret the findings after periodontal and orthodontic treatment.

Conclusion

Due to the limitations of the study and based on the meta-analysis, it is observed that after reconstructive surgery with periodontal improvement, orthodontic treatment is performed with higher success; Significant gain in CAL and reduction in PPD and BOP are observed.

Authors' Contributions

AM	https://orcid.org/0000-0003-4422-3364	Conceptualization, Methodology, Validation, Writing - Original Draft and Writing - Review and Editing.
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MS	https://orcid.org/0000-0002-4674-3024	Data Curation, Writing - Original Draft and Writing - Review and Editing.
AA	https://orcid.org/0000-0001-9416-808X	Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing - Original Draft and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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