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Research Article

Clear Aligners vs. Fixed Orthodontic Appliances: Effects on Periodontal Health and Plaque Accumulation

Touseef Ullah Khan[1], Faseeha Ali[2], Sana Rasheed[3]*, Bisma Saleem[4], Darshana Bai[5]

1. *Bachelor of Dental Surgery, Sardar Begum Dental College and Hospital, Peshawar, Pakistan*
2. *Bachelor of Dental Surgery, Liaquat College of Medicine and Dentistry, Karachi, Pakistan*
3. *House Officer, Punjab Dental Hospital, Lahore, Pakistan*
4. *Bachelor of Dental Surgery, Dow International Dental College, Karachi, Pakistan*
5. *Bachelor of Dental Surgery, Hamdard College of Medicine and Dentistry, Karachi, Pakistan*

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Abstract

Introduction: Orthodontic appliances, including fixed devices and clear aligners, are widely used to correct dental malocclusions and improve oral function. This study aimed to compare the effects of clear aligners and fixed orthodontic appliances on periodontal health, including plaque index (PI), gingival index (GI), probing pocket depth (PPD), and bleeding on probing (BOP), during orthodontic treatment.

Materials and Methods: In this prospective comparative study, 124 patients undergoing orthodontic treatment at Khyber College of Dentistry, Peshawar, were divided into two equal groups (n=62 each). Group A received clear aligners, and Group B received fixed orthodontic appliances. Clinical parameters PI, GI, PPD (mm), and BOP (%) were recorded at baseline, 6 months, and 12 months. Independent t-tests were used for statistical comparisons.

Results: The clear aligner group showed statistically significant reductions in PI (0.84 ± 0.32 vs 1.57 ± 0.40), GI (0.72 ± 0.28 vs 1.39 ± 0.36), and PPD (2.28 ± 0.38 mm vs 2.81 ± 0.45 mm) compared to the fixed appliance group ($p < 0.001$ for all). BOP was observed in 22.6% of patients with aligners and 53.2% with fixed appliances.

Conclusion: Clear aligners demonstrated a statistically significant improvement in periodontal parameters compared to fixed appliances. These findings suggest that aligners may promote better long-term periodontal health and oral hygiene during orthodontic treatment.

**Corresponding Author:*
Sana Rasheed
House Officer, Punjab Dental Hospital, Lahore, Pakistan
Email: sanarasheed384@gmail.com

Introduction

Orthodontic treatment functions as an essential method to fix malocclusion issues as well as enhance oral function while improving dental appearance [1]. Orthodontic patients typically receive fixated appliances (FOAs) either made from metal or ceramic braces which provide dependable results for most dental issues [2]. Prolonged usage of FOAs leads to worse plaque retention together with reduced oral hygiene abilities which results in the development of gingivitis and periodontal pocket formation [3]. The popularity of clear aligners has grown significantly during recent years because they offer removable convenience and attractive appearance as an alternative treatment solution [4]. Clear aligners have gained increasing popularity yet the analysis of their clinical strengths and drawbacks compared to traditional fixed appliances needs focused examination regarding gum health and plaque regulation [5].

Invisalign and other clear aligners serve as a new orthodontic treatment paradigm because they offer discreet and comfortable mouthpieces [6]. Better oral hygiene becomes possible when aligners are removable thus reducing the chances of plaque accumulation while preventing gingival inflammation [7]. The use of clear aligners by patients demonstrates superior results for gingival health compared to fixed appliances because patients exhibit reduced bleeding and lower plaque quantities with less enamel degradation according to eight published studies [8]. Patients with clear aligners gain multiple benefits since their absence of brackets and wires produces fewer germ-infected zones that are difficult to clean in typical braces [9].

The clinical efficiency of fixed orthodontic appliances leads to dental plaque accumulation due to their bracket-related niches [10]. The combination of brackets archwires along with ligatures forms barriers against effective teeth brushing and flossing which enables biofilm development that causes periodontal disease unless proper control measures are established [11]. The combination of compromised oral hygiene and existing gingival disease increases pocket depth as well as bleeding on probing which leads to overall periodontal damage in dental patients [12]. Although various preventive strategies such as fluoride mouth rinses, interdental brushes, and professional cleanings are recommended during orthodontic treatment, patient compliance remains a critical factor in determining periodontal outcomes.

Despite the growing body of literature comparing the two orthodontic modalities, results remain inconclusive and often vary depending on study design, sample size, follow-up duration, and periodontal assessment criteria. While some studies highlight the superior periodontal outcomes associated with clear aligners, others report minimal or no significant differences [13]. Furthermore, most existing studies are either limited to short-term evaluations or lack a standardized methodology for periodontal assessment.

Given this background, there remains a significant gap in high-quality comparative research assessing the long-term effects of clear aligners versus fixed orthodontic appliances on periodontal health and plaque accumulation; therefore, this study's goal is to assess and contrast the periodontal outcomes associated with these two orthodontic modalities.

Materials and Methods

Study Design and Setting

This prospective comparative study was conducted at the Department of Orthodontics, Khyber College of Dentistry (KCD), Peshawar. The study was carried out over duration of 12 months, from March 2022 to March 2023. The purpose of the study is to compare how fixed appliances, and clear aligners affect plaque control and gingival health, and overall oral hygiene during orthodontic treatment.

Sample Size Calculation

The sample size was calculated using the World Health Organization (WHO) sample size calculator, with a 95% confidence level, 80% statistical power, an expected effect size of 0.6, and a two-tailed significance level, based on parameters used in previous orthodontic studies [14]. This yielded a required minimum of 56 participants per group. To account for potential dropouts or incomplete data, the final sample size was increased to 62 participants in each group, totaling 124 individuals.

Sampling Technique and Group Allocation

The research study recruited eligible patients from hospital orthodontic treatment before dividing them into two balanced groups. The first group included 62 patients treated with clear aligners, and the second group received treatment with either metal or ceramic braces. A non-probability purposive sampling technique was chosen due to the practical limitations of random allocation in a clinical setting, where appliance selection often depends on patient preference, case complexity, and clinician recommendation.

Inclusion Criteria

Participants aged between 18 and 35 years, who had completed at least six months of active orthodontic treatment, and were systemically healthy, were included in the study. All participants had no history of periodontal disease and were willing to provide written informed consent.

Exclusion Criteria

Patients with systemic conditions affecting periodontal health (such as diabetes mellitus), those who had used antibiotics within the last four weeks, smokers, pregnant or lactating women, and those with poor oral hygiene compliance or a recent history of periodontal treatment were excluded.

Data Collection Procedure

An organized proforma was used to gather data, which recorded demographic details and clinical findings. All intraoral assessments were conducted by a single calibrated examiner to minimize variability and ensure consistency. The same calibrated clinician performed all periodontal assessments at each time point to ensure measurement consistency. Blinding of the examiner to the group allocation was not feasible due to visible differences in appliance type.

Clinical Parameters Assessed

The periodontal health of each participant was assessed using standard indices. Plaque accumulation was measured using the Plaque Index, and gingival inflammation was evaluated using the Gingival Index. Probing Pocket Depth was measured and the measurement process included UNC-15 periodontal probe, and bleeding on probing was also documented. Each analysis was performed at six distinct points on every tooth: mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual.

Data Analysis

The statistical analysis occurred through SPSS version 26.0. For Descriptive statistics, the research calculated statistics for quantitative variables which included means and standard deviations. For qualitative variables the results presented percentages and frequencies distributions. The independent sample t-test determined mean values of periodontal indices between these two groups. A statistical significance appeared at p-value levels below 0.05.

Ethical Considerations

Ethical approval for this study was obtained from the Institutional Ethical Review Board of Khyber College of Dentistry, Peshawar. Prior to participation, each patient was informed about the purpose and scope of the study, and written informed consent was obtained to ensure voluntary participation and confidentiality of personal data.

Results

A total of 124 patients participated in the study, with 62 patients in each group. Group A comprised 62 individuals who were using clear aligners, while Group B consisted of 62 individuals using fixed orthodontic appliances such as conventional metal or ceramic braces. The study participants were assessed for periodontal health and plaque accumulation across various clinical parameters. The mean age of participants in the clear aligner group was 24.6 ± 4.2 years, while in the fixed appliance group it was 25.1 ± 3.8 years. The age range for both groups was 18–35 years. In Group A, 33 (53.2%) participants were female and 29 (46.8%) were male. In Group B, 35 (56.5%) participants were female and 27 (43.5%) were male. There was no discernible difference in the two groups' distribution of ages or genders ($p > 0.05$). Regarding dental hygiene practices, 62.9% of participants in both groups said they brushed their teeth twice daily, and 37.1% brushed once a day. 16.9% of participants reported using interdental brushes or flossing. Regarding smoking status, 15.3% of participants in the clear aligner group were smokers, whereas 18.2% in the

fixed appliance group smoked. The two groups' smoking statuses did not differ significantly (p = 0.68), as shown in table 1.

Table 1: Demographic Characteristics of Study Participants

Variable		Clear Aligners (n=62)	Fixed Appliances (n=62)	Statistical Test	p-value
Age (years)	Mean ± SD	24.6 ± 4.2	25.1 ± 3.8	t = -0.72	0.47
Gender	Male	29	27	$\chi^2 = 0.13$	0.72
	Female	33	35		
Brushing Frequency	Twice a day (%)	62.9%	62.9%	$\chi^2 = 0.00$	1.00
	Once a day (%)	37.1%	37.1%	$\chi^2 = 0.00$	1.00
Interdental Cleaning (%)		16.9%	16.9%	$\chi^2 = 0.00$	1.00
Smoking	Yes	15.3%	18.2%	$\chi^2 = 0.17$	0.68
	No	84.7%	81.8%		

t = Independent t-test; χ^2 = Chi-square test

The clinical examination results revealed significant differences between the clear aligner and fixed appliance groups for various periodontal parameters. The mean Plaque Index (PI) for the clear aligner group was 0.84 ± 0.32, significantly lower than that of the fixed appliance group, which had a mean of 1.57 ± 0.40 (p < 0.001). Similarly, the mean Gingival Index (GI) for the clear aligner group was 0.72 ± 0.28, compared to 1.39 ± 0.36 in the fixed appliance group (p < 0.001). Probing Pocket Depth (PPD) was also significantly lower in the clear aligner group (2.28 ± 0.38 mm) compared to the fixed appliance group (2.81 ± 0.45 mm), with a p-value of < 0.001 (table 2)

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Table 2: Comparison of Periodontal Health between the Two Groups

Periodontal Parameter	Clear Aligners (n=62)	Fixed Appliances (n=62)	p-value
Plaque Index (PI)	0.84 ± 0.32	1.57 ± 0.40	<0.001
Gingival Index (GI)	0.72 ± 0.28	1.39 ± 0.36	<0.001
Probing Pocket Depth	2.28 ± 0.38 mm	2.81 ± 0.45 mm	<0.001

In contrast to the clear aligner group, the fixed appliance group had a noticeably higher rate of BOP. Bleeding on probing (BOP) was recorded as a patient-level percentage, defined as the presence of bleeding at one or more sites during probing. It was observed in 33 participants (53.2%) in the fixed appliance group and in 14 participants (22.6%) in the clear aligner group (p < 0.001, Chi-square test). This significant difference suggests that patients with fixed appliances experienced higher levels of gingival inflammation and bleeding, likely due to greater plaque accumulation and difficulty in maintaining oral hygiene. In contrast, the lower prevalence of BOP in the clear aligner group indicates a reduced inflammatory response, reinforcing the benefit of aligners in maintaining periodontal health while receiving orthodontic therapy (figure 1).

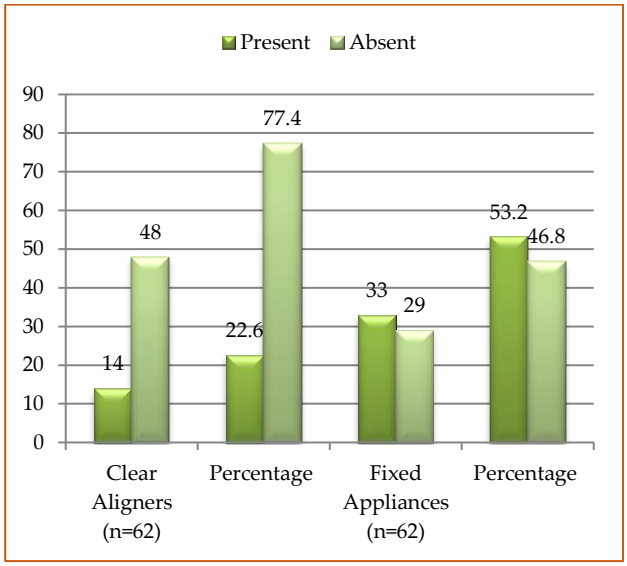

Figure 1: Frequency of Bleeding on Probing (BOP) Between Groups

The comparison of PI between genders within the two groups revealed no statistically significant

differences. Among participants using clear aligners, males had a mean PI of 0.88 ± 0.31, while females had a mean PI of 0.81 ± 0.34. In the fixed appliance group, male participants exhibited a mean PI of 1.61 ± 0.43, whereas females had a mean PI of 1.53 ± 0.39. Despite slight variations, the p-values for these differences were greater than 0.05, indicating that gender did not significantly influence plaque accumulation in either group. This suggests that plaque retention was more closely associated with the type of orthodontic appliance rather than gender differences (table 3).

Table 3: Plaque Index by Gender in Both Groups

Gender	Group	Mean PI ± SD	p-value (within group)
Male	Clear Aligners	0.88 ± 0.31	0.39
Male	Fixed Braces	1.61 ± 0.43	
Female	Clear Aligners	0.81 ± 0.34	0.27
Female	Fixed Braces	1.53 ± 0.39	

Analysis of the GI based on the duration of orthodontic treatment revealed that patients undergoing treatment for 12 months exhibited higher GI scores, particularly in the fixed appliance group. Among patients with fixed appliances, 68.4% of those treated for 12 months had elevated GI scores, compared to 57.1% of those with a treatment duration of 6 months ($p = 0.04$). In contrast, the clear aligner group showed minimal variation, with 35.5% of patients in the 12-month category and 32.3% in the 6-month category exhibiting elevated GI scores ($p > 0.05$). These findings suggest that prolonged use of fixed orthodontic appliances is associated with greater gingival inflammation, whereas clear aligners maintain more stable periodontal health over time (as illustrated in figure 2).

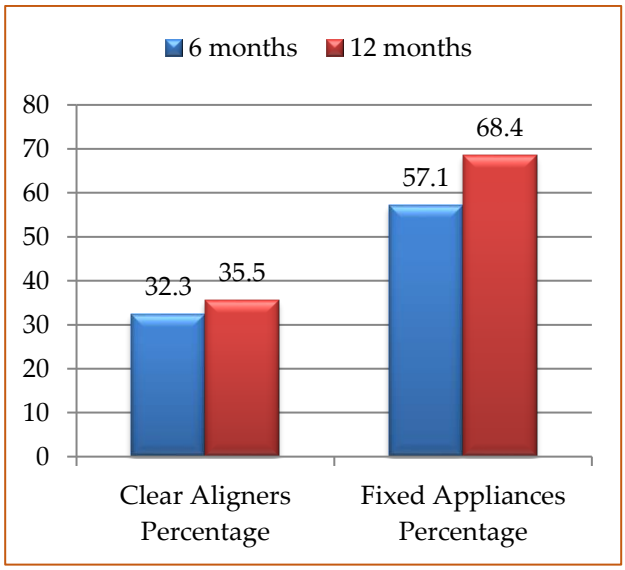

Figure 2: Gingival Index by Duration of Treatment

Discussion

The purpose of this study was to compare the effects of fixed orthodontic appliances and clear aligners on plaque buildup and periodontal health. The findings showed that clear aligners were linked to noticeably improve periodontal health, as indicated by a lower PI, GI, and PPD. In contrast, fixed orthodontic appliances led to higher plaque accumulation, greater gingival inflammation, and more frequent BOP. The findings of this study align with several other studies that have investigated the impact of orthodontic appliances on oral hygiene and periodontal health [15]. Because it can be challenging to clean around the brackets and wires, numerous studies have demonstrated that fixed braces are linked to increased plaque accumulation and gingival inflammation [16]. This contributes to higher plaque index and gingival index scores. In contrast, clear aligners, being removable, offer an advantage in maintaining oral hygiene as patients can clean their teeth without obstruction from the appliances [17].

The results of this study also support the literature that suggests fixed appliances result in a higher incidence of gingival bleeding, as these appliances create mechanical irritation to the gingiva, which may lead to gingival hypertrophy and inflammation over time [18]. The study participants using fixed appliances exhibited a significantly higher incidence of BOP compared to those using clear aligners, which is consistent with the well-documented negative

impact of fixed braces on gingival health [19]. The PPD was lower in the clear aligner group, suggesting less periodontal pocket formation compared to the fixed appliance group. This supports findings from earlier studies, which have highlighted that fixed appliances can cause periodontal pocketing around the teeth due to plaque accumulation, whereas clear aligners, being easier to remove and clean, help in maintaining a healthier periodontal environment [20].

In terms of gender differences in periodontal health, this study found no significant impact of gender on plaque accumulation or gingival health, which is consistent with several studies that have failed to establish a consistent relationship between gender and the effects of orthodontic appliances on oral health [21]. Furthermore, the impact of length of the treatment considerably affects the periodontal health, particularly in the fixed appliance group, where participants with treatment durations exceeding 12 months had worse gingival health [22]. This finding is in line with the literature, which suggests that the longer the treatment duration with fixed appliances, the greater the risk for developing periodontal issues such as gingival inflammation and pocket formation [23]. From a public health perspective, while clear aligners demonstrate superior periodontal outcomes, their accessibility and cost remain significant considerations. In low-resource settings, fixed appliances are more widely available and affordable. However, the potential long-term benefits of aligners in reducing periodontal complications may offset their initial costs. Future cost-effectiveness studies are warranted to evaluate their viability in broader population settings.

Limitations Future Suggestions

Despite the strengths of this study, several limitations must be noted. The study was conducted at a single center with a relatively modest sample size, limiting generalizability. The absence of randomization may introduce selection bias. Additionally, the study did not evaluate cost-effectiveness or patient satisfaction. Future research should include randomized controlled trials and multicenter studies to validate these findings across diverse populations. Investigating the accessibility and affordability of clear aligners, especially in low-income settings, is essential for guiding equitable orthodontic care.

Conclusion

This study demonstrates that clear aligners are a clinically effective and hygienically superior alternative to fixed orthodontic appliances in maintaining periodontal health during treatment. Patients using aligners showed significantly lower plaque accumulation, gingival inflammation, and probing pocket depth compared to those with fixed appliances. While maintaining oral hygiene remains critical in both treatment modalities, clear aligners may be preferable for suitable cases due to their positive periodontal outcomes. Further research with larger and more diverse populations is needed to confirm these findings and evaluate their long-term impact.

Authors' contributions

TUK: study design, literature review, data collection and analysis, drafting the manuscript and provided final approval. FA: data acquisition, performed the statistical analysis, contributed to the interpretation of findings, drafting the manuscript and gave final approval. SR: led the overall project coordination, supervised the research workflow, ensured the accuracy and consistency of data, manuscript drafting, editing, and submission, reviewed the final content and gave final approval. BS: clinical data collection, organized patient documentation, and participated in drafting the manuscript. She also reviewed and gave final approval. DB: literature review, helped in the preparation of tables and figures, contributed to drafting the manuscript, critically revised and gave final approval.

Conflict of interest

Nil.

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