

Evaluation of the Influence of Fixed Orthodontic Treatment Duration on the Severity of Inflammatory Gingival Enlargement (Fixed Orthodontic Induced Gingival Enlargements) and Some Properties of Saliva

Mohammed M. A. Abdullah Al-Abdaly^{1*}, Abdullah Mohammed A. Asiri², Ghadeer Mohammed Mohammed Al-Abdaly³, Mohammed Abdullah Ghabri², Moayad Abdullah H. Alqaysi², Abdulmajeed Mohammed S. Aljathnan², Yahya Saleem M. Al Naser², Naser Ali N. Alshahrani²

¹Periodontics and Community Dental Sciences Department, College of Dentistry, King Khalid University, Abha, KSA

²College of Dentistry, King Khalid University, Abha, KSA

³Faculty of Dentistry, Sana'a University, Sanaa, Republic of Yemen

Email: *malabdaly20@gmail.com

How to cite this paper: Al-Abdaly, M.M.A.A., Asiri, A.M.A., Al-Abdaly, G.M.M., Ghabri, M.A., Alqaysi, M.A.H., Aljathnan, A.M.S., Al Naser, Y.S.M. and Alshahrani, N.A.N. (2022) Evaluation of the Influence of Fixed Orthodontic Treatment Duration on the Severity of Inflammatory Gingival Enlargement (Fixed Orthodontic Induced Gingival Enlargements) and Some Properties of Saliva. *International Journal of Clinical Medicine*, 13, 132-146.

<https://doi.org/10.4236/ijcm.2022.133011>

Received: February 21, 2022

Accepted: March 13, 2022

Published: March 16, 2022

Copyright © 2022 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Background: Inflammatory gingival enlargement is a more common clinical feature with orthodontic therapy than other features. Therefore, this study was designed to the evaluation of the influence of fixed orthodontic treatment duration on the severity of inflammatory gingival enlargement (fixed orthodontic induced gingival enlargements) and some properties of saliva. **Material and Methods:** The sample size comprised 145 patients undergoing fixed orthodontic treatment for at least 6 months aged 13 - 32 years. They were divided according to orthodontic treatment duration into three groups. Group I (n = 47) included the patients who were treated for less than 6 months, group II (n = 51) included the patients who were treated for a period of 6 - 12 months, and group III (n = 47) included the patients who were managed for more than 12 months. Data were obtained from the outpatient clinics, college of dentistry, King Khalid University, Abha, Saudi Arabia, and some dental centers in Sana'a city, the Republic of Yemen. This study was conducted from October 2021 G to January 2022 G. Clinical examination was done for plaque index (PLI), gingival index (GI), and gingival enlargement indexes (GEI). Saliva was collected in sterile test tubes then salivary flow and pH were measured. Statistical analysis was done with SPSS (version 23) and ANOVA test to evaluate the impact of orthodontic treatment duration on the severity of in-

inflammatory gingival enlargement and some properties of saliva. **Results:** The statistical analysis demonstrated the highest mean plaque index (PLI) was among groups III and I participants whereas, the highest mean gingival index and mean gingival enlargement were among groups II and III participants. The present study revealed an increase in salivary flow with decreased salivary pH values with an increase in orthodontic therapy duration. There were statistically significant differences in clinical findings and salivary flow and pH values were observed in the comparison between groups I, II and III except PLI ($p < 0.05$). **Conclusion:** There was a higher inflammatory gingival enlargement associated with a higher plaque index in patients under orthodontic treatment for more than 12 months more than the patients for less than 6 months and the patients for a period of 6 - 12 months. There were correlations between an increase of salivary flow and pH values and an increase of other variables in this study, such as plaque index, gingival index, and gingival enlargement index with an increased orthodontic therapy duration.

Keywords

Inflammatory Gingival Enlargement, Orthodontic Treatment Duration, Some Salivary Properties

1. Introduction

Periodontal disease initiation and progression rely on a balance between the host immune system and microbial effect [1]. Gingival enlargement is a multifactorial clinical condition that develops in response to different factors and interactions between the host defense and these factors such as plaque and systemic disturbances moreover a rare gingival enlargement (idiopathic gingival fibromatosis) [2]. The prevalence rate of gingival enlargement is 10%, and it is one of the main periodontal tissue problems related to fixed orthodontic appliances [3].

Fixed orthodontic appliances impact passively on periodontal tissue health by obstructing access to good oral hygiene resulting in the accumulation of plaque [4]. The most common periodontal tissue alterations detected during fixed orthodontic therapy were gingivitis, gingival recession, and gingival over growth [5] [6]. The increase of inflammatory cells in the inflamed gingival tissues leads to edema formation and increase gingival size [7].

Fixed orthodontic therapy can cause gingival enlargement due to the effect of some link risk factors such as the mechanical effect of bands, chemical effect of cement, accumulation of plaque, and improper maintenance of oral hygiene [8]. Thus, the associated gingival enlargement with orthodontic therapy is considered an inflammatory reaction due to difficulty in self-performed mechanical plaque control. The capacity to do oral hygiene measures is difficult for patients with gingival enlargements especially, patients with fixed orthodontic appliances. These may cause more inflammation and increase of plaque accumula-

tion then change of the gingival sulcus to a periodontal pocket creating difficult areas for plaque removal [9].

Inflammatory gingival enlargement during orthodontic therapy is a localized or generalized exaggerated gingival tissues growth reaching to marginal gingiva, interdental papilla, and attached gingiva [10]. Acute or chronic inflammatory gingival enlargement in cases of fixed orthodontic appliances can be easily seen in chronic cases [2]. According to previous clinical study, generally, there was a link between orthodontic treatment and periodontal health decrease [11]. A hypertrophic form of gingivitis is one of the unwanted periodontal alterations [6]. Moreover, retardation of oral health status [12]. Generally, the clinical studies revealed that the gingival alterations during orthodontic therapy are not permanent damage to the periodontal and tissues [13] [14].

Few studies were conducted to evaluate the link between gingival enlargements, such as the study of Zanatta *et al.* which revealed that there was a positive link between fixed orthodontic therapy and inflammatory gingival enlargement [15].

Saliva plays a significant role in oral hygiene where its PH and the other enzymes help to diagnose and determine oral health and progression of some diseases of oral mucosa and their risk factors [16] [17]. Furthermore, Orthodontic therapy causes alterations in the ecological factors of the oral cavity that leads to changes in salivary characteristics [18].

However, an assessment impact of fixed orthodontic treatment of more prolonged times on inflammatory gingival enlargement severity and some salivary properties among orthodontic patients' needs more studies. Therefore, the present study was designed to the evaluation of the influence of fixed orthodontic treatment duration on the severity of inflammatory gingival enlargement (fixed orthodontic induced gingival enlargements) and some properties of saliva.

2. Material and Methods

2.1. Design and Sample Size of the Study

The current cross-sectional study groups included 145 participants, 100 males (69%) and 45 females (31%) who were undergoing fixed orthodontic treatment. All participants were selected from patients treated in orthodontics clinics, college of dentistry, King Khalid University, and some dental centers in Sana'a city, the Republic of Yemen from October 2021 G to January 2022 G. They were divided according to orthodontic treatment duration into three groups. Group I (n = 47) included the patients who were treated for less than 6 months, group II (n = 51) included the patients who were treated for a period of 6 - 12 months, and group III (n = 47) included the patients were managed for more than 12 months. The age range of the participants was between 13 ys and 32 ys (Figures 1-3).

2.2. Inclusion Criteria

The identification of participants number was based on the expecting that there was 10% difference of gingival enlargement with 30% theoretical proportion as



Figure 1. Clinical photograph of a patient before orthodontic treatment.

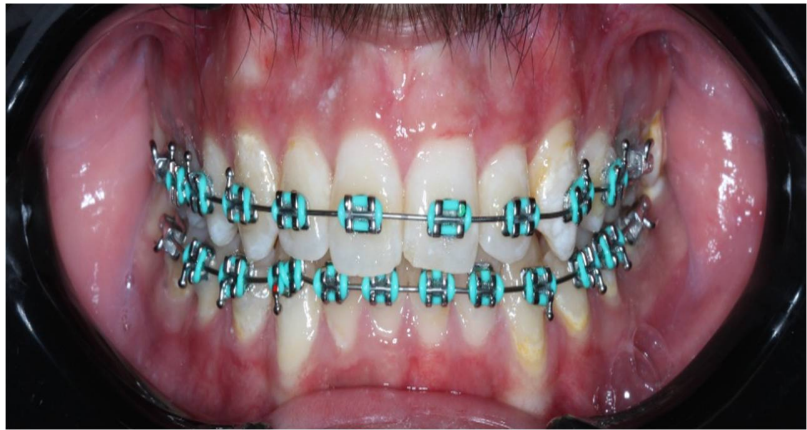


Figure 2. Clinical photograph of a patient was treated for a period of 6 - 12 months.



Figure 3. Clinical photograph of a patient was treated for more than 12 months.

the effect of orthodontic therapy duration on gingival tissues [4]. The patients who agreed to participate and signed an informed consent form, and the patients who were undergoing fixed orthodontic therapy for 6 months, 6 - 12 months, and more than 12 months were included in this study samples.

2.3. Exclusion Criteria

The exclusion from the samples of the current study were the patients of bacterial and viral infectious diseases such as COVID-19 that may be risks to the examiners, the patients who were using drugs inducing gingival enlargement, the patients who need antibiotics coverage for clinical examination, the patients who were affecting by the congenital anomaly, the patients with gingival cysts, and the patients with oral ulceration and acute gingival diseases or diabetic patients that maybe effect on clinical examination. Moreover, pregnant women, smokers, and breastfeeding mothers were also excluded.

2.4. Ethical Status

The protocol of this study was designed according to ethical approval requirements of the Institutional Review Board, college of dentistry, King Khalid University before this study started. The participants were informed about the study objectives, and a written informed consent form was obtained.

2.5. Clinical Examination

The clinical examination was conducted to record the periodontal parameters according to this study design. A manual conventional periodontal probe (Williams) was used for periodontal parameters evaluation in this study [19].

2.6. Assessment of Dental Plaque

Plaque index used to evaluate the dental plaque by Silness and Loë's plaque index (PLI) (0: No plaque; 1: non-visible plaque with the naked eye, but we can see it with a periodontal probe; 2: visible plaque with the naked eye; 3: abundantly visible plaque with the naked eye and extent to sulcus and the free gingiva margin) [20].

2.7. Assessment of Gingival Inflammation

Gingival index was used to evaluate the gingival inflammation by Loë and Silness gingival index (GI) (0: No inflammation, 1: mild inflammation, 2: moderate inflammation with gingival bleeding, 3: severe inflammation with spontaneously gingival bleeding) [21].

2.8. Assessment of Inflammatory Gingival Enlargement

Miller and Damm modified the original Angelopoulos and Goazindexused for evaluating the vertical gingival enlargement from cemento-enamel junction to the free gingival margin where there are three grades according to the covering of clinical crown (Grade 0: No gingival growth, Grade I: mild enlargement, ≤ 2 mm, gingiva covering the cervical third., Grade II: Moderate enlargement: 2 to 4 mm, gingival covering the middle third of the clinical crown and Grade III: Severe enlargement: ≥ 4 mm, gingival covering more than two thirds of the clinical crown [22].

2.9. Assessment of Some Salivary Properties

The Salivary samples were obtained according to the instructions of the WHO Organization for the collection of saliva. The saliva samples were collected in sterile glass containers (0.5 ml) for 10 minutes. pHep pocket-sized pH meter was used to measure the pH of salivary samples. It is a calibrated instrument between 0.0 to 14.0 manufactured by Hanna Instruments with a replaceable electrode. The instrument was calibrated every day by its buffer solution. The saliva quantity (milliliters per minute) was measured and divided by 10 to account for the flow rate in millimeters per minute [23].

2.10. Statistical Analysis

The data were coded and introduced to the computer then analyzed using SPSS (version 23). The descriptive statistics were represented in percentages, means, and standard deviations, while inferential statistics were used to detect significant differences at 0.05 alpha level. Analysis of variances (ANOVA) was used to identify the significant mean difference between study groups regarding age, gingival index, plaque index, gingival enlargement Index, and salivary flow and pH values.

2.11. Results

A total of 145 patients were included in this study, 47 (32.4%) of them were in treated for less than 6 months, 51 (35.2%) were treated for a period of 6 – 12 months, and 47 (32.4%) were managed for more than 12 months (**Table 1** and **Figure 4**). The minimum age was 13 years old and maximum age was 32, while mean age for all study participants was 21.98 ± 3.6 . The mean plaque index, gingival index, and gingival enlargement index were 1.67 ± 0.60 , 1.60 ± 0.55 , and 1.65 ± 0.56 respectively (**Table 2**). The mean age was the highest among group III (23.06 ± 3.49 years old), followed by mean of group II and group I with 21.82 ± 3.60 and 21.06 ± 3.4 , respectively. The analysis of variances shows significant difference in age between patients treated for <6 months and those treated for >12 months with $p = 0.017$ (**Table 3** and **Figure 5**).

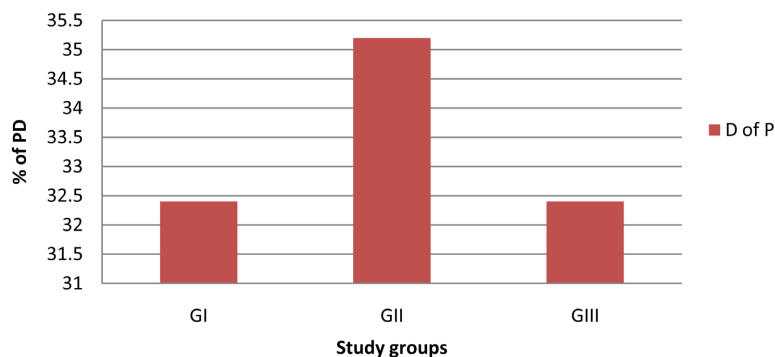


Figure 4. The distribution of study participants on study groups. D of P: Distribution of participants. GI: group I. GII: Group II. GIII: Group III. % of PD: Percentage of participants distribution.

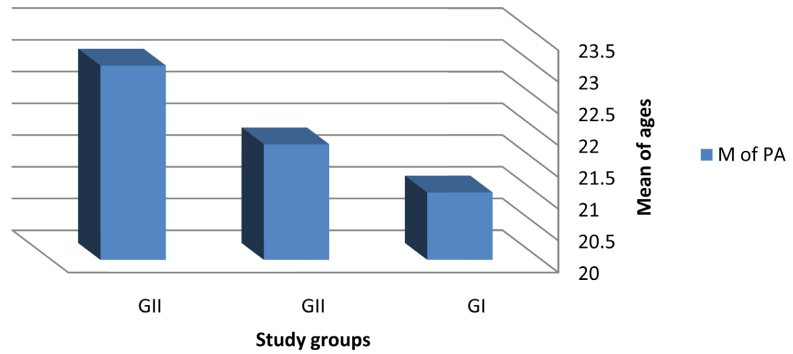


Figure 5. Comparing means of participants' age between study groups. GI: group I. GII: Group II. GIII: Group III. M of PA: Mean of patients' age.

Table 1. The distribution of study participants on study groups.

Study groups	Frequency	Percent (%)
Group I (less than 6 months)	47	32.4
Group II (6 - 12 months)	51	35.2
Group III (More than 12 months)	47	32.4
Total	145	100.0

Table 2. The descriptive statistics of study variables.

	Minimum	Maximum	Mean	Std. Deviation
Age	13	32	21.98	3.6
Plaque index	1	3	1.67	0.60
Gingival index	1	3	1.60	0.55
Gingival enlargement index	1	3	1.65	0.56

Table 3. Comparing means of participants' age between study groups.

Groups	Mean	(±SD)	Comparison	p value
Group I (<6 months orthodontic treatment)	21.06	3.40	Group I and II	0.532
			Group I and III	0.017*
Group II (6 - 12 months orthodontic treatment)	21.82	3.60	Group II and III	0.189
Group III (>12 months orthodontic treatment)	23.06	3.49		

*Significant difference.

The highest mean plaque index was reported among patients with treatment duration > 12 months (1.70 ± 0.51), while the lowest plaque index was in patients treated for a period 6 - 12 months. No significant difference of plaque index was seen between group I, II and III ($p > 0.05$). The highest mean gingival

index was reported in patients with >12 months orthodontic treatment (2.07 ± 0.50), while the lowest was reported among patients with <6 months orthodontic treatment (1.74 ± 0.57). The differences in plaque index between study groups were not statistically significant ($p = 0.819$). However, using ANOVA showed significant difference in gingival index between study groups ($p = 0.047$) and post hoc Tukey tests demonstrated that significant difference was between patients treated for <6 months and those treated for >12 months with $p = 0.036$.

Gingival enlargement index was the highest among patients with >12 months orthodontic treatment (2.72 ± 0.50) in comparison to means of 1.63 and 1.60 among patients with 6 - 12 months orthodontic treatment and those with <6 months orthodontic treatment, respectively. There were statistically significant differences in gingival enlargement associated with the duration of orthodontic therapy among the patients of groups II, III, and I ($p < 0.05$) (Table 4 and Figure 6).

On the other hand, Table 5 and Table 6 and Figure 7 and Figure 8 reveal the salivary pH and salivary flow rate values in the three groups. It was found that the mean salivary pH and salivary flow rate of group III participants were the highest when compared with groups I and II. Salivary flow rate and salivary pH

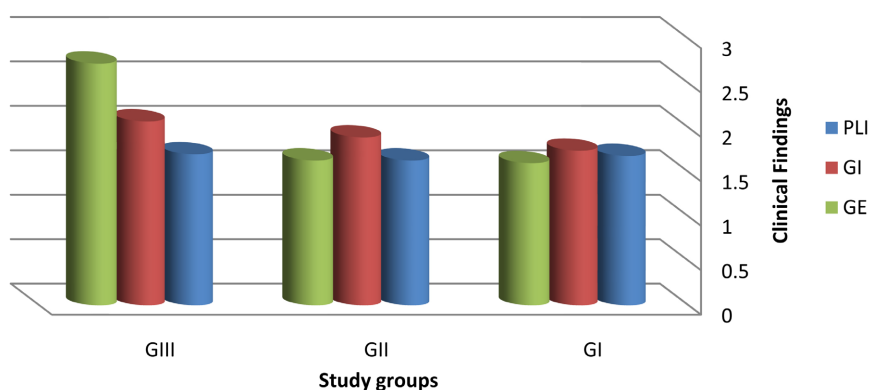


Figure 6. Comparing of periodontal health indices among study groups. PLI: Plaque index. GI: Gingival index. GEI: Gingival enlargement index. GI: group I. GII: Group II. GIII: Group III.

Table 4. Comparing means of periodontal health indices among study groups.

Periodontal Health Indices	Group			P value
	<6 months orthodontic treatment (GI)	6 - 12 months orthodontic treatment (GII)	>12 months orthodontic treatment (GIII)	
PLI	1.68 ± 0.66	1.63 ± 0.63	1.70 ± 0.51	0.819
GI	1.74 ± 0.57	1.89 ± 0.54	2.07 ± 0.50	0.047*
GEI	1.60 ± 0.61	1.63 ± 0.56	2.72 ± 0.50	<0.05*

PLI: Plaque index. GI: Gingival index. GEI: Gingival enlargement index. *Significant difference. **GI**: group I. **GII**: Group II. **GIII**: Group III.

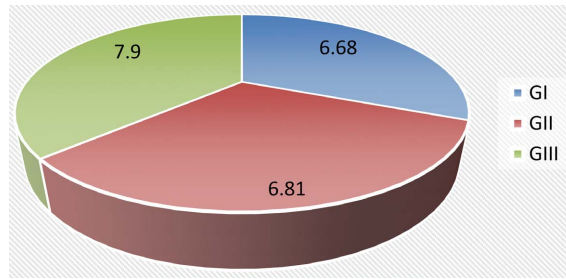


Figure 7. Comparing means of salivary pH values among study groups. GI: group I. GII: Group II. GIII: Group III.

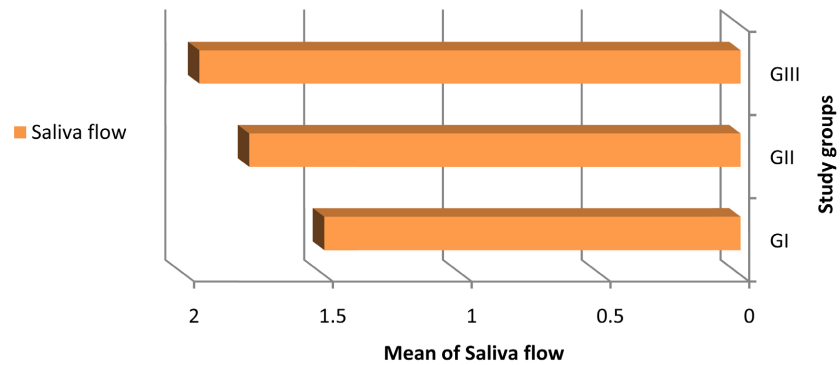


Figure 8. Comparing means of saliva flow values among study groups. GI: group I. GII: Group II. GIII: Group III.

Table 5. Comparing means of salivary pH values among study groups.

	Salivary pH		ANOVA	
	Range	Mean ± SD	F	P-value
Group I	5 - 8	6.68 ± 0.316	3.997	0.042*
Group II	6 - 8	6.81 ± 1.07		
Group III	6 - 9	7.9 ± 1.22		

*Significant difference.

Table 6. Comparing means of salivary flow values among study groups.

	Salivary flow		ANOVA	
	Range	Mean ± SD	F	P-value
Group I	1 - 2	1.12 ± 0.058	0.628	0.033*
Group II	1 - 2	1.77 ± 0.035		
Group III	1 - 2	1.95 ± 0.011		

*Significant difference.

decreased after commencing orthodontic therapy then significantly increased 6 and 12 months after orthodontic therapy. There were statistically significant differences between the mean salivary flow rate values ($p = 0.033$) and salivary pH values ($p = 0.042$) among the groups of the current study.

3. Discussion

Inflammatory gingival enlargement is a more common clinical feature with orthodontic therapy [6]. The presence of orthodontic appliances may lead to plaque accumulation and difficulty in oral hygiene maintenance [24]. When PLI, GI, and GEI were evaluated, statistically significant differences between these clinical parameters except PLI were observed, where the clinical relationship of these differences with orthodontic therapy duration revealed clinical differences for the severity of inflammatory gingival enlargement grades I and II. The clinical findings of our study revealed that there was an association between orthodontic therapy duration and dental plaque accumulation. This agrees with the clinical findings of other previous studies that have demonstrated an increase in plaque accumulation and change in the composition and types of oral bacteria during orthodontic therapy [25] [26]. The Plaque index (PLI) in the present study demonstrates the relation between plaque accumulation and duration of orthodontic therapy with the progression of inflammatory gingival enlargement. Consequently, the duration of orthodontic therapy may be considered a predisposing factor.

Gong Y and Ding X reported in their study that gingival enlargement is an inflammatory reaction against the microbiota dental plaque, and its products are attributed to that the orthodontic appliances facilitate the collection and the colonization of bacteria; consequently, the gingiva becomes more susceptible to inflammation and bleeding that corresponds with the results of the present study [1] [27]. According to the current study, the highest plaque index, gingival index, and gingival enlargement appeared among the patients of group III more than in other groups. But, no significant effect of duration on the severity of inflammatory was seen from 1 to 6 months of orthodontic therapy; this agrees with the similar plaque index and gingival index that appeared in these groups, thus supporting the inflammatory nature of an increase of gingival size in the current study. The increase of gingival tissue size in the present study may be due to gingival tissues being more sensitive to dental plaque and the hyperplastic reaction of the gingival tissues [28] that agrees with a previous study, reported that there were effects of fixed orthodontic appliances on the profile of oral microbiota, and added that gingival health is fundamental before beginning orthodontic therapy [29].

This effect of orthodontic therapy duration on the severity of inflammatory gingival enlargement may explain that the participants are more likely to have low preventive attitudes and habits with an increased time of orthodontic therapy. Thus, gingival phenotype and plaque control should be considered [30]. In this study, the amount of dental plaque and duration of orthodontic therapy played a role in the incident of gingival enlargement where plaque index and gingival enlargement index among the participants of group III more than other groups, that may be due to the various response and time for clinical reaction, moreover microbial challenge and individual local and systemic resistance [16]

[31]. These results agree with several previous studies which revealed that the fixed orthodontic therapy change the qualitative composition of dental plaque [24] [32].

On the other hand, the flow rate of saliva plays a significant role in oral health where the increase of saliva leads to physical cleansing action for accelerates clearance of substrates as well as raise its antimicrobial effectiveness, whereas low salivary flow rate adversely affects oral health [33].

In the present study, there was a significant decrease in salivary pH after starting orthodontic therapy. These findings are convenient with a previous study that revealed a decrease in pH after put fixed orthodontic appliances [23]. But another previous study demonstrated that there was a significant increase in salivary flow rate during orthodontic therapy [34]. These findings are in agreement with the results of the present study where salivary flow rate was an increase in 6 - 12 months and more than 12 months orthodontic therapy durations when compared to less than 6 months of orthodontic therapy duration. That may be due to the presence of orthodontic appliances, which act as a mechanical motivation in salivary secretion. These findings agree the results of studies that done by Kanaya *et al.*, Kanaya *et al.*, and Chang *et al.* [35] [36] [37].

Furthermore, another previous study showed increased salivary flow and pH during orthodontic therapy [38]. This agrees with the results of the present study, which explains that the increased salivary flow and pH may be due to the sensitivity against orthodontic appliances in the oral cavity as well as, the orthodontic appliances provide ideal areas for adhesion and proliferation of oral micro-biota that lead to defect in oral hygiene and difficulty in brushing during orthodontic therapy [39] [40].

Baliga, *et al.* detected an increase in salivary pH among the patients with chronic gingivitis more than in the control group [41]. That agrees with the findings of this study where there was a direct relationship between the increase in the salivary pH and the increase in the severity of gingivitis and inflammatory gingival enlargement, with the increased orthodontic therapy duration.

Salivary samples can be easily collected, compared to the serum and blood samples for comfort to the patient. Consequently, the saliva can be obtained in the dental office and used as an easy diagnostic aid [42] [43].

4. Strength and Limitations of the Study

The strengths of this study in demonstrating that there were side effects of orthodontic therapy duration on gingival tissues and salivary flow and salivary pH values. Consequently, they may be considered as predisposing factors of Orthodontic treatment-induced gingival enlargement that needs continuous recall visits of periodontal therapy during orthodontic therapy duration. The results of this study help to clarify the importance of patient motivation and patient compliance in the treatment of inflammatory gingival enlargement that may be associated with orthodontic therapy. Oral hygiene instructions and motivation

should begin at the first phases of orthodontic therapy to gain good results.

There were some limitations of this study, such as the cross-sectional design of the study as well as sample sizes were smaller, and standardization was not enough. Therefore, longitudinal studies, an increase of sample size, and standardization can assist in confirming the findings of this study regarding the impact of orthodontic therapy duration on the severity of inflammatory gingival enlargement and salivary flow and salivary pH values. Thus, at the end of this study, it can be recommended that the gingival parameters, salivary flow, and salivary pH values should be considered during orthodontic therapy times because the orthodontic appliances might negatively influence gingival tissues

5. Conclusion

We conclude that gingival index and gingival enlargement index as well as salivary flow and pH salivary values can be used to monitor the severity of inflammatory gingival enlargement during orthodontic therapy and can have prognostic values also for inflammatory gingival enlargement and its therapy. Using salivary samples as diagnostics aids are obtaining interest, and the present study considered a new insight into this aspect.

Acknowledgements

The authors would like to thank the staff in the orthodontics and periodontics clinics in the college of dentistry, King Khalid University, as well as the orthodontists in some dental centers in Sana'a city, and to the participants of this study for their support and interest.

Conflicts of Interest

The authors stated no possible conflicts of interest to this research manuscript authorship and publication.

References

- [1] Gong, Y., Lu, J. and Ding, X. (2011) Clinical, Microbiologic, and Immunologic Factors of Orthodontic Treatment-Induced Gingival Enlargement. *American Journal of Orthodontics and Dentofacial Orthopedics*, **140**, 58-64.
<https://doi.org/10.1016/j.ajodo.2010.02.033>
- [2] Carranza, F.A., and Hogan, E.L. (2006) Gingival Enlargement. In: Newman, M.G., Takei, H.H., Klokkevold, P.R. and Carranza, F.A., Eds., *Carranza's Clinical Periodontology*, 11th Edition, W.B. Saunders Company, Philadelphia, 373-390.
- [3] Sinclair, P.M., Berry, C.W., Bennett, C.L. and Israelson, H. (1987) Changes in Gingiva and Gingival Flora with Bonding and Banding. *The Angle Orthodontist*, **57**, 271-278.
- [4] Pinto, A.S., Alves, L.S., do Zenkner, J.E., Zanatta, A. and Maltz, F.B. (2017) Gingival Enlargement in Orthodontic Patients: Effect of Treatment Duration. *American Journal of Orthodontics and Dentofacial Orthopedics*, **152**, 477-482.
<https://doi.org/10.1016/j.ajodo.2016.10.042>
- [5] Chapple, I.L.C., Mealey, B.L., Van Dyke, T.E., Bartold, P.M., Dommisch, H., Eick-

- holz, P., *et al.* (2018) Periodontal Health and Gingival Diseases and Conditions on Anintact and a Reduced Periodontium: Consensus Report of Workgroup 1 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *Journal of Periodontology*, **89**, s74-s84.
<https://doi.org/10.1002/JPER.17-0719>
- [6] Kouraki, E., Bissada, N.F., Palomo, J.M. and Ficara, A.J. (2005) Gingival Enlargement and Resolution during and after Orthodontic Treatment. *New York State Dental Journal*, **71**, 34-37.
- [7] de Oliveira Guaré, R., Costa, S.C., Baeder, F., de Souza Merli, L.A. and Dos Santos, M.T. (2010) Drug-Induced Gingival Enlargement: Biofilm Control and Surgical Therapy with Gallium-Aluminum-Arsenide (GaAlAs) Diode Laser—A 2-Year Follow-Up. *Special Care in Dentistry*, **30**, 46-52.
<https://doi.org/10.1111/j.1754-4505.2009.00126.x>
- [8] Kloehn, J.S. and Pfeifer, J.S. (1974) The Effect of Orthodontic Treatment on the Periodontium. *The Angle Orthodontist*, **44**, 127-134.
- [9] Surlin, P., Rauten, A.M., Mogoantă, L., Siloși, I., Oprea, B. and Pirici, D. (2010) Correlations between the Gingival Crevicular Fluid MMP8 Levels and Gingival Overgrowth in Patients with Fixed Orthodontic Devices. *Romanian Journal of Morphology and Embryology*, **51**, 515-519.
- [10] Zanatta, F.B., Moreira, C.H.C. and Rosing, C.K. (2011) Association between Dental Floss Use and Gingival Conditions in Orthodontic Patients. *American Journal of Orthodontics and Dentofacial Orthopedics*, **140**, 812-821.
<https://doi.org/10.1016/j.ajodo.2011.06.028>
- [11] Levin, L., Samorodnitzky-Naveh, G.R. and Machtei, E.E. (2008) The Association of Orthodontic Treatment and Fixed Retainers with Gingival Health. *Journal of Periodontology*, **79**, 2087-2092. <https://doi.org/10.1902/jop.2008.080128>
- [12] Somacarrera, M.L., Lucas, M., Scully, C. and Barrios, C. (1997) Effectiveness of Periodontal Treatments on Cyclosporine-Induced Gingival Overgrowth in Transplant Patients. *British Dental Journal*, **183**, 89-94. <https://doi.org/10.1038/sj.bdj.4809430>
- [13] Gomes, S.C., Varela, C.C., Veiga, S.L., Rosing, C.K. and Oppermann, R.V. (2007) Periodontal Conditions in Subjects Following Orthodontic Therapy. A Preliminary Study. *European Journal of Orthodontics*, **29**, 477-481.
<https://doi.org/10.1093/ejo/cjm050>
- [14] Sadowsky, C. and Begole, E.A. (1981) Long-Term Effects of Orthodontic Treatment on Periodontal Health. *American Journal of Orthodontics*, **80**, 156-72.
[https://doi.org/10.1016/0002-9416\(81\)90216-5](https://doi.org/10.1016/0002-9416(81)90216-5)
- [15] Zanatta, F.B., Ardenghi, T.M., Andonuzzi, R.P. and Pinto, T.M.P. (2014) Association between Gingivitis and Anterior Gingival Enlargement in Subjects Undergoing Fixed Orthodontic Treatment. *Dental Press Journal of Orthodontics*, **19**, 59-66.
<https://doi.org/10.1590/2176-9451.19.3.059-066.oar>
- [16] Nair, A.U., Thavarajah, R. and Ranganathan, K. (2012) Saliva and Dental Practice. *Journal of Dr. NTR University of Health Sciences*, **1**, 72-76.
<https://doi.org/10.4103/2277-8632.98328>
- [17] Lasisi, T.J., Duru, M.E. and Lawal, B.B. (2015) Salivary Secretion and Composition in Malaria: A Case-Control Study. *Nigerian Journal of Physiological Sciences*, **30**, 119-123.
- [18] Almosa, N.A., Lundgren, T., Al-Mulla, A., Birkhed, D. and Kjellberg, H. (2018) Caries Risk Profiles in Orthodontic Patients: A 4-Year Follow-Up Study Using the Cariogram Model in Governmental vs. Private Clinics. *Saudi Dental Journal*, **30**,

- 166-174. <https://doi.org/10.1016/j.sdentj.2018.02.001>
- [19] Barendregt, D.S. and Van der Velden, U. (2006) Comparison of Two Automated Periodontal Probes and Two Probes with a Conventional Readout in Periodontal Maintenance Patients. *Journal of Clinical Periodontology*, **33**, 276-282. <https://doi.org/10.1111/j.1600-051X.2006.00900.x>
- [20] Silness, J. and Loe, H. (1964) Periodontal Disease in Pregnancy. II. Correlation between Oral Hygiene and Periodontal Condition. *Acta Odontologica Scandinavica*, **22**, 121-135. <https://doi.org/10.3109/00016356408993968>
- [21] Loe, H. and Silness, J. (1963) Periodontal Disease in Pregnancy. I. Prevalence and Severity. *Acta Odontologica Scandinavica*, **21**, 533-551. <https://doi.org/10.3109/00016356309011240>
- [22] Miller, C.S. and Damm, D.D. (1992) Incidence of Verapamil-Induced Gingival Hyperplasia in a Dental Population. *Journal of Periodontology*, **63**, 453-456. <https://doi.org/10.1902/jop.1992.63.5.453>
- [23] Li, Y., Hu, B., Liu, Y., Ding, G., Zhang, C. and Wang, S. (2009) The Effects of Fixed Orthodontic Appliances on Saliva Flow Rate and Saliva Electrolyte Concentrations. *Journal of Oral Rehabilitation*, **36**, 781-785. <https://doi.org/10.1111/j.1365-2842.2009.01993.x>
- [24] Lee, S.M., Yoo, S.Y., Kim, H.S., Kim, K.W., Yoon, Y.J., Lim, S.H., Shin, H.Y. and Kook, J.K. (2005) Prevalence of Putative Periodontopathogens in Subgingival Dental Plaques from Gingivitis Lesions in Korean Orthodontic Patients. *Journal of Microbiology*, **43**, 260-265.
- [25] Huser, M.C., Baehni, P.C. and Lang, R. (1990) Effects of Orthodontic Bands on Microbiologic and Clinical Parameters. *American Journal of Orthodontics and Dentofacial Orthopedics*, **97**, 213-218. [https://doi.org/10.1016/S0889-5406\(05\)80054-X](https://doi.org/10.1016/S0889-5406(05)80054-X)
- [26] Ristic, M., Svabic, M.V., Sasic, M. and Zelic, O. (2007) Clinical and Microbiological Effects of Fixed Orthodontic Appliances on Periodontal Tissues in Adolescents. *Orthodontics & Craniofacial Research*, **10**, 187-195. <https://doi.org/10.1111/j.1601-6343.2007.00396.x>
- [27] Kossack, C. and Jost-Brinkmann, P.G. (2005) Plaque and Gingivitis Reduction in Patients Undergoing Orthodontic Treatment with Fixed Appliances-Comparison of Toothbrushes and Interdental Cleanings. A 6-Month Clinical Single-Blind Trial. *Journal of Orofacial Orthopedics*, **66**, 20-38. <https://doi.org/10.1007/s00056-005-0344-4>
- [28] Markou, E., Eleana, B., Lazaros, T. and Antonios, K. (2009) The Influence of Sex Steroid Hormones on Gingiva of Women. *The Open Dentistry Journal*, **3**, 114-119. <https://doi.org/10.2174/1874210600903010114>
- [29] Sukontapatipark, W., El-Agroudi, M.A., Selliseth, N.J., Thunold, K. and Selvig, K.A. (2001) Bacterial Colonization Associated with Fixed Orthodontic Appliances. A Scanning Electron Microscopy Study. *European Journal of Orthodontics*, **23**, 475-484. <https://doi.org/10.1093/ejo/23.5.475>
- [30] Wennstrom, J.L. (1987) Lack of Association between Width of Attached Gingiva and Development of Soft Tissue Recession. A 5-Year Longitudinal Study. *Journal of Clinical Periodontology*, **14**, 181-184. <https://doi.org/10.1111/j.1600-051X.1987.tb00964.x>
- [31] Trombelli, L., Scapoli, C., Tatakis, D.N. and Grassi, L. (2005) Modulation of Clinical Expression of Plaque-Induced Gingivitis: Effects of Personality Traits, Social Support and Stress. *Journal of Clinical Periodontology*, **32**, 1143-1150. <https://doi.org/10.1111/j.1600-051X.2005.00835.x>

- [32] Lo, B.A.M., Di Marco, R., Milazzo, I., Nicolosi, D., Cali, G., Rossetti, B., et al. (2008) Microbiological and Clinical Periodontal Effects of Fixed Orthodontic Appliances in Pediatric Patients. *New Microbiologica*, **31**, 299-302.
- [33] Chang, H.S., Walsh, L.J. and Freer, T.J. (1997) Enamel Demineralization during Orthodontic Treatment. Aetiology and Prevention. *Australian Dental Journal*, **42**, 322-327. <https://doi.org/10.1111/j.1834-7819.1997.tb00138.x>
- [34] Peros, K., Mestrovic, S., Anic-Milosevic, S. and Slaj, M. (2011) Salivary Microbial and Nonmicrobial Parameters in Children with Fixed Orthodontic Appliances. *The Angle Orthodontist*, **81**, 901-906. <https://doi.org/10.2319/012111-44.1>
- [35] Kanaya, T., Kaneko, N., Amaike, C., Fukushima, M., Morita, S., Miyazaki, H., et al. (2005) The Effect of Orthodontic Appliances on Levels of *Streptococcus mutans*, *Streptococcus sobrinus* and Microbial Flora in Saliva. *International Congress Series*, **1284**, 189-190. <https://doi.org/10.1016/j.ics.2005.07.061>
- [36] Kanaya, T., Kaneko, N., Amaike, C., Fukushima, M., Morita, S., Miyazaki, H., et al. (2007) A Study on Changes in Caries Risk and Microbial Flora with the Placement of Edgewise Appliance. *Orthodontic Waves*, **66**, 27-32. <https://doi.org/10.1016/j.odw.2007.03.001>
- [37] Chang, H.S., Walsh, L.J. and Freer, T.J. (1999) The Effect of Orthodontic Treatment on Salivary Flow, pH, Buffer Capacity, and Levels of *Mutans streptococci* and *Lactobacilli*. *Australasian Orthodontic Journal*, **15**, 229-234.
- [38] Wu, K.P., Ke, J.-Y., Chung, C.-Y., Chen, C.-L., Hwang, T.-L., Chou, M.-Y., et al. (2008) Relationship between Unstimulated Salivary Flow Rate and Saliva Composition of Healthy Children in Taiwan. *Chang Gung Medical Journal*, **31**, 281-286.
- [39] Ortendahl, T., Thilander, B. and Svanberg, M. (1997) *Mutans streptococci* and Incipient Caries Adjacent to Glass Ionomer Cement or Resinbased Composite in Orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics*, **112**, 271-274. [https://doi.org/10.1016/S0889-5406\(97\)70255-5](https://doi.org/10.1016/S0889-5406(97)70255-5)
- [40] Ogaard, B., Rølla, G. and Arends, J. (1988) Orthodontic Appliances and Enamel Demineralization. Part 1. Lesion Development. *American Journal of Orthodontics and Dentofacial Orthopedics*, **94**, 68-73. [https://doi.org/10.1016/0889-5406\(88\)90453-2](https://doi.org/10.1016/0889-5406(88)90453-2)
- [41] Baliga, S., Muglikar, S. and Kale, R. (2013) Salivary pH: A Diagnostic Biomarker. *Journal of Indian Society of Periodontology*, **17**, 461-465. <https://doi.org/10.4103/0972-124X.118317>
- [42] Carolina, D.N., Rusyanti, Y. and Susanto, A. (2017) Comparison of Salivary Alpha-Amylase Levels in Gingivitis and Periodontitis. *Dentistry Journal*, **50**, 216-219. <https://doi.org/10.20473/j.djmk.v50.i4.p216-219>
- [43] Nabi, T. and Singh, S. (2019) Periodontal Disease and Salivary pH: Case Control Study. *International Archives of Integrated Medicine*, **6**, 1-6.