

# The Effect of AcceleDent® Device on Both Gingival Health Condition and Levels of Salivary Interleukin-1-β and Tumor Necrosis Factors-Alpha in Patients under Fixed Orthodontic Treatment

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## ABSTRACT

**Background:** Traditional orthodontic treatment takes a long time and this may lead to several disadvantages like higher predisposition to periodontal diseases and dental caries. Recently, many researchers focus on shorter orthodontic treatment time through different methods like the use of: vibration, surgical approach, adjunctive medicine, laser and others. This study aimed to determine the effect of AcceleDent vibration device on the gingival health condition and the changes in levels of salivary IL-1β and TNF-α among patients under fixed orthodontic appliance during orthodontic treatment.

**Material and Methods:** A total of 32 adult patients with an age ranged between 19-23 years were participated in this study. They were divided into two groups: 14 patients under fixed orthodontic appliance with the use of AcceleDent vibration device as study group and 18 patients under fixed orthodontic appliance only as control group. All patients were with Class I and /or Class II malocclusion cases requiring bilateral extraction of their maxillary first premolar teeth, underwent a session of professional oral hygiene and received oral hygiene instructions before and during the period of study. The collection of the unstimulated salivary samples from the individuals was performed at different times after placement of the fixed orthodontic appliance; base line (T0), after 1 hour (T1), after one week (T2), after two week (T3). The levels of salivary IL-1β and TNF-α were estimated by using commercially available ELISA kits. Oral cleanliness were determined by using of gingival index (GI) and plaque index (PI).

**Results:** For both study and control groups, results reported that the mean value of salivary IL-1-β (pg/ml) and TNF-α (pg/ml) were highest at T1, followed by T2, then T3 and lowest T0 with highly statistically significant difference ( $P < 0.01$ ). The mean value of both salivary IL-1-β (pg/ml) and TNF-α (pg/ml) among study group were higher than control group at T1, followed by T2, then T3 with statistically significant difference ( $P < 0.05$ ). Among study group only, results of this study recorded a negative direction correlation between both IL-1-β (pg/ml) and TNF-α (pg/ml) and gingivitis at the (T2 and T3) and (T3) with statistically highly significant and significant respectively.

**Conclusion:** The application of AcceleDent device play important role in improving the gingival health condition and increasing the levels of salivary IL-1β and TNF-α secretion among patients under fixed orthodontic appliance in comparison to other under fixed orthodontic appliance.

**Keywords:** AcceleDent, Fixed orthodontic appliance, salivary IL-1β, TNF-α. (J Bagh Coll Dentistry 2015; 27(4):180-187).

## INTRODUCTION

Orthodontic tooth movement (OTM) is generated by the coupling of bone resorption on the compressed side of the periodontal ligament (PDL) and through bone formation on the stretched side of the PDL as a consequence of therapeutic mechanical stress <sup>(1)</sup>. Mechanical stress from fixed orthodontic appliances is believed to induce cells in the periodontal ligament (PDL) to form biologically active substances, such as enzymes, cytokines such as interleukin-1(IL-1β and IL-1α), (IL-6), and receptor activator for nuclear factor B ligand (RANKL) which are inflammatory mediators or proinflammatory remodelers of the (PDL) responsible. And for connective tissue remodeling, RANKL is reportedly essential to the osteoclast formation, function, and survival <sup>(2,3)</sup>.

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Cytokines play important role in bone remodeling and they are involved in initiating, amplifying, perpetuating, and resolving inflammatory responses. Both the IL-1β and TNF-α are inducing vascular dilatation which increased permeability and enhancing inflammatory response <sup>(4)</sup>. By using already available oral hygiene instrument that uses electric power to generate oscillatory pattern, which in term create the vibration motion result in up-regulation of the mechanical signal for alveolar bone remodeling <sup>(5)</sup>. Studies reported a greater incidence of gingivitis among orthodontic treatment patients, this may be due to the mechanical and chemical irritation of orthodontic bands and plaque control level <sup>(6,7)</sup>.

Since orthodontic treatment usually takes place over a long period of time and the dental problems of both periodontal disease and dental caries are burdensome for the patient. In comparison to the invasive methods, new AcceleDent vibration device has been introduced in orthodontic field as non-invasive method with minimal side effects like periodontal diseases and

orofacial pain, to accelerating tooth movement and has proven to be a safe low impact alternative that enhances bone remodeling in the medical field<sup>(3,8)</sup>. The present study can be represented as a first Iraqi study that deals with the effect of using Acceledent vibration device on gingival health condition and levels of salivary IL-1- $\beta$  and TNF- $\alpha$  among patients with fixed orthodontic appliance during orthodontic treatment.

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## MATERIALS AND METHODS

### Dental and Laboratory Materials

They involved the diagnostic instruments (dental mirror, dental tweezers, dental probe), cotton roll, kidney dish, portable saliva ejector machine, alginate impression materials, dental stone centrifuge, disposable test tube, eppendroffs tubes (0.25ml, 1ml, and 2ml), ELIZA kits, glass pasteur pipettes, bracket holder, tucker, light cutter, and super looper pliers.

### Orthodontic Materials:

- 0.014 inch light, round, nickel titanium arch wire (Orthotechnology).
- 0.018 x 0.022 inch, stainless steel Bracket (Orthotechnology).
- Molar tube for maxillary first molar right and left (Orthotechnology).
- Ligature wire (Orthotechnology).
- Light cure composite and bonding (Orthotechnology).

### Sample and Methods:

The sample of the present study involved thirty two Iraqi volunteers aged 19-23 years old under orthodontic treatment and they were divided into control group (which included subject under fixed orthodontic appliance only) and study group (which included subject under fixed orthodontic appliance with the use of Acceledent vibration device (Figure 1).

Moreover, this device used at time (10:00 am) after selection of proper tray for each subject in study group and based it on delivery of high frequency vibration (30Hz) to the teeth for approximately 20 minutes continuously per day<sup>(9)</sup>.



**Figure (1): Acceledent Vibration Device**

To be eligible for the study, all subjects were selected according to the following criteria: they should be with Class I and /or Class II malocclusion cases requiring bilateral extraction of their maxillary first premolar teeth. They should have no history of previous orthodontic and facial surgical treatments, smoking, pregnancy, lactation, dental caries, pulp pathology, periodontal disease and history of systemic disease. Each subject prior the placement of the fixed orthodontic appliance should extracted both upper first premolars (right and left) at least before 20 days. During this period, all the subjects were instructed to maintain good oral hygiene regime through checking of plaque index PI, gingival index GI<sup>(10-12)</sup>. Following these 20 days the complete fixed appliance was placed on the upper arch only by bonding the teeth including from the upper second premolar of one side to the second premolar on the other side of the same arch in addition of bonding the upper first molar of both side by molar tube.

The collections of the whole unstimulated salivary samples from the volunteer were formed under standardized conditions. The person should not eat or drink except water one hour before sample collection. The person should not smoke or undergo heavy physical stress before collection. The person should sit in a relaxed position on an ordinary chair and the samples containing blood should be discarded if chemical analysis of saliva is planned<sup>(13,14)</sup>. In this study three milliliter of whole unstimulated saliva were collected into a sterile plastic tube between 9-12 am at different stages of time; before placement of the fixed orthodontic appliance as a baseline (T0), then 1 hour after placement of orthodontic appliance (T1), one week (T2), two week (T3).

The samples were stored at -20°C in a deep freeze until processed <sup>(15)</sup>. Then the saliva were centrifuged at 3000 rpm for 10 minutes, the supernatants layer were collected and frozen until processed. The levels of salivary IL-1β and TNF-α were estimated by using commercially available ELISA kits following the manufactures' instructions. At different time (T0), (T2), (T3), the oral cleanliness were determined using gingival index (GI) and plaque index (PI). All data of analyses were performed by using the SPSS statistical software program (version 10 for Windows, SPSS).

**RESULTS**

Table 1 illustrated the mean and standard deviation values of plaque index among study and control groups. For both study and control groups, the results showed that the mean values of plaque index were higher at T3 with no significant difference (P>0.05) among total sample and both males and females. Concerning study group,

results showed that the mean value of plaque index among males was higher than females with significant difference (P<0.05) at T3 only while it was not significant at T0 and T2. Among control group, the same results were recorded but with no significant difference (P>0.05) at T3, T2 and T0.

The mean values of gingival index among study and control groups are shown in table 2. Concerning study group, results showed that the mean value of gingivitis was lowest at T3 with highly significant difference (P<0.01) among total sample and both males and females. The same results was recorded concerning control group while with no significant difference (P>0.05) among total sample and both males and females. According to the T-test for study group, the mean values of gingival index among males was higher than females with significant difference (P<0.05) at T2 and T3 while it was not significant for T0. While for control group, no gender difference was recorded for T1, T2 and T3.

**Table (1): Mean of Plaque Index among Study and Control Groups**

Groups	Gender	No.	Base line (T0)		After 1 week (T2)				After 2 week (T3)				ANOVA test			
			Mean	SD	T-test		Mean	SD	T-test		Mean	SD	T-test		F	p
					t	p			t	p			t	p		
Study	Males	6	0.52	0.13	0.802	0.441	0.50	0.16	0.946	0.367	0.69	0.11	2.487	0.032*	1.74	0.217
	Females	8	0.46	0.11			0.42	0.15			0.44	0.20			0.08	0.969
	Total	14	0.48	0.12			0.45	0.15			0.54	0.21			0.24	0.871
Control	Males	8	0.54	0.09	1.947	0.073	0.59	0.12	1.799	0.095	0.63	0.14	1.650	0.123	0.57	0.644
	Females	10	0.40	0.15			0.42	0.21			0.44	0.25			0.05	0.985
	Total	18	0.46	0.14			0.49	0.20			0.52	0.23			0.57	0.839

\* (Significant) = P value<0.05 (within group)

**Table (2): Mean of Gingival Index among Study and Control Groups**

Groups	Gender	No.	Base line (T0)		After 1 week (T2)				After 2 week (T3)				ANOVA test			
			Mean	SD	T-test		Mean	SD	T-test		Mean	SD	T-test		F	p
					t	p			t	p			t	p		
Study	Males	6	0.65	0.10	1.641	0.132	0.34	0.09	2.484	0.032	0.07	0.04	-2.304	0.044*	39.71	0
	Females	8	0.55	0.11			0.20	0.10			0.16	0.08			20.44	0
	Total	14	0.59	0.12			0.26	0.12			0.13	0.08			40.18	0
Control	Males	8	0.66	0.09	1.947	0.073	0.59	0.12	2.154	0.051	0.56	0.21	1.290	0.220	0.38	0.772
	Females	10	0.52	0.15			0.39	0.21			0.41	0.24			0.75	0.535
	Total	18	0.58	0.14			0.47	0.20			0.47	0.23			0.97	0.419

\* (Significant) = P value<0.05 (within group), \*\* (Highly significant) = P value<0.01 (within group)

Data of the present study for both study and control groups showed that the mean value of salivary IL-1β (pg/ml) and TNF-α (pg/ml) were highest at T1, followed by T2, then T3 and T0 with highly statistically significant difference (P<0.01) among total sample and both males and females as shown in tables 3 and 4 respectively. According to the t-test, the mean value of salivary

IL-1β (pg/ml) among males was higher than females with no significant difference (P>0.05) at T0, T1, T2 and T3. The same results were recorded concerning TNF-α (pg/ml). The mean value of both salivary IL-1β (pg/ml) and TNF-α (pg/ml) among study group were higher than control group at T1, followed by T2, then T3 with statistically significant difference (P<0.05).

The correlation coefficient (r) between IL-1β concentration (pg / ml) and plaque and gingival indices among study and control group are shown in table 5. Concerning study group after one week

(T2) and two week (T3), results reported that the correlation coefficient between IL-1 $\beta$  concentration and gingival index were significant in negative direction for males. And among total and females the correlation was highly significant with negative direction. Concerning study group at base line, data analysis reported no significant correlation between IL-1 $\beta$  concentration and gingival index. Concerning control group at base line (T0), after one week (T2) and two week (T3), results reported that the correlation coefficient between TNF- $\alpha$  (pg/ml) and both plaque and gingival indices were not significant in negative direction for total and both gender.

Table 6 illustrated the correlation coefficient (r) between TNF- $\alpha$  concentration (pg / ml) and plaque and gingival indices among study and control group. Concerning study group after two week (T3), results reported that the correlation coefficient between TNF- $\alpha$  (pg/ml) concentration and gingival index were significant in negative direction for total and females. Among males the correlation was not significant with negative direction. Concerning study group at base line and after one week (T2), data analysis reported no significant correlation between TNF- $\alpha$  (pg/ml) concentration and gingival index. Concerning control group at base line (T0), after one week (T2) and two week (T3), results reported that the correlation coefficient between TNF- $\alpha$  (pg/ml) and both plaque and gingival indices were not significant in negative direction for total and both gender.

## DISCUSSION

Many researchers have been utilized to increase rate of orthodontic tooth movement, whether it be by reducing friction in the fixed orthodontic appliances<sup>(16)</sup>, surgical corticotomy techniques<sup>(17)</sup>, adjunctive medicinal or hormonal therapies (local or systemic) such as pharmacological approaches with the injection of prostaglandin E2 (PGE2) and 1,25-(OH)<sub>2</sub>D<sub>3</sub><sup>(18)</sup>, physical approaches with low-energy laser irradiation<sup>(19)</sup> and magnetic fields<sup>(20)</sup>. Moreover, previous researches into these strategies revealed some disadvantages involving increase discomfort for patients, local pain and root resorption. Recently as a new developed technology, Acceleident device introduced in orthodontic treatment and act to accelerate the rate of orthodontic tooth movement and reduce treatment time to reach up to 30-40%<sup>(3,21)</sup> in addition to diminish adverse effects on oral health conditions in compare to previous techniques.

In general, changes in IL-1 $\beta$  profile of salivary form pressure site elicit the bone resorbing pattern

which comes from orthodontic tooth movement<sup>(22-24)</sup>. For both study and control group, data reported a gradual elevated significantly of IL-1 $\beta$  and TNF- $\alpha$  at T1 followed with obvious decrease afterward at T2 then T3 this might indicated an early upregulation activity of the anti-inflammatory cytokines such as IL-10, including suppression of the proinflammatory cytokines and stimulation that play a role in bone resorption and periodontal tissue destruction<sup>(25)</sup>; the finding of present study is in agreement with other studies<sup>(26-28)</sup>. While disagreement with<sup>(29-30)</sup> who were representing no change, this may be as a result of the differences in the design of study involving sample size, age group, gender and type of salivary sample, especially when many of these studies did not included these factors in the multivariate analysis. Results reported a higher IL-1 $\beta$  level among study group than control group at T1, T2 and T3, this could be due to a lack of additional force consistency of Acceleident vibration device among control group in comparison to study group<sup>(31)</sup>. With respect to the rate of tooth movement, there is a study that found a positive correlation with the IL-1 $\beta$  IL-1 receptor antagonist ratio. Furthermore, this study reported that the mean values of IL-1 $\beta$  were higher among study group than control group; this may reflect the possible function of more IL-1 $\beta$  secretion as a consequence of vibratory stimulation beside the conventional orthodontic force<sup>(32-33)</sup>. Among both study and control group, results of present study reported no gender differences concerning IL-1 $\beta$  and TNF- $\alpha$  at T1, T2 and T3, this finding in agreement with Serra et al.<sup>(34)</sup>; this may be due to no differences in enzymatic activity during orthodontic tooth movement between males and females.

In present study, the vibration of Acceleident device has reduced or eliminated the invasive nature to achieve the Regional Acceleratory Phenomenon that come with additional advantages such as reduced rates of: relapse, orthodontic pain and root resorption. Moreover, the fluctuation of salivary IL-1 $\beta$  and TNF- $\alpha$  during orthodontic tooth movement are only partly due to changes in the severity of gingival inflammation and this can be rationalize by the transport of them from the gingival sites<sup>(35-36)</sup>.

Among study group only, results of this study recorded a negative direction correlation between both IL-1- $\beta$  (pg/ml) and TNF- $\alpha$  (pg/ml) and gingivitis at the (T2 and T3) and (T3) with statistically highly significant and significant respectively, this in agreement with the previous studies<sup>(37-38)</sup>, while disagree with Dinarello<sup>(39)</sup>, these finding were in similarity to the

effectiveness of vibration magnitude of the toothbrush on reducing the severity of gingivitis<sup>(40)</sup>. While among control group, results of this study recorded no correlation between both IL-1- $\beta$  (pg/ml) and TNF- $\alpha$  (pg/ml) and gingivitis at T1, T2 and T3, this may be due to lack additional consequence of vibratory stimulation beside the conventional orthodontic force.

As conclusion; the use of Acceledent device during fixed orthodontic treatment was found to be the effective method in decrease the severity of gingivitis and markedly increase in level of salivary both IL-1- $\beta$  (pg/ml) and TNF- $\alpha$  (pg/ml) during first 3 weeks of orthodontic treatment period. Further studies with large sample size, among different age group and full duration of orthodontic treatment are necessary to get more clear and obvious results of Acceledent device effect in reducing both treatment time and enhancing oral health conditions of patients.

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Appendices:

**Table (3): Mean of IL-1 $\beta$  Concentration (pg / ml) among Study and Control Groups**

Groups	Genders	No.	Base line (T0)		After 1hour (T1)				After 1 week (T2)				After 2 week (T3)				ANOVA test			
			Mean	SD	T-test		Mean	SD	T-test		Mean	SD	T-test		Mean	SD	T-test		F	Sig
					t- value	Sig			t- value	Sig			t- value	Sig			t- value	Sig		
Study	Males	6	161.32	3.98	2.108	0.061	462.78	10.23	1.549	0.152	275.47	6.37	1.098	0.298	247.48	5.75	1.166	0.271	718.885	0
	Females	8	152.60	8.51			448.63	18.33			267.76	14.58			240.55	12.23				
	Total	14	156.23	8.09			454.52▲	16.57			270.97▲	12.10			243.44▲	10.31			602.696	0
Control	Males	8	161.02	6.31	1.613	0.131	437.17	22.65	1.207	0.249	259.42	11.53	1.704	0.112	233.78	10.51	1.409	0.182	414.656	0
	Females	10	156.68	4.16			422.40	23.57			251.09	7.53			227.23	7.58			665.879	0
	Total	18	158.41	5.38			428.30	23.60			254.42	9.89			229.85	9.12			1026.266	0

**Table (4): Mean of TNF-  $\alpha$  Concentration (pg / ml) among Study and Control Groups**

Groups	Genders	No.	Base line (T0)		After 1hour (T1)				After 1 week (T2)				After 2 week (T3)				ANOVA test			
			Mean	SD	T-test		Mean	SD	T-test		Mean	SD	T-test		Mean	SD	T-test		F	Sig
					t- value	Sig			t- value	Sig			t- value	Sig			t- value	Sig		
Study	Males	6	2.02	0.02	-0.101	0.921	6.09	0.11	-1.219	0.251	3.66	0.30	-1.198	0.259	3.04	0.02	0.407	0.693	8893.394	0
	Females	8	2.03	0.17			6.55	0.84			3.86	0.28			3.04	0.02			2541.076	0
	Total	14	2.02	0.12			6.36▲	0.67			3.77▲	0.29			3.04▲	0.02			5870.361	0
Control	Males	8	2.02	0.04	-0.057	0.956	5.59	0.18	-1.203	0.250	3.65	0.07	0.473	0.644	2.92	0.05	-0.462	0.652	2874.095	0
	Females	10	2.02	0.07			5.75	0.30			3.63	0.10			2.94	0.08			7817.294	0
	Total	18	2.02	0.05			5.69	0.26			3.64	0.09			2.93	0.07			9199.709	0

**Table (5): Correlation Coefficient (r) between IL-1 $\beta$  Concentration (pg / ml) and Plaque and Gingival Indices among Study and Control Groups**

Genders	No.	Base line (T0)				After 1 week (T2)				After 2 week (T3)			
		Plaque index		Gingival index		Plaque index		Gingival index		Plaque index		Gingival index	
		r	P-value	r	P-value	r	P-value	r	P-value	r	P-value	r	P-value
Males	6	0.188	0.762	-0.495	0.396	-0.644	0.241	-0.898	0.038*	-0.23	0.71	-0.871	0.032*
Females	8	0.303	0.509	0.567	0.185	-0.489	0.266	-0.903	0.005**	-0.256	0.579	-0.911	0.001**
Total	14	0.314	0.321	0.432	0.161	-0.314	0.32	-0.762	0.004**	-0.087	0.789	-0.902	0.009**
Males	8	0.417	0.411	0.417	0.411	0.276	0.596	0.276	0.596	0.306	0.556	0.366	0.475
Females	10	0.121	0.756	0.121	0.756	0.083	0.831	0.135	0.73	0.074	0.849	0.123	0.752
Total	18	0.36	0.187	0.36	0.187	0.298	0.28	0.347	0.205	0.27	0.33	0.319	0.247

**Table (6): Correlation Coefficient (r) between TNF-  $\alpha$  Concentration (pg / ml) and Plaque and Gingival Indices among Study and Control Groups**

Genders	No.	Base line (T0)				After 1 week (T2)				After 2 week (T3)			
		Plaque index		Gingival index		Plaque index		Gingival index		Plaque index		Gingival index	
		r	P-value	r	P-value	r	P-value	r	P-value	r	P-value	r	P-value
<b>Males</b>	6	0.123	0.843	-0.639	0.246	-0.616	0.268	-0.485	0.407	-0.143	0.818	-0.673	0.021*
<b>Females</b>	8	0.296	0.519	0.582	0.171	-0.413	0.357	-0.541	0.21	-0.308	0.502	-0.822	0.023*
<b>Total</b>	14	0.309	0.328	0.447	0.145	-0.352	0.261	-0.334	0.289	-0.25	0.434	-0.661	0.019*
<b>Males</b>	8	0.419	0.408	0.419	0.408	0.238	0.65	0.238	0.65	0.391	0.443	0.593	0.215
<b>Females</b>	10	0.122	0.754	0.122	0.754	0.531	0.142	0.537	0.136	0.38	0.313	0.328	0.388
<b>Total</b>	18	0.342	0.211	0.342	0.211	0.266	0.337	0.232	0.405	0.399	0.141	0.412	0.127