ORIGINAL ARTICLE

# Assessment of Gingival, Periodontal Conditions, and Enamel Decalcification During and After Orthodontic Treatment

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## ABSTRACT

**Introduction:** Orthodontic treatment can significantly impact oral health, potentially increasing the risk of plaque accumulation, gingival inflammation, enamel decalcification, and periodontal issues. However, the extent and progression of these changes during and after orthodontic treatment remain unclear. This study investigated the plaque, the gingival index, enamel decalcification index, and community periodontal index during and after orthodontic treatment. **Materials and methods:** Two groups of adults, where 56 adults with fixed orthodontic fixed appliance (experimental group) and 56 adults without the appliance (control group), who were treated at Fallujah Specialist Dental Center underwent a comprehensive measurement of the plaque and gingival index, enamel decalcification index, and community periodontal index. The measurement was done at 4 months before appliance removal, during, and 4 months after. **Results:** For the experimental group, there were significant reductions in the plaque index (1.05 to 0.42) (p=0.05), enamel decalcification index (1.08 to 1.02) (p=0.05), and community periodontal index (2.52 to 1.2) (p=0.02) throughout the study period. GI index showed no significant changes.On the other hand, during the eight months, the control group's indices did not exhibit any noticeable changes. **Conclusion:** Orthodontic treatment with fixed appliances significantly affects oral health, increasing plaque accumulation, gingival inflammation, enamel decalcification, and periodontal issues during treatment. These indices improved after appliance removal, with plaque and gingival inflammation decreasing and enamel decalcification showing recovery. Periodontal health worsened during treatment but improved post-debonding. These findings highlight the importance of monitoring and preventive measures to minimize these effects during orthodontic treatment.

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## INTRODUCTION

Fixed orthodontic appliances are commonly used to improve oral function, enhance aesthetics, and correct malocclusion. However, despite their therapeutic benefits, these orthodontic appliances pose significant challenges to maintaining optimal oral hygiene (1). The presence of brackets, bands, and archwires facilitates dental plaque accumulation and alters the oral microbial environment, putting patients at increased risk for various oral health issues. Among the most common and concerning complications are gingival inflammation, periodontal disease, and enamel decalcification, often presented as white spot lesions (WSLs).

It is well established that plaque-induced lesions can develop during orthodontic treatment. Fixed appliances create retention sites that hinder effective cleaning, particularly around the bracket margin, leading to increased plaque accumulation (2). Consequently, patients may experience gingival irritation, bleeding, and, in some cases, early signs of periodontal diseases (3). Additionally, WSL can occur adjacent to brackets, changes that develop rapidly and may be irreversible (4). Clinical evidence has demonstrated a wide variation in the prevalence of these enamel alterations, with

many orthodontic patients experiencing some degree of decalcification during treatment (5).

There is considerable interest in understanding the impact of fixed orthodontic treatment on gingival and dental tissue health. Most studies have reported increases in plaque accumulation, gingival index scores, enamel decalcification, and community periodontal index values within 1-3 months following placement of an orthodontic appliance. However, further study is required to explore the long-term effects of orthodontic treatment on periodontal health(6) (7). Assessing gingival and periodontal status following orthodontic treatment is critical, as treatment-induced changes in tooth positioning and oral hygiene challenges may contribute to periodontal deterioration.

The objective for this study is to compare the gingival, periodontal, and enamel decalcification states during and after orthodontic treatment. Understanding these changes is essential for improving preventive strategies and minimizing adverse oral health outcomes associated with orthodontic care.

## MATERIALS AND METHODS

### Ethical approval

This study was approved by the ethics committee of Al-Hadi University College (protocol No HD231203). All participants were enrolled after obtaining a consent form; for participants under the age of 18, written consent form was obtained from their parents or legal guardians.

### Study design and participants

This study was conducted from March 2023 to March 2024 at Fallujah Specialist Dental Center, Al-Anbar, Iraq. The sample size was calculated using G*Power (version 3.1.9.6) free software; the alpha level was set as 0.05, the power was 8%, and the effect size was 0.5. With consideration of a dropout out of 10%, 112 subjects were included in this study. 56 patients with the orthodontic fixed appliance (experimental group) and 56 patients without the appliance (control group) who attended the dental center were conveniently selected. For the experimental group, the subject must be on 0.019X0.025-inch stainless steel near-end treatment. Both groups should have no teeth extraction (full permanent dentition). All subjects were using fluoridated toothpaste as their daily oral hygiene routine.

For the experimental group, data collection was carried out four months before appliance removal (P1), on the day of removal (P2), and after four months of appliance removal (P3). For the control group, data collection was carried out at the same checking points of orthodontic patients (P1, P2, P3).

The data collected at each time point were plaque index (PI), gingival index (GI), enamel decalcification index (EDI), and community of periodontal index (CPI). The examination involved 6 teeth, which included the upper right 1st molar, lower left 1st molar, lower right lateral, lower left lateral, upper left first premolar, and upper right first premolar for PI, GI, and CPI. Meanwhile, for EDI, the anterior teeth were examined. The measurement was conducted using a straight explorer and a Williams graduate periodontal probe.

### Periodontal and oral health examination

All clinical assessments were carried out by a calibrated examiner using a mirror and periodontal probe under a dental chair light. PI and GI were measured according to Woelber&Johen et al., (2024) (8). For PI, plaque accumulation was measured on the gingival third of tooth surfaces at a scale of 0 to 4. GI was scored by the gingival inflammation on a scale from 0 to 3.

The EDI was assessed following the modification index described by Erbe et al., (2021) (9), which quantifies white spot lesions adapting to the orthodontic brackets. The CPI, which assesses the periodontal health status and treatment needs, was conducted using the periodontal probe as reported by D. Bangera, K. Vishwanathan et., al (2022) (10).

To evaluate the inter-examiner reliability, a subdivision of patients (n=35) was assessed independently by two examiners. The level of agreement was determined by using an intraclass correlation coefficient (ICC) dependent on the nature of the data, and the range of agreement level was between 0.80 to 0.90, indicating good to excellent reliability (11).

To address potential confounding habits, such as oral hygiene and dietary habits, the patients received standardized oral hygiene instructions and nutritional guidelines, with adherence monitored through a follow-up monthly clinical evaluation.

### Data analysis

The results were expressed as mean ± SD to describe the continuous variables (GI, PI, EDI, CPI). Post-hoc analysis using Bonferroni in one-way ANOVA analysis was used to evaluate the significant differences between the interval periods in PI, GI, EDI, and CPI. The significance level was $P < 0.05$ with 95% confidence intervals.

Data were assessed for normality using the Shapiro-Wilk test and for homogeneity of variance using Levene's test. Both tests confirmed that the assumptions for ANOVA were met, validating its appropriateness for comparing multiple groups over time. In addition, the high intraclass correlation coefficients (ICC: 0.80–0.90) for intra- and inter-examiner reliability affirm the methodological

consistency and precision of clinical assessments. The robust reliability adds validity to the trends observed and minimizes the potential for measurement bias.

## RESULT

In the experimental group, which received fixed orthodontic appliances, a notable decline in GI (from 1.95 to 1.02) was observed from baseline to the final follow-up; however, it was not significant. PI and EDI showed progressive and significant lower score over time, particularly when compared between P1 and P3 (1.05 to 0.42) and (1.08 to 1.02), respectively (P<0.05) (Table I, Fig. 1). CPI also showed significant changes throughout the study period, where most changes reflected a shift from code 2.52 to 1.2, without evidence of advanced attachment loss or deep periodontal pockets.

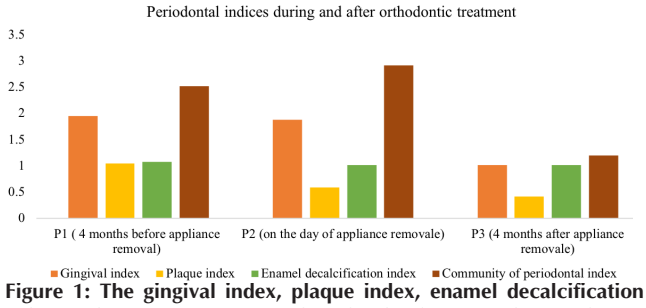


**Figure 1: The gingival index, plaque index, enamel decalcification index, and community of periodontal index before and after placing of the fixed orthodontic appliance for the experimental group.**

**Table I: Mean and standard deviation gingival index, plaque index, enamel decalcification index, and community of periodontal index before and after placing the fixed orthodontic appliance for the experimental group**

| Indices | Mean± SD | | | |
|---|---|---|---|---|
| Time interval | P1 | P2 | P3 | P* value |
| Gingival index | 1.95±0.312 | 1.88±0.288 | 1.02±0.3 | 0.52 |
| Plaque index | 1.05±0.13 | 0.59±0.15 | 0.42±0.32 | 0.05* |
| Enamel decalcification index | 1.08±0.32 | 1.02±0.288 | 1.02±0.3 | 0.05* |
| Community of periodontal index | 2.52±0.312 | 2.92±0.288 | 1.2±0.3 | 0.02* |

P* value indicates the statistical significance of changes within the same group over the different time intervals (P1, P2, P3), analyzed using repeated measures ANOVA

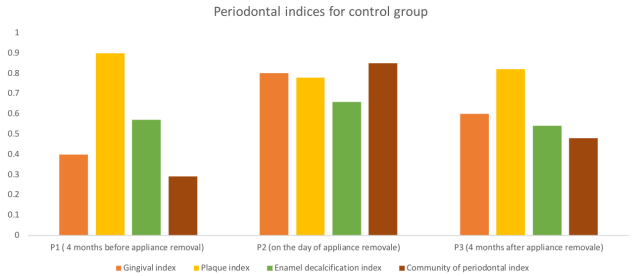


**Figure 2: The gingival index, plaque index, enamel decalcification index, and community of periodontal index before and after placing the fixed orthodontic appliance for the control group**

In contrast, the control group did not show any statistically significant changes in PI, EDI, or CPI across the same period (P > 0.05) (Table II, Fig. 2). Minor fluctuations in indices were observed. Still, they remained within a stable range, and the GI scores stayed relatively low.

**Table II: Mean and standard deviation gingival index, plaque index, enamel decalcification index, and community of periodontal index before and after placing the fixed orthodontic appliance for the control group**

| indices | Mean± SD | | | |
|---|---|---|---|---|
| Time interval | P1 | P2 | P3 | P* value |
| Gingival index | 0.4±0.23 | 0.8±0.28 | 0.6±0.35 | 0.6 |
| Plaque index | 0.9±0.13 | 0.78±0.16 | 0.82±0.19 | 0.8 |
| Enamel decalcification index | 0.57±0.32 | 0.66±0.28 | 0.54±0.21 | 0.8 |
| Community of periodontal index | 0.29±0.32 | 0.85±0.25 | 0.48±0.34 | 0.2 |

P* value indicates the statistical significance of changes within the same group over the different time intervals (P1, P2, P3), analyzed using repeated measures ANOVA

## DISCUSSION

The present study investigated the longitudinal effects of fixed orthodontic appliances on periodontal and enamel health by comparing clinical parameters between patients undergoing orthodontic treatment and the control group over an 8-month observation period. The use of indices such as PI, GI, EDI, and CPI allowed for a comprehensive assessment of both soft and hard tissue changes associated with orthodontic fixed appliances (12).

The findings revealed a statistically significant reduction in PI and EDI scores among the orthodontic group from during the treatment period (P1) to appliance removal (P2) and further to the post-removal phase (P3). This trend underscores the detrimental impact of fixed appliances on plaque accumulation and enamel integrity. Orthodontic brackets and wires are known to create retentive niches that compromise effective oral hygiene, thereby promoting biofilm development(13). This aligns with previous studies demonstrating increased bacterial colonization and a rise in cariogenic challenges during orthodontic treatment, and this could lead to plaque formation (14). One expected explanation for the reduction in PI is related to patient behaviour and compliance. The removal of brackets alone may not result in improved oral hygiene if patients fail to adopt sufficient oral hygiene practices post-treatment (15).

The progression of enamel decalcification also emphasizes the susceptibility of enamel surfaces, especially in the anterior region, to demineralization due to prolonged plaque retention around brackets (16). EDI recovery usually starts after 6-12 weeks of appliance removal, with apparent improvement lasting 6-12 months, depending on lesion severity and oral care (16). Hence, the significant reduction of EDI after a 4-month appliance removal. To decrease decalcification, patients should maintain excellent oral hygiene, use fluoride toothpaste and mouth rinses, apply remineralizing agents like CPP-ACP, restrict acidic and sugary diets, and attend regular dental check-ups(17).

Interestingly, despite the significant reduction in plaque accumulation and enamel demineralization, the GI

scores in the experimental group exhibited only a mild decline from baseline to post-treatment. This observation may be attributed to improved gingival health awareness and reinforced oral hygiene instructions provided during orthodontic treatment(18). The decrease in GI scores following treatment indicates that gingival inflammation responds quickly to improved hygienic factors when the appliances are removed. This emphasises the dynamic nature of soft tissue responses, as well as the significance of early intervention and patient education during orthodontic treatment (19).

Furthermore, the periodontal changes, as reflected by CPI scores, were significantly high during orthodontic treatment, indicating the presence of gingival bleeding or calculus without clinical attachment loss. This suggests that although inflammation and plaque accumulation increased, the severity did not reach levels which indicative of periodontitis within the monitored time frame (20). The CPI results also reduced significantly after treatment, dropping from a mean of 2.52 to 1.2. This shows an improvement in periodontal health; it is worth noting that minor periodontal problems persisted. Nonetheless, there was little evidence of severe periodontal disease (e.g., pocketing or attachment loss), indicating that, while inflammation and calculus were concerns throughout therapy, the tissue reaction after debonding was reversible primarily (21).

The control group, devoid of orthodontic appliances, displayed relatively stable periodontal and enamel health across all time points. The lack of significant changes in PI, EDI, or CPI in this group reinforces the conclusion that the alterations observed in the experimental group were primarily attributable to the presence of fixed appliances rather than natural variation or environmental factors.

The implications of these findings are clinically significant. They highlight the necessity of rigorous preventive strategies during orthodontic treatment, including tailored oral hygiene instructions, fluoride supplementation, and frequent monitoring of plaque and decalcification status. Moreover, GI improvement suggests that gingival inflammation can be mitigated through proper education and compliance, even in the presence of mechanical challenges posed by orthodontic treatment (22).

Nevertheless, the study has certain limitations. The relatively short follow-up period post-appliance removal (four months) may not fully capture the long-term trajectory of enamel recovery or periodontal stability. Furthermore, the enamel decalcification assessment was limited to anterior teeth, which, although most visibly affected, may not reflect generalized trends. Future longitudinal studies with extended follow-up durations and radiographic evaluations would be beneficial in elucidating the progression and potential resolution of orthodontically induced enamel and periodontal changes.

## CONCLUSION

With the limitation of this study, PI, EDI, and CPI showed high scores during orthodontic treatment but improved significantly during post-treatment. GI also indicates a reduction in the score throughout the study period, but it was not significant. The findings highlight the importance of careful monitoring and preventive strategies to minimize periodontal health risks during orthodontic treatment.

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