Short-Term Effect of Fixed Orthodontic Appliances on Salivary pH and Its Correlation with Periodontal Health Indicators

Sazgar Kamil Hussein [1*], Faraedon M. Zardawi [2]

[1] BDS, Orthodontic Trainee of Kurdistan Higher Council of Medical Specialties, Sulaimaniyah, Kurdistan Region - Iraq

[2] BDS, MSc, MPhil, PhD-Sheffield University (UK), Dean of Faculty of Dentistry, Qaiwan International University, Sulaimaniyah, Kurdistan Region-Iraq

*Corresponding Author: Sazgar.kamil27@gmail.com

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ABSTRACT:

Background: Fixed orthodontic appliances (FOA) may alter the oral ecosystem by changing salivary pH (SpH) and promoting dental biofilm retention.

Objectives: This study aimed to evaluate short-term SpH changes after FOA placement and examined correlations between SpH and periodontal health parameters (PHPs) across early-treatment follow-up visits (baseline, 3 months, and 6 months).

Methods: In this prospective single-arm repeated-measures clinical trial, 30 patients (13–45 years) were assessed at T0 (baseline, pre-bonding), T1 (3 months post-bonding), and T2 (6 months post-bonding). Unstimulated whole saliva was collected in the morning and SpH measured immediately using a calibrated digital pH meter (mean of three readings). PHIs included plaque index (PI), gingival index (GI), mean probing pocket depth (PPD), and bleeding on probing (BOP%). Statistical analysis was conducted on the collected data using SPSS (v30), with paired comparisons across time points and correlation testing between SpH and PHPs.

Results: Mean SpH increased from 6.971±0.431 at baseline to 7.176±0.625 at 6 months, but the overall change was not statistically significant ($p=0.079$). PPD increased significantly over time (2.577±0.191 to 3.125±0.216; $p<0.001$), as did plaque index (0.437±0.324 to 0.735±0.423; $p<0.001$). Gingival inflammation and bleeding on probing did not change significantly ($p=0.080$ and $p=0.055$, respectively). SpH showed a significant positive correlation with bleeding on probing at baseline ($r=0.386$, $p=0.035$), while other correlations were weak and non-significant.

Conclusions: Fixed orthodontic treatment was associated with measurable worsening in selected periodontal indices over 6 months, whereas SpH showed only a modest, non-significant upward trend. These findings support careful periodontal monitoring and reinforced oral hygiene during early orthodontic treatment.

Keywords: Orthodontic Appliances, Saliva, pH, Periodontal Index, Probing Pocket Depth, Plaque Index, Gingival Inflammation.

1. Introduction

Globally, malocclusion is one of the most common oral health conditions. According to the World Health Organization, malocclusion ranks as the 3rd most commonly occurring oral disease worldwide.(De Ridder, Aleksieva, Willems, Declerck, & Cadenas de Llano-Pérula, 2022) Fixed orthodontic appliances (FOAs) are an extensively used method for correcting malocclusion and improving dentofacial appearance and function (such as improved chewing, stable bite, and speech) within today's dental practice.(Jakavičė & Žarovienė, 2023) Nevertheless, the application of FOAs can produce detrimental effects on gingival tissues (soft and hard tissues) and on the teeth themselves as well as on saliva due to the difficulty associated with cleaning around brackets. The prolonged retention of dental biofilm may lead to the development of white spot lesions on enamel, as well as to the onset of gingivitis. The biological effects of FOAs, in part, are produced because FOAs provide retentive surfaces in the oral cavity which may allow for microbial aggregation and dental biofilm formation, as well as impede oral hygiene (OH) maintenance.(Peterson, Tjakkes, Renkema, Manton, & Ren, 2024)

The main function of saliva is as a biological defence of the oral cavity by acting as both an antimicrobial substance and lubricant. Saliva is important for maintaining good health of the oral cavity because it buffers acids, rematerialises tooth structure, and helps to clear food particles from the area of the teeth.(Okuyama & Yanamoto, 2024) The normal range of saliva pH (SpH) in healthy individuals is between 6.7 and 7.3; however, some types of orthodontic treatment may reduce the SpH and affect the population of microorganisms in the mouth, thereby increasing the risk of decalcification and loss of dental hard tissue and potentially exacerbating gingival inflammation when SpH decreases.(Jakavičė & Žarovienė, 2023)

The periodontal apparatus and FOAs interact in a more complicated way. The materials associated with FOA can influence dental biofilm formation and make it more difficult to keep teeth clean.(Samulak, Suwała, Górski, & Machoy, 2024) As microbial dental biofilm accumulates on teeth, the bacteria in plaque will metabolize sugars, resulting in decreased pH levels, creating an acidic environment that facilitates the growth of acidogenic and acid-resistant bacteria with subsequently increased risk for caries formation. Additionally, the mechanical forces exerted by orthodontic appliances can induce gingival inflammation in susceptible patients when the gingival barrier is disrupted, allowing bacteria to penetrate the gingival tissues and trigger an inflammatory response.(Peterson et al., 2024)

A systematic review found that FOAs have an impact on salivary flow rate and pH during different stages of treatment.(Samulak et al., 2024) Similarly, a study by Chandra et al. (2024), which collected data on SpH, buffer capacity, Streptococcus mutans, and Lactobacillus spp. at baseline and after 6 months, demonstrated that wearing FOAs was significantly associated with elevated Streptococcus mutans and Lactobacillus levels, implying a pH-driven shift toward a more cariogenic oral microenvironment.(Chandra et al., 2024)

Despite these findings, a critical gap persists, as few prospective clinical trials have directly and simultaneously evaluated short-term SpH changes alongside standardized periodontal health indicators (PHIs) within a unified protocol. Furthermore, whether early SpH alterations could serve as a predictive biomarker for periodontal deterioration in orthodontic patients remains largely unexplored. Therefore, the present prospective clinical trial was designed to evaluate short-term SpH changes following FOA placement at baseline, 3 months, and 6 months post-bonding, and to examine its correlation with key PHIs, with the aim of determining whether salivary shifts during the first 6 months of fixed orthodontic therapy are associated with periodontal response.

2. Methodology

2.1. Study design and setting

This study was conducted as a prospective, single-arm clinical trial with repeated measures to evaluate short-term changes in salivary pH (SpH) following placement of FOA and to examine correlations between SpH and periodontal health parameters. The study was carried out at the Orthodontic Center of Sulaimaniyah (Goizha City), Sulaimaniyah, Iraq. Participant enrollment and follow-up were completed between June 2025 and June 2026.

2.2. Participants

A convenience sampling method was used by enrolling consecutive eligible patients who presented to begin fixed orthodontic treatment during the study period. Sample size was determined using G*Power (v3.1.9.4) with a t-test family (paired comparisons), effect size (Cohen's d) = 0.50, $\alpha = 0.05$, power $(1-\beta) = 0.84$, and one-tailed testing, which yielded a required sample of 30 participants. Each participant was assessed at three scheduled visits, generating 90 participant-visits (30×3) for the main dataset (see Appendix 1).

2.2.1. Inclusion criteria

Inclusion criteria were: (1) healthy participants aged 13–45 years; (2) initiation of fixed orthodontic treatment at the study center; (3) absence of systemic diseases known to affect periodontal tissues (e.g., diabetes mellitus, autoimmune disorders); (4) no clinically significant periodontal disease at baseline screening; and (5) willingness to comply with the protocol and attend follow-up visits.

2.2.2. Exclusion criteria

Exclusion criteria were: (1) pregnancy or breastfeeding; (2) systemic conditions with potential oral/periodontal impact (e.g., uncontrolled diabetes); (3) tobacco use (smoked or smokeless); and (4) severe periodontal disease or active oral infections requiring immediate care.

2.3. Orthodontic intervention and standardization

All participants received fixed appliances bonded according to routine clinical protocols at the center. Where feasible, bracket prescription and slot size were standardized (MBT prescription, 0.022-inch slot). Before bonding, each participant received standardized OH instruction targeting plaque control around brackets and gingival margins. Any deviations (e.g., prescribed antiseptic mouthrinses for clinical indications) were recorded to support interpretation of periodontal findings.

2.4. Measurement schedule and outcomes

Assessments were performed at three time points: T0 (baseline): immediately before appliance placement; T1: 3 months after placement; and T2: 6 months after placement. The primary outcome was unstimulated whole SpH. Secondary outcomes included plaque index, gingival inflammation, probing pocket depth (PPD), and bleeding on probing (BOP).

2.5. Saliva collection and pH measurement

To limit variability throughout sampling period, unstimulated whole saliva was collected between hours of ten and eleven in the morning (10:00 a.m. – 11:00 a.m.). Participants were instructed to eliminate consumption of foods and fluids (excluding water), gum chewing, and performing OH procedures for at least ninety minutes prior to saliva collection. Participants were instructed to remain upright while allowing saliva to accumulate in their mouth and then drool into a sterile polypropylene tube slowly for approximately five minutes until a minimum of two ml of unstimulated saliva was obtained.

Salivary pH readings were taken immediately following saliva collection using a calibrated portable digital pH meter (Model C-600; Backlights see figure 1). A pH meter was calibrated prior to each measurement session using standard buffer solutions (pH 4.00 and pH 6.86; pH 9.18 was used as needed for meter calibration; see figure 2). Between measurements, electrodes were rinsed with distilled water and dried with paper towels. For each measurement,

three pH values were averaged to produce a single measurement for each participant during each visit. Samples were not centrifuged because SpH readings were measured immediately following sample collection which minimized the potential for any handling or time dependent changes (e.g., loss of CO_2) to modify SpH values.

Figure 1. Portable digital pH meter (Model C-600) used for immediate measurement of unstimulated whole SpH.

Figure 2. Calibration and use of the digital pH meter for immediate measurement of unstimulated whole SpH using standard buffer solutions (pH 4.00, 6.86, and 9.18).

2.6. Periodontal examination and periodontal screening calculations

A single trained examiner performed all periodontal assessments using a UNC periodontal probe (see Figure 3) under consistent clinical conditions (mouth mirror, cotton isolation, and standardized lighting). Periodontal measures were recorded at the same visit as saliva collection.

Figure 3. UNC-15 periodontal probe used for periodontal measurements (PPD and BOP).

Plaque index (PI): Plaque was scored using a standardized PI approach (Silness–Löe methodology (1964)).(Karimi, Esfahanian, & Khadem, 2012; Silness & Loe, 1964) Participant-level PI was computed using the screening equation:

PI(mean) = (Σ surface scores) / (number of scored surfaces).

Gingival inflammation (GI): Gingival condition was scored using a recognized gingival index (e.g., Löe–Silness or equivalent). Participant-level GI was calculated as:

GI(mean) = (Σ surface scores) / (number of scored surfaces).

PPD: Probing depth was recorded in millimeters at six sites per tooth (MB, B, DB, ML, L, DL) on the examined dentition per center feasibility. The participant-level mean PPD was computed for each visit.

BOP: BOP index (Gingival Bleeding Index; Ainamo & Bay, 1975)(Ainamo & Bay, 1975) was recorded as the presence or absence of bleeding after gentle probing, assessed within approximately 10–15 seconds. BOP was summarized as:

BOP(%) = (bleeding sites / total sites probed) × 100.

2.7. Examiner calibration and reliability

Intra-examiner reliability was evaluated by repeating periodontal measurements in a subset of participants (approximately 10% of the sample) within 24–48 hours when feasible. Reliability was quantified using intraclass correlation coefficients (ICC) for continuous measures (e.g., PPD) and Cohen's kappa for categorical outcomes (e.g., BOP). Inter-examiner calibration was also performed using the same subset prior to the main measurements; agreement was quantified using ICC for continuous variables and Cohen's kappa for categorical variables.

2.8. Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics (Version 30; IBM Corp., Armonk, NY, USA). Categorical variables were summarized as frequencies and percentages, while continuous variables were presented as mean ± standard deviation (SD). The normality of continuous outcomes at each time point (T0, T1, and T2) was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Changes over time in salivary pH (SpH) and periodontal parameters (PPD, GI, BOP, and plaque index) were evaluated using repeated-measures analysis of variance (ANOVA), with additional analyses stratified by gender. Associations between SpH and periodontal health indicators at each visit were examined using the Pearson correlation coefficient. All tests were two-tailed, and statistical significance was set at $P < 0.05$.

3. Results

Figure 4 presents the distribution of participants according to their date of birth. The study population included individuals born between 1986 and 2014. The highest frequency was observed among participants born in 2011, with 5 (16.7%) individuals, followed by participants born in 2001, 2009, and 2014, each including 3 (10%) individuals. Birth years 1991, 1997, 1999, 2004, 2008, 2010, and 2012 each included 2 (6.7%) participants, while the remaining birth-year categories included one (3.3%) participant each.

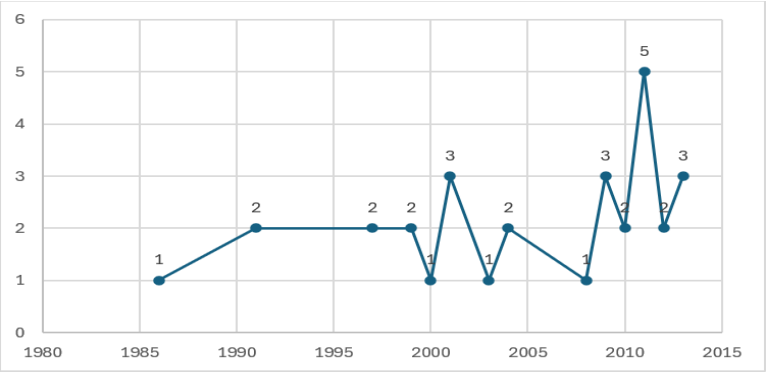

Figure 4. Distribution of participants according to date of birth.

A total of 30 participants were included in the study. The study population consisted of 10 (33.3%) males and 20 (66.7%) females. All participants had no history of diabetes mellitus, smoking, medication use, previous periodontal treatment, or family history of periodontal disease. Accordingly, 100% of participants were classified as non-diabetic, non-smokers, and had no previous periodontal treatment or relevant family history (Table 1).

Table 1. Demographic and baseline characteristics of the study participants

Variable		No.	%
Gender	Male	10	33.3%
	Female	20	66.7%
DM	No	30	100
	Yes	-	-
Smoking	No	30	100
	Yes	-	-
Medication	No	30	100
	Yes	-	-
Previous periodontal treatment	No	30	100
	Yes	-	-
Family history	No	30	100
	Yes	-	-

The mean SpH values at baseline (T0), 3 months (T1), and 6 months (T2) after fixed orthodontic appliance placement were 6.971 ± 0.431, 6.970 ± 0.432, and 7.176 ± 0.625, respectively. The difference in SpH values across the three assessment points was not statistically significant (P = 0.079).

When SpH values were analyzed according to gender, males showed mean pH values of 7.114 ± 0.530 at T0, 7.110 ± 0.534 at T1, and 7.135 ± 0.819 at T2, with no statistically significant difference among the follow-up periods (P = 0.923).

Among females, the mean SpH values were 6.900 ± 0.367 at T0, 6.900 ± 0.367 at T1, and 7.196 ± 0.527 at T2. A statistically significant difference was observed among the three time points in females (P = 0.025) (Table 2).

Table 2. Changes in SpH during the early period after fixed orthodontic appliance placement.

pH measurement	T0 (Immediately before appliance placement)	T1 (3 months after placement)	T2 (6 months after placement)	P-value*
pH	6.971 ± 0.431	6.970 ± 0.432	7.176 ± 0.625	0.079
Ph by gender				
Male	7.114 ± 0.530	7.110 ± 0.534	7.135 ± 0.819	0.923
Female	6.900 ± 0.367	6.900 ± 0.367	7.196 ± 0.527	0.025

* P-value from repeated-measures ANOVA

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
T0	.117	30	.200*	.975	30	.675
T1	.118	30	.200*	.974	30	.649
T2	.071	30	.200*	.980	30	.824

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The mean PPD values increased from 2.577 ± 0.191 at baseline (T0) to 3.107 ± 0.186 at 3 months (T1) and 3.125 ± 0.216 at 6 months (T2). The difference in PPD values across the three time points was statistically significant (P = 0.001).

According to gender, the mean PPD values among males were 2.608 ± 0.203 at T0, 3.156 ± 0.168 at T1, and 3.199 ± 0.117 at T2, with a statistically significant difference across follow-up assessments (P = 0.001). Among females, the corresponding values were 2.561 ± 0.189, 3.083 ± 0.194, and 3.088 ± 0.246, respectively, with a statistically significant difference among time points (P = 0.001).

The mean gingival inflammation (GI) scores were 0.076 ± 0.105 at T0, 0.149 ± 0.215 at T1, and 0.065 ± 0.099 at T2, with no statistically significant difference among the assessment periods (P = 0.080). In males, GI values were 0.117 ± 0.120, 0.297 ± 0.281, and 0.056 ± 0.077 at T0, T1, and T2, respectively (P = 0.749). In females, the corresponding values were 0.056 ± 0.093, 0.075 ± 0.127, and 0.070 ± 0.110, with no significant difference across time points (P = 0.060).

The mean bleeding on probing (BOP) values was 10.866 ± 11.658 at T0, 10.970 ± 11.573 at T1, and 5.346 ± 7.685 at T2. The difference between time points was not statistically significant (P = 0.055). Among males, BOP values were 18.784 ± 14.747, 17.261 ± 14.406, and 4.393 ± 6.519 at T0, T1, and T2, respectively (P = 0.702). Among females, BOP values were 7.056 ± 7.654 at T0, 7.824 ± 8.653 at T1, and 5.822 ± 8.325 at T2 (P = 0.090).

The mean Plaque index scores were 0.437 ± 0.324 at baseline, 0.806 ± 0.357 at 3 months, and 0.735 ± 0.423 at 6 months. A statistically significant difference was observed among the three time points (P = 0.001).

In male participants, PA values were 0.620 ± 0.328 at T0, 0.989 ± 0.385 at T1, and 0.972 ± 0.491 at T2, showing a statistically significant difference across follow-up periods (P = 0.001). In females, PA values were 0.345 ± 0.287, 0.714 ± 0.314, and 0.616 ± 0.339 at T0, T1, and T2, respectively, with no statistically significant difference (P = 0.132) (Table 3).

Table 3. Changes in periodontal health indicators during follow-up after fixed orthodontic appliance placement.

Periodontal Health Indicator		T0 (Immediately before appliance placement)	T1 (3 months after placement)	T2 (6 months after placement)	P-value*
PPD		2.577 ± 0.191	3.107 ± 0.186	3.125 ± 0.216	0.001
	Male	2.608 ± 0.203	3.156 ± 0.168	3.199 ± 0.117	0.001

PPD by gender	Female	2.561 ± 0.189	3.083 ± 0.194	3.088 ± 0.246	0.001
Gingival Inflammation (GI)		0.076 ± 0.105	0.149 ± 0.215	0.065 ± 0.099	0.080
GI by gender	Male	0.117 ± 0.120	0.297 ± 0.281	0.056 ± 0.077	0.749
	Female	0.056 ± 0.093	0.075 ± 0.127	0.070 ± 0.110	0.060
bleeding on probing (BOP)		10.866 ± 11.658	10.970 ± 11.573	5.346 ± 7.685	0.055
BOP by gender	Male	18.784 ± 14.747	17.261 ± 14.406	4.393 ± 6.519	0.702
	Female	7.056 ± 7.654	7.824 ± 8.653	5.822 ± 8.325	0.090
Plaque index		0.437 ± 0.324	0.806 ± 0.357	0.735 ± 0.423	0.001
PA by gender	Male	0.620 ± 0.328	0.989 ± 0.385	0.972 ± 0.491	0.001
	Female	0.345 ± 0.287	0.714 ± 0.314	0.616 ± 0.339	0.132

* P-value from repeated-measures ANOVA

The correlation analysis between SpH and periodontal health indicators was performed at baseline (T0), 3 months (T1), and 6 months (T2) (see Table 4).

At baseline, SpH showed a weak positive correlation with PPD (r = 0.011, P = 0.954), GI (r = 0.254, P = 0.175), and BOP (r = 0.386, P = 0.035). The correlation between SpH and PA was weak and negative (r = −0.043, P = 0.822).

At the 3-month follow-up, SpH demonstrated non-significant correlations with PPD (r = 0.213, P = 0.259), GI (r = 0.356, P = 0.053), and BOP (r = 0.333, P = 0.072). The correlation between pH and PA remained weak and negative (r = −0.010, P = 0.960).

At the 6-month follow-up, SpH showed a non-significant correlation with PPD (r = −0.278, P = 0.137), and weak positive correlations with GI (r = 0.133, P = 0.483) and BOP (r = 0.292, P = 0.117). The correlation between SpH and PA was weak and negative (r = −0.041, P = 0.830).

Table 4. Correlation between SpH and periodontal health indicators at different follow-up visits.

	pH 0		pH 1		pH 2
PPD 0	r = 0.011 P ≤ 0.954*	PPD 1	r = 0.213 P ≤ 0.259	PPD 2	r = - 0.278 P ≤ 0.137
GI 0	r = 0.254 P ≤ 0.175	GI 1	r = 0.356 P ≤ 0.053	GI 2	r = 0.133 P ≤ 0.483
BOP 0	r = 0.386 P ≤ 0.035	BOP 1	r = 0.333 P ≤ 0.072	BOP 2	r = 0.292 P ≤ 0.117
PA 0	r = - 0.043 P ≤ 0.822	PA 1	r = - 0.010 P ≤ 0.960	PA 2	r = - 0.041 P ≤ 0.830

*P-value Pearson correlation coefficient

4. Discussion

Recently, attention has turned to alterations of the oral environment accompanying treatment using FOA. Fixed orthodontic treatment is a way to correct dentofacial discrepancies and may disrupt the ecological balance of the oral cavity.(Niu et al., 2024) The use of brackets, bands, and archwires in the mouth will definitely create areas of plaque retention and facilitate accumulation of microbial biofilm, which may influence the microbial and inflammatory conditions of the periodontal tissues, as well as the characteristics of saliva.(Abutayyem, Abdullatif Alshehhi, Alameri, & Sohail Zafar, 2024) One of the common salivary variables that is commonly assessed in orthodontic research is SpH due to its role in maintaining oral homeostasis, its ability to modulate microbial metabolism, and its role in preventing dental hard tissue defects.(Narasimman et al., 2025) However, existing data pertaining to the direction and extent of changes in SpH following the placement of FOA is somewhat inconsistent and sparse. Therefore, assessments of SpH in conjunction with indices of periodontal health may lead to an increased understanding of the initial biological response to fixed orthodontic therapy.(Gavrilescu et al., 2026)

Short-term changes to SpH and possible relationships between these changes and periodontal indices were evaluated after placement of a fixed orthodontic appliance. SpH showed a slight upward trend over the first 6 months but was not statistically significant. The PI and periodontal probing depth increased significantly during the time studied however, the GI and bleeding on probing were not statistically significant. SpH values had no stable or statistically significant association with GI or bleeding on probing in this study.

Pursuant to the six months interval after fixed orthodontic appliance placement with respect to saliva's pH, the current investigation concurs with Papadimitriou et al., whose prospective study of adolescents assigned to orthodontic treatment using self ligation brackets reported little evidence of post placement periodontal change and that the changes in SpH during the course of treatment were not generally predictable or uniform. Papadimitriou et al. also indicated that studies reported conflicting results; some showed a rise in the pH level while others showed a decrease in the level of pH.(Papadimitriou et al., 2021) Kouvelis et al. found no statistically significant differences among pH levels of saliva and oral microbial flora.(Kouvelis et al., 2021)

The results of this study showed major discrepancies with previous research in this area. For example, Singh et al in their investigation evaluated the influence of orthodontic fixed therapy on SpH levels, and reported there was a statistically significant depletion of SpH at 6, 12, and 18 weeks after initiation of orthodontic therapy.(Singh et al., 2023) Likewise, Arab et al showed that there was a significant decrement of SpH levels during treatment of fixed orthodontics.(Arab et al., 2016) Additionally, Al-Haifi and associates showed that the different types of ligatures used in conjunction with FOA could affect SpH, specifically that use of elastomeric ligatures was associated with a reduction in SpH, while the use of stainless steel ligatures was linked to a slow increase in SpH levels.(Al-Haifi, Ishaq, & Al-Hammadi, 2021)

The discrepancies between our findings and previous studies may be attributed to differences in study populations, saliva collection protocols, follow-up duration, orthodontic appliances, and oral hygiene practices. In addition, salivary pH reflects the buffering capacity of whole saliva rather than the localized acidic environment around orthodontic brackets. Therefore, localized biofilm acidification may occur without producing significant changes in whole salivary pH, which may explain the differences observed among studies.

Multifactorial determinants of saliva pH help to explain the heterogeneity of oral pH. Several factors play a part in shaping oral pH; including salivary buffering capacity, flow rate, diet composition, number and type of microbes, and OH practices.(Nath et al., 2025) In addition, brackets exert two opposing influences. The

brackets will both promote increased plaque index, which creates a more acid environment, but also increase salivary flow and improve buffering capacity through mechanical stimulation. Because of this competing nature of these two mechanisms, the overall pH change observed in the current analysis did not reach significance.(Kouvelis et al., 2021)

Another possible explanation for the absence of a statistically significant change in salivary pH is the strong buffering capacity of saliva. Although bacterial metabolism within dental plaque generates organic acids that lower the local plaque pH, whole saliva possesses efficient bicarbonate, phosphate, and protein buffering systems that maintain the overall salivary pH within a relatively narrow physiological range.(Bostanghadiri et al., 2024; Ştefârţă et al., 2026) Consequently, localized acidic microenvironments adjacent to orthodontic brackets may not be adequately reflected by measurements of unstimulated whole saliva.(Inchingolo et al., 2024) This physiological buffering may account for the discrepancy between the significant deterioration in periodontal parameters and the relatively stable salivary pH observed in the present study.

Based upon the current data, stratifications of the analyses were performed by sex. It was noted that male participants experienced no significant changes in pH levels from baseline to month 6 whereas female participants demonstrated a significant increase in pH levels by month 6. The difference in pH level between sexes may be attributable to differences in OH habits, composition of saliva, and/or hormonal variables.(Holtkamp, Beuer, Wolf, & Naumann, 2026) Rajeh et al. also noted that females tended to brush their teeth more consistently than males; therefore, this may have an effect on salivary parameters.(Rajeh, 2022)

During the follow-up period, probing depth and plaque index increased significantly. These findings are consistent with numerous studies of other studies performed in the past. For example, Vrankova et al., have stated that the oral status of 60% of patients deteriorated following the application of FOA as measured using a plaque index.(Marincak Vrankova et al., 2022) Moreover, İşler and Erdem provided evidence for changes in microbiologic and periodontal parameters over a period of time following the removal of fixed appliances.(Atasever İşler & Erdem, 2026)

The significant increase in PI and probing pocket depth observed during follow-up is biologically plausible because fixed orthodontic appliances introduce numerous retentive surfaces that hinder effective plaque removal.(Bucur, Haddad, Mitariu, Mitariu, & Pacurar, 2026) Brackets, bands, ligatures, and archwires create sheltered niches that promote biofilm maturation and increase bacterial biomass.(Anbarasu et al., 2025) As the microbial biofilm matures, the local inflammatory response intensifies, resulting in gingival edema and increased probing depth, which may initially represent pseudo-pocket formation caused by inflammatory enlargement rather than irreversible periodontal attachment loss.(Basic & Dahlén, 2023) This mechanism explains why probing depth increased despite the absence of significant changes in gingival index and bleeding on probing, indicating that early periodontal changes during orthodontic treatment are predominantly inflammatory and reversible when adequate oral hygiene is maintained.

An earlier study in Greece showed a positive correlation between plaque or PI over time along with no statistical variance in terms of GI.(Papadimitriou et al., 2021) This study's result was similar to data obtained from the current study. One possible explanation is that the physical presence of braces and archwires creates a mechanical barrier which limits how effective plaque removal is and thus increases PI for these subjects. The gingival soft tissue response may not necessarily be directly proportional to the amount of plaque.(Vincent-Bugnas, Borsa, Gruss, & Lupi, 2021)

The present study demonstrated a non-significant reduction in bleeding on probing (BOP) at 6 months compared with baseline and 3 months. Although this change did not reach statistical significance, a similar trend has been reported in

previous prospective studies of fixed orthodontic treatment. Papadimitriou et al., observed that gingival inflammation and bleeding did not progressively worsen throughout follow-up despite increased plaque index, suggesting that periodontal tissues may partially adapt when patients maintain adequate oral hygiene.(Papadimitriou et al., 2021) This pattern may also reflect improved patient compliance with oral hygiene instructions over the course of treatment and the establishment of a more stable periodontal condition despite the continued presence of orthodontic appliances.

Additionally, there was no significantly consistent correlation between SpH and periodontal parameters. There was only a very weak correlation between pH and bleeding on probing (BOP) at baseline, and there were no statistically significant correlations at any of the other evaluations. As such, this suggests that in orthodontic patients, periodontal status is not entirely dependent on fluctuations in pH; instead, it is likely to be influenced by the combined effects of biofilm microbial composition, host immune responses, the quality of OH, and other general characteristics of saliva.(Di Nicolantonio, Altamura, Pietropaoli, Monaco, & Ortu, 2025; Huerta-García et al., 2026) Therefore, researchers should be cautious in their judgment of SpH as an independent predictor for the periodontal health of patients in the first 6 months of orthodontic treatment.

From an investigation of the biological aspect, the results were consistent with findings established by laboratory evidence. Fróis et al. reported that acidified or low pH environments had a negative impact on how orthodontic materials functioned, they increased corrosion rates of orthodontic materials and increased metal ion release into the oral environment. In the current study, salivary pH was maintained within a relatively neutral range; therefore, potential conditions which could cause more dramatic biochemical changes in the oral environment were not likely present.(Fróis, Evaristo, Santos, & Louro, 2021)

Therefore, careful attention to proper OH technique education, routine monitoring of periodontal status, and implementation of preventive strategies throughout orthodontic treatment are essential. Future research conducting larger sample sizes, with longer follow up periods, and include both microbiological outcomes and the functional evaluation of saliva will provide a clearer understanding of how the salivary environment interacts with periodontal health during orthodontic treatment.

Strengths and limitations

The strengths of this prospective study include the simultaneous assessment of salivary pH and clinical periodontal parameters at three standardized time points, the use of a uniform treatment protocol, and its prospective repeated-measures design. Nevertheless, several limitations should be acknowledged. The study included a relatively small sample size and lacked a parallel control group of individuals not undergoing fixed orthodontic treatment, which limited our ability to distinguish treatment-related changes from normal temporal variations. In addition, salivary buffering capacity, salivary flow rate, and microbiological parameters were not evaluated, and the follow-up period was limited to six months. Finally, the study may have been underpowered to detect small changes in salivary pH, increasing the possibility of a Type II error.

5. Conclusion

In the first six-month period of fixed orthodontic treatment, patients experienced increases in both plaque index and periodontal probing depth. No significant change was observed for SpH. There were no statistically significant, long-term associations between SpH and periodontal health indicators. Based on these findings, the early onset of change in periodontal health for orthodontic patients is primarily driven by local factors associated with biofilm retention or difficulties managing plaque as opposed to change in SpH.

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Author Declaration

The authors guarantee that this study is the result of their original work and that all stages of the research, including idea generation, data collection, data analysis, and writing the study report in the form of an article, were carried out by the authors.

Conflict of interest: All authors assert the absence of any conflict of interest.

Ethical considerations

Ethical approval was obtained from the scientific and ethic committee of Kurdistan Higher Council of Medical Specialties (proposal approval No.: [1558], dated [05/05/2025]). Written informed consent was obtained from adult participants; for minors, assent and guardian consent were secured.

Appendix 1