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Evaluation of Plaque and Gingival Indices in Patients Treated with Fixed Orthodontic Appliances.

Samia Dammaj[1]* , Ahmed Obeyah[1], Fuad Almuttareb[1], Ahmad Kahoul[1] and Salma Al-aqab[2]

[1]**Department of Orthodontics, Pedodontics and Prevention Dentistry, Faculty of Dentistry, Sana'a University, Sana'a, Yemen,**
[2]**Department of Conservative Dentistry, Faculty of Dentistry, Sana'a University, Sana'a, Yemen.**

*Corresponding author:Email: dr.samiadammaj@gmail.com

Abstract

Background/Aim:

The adverse effects of fixed orthodontic appliances in terms of gingivitis and periodontal plaque accumulation are well known, and the importance of patient education, motivation, and oral hygiene habits in periodontal health maintenance cannot be overestimated. This study aimed to prospectively determine the plaque and gingival indices of patients receiving fixed orthodontic treatment at Sanaa University, Yemen.

Methods:

This longitudinal observational study included forty-eight orthodontic patients (aged 16-30 years) undergoing active treatment for at least four months. The Plaque Index (PI) and Gingival Index (GI) were blindly assessed at baseline (T0), two months (T1), and four months (T2). Inter-arch and intra-arch (anterior vs. posterior) comparisons were performed using the Mann-Whitney U test. Changes over time were analyzed using the Wilcoxon signed-rank test, with post-hoc Bonferroni tests for multiple comparisons (α = 0.05). Throughout the study, the patients received motivational support, including educational videos and regular WhatsApp reminders.

Results:

The general trends in GI scores showed a significant decline over time and a highly significant improvement at T0-T1 and T0-T2 ($P < 0.001$). The plaque score increased mildly during T0 and T1 but significantly dropped during T1 and T2 ($P < 0.001$). Plaque and gingival indices were always higher in the lower arch than in the upper arch. The anterior-posterior difference in teeth was minimal and not significant.

Conclusion:

Fixed orthodontic appliances are not harmful to the health of the gums if the patients take proper care of the oral cavity. Permanent motivational reinforcement, education, and follow-up play a major role in enhancing plaque control and gingival status during orthodontic treatment.

Article Info

Keywords:
Gingival indext, Plaque indext, Patient motivationt, Oral hygienet, Fixed Orthodontic appliances

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1. INTRODUCTION

The use of fixed appliances as an orthodontic method for correcting malocclusion and improving the aesthetic appearance of the teeth has become the norm. However, they are associated with several adverse effects owing to difficulties in cleaning using natural mechanisms or other means, such as toothbrushes. Improper flossing is the most frequent issue. All these factors cause the accumulation of food and plaque around orthodontic appliances, leading to gingival inflammation and enlargement [1]. Approximately 700 types of bacteria are found in the human mouth, making it one of the most diverse bacterial environments in the human body. Oral health is a significant component of general health[2, 3]. An ideal oral condition is characterized by the absence of periodontal disease, tooth decay, and other oral conditions that prevent an individual

from eating, smiling, or talking comfortably. Moreover, research in microbiology has shown great variation in microbial stagnation rates within the dental plaque of the subgingival cavity, implying that orthodontic treatment may alter the ratio of microorganisms and stimulate their increase[4, 5]. Previous studies have demonstrated that the incidence of Streptococcus mutans, which is considered a significant risk factor for dental caries, increases following the placement of fixed orthodontic appliances[6, 7]. According to several studies, the placement of fixed appliances changes the oral environment in a way that promotes demineralization[8]. These appliances cause dental plaque, which is commonly more acidic than that in non-orthodontic people, to accumulate quickly. Poor oral hygiene adherence is one of several risk factors that lead to the development of white spot lesions (WSLs) [9, 10]. Gender can also impact oral health because women tend to be more conscious of and have better attitudes toward oral health care than men, who generally exhibit poor oral hygiene habits. Oral health is usually considered in relation to the quality of life because dental problems can be both painful and unattractive. They also have higher oral health literacy; these differences may be influenced by behavioral, hormonal, and sociocultural factors, although the results are not always consistent[11, 12]. According to Kadu et al. (2015)[13], patient awareness, motivation, cooperation, and attitude are essential for maintaining good oral hygiene throughout fixed orthodontic treatment. Carelessness or misunderstanding can lead to poor hygiene[14]. Age, attitude, and length of treatment also affect how well-informed orthodontic patients are regarding their periodontal health, according to studies[15]. Evaluating plaque and gingival indices in orthodontic patients offers several benefits, including enabling clinicians to monitor patients' oral hygiene status, assess the effectiveness of oral hygiene instructions, identify those at risk of periodontal problems, and take prompt action to avoid negative consequences[16, 17].To measure plaque accumulation and gingivitis, some indices have been developed, including the Plaque Index (PI), Gingival Index (GI), Bleeding on Probing (BOP), and modified indices that have been developed specifically to measure the situation in orthodontic patients. To minimize such negative effects, patients must play a critical role in ensuring that they practice adequate dental care. Patients who are not willing to comply with oral hygiene instructions are not ideal candidates for orthodontic treatment. With proper knowledge and motivation, a patient may overcome the difficulties of keeping the area around orthodontic devices clean and can greatly decrease the chances of plaque accumulation and inflammation of the gingiva.

Despite the considerable amount of research conducted in different countries concerning the oral health consequences of fixed orthodontic appliances, limited local studies on the measurement of plaque and gingival indices of patients in Sana, Yemen, have been conducted. As a result, such a lack of data limits the capacity of clinicians to understand the oral hygiene condition and periodontal reactions typical of Yemeni orthodontic patients, who may not be similar to other groups owing to different behavioral, cultural, and environmental influences. Measuring both the plaque and gingival index of this cohort is critical in establishing individuals who are at a high risk of periodontal complications, the effectiveness of oral hygiene instructions, and the establishment of separate preventive measures. Locally relevant data will be acquired to provide evidence to support clinical decisions and improve the oral health outcomes of orthodontic care in Yemen. Thus, the objective of this study was to determine the plaque and gingival indices in orthodontic patients undergoing fixed orthodontic treatment in Sana, Yemen, to support evidence-based advice on oral hygiene control and oral preventive care.

2. MATERIALS AND METHODS:

Study design:

It is a prospective longitudinal observational study that would evaluate plaque and gingival indices in patients undergoing fixed orthodontic treatment.

The study was approved by the Ethics Committee of the Medical Research Faculty of Dentistry, Sana'a University in Yemen (OR:01/12/2024).

Study area:

This study will be carried out at the orthodontic department clinics, Faculty of Dentistry, Sana'a University.

- Inclusion criteria: Age 16–30 years; patient undergo to orthodontic treatment at least 4 months into active treatment; good systemic health.
- Exclusion criteria: Periodontal disease, systemic conditions affecting oral health, recent antibiotic therapy.

Sample size:

The sample size of the study was 48 participants, which was the entire cohort that was available.

Data Collection and Analysis for Plaque Index and Gingival Index:

This study included 48 subjects. The Plaque Index (PI) and Gingival Index (GI) were used to determine their clinical status at T0 fig.(3), T1 (Fig.4), and T2 (Fig.5).

Examiner Blinding:

PI and GI were assessed clinically by a blinded examiner who was not informed of any details of the participants that could affect the score. To evaluate the participants objectively and without bias, the identities of the participants and previous measurements were hidden to observe the results at the three time points.

Statistical Analysis:

Repeated-measures ANOVA was used to compare the change in PI and GI over time points (or the Friedman test in the case of non-normality of data). Post-hoc Bonferroni tests were used to determine significant differences between time points. The level of statistical significance was set at = 0.05.

Reliability analysis:

Paired t-tests and intraclass correlation coefficients (ICCs) were performed to assess systematic and random errors. There was a very good inter-observer agreement regarding the reliability coefficients of all measurements, ranging from 0.466 to 0.933. There were no significant differences in the inter-observer agreement. There was also a very good intra-observer agreement regarding all measurement reliability coefficients, ranging from 0.379 to 1.000. There were no significant differences in the intra-observer agreement.

Plaque Index (PI) Measurement:

Before beginning the examination, the participant was seated comfortably in the dental chair under proper illumination and positioned in the standard supine position. Using a dental mirror, the cheek was carefully lifted, and the teeth and gingiva were dried with an air-water syringe to ensure that they were clearly visible. The Plaque Index assessment followed the procedure described by Leo and Silness 1963 and silness1964 [17, 18]. A periodontal probe (Avion, Pakistan) was used with the pen grasp technique to evaluate plaque deposits. The scoring was documented by an assistant on a data sheet, while a voice recording was made to verify the collected information. For each participant, the evaluation began from the upper right first molar, continuing sequentially to the upper left, and then from the lower left to the lower right first molars. All four surfaces (mesial, distal, buccal (facial), and lingual (palatal]) of each permanent tooth were examined, giving a total of approximately 24 teeth per participant. The Plaque Index was scored based on the following criteria:

1. 0: No visible plaque.
2. 1: Thin film of plaque detectable only by probing the gingival margin.
3. 2: Moderate accumulation of plaque visible to the naked eye.
4. 3: Heavy deposits on the tooth surface and within the gingival pockets.

After all measurements were completed, the mean PI score for each participant was calculated by dividing the sum of plaque scores by the number of examined sites. Based on the mean value, oral hygiene was interpreted as follows:

1. 0.0–0.9: Good to excellent hygiene.
2. 1.0–1.9:
3. $\geq$2.0: Poor hygiene, requiring

Gingival Index (GI) Measurement:

- The condition of the participants' gingival tissues was systematically examined by Leo and Silness 1963 [19]. observing both visual signs of inflammation and the response to gentle probing (Fig.2). To ensure a thorough assessment, the labial surface of each tooth was divided into three specific regions: mesial (M), mid-labial (Mid), and distal (D) [19].
- This subdivision allowed for consistent evaluation across all sites and facilitated reliable comparison between participants.
- During the examination, the clinician employed a Williams periodontal probe together with a dental mirror for optimal visualization. The probe was handled with a controlled pen grasp and carefully inserted into the gingival sulcus to assess the tissue condition without causing trauma or bleeding unless inflammation was already present. The procedure was conducted under adequate lighting,
- Each measurement was recorded directly in the participant's clinical case sheet by an assistant, while a voice recording was made to ensure that all observations could be verified later, minimizing potential errors.

Scoring of gingival health followed these criteria:

1. 0: Healthy gingiva with no visible inflammation.
2. 1: Mild inflammation, indicated by slight color changes and minimal swelling with no bleeding on probing.
3. 2: Moderate inflammation with redness, edema, glazed appearance, and bleeding upon probing.
4. 3: Severe inflammation, characterized by marked redness, swelling, ulceration, and spontaneous bleeding.

The mean GI score for each participant was calculated by summing the scores from all examined surfaces and dividing by the total number of sites.

- **Interpretation of GI values:**

1. 0.0–0.1: Healthy gingiva

(a) Figure (1) **(b)** Figure (2)

(c) Figure (3) T0

(d) Figure (4) T1

(e) Figure (5) T2

2. 0.1–1.0: Mild inflammation
3. 1.1–2.0: Moderate inflammation
4. 2.1–3.0: Severe inflammation

The encouragement of these oral hygiene guidelines was persistently given throughout the research period during the follow-up visits.

In addition, a WhatsApp group was established to maintain communication with participants throughout the study period. This group received regular reminders about oral hygiene practices, dietary restrictions, and educational videos demonstrating the correct tooth brushing technique.

3. RESULTS:

Compare between arch for the gingival and plaque index of mesial, distal, and buccal at the measured time points:

Table 1 provides a comparison of the gingival and plaque indices between the upper and lower arches at T0, T1, and T2. Statistical analysis was performed using the Mann-Whitney test.

Overall Gingival Index: At T0, there was a highly significant difference ($P < 0.001$) between the arches, with the lower arch showing a higher gingival index. This difference was not significant (NS) at T1. However, by T2, a statistically significant difference re-emerged ($P < 0.05$), with the lower arch still having a higher mean gingival index compared than the upper arch.

Overall Plaque Index: The plaque index was consistently higher in the lower arch than in the upper arch across all measured time points. This difference was statistically significant at T0 ($P < 0.05$) and highly significant at both T1 and T2 ($P < 0.001$). These findings suggest that plaque accumulation is a more

Table 1. Comparison between the arch for the gingival and plaque index of mesial, distal, and buccal at the measured time points.

	T0			T1			T2		
	Upper	Lower	P-value	Upper	Lower	P value	Upper	Lower	P value
Gingival index	0.26 ± 0.4	0.34 ± 0.5	***	0.21 ± 0.3	0.24 ± 0.4	NS	0.17 ± 0.3	0.29 ± 0.3	*
Plaque index	0.38 ± 0.4	0.43 ± 0.4	*	0.40 ± 0.5	0.49 ± 0.4	***	0.35 ± 0.4	0.46 ± 0.4	***

Mann-Whitney Test, * P <.05, **P < 0.01, *** P < 0.001, NS = Not significant.

significant issue in the lower arch during the study period.

Comparison of gingival index scores on anterior and posterior teeth of the upper and lower arch:

Table 2 analysis compares the gingival index scores on anterior and posterior teeth of the upper and lower arches over four months. The Mann-Whitney Test was used to determine the significance of the differences, with a p-value of less than 0.05 indicating a statistically significant result.

Upper Arch: At baseline, the mean gingival index scores were 0.26 (SD 0.47) for anterior teeth and 0.26 (SD 0.42) for posterior teeth, with no significant difference found (P=1.000). At two months, the mean scores were 0.21 (SD 0.34) for anterior teeth and 0.20 (SD 0.30) for posterior teeth, which was also not statistically significant (P=0.911). At four months, a statistically significant difference was observed (P=0.027). The mean scores were 0.19 (SD 0.27) for the anterior teeth and 0.15 (SD 0.23) for the posterior teeth.

Lower Arch: At baseline, the mean gingival index scores were 0.35 (SD 0.51) for anterior teeth and 0.32 (SD 0.50) for posterior teeth, showing no significant difference (P=0.462). At two months, the mean scores were 0.25 (SD 0.36) for anterior teeth and 0.23 (SD 0.37) for posterior teeth, with no significant difference found (P=0.225). At four months, a statistically significant difference was found between the groups (P=0.021). The mean scores were 0.25 (SD 0.32) for the anterior teeth and 0.20 (SD 0.31) for the posterior teeth.

Post hoc power analysis (Table 1)

1. Gingival Index (GI): Upper Arch versus Lower Arch at T1

The Standardized Test Statistic (Z) was found to be (-0.366), from which an Effect Size (r) of 0.053 was derived. The negligible effect size indicates that the practical difference in the Gingival Index between the upper and lower arches at the two-month follow-up was trivial (negligible). This confirms that the failure to achieve statistical significance is attributable to the inherently small magnitude of the practical difference.

2. Plaque Index (PI): Upper Arch versus Lower Arch at T0

The Standardized Test Statistic (Z) was (-2.292), corresponding to the reported Effect Size, from which an Effect Size (r) of 0.331 was derived. The medium effect size suggests that the difference in the Plaque Index between the upper and lower arches at baseline (T0) had clear practical significance. This strongly supports the statistically significant result, demonstrating that the observed difference was substantive rather than a mere chance.

Comparison of plaque index scores on anterior and posterior teeth of the upper and lower arch:

Post hoc power analysis (Table 2):

All comparisons for the Plaque Index between anterior and posterior teeth throughout the study were not statistically significant. The calculated effect sizes for all time points and both arches were consistently small or very small (r) ranging from (0.004 to 0.222). This analysis confirmed that the lack of statistical significance was due to the limited practical difference in plaque accumulation between the anterior and posterior segments. This suggests that the motivational and hygiene interventions were equally effective across both dental regions.

Table 3 illustrates the comparison of plaque index scores on anterior and posterior teeth of the upper and lower arches.

The analysis used the Mann-Whitney Test, with a P-value of less than 0.05 considered statistically significant.

Upper Arch: At baseline, the mean plaque index scores were 0.38 (SD 0.43) for anterior teeth and 0.37 (SD 0.39) for posterior teeth, with no significant

Table 2. Comparison of gingival index scores on anterior and posterior teeth of the upper and lower arch

Arches	Treatment	Surfaces	Mean	SD	T-value	P-value	Z value	Effect Size (r)	Interpretation (Cohen)
Upper arch	Baseline	Anterior	0.26	0.47	0.00	1.000 NS	-0.703	0.101	Small
		Posterior	0.26	0.42					
	2 months	Anterior	0.21	0.34	0.52	0.911 NS	-0.111	0.016	Very Small
		Posterior	0.20	0.30					
	4 months	Anterior	0.19	0.27	2.07	0.027*	-2.211	0.319	Medium
		Posterior	0.15	0.23					
Lower arch	Baseline	Anterior	0.35	0.51	0.75	0.462 NS	-0.735	0.106	Small
		Posterior	0.32	0.50					
	2 months	Anterior	0.25	0.36	0.76	0.225 NS	-1.214	0.175	Small
		Posterior	0.23	0.37					
	4 months	Anterior	0.25	0.32	1.81	0.021*	-2.307	0.333	Medium
		Posterior	0.20	0.31					

Mann-Whitney Test, * P < 0.05, NS = Not significant.

difference (P=0.979). At two months, the mean scores were 0.43 (SD 0.47) for anterior teeth and 0.38 (SD 0.44) for posterior teeth, with no significant difference (P=0.124). At four months, the mean scores were 0.33 (SD 0.41) for anterior teeth and 0.36 (SD 0.39) for posterior teeth, showing no statistically significant difference (P=0.293).

Lower Arch: At baseline, the mean plaque index scores were 0.43 (SD 0.44) for anterior teeth and 0.44 (SD 0.43) for posterior teeth, and the difference was not significant (P=0.817). At two months, the mean scores were 0.49 (SD 0.40) for anterior teeth and 0.50 (SD 0.39) for posterior teeth, with no significant difference (P=0.547). At four months, the mean scores were 0.45 (SD 0.41) for anterior teeth and 0.47 (SD 0.42) for posterior teeth, and the difference was not statistically significant (P=0.579)

Post hoc power analysis (Table 3):

All comparisons for the Plaque Index between anterior and posterior teeth throughout the study were not statistically significant. The calculated effect sizes for all time points and both arches were consistently small or very small (r ranging from 0.004–0.222). This analysis confirms that the lack of statistical significance is due to the limited practical difference in plaque accumulation between the anterior and posterior segments. This suggests that the motivational and hygiene intervention was equally effective across both dental regions.

4. DISCUSSION:

Plaque deposition and gingival inflammation are among the most important complications related to fixed orthodontic braces, especially in patients who do not pay excessive attention to oral hygiene. The shape of the orthodontic device and the additions around it, such as Otay, power chain, ligature wire, and bands, require excessive cleaning to remove stuck food residues. There is a lot of research that has addressed this topic from several aspects. Some studies have examined plaque accumulation and gingivitis in the patient's mouth and compared the anterior and posterior teeth, while others have compared females and males, as well as the prevalence of this phenomenon among orthodontic diseases. In this study, we evaluated the presence of plaque and gingivitis indices among orthodontic patients in Sana'a, Yemen. which was found in the present study, both the Plaque Index (PI) and Gingival Index (GI) were assessed at every evaluation point to check the status of oral hygiene and gingival health during treatment. Special emphasis was given to patient motivation, and participants were given repeated sessions of reinforcement advice about the importance of maintaining oral hygiene, an educational video about proper brushing, and a reminder in group WhatsApp before and throughout the orthodontic

Table 3. Comparison of Plaque index scores on anterior and posterior teeth of the upper and lower arch

Arches	Treatment	Surfaces	Mean	SD	T-value	P-value	Z value	Effect Size (r)	Interpretation (Cohen)
Upper arch	Baseline	Anterior	0.38	0.43	0.23	0.979 NS	-0.026	0.004	Negligible
		Posterior	0.37	0.39					
	2 months	Anterior	0.43	0.47	1.35	0.124 NS	-1.539	0.222	Small
		Posterior	0.38	0.44					
	4 months	Anterior	0.33	0.41	-0.83	0.293 NS	0.293	0.042	Very Small
		Posterior	0.36	0.39					
Lower arch	Baseline	Anterior	0.43	0.44	-0.10	0.817 NS	-0.232	0.033	Very Small
		Posterior	0.44	0.43					
	2 months	Anterior	0.49	0.40	-0.36	0.547 NS	-0.603	0.087	Very Small
		Posterior	0.50	0.39					
	4 months	Anterior	0.45	0.41	-0.55	0.579 NS	-0.554	0.080	Very Small
		Posterior	0.47	0.42					

Mann-Whitney Test, NS = Not significant.

treatment to maintain optimal oral hygiene. This methodological approach allowed us to study not only the longitudinal clinical changes in PI and GI but also the effects of continuous motivational interventions on these indices. The results showed a significant decrease in the Overall Gingival Index over time. There was a highly statistically significant difference ($P < 0.001$) between T0 and T1 and T0 and T2, which points to a large extent of improvement in the state of gingival health. A statistically significant difference ($P < 0.01$) also existed between T1 and T2, suggesting that the improvement continued. In addition, the Overall Plaque Index showed a statistically significant difference between T0 and T1 ($P < 0.001$), and the mean value slightly increased. However, the difference between T0 and T2 was not statistically significant (NS). A highly significant decrease ($P < 0.001$) in the plaque index was observed between T1 and T2, indicating an improvement in plaque control during this period. These findings are similar to the conclusion of the systematic review by [20], in which motivational methods had a statistically significant advantage regarding PI and GI in the study group.

The present study also assessed the differences in Plaque Index and Gingival Index between the maxillary and mandibular arches. This suggests that gingival inflammation and plaque accumulation are more significant occurrences in the lower arch throughout the study period. To the best of our knowledge, previous studies that focused on comparisons between the upper and lower arches were limited.

According to their studies, fixed orthodontic appliances do not have a direct adverse effect on the health of the gingiva when patients adhere to the prevention rules and maintain good oral hygiene. In other words, regardless of the state of proper dental hygiene, the mere presence of braces does not necessarily lead to an increase in plaque or gingival irritation. This finding was similar to that of Atassi et al. (2010).

Studies have shown that it is not the orthodontic appliance but rather poor oral hygiene that is the principal cause of gingival irritation and accumulation of plaque [21, 22]. During treatment, patients may have healthy gingiva, provided that they brush their teeth regularly, use interdental aids, and follow the advice of the professional.

5. CONCLUSION:

Fixed orthodontic appliances are not harmful to the gingiva directly unless patients take into consideration good oral health. However, a greater difference in the plaque and gingival indices was observed in the lower arch. The plaque and gingival index scores were low throughout the study, with no major differences between the anterior

and posterior teeth. The primary determinants of periodontal outcomes are patient compliance and regular oral health care procedures, not the appliance itself.

6. LIMITATIONS:

The sample was small, which had an impact on generalizability. The follow-up period (4 months) may not be sufficient to measure long-term effects, and hygiene adherence based on self-reporting can lead to reporting bias.

7. RECOMMENDATIONS:

Give oral hygiene education (brushing, interdental cleaning, orthodontic aids) continuously and arrange periodic professional check-up visits to plaque important to avoid complications associated with the deposition of plaque around brackets during orthodontic treatment. Larger studies with extended follow-up periods and learning patient motivation techniques are needed to enhance oral hygiene treatment.

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