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Effect of Khat Chewing on Gingival Health of Patients with Fixed Orthodontic Appliances: A Controlled-Clinical Trial

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ABSTRACT

This clinical trial aimed to evaluate the effect of Khat chewing on the gingival health of patients with fixed orthodontic appliances (FOAs) by measuring some periodontal parameters before and during 6-time intervals of orthodontic therapy. It also aimed to evaluate this effect regarding gender. The study included 39 Yemeni orthodontic patients with a mean age of 25.7±4.5; divided into two groups, a control (non-chewers) with a mean age of 25.81±4.3 and an experimental (chewers) group with a mean age of 25.61±4.8. An examination sheet was used for data collection, including the patient's personal information, oral health status, and three periodontal parameters: plaque index (PI), gingival index (GI), and pocket depth (PD). These data measurements were analyzed using SPSS v.24. The study showed an increase in mean plaque, gingival, and pocket depth indices at all-time visits after the appliance insertion compared to all patients' pre-treatment status. It indicates that Khat chewing harms all periodontal parameters during the orthodontic treatment period. Mean PI, GI and PD were lower in female patients than male patients after the appliance insertion. The khat chewing process mechanically removes the dental plaque, decreasing PI and GI, while PD was worse in Khat chewers than non-chewers. Finally, it is recommended that chewing Khat should be avoided during orthodontic therapy.

Keywords: Clinical trial, fixed orthodontic appliances, gingival health, Khat chewer patients, Yemen

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INTRODUCTION

Treatment of malocclusion may be achieved by orthodontic appliances generally classified into removable and fixed types. On average, treatment with fixed orthodontic appliances (FOAs) lasts between 18 to 36 months (Rashkova, 2012; Tsichlaki et al., 2016). The orthodontic treatment outcome depends on the periodontal tissue condition, which ought to be optimal (Kitaura et al. 2014). Fixed orthodontic therapy represents a potential risk for the periodontal health due to the difficulty in maintaining the oral hygiene, thus increasing the accumulation of the plaque (Baseer et al., 2021; Türkkahraman et al., 2005), the oral biofilm and inflammation of the periodontal tissues (Lee et al. 2005).

Dental plaque is "a highly complex bacterial structure which causes periodontal diseases" (Rakhshan & Rakhshan, 2015, p. 87). It is commonly accumulated during orthodontic treatment leading to gingival hyperplasia, swelling, and bleeding (Guo et al., 2016). Besides, the short-term effect of the orthodontic band on gingival tissues occurs after the placement of the fixed appliances. The probing depth increase can result from the gingival enlargement throughout the orthodontic treatment (Alexander, 1991; Kumar et al., 2021). In addition, mechanical irritations resulting from the brackets, bands, cement, and trapped plaques may be implicated (Boyd et al., 1989). When such an iatrogenic irritation is inevitable, risks of attachment loss can be expected (Alexander, 1991; Kumar et al., 2021).

Patients with previous periodontal diseases have higher risks if plaque control is compromised (Al-Anezi & Harradine 2012; Karkhanechi et al. 2013). Periodontal diseases are caused by many factors, including plaque accumulation, immune factors, and Khat chewing habit.

Khat is "the name generally used for *Catha edulis*, a dicotyledonous evergreen shrub of the family Celastraceae" (Al-Hebshi & Skaug, 2005b, p. 299). It has various types because it is widely cultivated in many different areas in Yemen and East Africa, wherein chewing Khat is a commonly practiced habit (Al-Hebshi & Skaug, 2005b). Chewing Khat implies turning Khat leaves into the right or left side of the mouth in the lower distal mesiobuccal fold, chewing them, and keeping them in that vascular side of the mouth for a long time. This process is repeated until an observably large bolus is noticed. It is practiced for different time intervals ranging from 2 to 10 hours (Al-Hajj et al., 2020; Al-Hebshi & Skaug, 2005b). Additionally, the noticeably large bolus of chewed Khat in the mouth creates a relevant question about the effect of this habit on periodontal health (Al-Hajj et al., 2020).

The association of periodontal health with the orthodontic treatment has been an essential issue in previously published studies, which revealed a controversy regarding the long and short-term FOAs effect on the periodontium (Al-Moghrabi et al., 2016; Cerroni et al., 2018; Chhibber et al., 2018; Mazin et al., 2016).

Furthermore, studies that evaluated Khat chewing effects on the periodontium showed controversial results and reported that higher levels of periodontitis were found on Khat

chewing sides than on non-chewing sides (Al-Akhali, 2002; Al-Hajj et al., 2020; Ali, 2007; Al-Sharabi, 2003). For example, Al-Sharabi et al. (2013), Al-Hebshi, and Al-Ak'hali (2010) reported that Khat chewing per se cannot be considered a risk factor for periodontium because periodontal parameters' values of Khat-chewing sides were significantly lower than those of non-chewing sides. On the contrary, Al-Hajj et al. (2020) stated that Khat chewing leads to a higher rate of periodontitis. Similarly, Al-Sharabi (2003) reported that gingivitis, increased pocket depth (PD), gingival recession, tooth mobility, and mortality are due to Khat chewing.

However, none of the studies mentioned above have been performed to evaluate the effect of Khat chewing habit on the orthodontic patients' periodontal health. Therefore, this clinical trial aimed to evaluate the Khat chewing effect on the gingival health of patients with fixed orthodontic appliances (FOAs). Furthermore, it also aimed to evaluate this effect regarding gender. Therefore, a hypothesis (H) can be set which states, "There is a significant effect of Khat chewing on the gingival health of patients with FOAs," from which a sub-hypothesis was derived which states (Ha) "There is a significant effect of Khat chewing on the gingival health of patients with FOAs attributed to gender."

MATERIALS AND METHODS

Study Design

The study was designed as a controlled clinical trial.

Study Setting

The study was conducted at the clinics of the Faculty of Dentistry, University of Science and Technology, Sana'a, Yemen, between November 2018 and June 2019.

Participants

The study was conducted on male and female orthodontic patients who underwent fixed orthodontic treatment in the clinics of the Faculty of Dentistry at the USTY. The inclusion criteria comprised patients requiring FOAs on upper and lower arches aged 18–35. However, patients with smoking habits, cleft palatal or congenital malformation, history of systemic diseases, periodontal problems, or previous orthodontic or prosthetic therapy treatment were excluded.

Study Sample Size

The required sample size was calculated using the OpenEpi® statistics calculation software (Sullivan et al., 2009), considering a confidence level of 95 % and power of 80 % using the study of Lees and Rocks (2000) a reference. Therefore, the minimal sample size required

was 40 orthodontic patients wearing FOAs. The initial study sample was 62 male and female orthodontic patients. After applying the inclusion and exclusion criteria, the remaining participants were 42 orthodontic patients. Then three participants were withdrawn two months after bonding the appliance. Consequently, the study sample was 39 participants divided into 18 Khat chewer patients (Experimental group) and 21 non-chewer patients (control group). All participants in the experimental group are chronic Khat chewers as they have been chewing Khat for at least five years, 3 hours a day.

Variables

The study was conducted to evaluate the effect of Khat chewing on the gingival health of patients with fixed orthodontic appliances (FOAs) by measuring some periodontal parameters before and at 6-times intervals of orthodontic therapy. Therefore, the study variables included an independent variable (i.e., Khat chewing) and a dependent variable (i.e., gingival health). The latter has three parameters (i.e., dental plaque (PI), gingival index (GI), and pocket depth PD). Besides, the demographic variables include gender and age.

Interview Questions

Before the appliance insertion, an interviewed questionnaire was distributed to every participant to collect data consisting of his/her personal information, including gender, age, and Khat chewing status (Mahindra et al., 2017).

Clinical Examination

A clinical examination sheet was used by one examiner (A.T.A) to record the measurements of three clinical parameter indices: plaque index (PI) (Silness & Löe, 1964), GI (Löe & Silness, 1963), and PD (Newman et al., 2011) at seventh-time visits (T0–T6) before and after first, second, third, fourth, fifth and sixth months of the appliance insertion. These parameters were evaluated on mesiodistal vestibular, middle surfaces of 6 examined teeth which were designated for epidemiological studies of human periodontal diseases by Ramfjord (1959) and called Ramfjord teeth (RT), including upper right first molar, upper left central incisor, upper left first premolar, lower left first molar, lower right central incisor, and lower right first premolar (Rams et al., 1993).

A week before the FOAs insertion, patients were subjected to a protocol of oral hygiene motivation, including scaling, polishing, and instructions regarding brushing teeth three times a day as per the Bass modified technique with toothpaste consisting of fluoride concentration following the placement of the appliance (Peros et al. 2011). FOAs of the 0.022*0.028 slot MBT bracket system (SIA, Italy) were placed (Figure 1). Bands were placed on the first molars according to each patient's treatment needs. Adhesive

materials (Trans bond, 3M Unitek, USA) were used (Figure 2). All patients were supplied with adequate materials for cleaning aids and toothbrushes.

Appliances were inserted using additional instruments and materials, including dental mirrors No. 4, bracket holder, light cure, kidney dishes, masks, gloves, and cotton (for dryness). The insertion procedure of the fixed appliance is described in Figure 3.

Dental plaque was assessed using the modified PI of Silness and Löe (1964), classified into four grades (0, 1, 2, and 3), as explained in Table 1.

The gingival condition was assessed using the GI of Löe and Silness (1963), classified into four grades (0, 1, 2, and 3), as explained in Table 2.

Figure 1. SIA bracket system

Figure 2. 3M Unitek adhesive material

- Oral hygiene motivation, involves scaling and polishing their teeth and instructions.
- Rinse and dry.
- After prophylaxis with a rubber cup and pumice, 37 % phosphoric acid gel was applied for 15 seconds, followed much washing for 30 seconds and drying with an oil-free air spray for 15 seconds.
- A thin coat of Transbond XT primer (3M, Unitek, USA) was applied, followed by a brief air spray and light-curing for 20 seconds.
- Stainless steel brackets 0.22-inch slot MBT bracket system (SIA, Italy), bonded to the teeth using Transbond XT light-cure composite resin (3M, Unitek, USA).
- A small amount of bonding agent is squeezed into the mesh on the back of the bracket, and it is pressed to place on the tooth surface. Excess bonded material is removed from around the bracket.
- For light-cured materials, a cordless light is used to activate the adhesive bonding process, and the bracket is bonded in place. The duration of light incidence was 20 seconds, 10 seconds on each side (mesial and distal).

Figure 3. Insertion procedure of fixed appliance

Table 1
Modified PI of Silness and Löe (1964)

Score	Criteria
0	"No plaque."
1	"A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque which cannot be seen with the naked eye may be seen in situ only after application of disclosing solution or by using the probe on the tooth surface."
2	"Moderate accumulation of soft deposits within the gingival pocket, or the tooth and gingival margin which can be seen with the naked eye."
3	"Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin."

Table 2
Löe and Silness (1963) gingival index

Score	Criteria
0	"Absence of inflammation."
1	"Mild inflammation—slight change in color and little change in texture."
2	"Moderate inflammation—moderate glazing, redness, oedema, and hypertrophy. Bleeding on pressure."
3	"Severe inflammation—marked redness and hypertrophy, ulceration. Tendency to spontaneous bleeding. Ulceration."

PD was recorded by measuring the distance from the sulcus/ pocket base to the free gingival margin (Eckley et al., 2012) using a millimeter-calibrated periodontal probe (Michigan O probe with William's markings) having markings at 3, 6, and 8 mm and William's probe having circumferential lines at 1, 2, 3, 5, 7, 8, 9, and 10 mm. Graduated periodontal probes were used to explore and measure gingival pockets (Dannan et al., 2008; Newman et al., 2011). The probe was inserted with gentle pressure into the deepest part of the gingival sulcus (Dannan et al., 2008; Newman et al., 2011).

For the examination reliability of measurements, the investigator was trained by a periodontist to perform the measurements of dental parameter indices (i.e., PI, GI, and PD). Then he assessed five participants. After a week, both examined the same five participants to calibrate their examination methods. Finally, Cohen's Kappa was used to compare the two measurement results, which showed a 'substantial' agreement.

Statistical Analysis

SPSS v.24 was used for data analysis using frequencies for the study sample distribution according to demographic characteristics and the Shapiro-Wilk test for the normality assessment. For comparing between two groups, the Mann-Whitney U test was used. In addition, Wilcoxon signed ranks test was used for assessing the difference between every two-time visit. Results were presented using the mean with standard deviation (SD), and the p-value < 0.05 was considered statistically significant.

Bioethical Considerations

Ethical approval was attained from the Ethics Committee of the Faculty of Medicine and Health Sciences at the University of Science and Technology, Yemen (USTY) (MECA No.: EAC/UST164). Furthermore, a consent form was received from all participants who had the right to accept or refuse their study participation.

RESULTS

Figure 4 shows a CONSORT format presenting how the study was designed and how the participants were allocated, excluded, or followed up.

Both genders showed equal distribution in the experimental group, whereas the control group included 42.9 % male and 57.1 % female patients. Regarding age, the experimental group included 27.8 %, 61.1 %, and 11.1 % of patients aged 18–23, 24–30, and 31–35 years, respectively, while the control group included 38.1 %, 42.9 %, and 19.0 % of patients aged 18–23, 24–30 and 31–35 years, respectively (Table 3).

Mann-Whitney U test was also used to evaluate the differences in PI, GI, and PD scores between Khat chewer and non-chewer patients (Tables 4 and 5). The differences in all parameters (i.e., PI, GI, and PD) scores at all visits (T1, T2, T3, T4, T5, and T6) showed a statistically significant increase ($p < 0.05$) in Khat chewer than non-chewer patients.

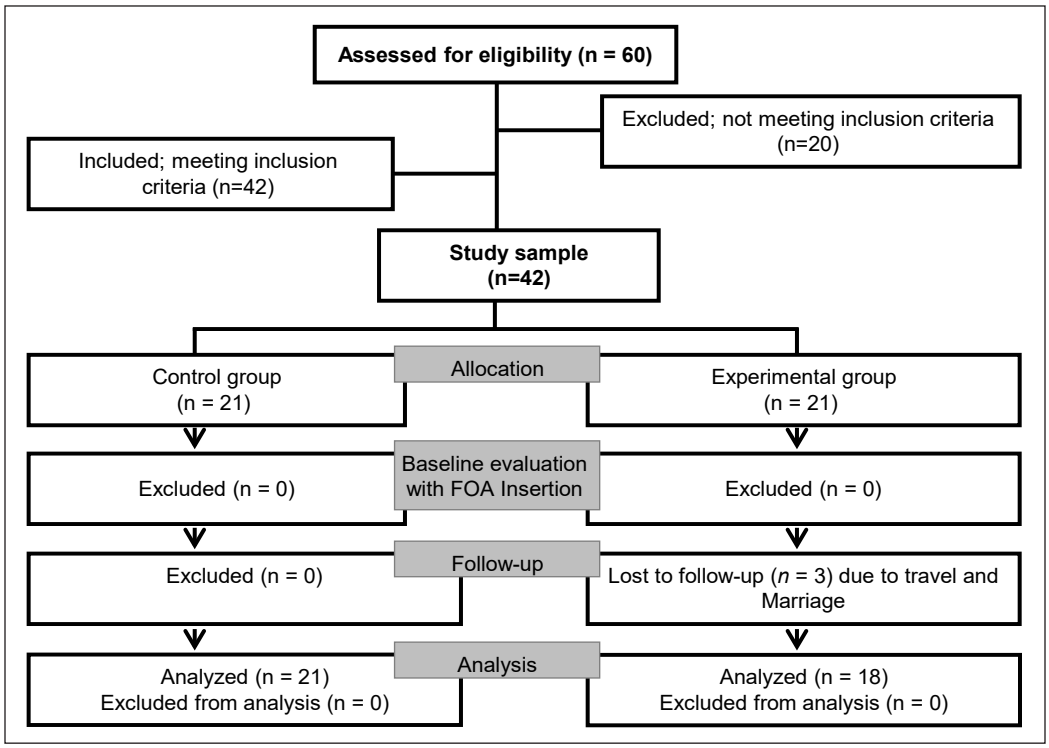

Figure 4. CONSORT format for presenting allocation, evaluation, or follow-up of a sample

Table 3
Distribution of study sample in both groups

Variable		Experimental group (Chewers, n=18)		Control group (Non-chewers, n=21)	
		N	%	N	%
Gender	Male	9	50	9	42.9
	Female	9	50	12	57.1
Age	18-23 years	8	38.1	5	27.8
	24-30 years	9	42.9	11	61.1
	31-35 years	4	19.0	2	11.1
Total		**21**	**53.8**	**18**	**46.2**

Table 4
Comparison of PI, GI, and PD scores between groups

Parameter	Time	Chewer (n=18)		Non-chewer (n=21)		*P-value*
		Mean	SD	Mean	SD	
PI	T1	0.85	0.36	1.27	0.26	0.001*
	T2	0.90	0.40	1.34	0.39	0.001*
	T3	1.20	0.35	1.47	0.32	0.017*
	T4	1.29	0.40	1.61	0.31	0.013*
	T5	1.37	0.43	1.66	0.29	0.034*
	T6	1.45	0.43	1.79	0.25	0.025*
GI	T1	0.22	0.24	0.46	0.35	0.021*
	T2	0.28	0.24	0.58	0.32	0.004*
	T3	0.39	0.30	0.72	0.30	0.002*
	T4	0.47	0.29	0.80	0.32	0.003*
	T5	0.57	0.24	0.87	0.39	0.008*
	T6	0.63	0.30	0.99	0.37	0.004*
PD	T1	3.16	0.15	3.02	0.04	0.003*
	T2	3.34	0.16	3.16	0.14	0.002*
	T3	3.52	0.19	3.28	0.15	0.000*
	T4	3.81	0.30	3.42	0.17	0.000*
	T5	4.30	0.29	3.54	0.23	0.000*
	T6	4.60	0.36	3.69	0.25	0.000*

* Significant at $p < 0.05$

Table 5
Comparison of PI, GI, and PD scores at T1 and T6 between groups

Parameter	Chewer (n=18)		Non-chewer (n=21)		*P-value*
	Mean	SD	Mean	SD	
PI	1.15	0.38	1.53	0.20	0.001*
GI	0.43	0.24	0.73	0.33	0.008*
PD	3.88	0.23	3.36	0.13	0.000*

* Significant at $p \leq 0.05$

Moreover, statistically significant differences ($p < 0.05$) were shown in the PI, GI, and PD scores at T1 and T6 between Khat chewer and non-chewer patients. Scores of PI and GI were worse in non-chewer than chewer patients. However, those of PD were better in non-chewer than chewer patients. Therefore, the study hypothesis (H) was accepted.

Mann-Whitney U test assessed the differences in PI, GI, and PD scores between male and female patients, and within the control and experimental group.

Generally, it was revealed that the differences in PI, GI, and PD scores at all visits (T1, T2, T3, T4, T5, and T6) showed a statistically significant increase ($p < 0.05$) in males than female patients (Table 6).

Within groups, the differences in PI, GI, and PD scores within the experimental group at all visits showed a statistically significant increase ($p < 0.05$) in male than female chewer patients. However, the difference in PI scores within the control group at only T6 showed a statistically significant increase ($p < 0.05$) in male than female patients. However, the PI scores' differences in the control group during the remaining visits showed an insignificant increase ($p > 0.05$) in male than female patients, except for T4, at which the difference showed an insignificant decrease ($p > 0.05$) in male than female patients. Unlike the differences in T1, T2, and T3, T4, T5, and T6 GI scores within the control group showed a statistically significant increase ($p < 0.05$) in male than female patients. On the contrary, the differences in PD scores within the control group showed a statistically insignificant increase ($p > 0.05$) in male than female patients (Table 7).

The differences in PI and PD scores of T1 and T6 in general and within the experimental group (chewer patients) showed a statistically significant increase ($p < 0.05$) in male than female patients. In contrast, those within the control group (non-chewer patients) showed an insignificant increase ($p > 0.05$) in male than female patients. However, the differences in GI scores of T1 and T6 in general and within both groups showed a statistically significant increase ($p < 0.05$) in male than female patients (Table 8). Therefore, the study sub-hypothesis was accepted.

Table 6
Comparison of PI scores by gender

Time	Male (n=18)		Female (n=21)		*P-value*
	Mean	SD	Mean	SD	
T1	1.24	0.25	0.94	0.41	0.024*
T2	1.32	0.39	0.98	0.44	0.016*
T3	1.50	0.26	1.21	0.38	0.019*
T4	1.61	0.28	1.34	0.43	0.046*
T5	1.69	0.29	1.38	0.41	0.015*
T6	1.83	0.17	1.46	0.43	0.004*

* Significant at $p \leq 0.05$

Table 7
Comparison of PI, GI, and PD scores within groups by gender

Parameter	Time	Experimental group (n=18)					Control group (n=21)				
		Male (n=9)		Female (n=9)		*P-value*	Male (n=9)		Female (n=12)		*P-value*
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
PI	T1	1.16	0.13	0.54	0.21	0.000*	1.32	0.31	1.23	0.21	0.564
	T2	1.24	0.13	0.56	0.25	0.000*	1.40	0.54	1.29	0.23	0.141
	T3	1.47	0.10	0.93	0.30	0.000*	1.53	0.36	1.43	0.30	0.465
	T4	1.62	0.19	0.97	0.25	0.000*	1.59	0.36	1.63	0.28	0.971
	T5	1.72	0.20	1.01	0.25	0.000*	1.67	0.36	1.66	0.24	0.797
	T6	1.76	0.13	1.14	0.41	0.004*	1.91	0.18	1.69	0.26	0.036*
GI	T1	0.39	0.21	0.06	0.13	0.001*	0.61	0.42	0.35	0.25	0.169
	T2	0.43	0.17	0.12	0.20	0.004*	0.71	0.38	0.48	0.24	0.095
	T3	0.57	0.22	0.22	0.27	0.011*	0.84	0.30	0.63	0.28	0.148
	T4	0.62	0.18	0.32	0.30	0.024*	0.99	0.24	0.65	0.30	0.015*
	T5	0.69	0.18	0.46	0.25	0.024*	1.17	0.17	0.65	0.36	0.000*
	T6	0.77	0.17	0.50	0.34	0.025*	1.31	0.15	0.75	0.29	0.000*
PD	T1	3.28	0.08	3.03	0.07	0.000*	3.01	0.03	3.03	0.05	0.422
	T2	3.46	0.10	3.22	0.11	0.001*	3.17	0.15	3.16	0.14	0.917
	T3	3.63	0.13	3.40	0.18	0.006*	3.31	0.16	3.26	0.14	0.554
	T4	4.01	0.25	3.60	0.19	0.000*	3.44	0.17	3.40	0.18	0.554
	T5	4.49	0.23	4.11	0.20	0.002*	3.62	0.28	3.48	0.17	0.219
	T6	4.83	0.35	4.37	0.19	0.001*	3.80	0.32	3.61	0.14	0.169

* Significant at $p < 0.05$

Table 8
Differences between PI, GI, and PD scores of T1 and T6 by gender

Parameter	Group		Mean	SD	*P-value*
PI	Experimental group	Male	1.46	0.12	0.000*
	(Chewer patients)	Female	0.84	0.29	
	Control group	Male	1.62	0.19	0.129
	(Non-chewer patients)	Female	1.46	0.19	
	Total	Male	1.54	0.17	0.006*
		Female	1.20	0.39	
GI	Experimental group	Male	0.58	0.13	0.003*
	(Chewer patients)	Female	0.28	0.23	
	Control group	Male	0.96	0.27	0.004*
	(Non-chewer patients)	Female	0.55	0.24	
	Total	Male	0.77	0.29	0.001*
		Female	0.43	0.27	
PD	Experimental group	Male	4.06	0.16	0.000*
	(Chewer patients)	Female	3.70	0.11	
	Control group	Male	3.41	0.16	0.193
	(Non-chewer patients)	Female	3.32	0.09	
	Total	Male	3.73	0.37	0.035*
		Female	3.48	0.21	

* Significant at $p < 0.05$

DISCUSSION

This clinical trial aimed to evaluate the effect of Khat chewing on the gingival health of patients with fixed orthodontic appliances by measuring some periodontal parameters before and during 6-time intervals of orthodontic therapy. In addition, to evaluate this effect regarding gender. The study included 39 Yemeni orthodontic patients divided into two groups, a control (non-chewers) and an experimental (chewers) group. An examination sheet was used for data collection, including the patient's personal information, oral health status, and three periodontal parameters: plaque index (PI), gingival index (GI), and pocket depth (PD). The study findings showed a significant worsening of all the outcomes measured throughout the study compared to patients' pre-treatment status. This result is similar to the finding of Altaee et al. (2015), Bue et al. (2008), Cerroni et al. (2018), Chhibber et al. (2018), Karkhanechi et al. (2013), Kumar et al. (2021), Mazin et al. (2016), Peng et al. (2014), and Ren et al. (2014). The study findings also showed changes in PI, GI, and PD observed at the first visit (T1). This finding agrees with that of Faridha and Navaneethan (2018), Mazin et al. (2016), and Ristic et al. (2007), who showed an increase in PI, GI, and PD parameters after one month of appliance placement. It is due to the increase in plaque and the inability of the patient to perform adequate oral hygiene. Similarly, Karacaoğlu et al. (2016), Kaygisiz et al. (2015), and Nalçacı et al. (2014) reported that PI and GI showed changes after 4 and 6 weeks of the FOAs insertion. Besides, Zachrisson and Zachrisson (1971) indicated that mild to moderate gingivitis was shown within one and two months after the FOAs insertion.

The increase in PI and GI may also occur because the placement of the brackets influences the ecological environment through accumulating the biofilm at the retentive sites, leading to more inflammation and bleeding that deteriorate the periodontal condition (Kumar et al., 2021; Naranjo et al., 2006). PI and GI were increased because the plaque retentive properties of FOAs may lead to increased plaque accumulation and gingival inflammation (Abbate et al., 2015; Jiang et al., 2017; Ristic et al., 2007). Fixed orthodontic bands and brackets make tooth brushing difficult and reduce natural self-cleansing through the saliva and tongue (Ren et al., 2014; Türkkahraman et al., 2005). Since fixed orthodontic patients face difficulty maintaining good oral hygiene, gingivitis and enamel demineralization could be caused by the accumulated plaque (Bue et al., 2008; Kumar et al., 2021; Peng et al., 2014), leading to increased PI and GI. This result agrees with that of Moosa et al. (2015), who reported that the probing depth and plaque accumulation could be increased in patients with FOAs, leading to destructed periodontal tissue, which according to Almansob et al. (2021) and Jadhav et al. (2013), increases plaque accumulation leading to gingival hyperplasia and gingival pockets. The increase in PD scores could be attributed to the increase in the overall anaerobic bacterial species in the banded-bracketed sites (Karkhanechi et al., 2013)

or the pseudopocket or deeper-probe penetrations into the weakened connective tissue (Gastel et al., 2011). Although fixed appliances may adversely affect all periodontal parameters, which influence the periodontal condition in a short-time period starting instantly after the band and bracket placement, they do not have destructive effects due to their transient conditions (Ristic et al., 2007).

The current study showed that periodontal PI and GI parameters at all visits were better in chewer than non-chewer patients regarding Khat chewing habit. However, the PD parameter was worse among chewers than non-chewer patients. Besides, the PI, GI, and PD parameters increased more among male chewers than female chewer patients.

According to gender, the current study generally showed a significant worsening of all periodontal parameters (i.e., PI, GI, and PD) at all visits in male than female patients after six months of the appliance placement. This result is consistent with that of Almansob et al. (2021), Amran and Alhajj (2016), Karacaoğlu and Akkaya (2018), and Kumar and Shristi (2015) who reported that females showed better oral self-care, gingival health, knowledge about oral health, and more involved in dental behaviors than males.

However, studies that assessed associations of Khat chewing with periodontal health supported the results of the current study regarding this independent factor (i.e., Khat chewing). Some studies showed that repeated chewing of Khat modifies the subgingival biofilm microbial composition incompatibility with the periodontal health (Al-Hebshi & Skaug, 2005a; Al-Hebshi et al., 2010). Moreover, Khat chewing seems to mechanically cleanse dental plaque, decrease GI (Al-Hebshi & Al-Akhali, 2010; Al-Maweri & Al-Akhali, 2017), and increase PD (Al-Maweri & Al-Akhali, 2017; Amran & Alhajj, 2016; Dhaifullah et al., 2015). Additionally, repeatedly chewing Khat may cause chronic trauma and vertical impaction to the periodontium (Al-Sharabi et al., 2013) that most likely leading to increases in the PD (Al-Hajri et al., 2013; Al-Hebshi & Al-Akhali, 2010; Ali, 2007; Al-Kholani, 2010).

On the other side, some studies are inconsistent with the present study findings. They reported that Khat chewing harms oral hygiene and periodontal condition in the form of gingival inflammation and is associated with a higher prevalence of gingival bleeding (Al-Juboury, 2006; Amran & Alhajj, 2016; Dhaifullah et al., 2015). Moreover, Al-Kholani (2010) showed that PI and GI parameters were significantly higher in Khat chewers than in non-chewer patients. Al-Hebshi and Skaug (2005a) and Al-Maweri and Al-Akhali (2017) reported that Khat chewing affected the PD parameter positively.

Accordingly, the study findings showed significant changes in the patients' periodontal condition, which agrees with Kumar et al. (2021) and Naranjo et al. (2006), who reported that the FOA placement influences the ecological environment through accumulating the biofilm at the retentive sites.

CONCLUSION

The current study concluded that fixed appliances negatively affect all periodontal parameters during the treatment period, and periodontal PI, GI, and PD parameters at all visits after the appliance insertion were better in females than in males. Besides, Khat chewing was considered an independent factor with significant and remarked changes in the association of fixed appliances with periodontal tissues. It also seems to cleanse dental plaque, which decreases PI and GI mechanically. Frequent chewing of Khat may cause chronic trauma and vertical impaction to the periodontium, which most likely leads to increases in the PD. Therefore, further research is recommended to conduct a similar study among similar populations but with more independent variables, including smoking, tobacco, age, and/or gum chewing.

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