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Effect of Two Self-Ligating Bracket Systems on Mechanical and Biological Evaluation of Tooth Movement (Randomized Clinical Study)

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ORIGINAL STUDY

Effect of Two Self-ligating Bracket Systems on Mechanical and Biological Evaluation of Tooth Movement (Randomized Clinical Study)

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Abstract

Purpose: This study aimed to compare two self-ligating systems in terms of biological mediators Interleukin-I (IL-1) and TNF-α found in the gingival crevicular fluid (GCF) and the mechanical deterioration of Copper Titanium (CU-Niti) wires being used in this study. **Subjects and methods:** Patients aged 18−25 years old were randomly assigned to one of three groups: patients in Group I were treated with the conventional Foresta-dent system (control), patients in Group II were treated by Ortho-Pro self-ligating brackets, and finally, Group III patients were treated with Foresta-dent self-ligating systems. For each group, changes were assessed, and data management was performed by the Statistical Package for Social Sciences (SPSS) version 18. Post hoc and Wallis tests were used to compare the three groups. **Results:** The control group had the highest mean values in TNF-α and IL-1, followed by Foresta-dent and Ortho-pro self-ligating. The ANOVA test revealed no significant difference between group II and group III. The two experimental groups had significantly lower values than the control group ($P = 0.00$). **Conclusions:** The two experimental groups recorded a significantly lower value in comparison to the control ($P = 0.00$).

Keywords: Biological markers, Lower anterior crowding, Self-lighting brackets

1. Introduction

Recently, the biology of tooth movement has shifted to a different set of priorities. Fixed orthodontic treatment entails the application of controlled forces involving and acting on the teeth and associated structures, as well as therapy to move them into the desired position. Alveolar bone remodeling allows for tooth movement [1]. We are also using this knowledge to try to control, minimize, and predict the occurrence of iatrogenic effects in order to deliver a better treatment experience for our patients.

Orthodontic treatment improves patient's self-image by achieving better aesthetics and a more attractive smile. As a result, healthy gingiva and periodontium are the primary requirements for achieving the best orthodontic treatment outcome. Plaque retention is improved by the design, surface characteristics of fixed orthodontic attachments, and the composite used for bonding [2].

Orthodontic appliances significantly reduce the efficacy of tooth brushing and saliva self-clearance. As a result, a combination of orthodontic therapy for about 1−2 years and poor oral hygiene are factors that cause serious periodontal damage due to the accumulation of microbial dental plaque. As a result of an inflammatory condition, such as gingivitis, the response to forces applied for tooth movement is also delayed. Arch wires are held to brackets in fixed orthodontic appliances and require an elastic or wire ligature [3].

The method of ligation has been linked to changes in microbial flora [1]. These changes are an aesthetic issue that persists after treatment for many years [3]. Self-ligating brackets (SLBs) use an integrated system to enclose the bracket slot, assuming that ligating modules are eliminated, reducing friction and treatment time [2−4].

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Any orthodontic appliance promotes significant changes in the homeostasis of the periodontal tissues through the increase of dental plaque, as well as the release of chemical mediators in the gingival sulcus. Cytokines are responsible for a chronic inflammatory response in the periodontium. Gingivitis increases vascular permeability and inflammatory cell migration (neutrophils and macrophages) to the gingival crevicular fluid (GCF). T and B lymphocytes then merge at the site of the injury. Cytokines, such as IL-1, IL-1, IL-6, IL-8, TNF-α, and prostaglandins are produced and released by host cells, with this literature emphasizing the role of cytokines in orthodontic movement and resorption during orthodontic treatment [5].

Typically, the mechanical and surface properties of the arch wires would be useful. Arch wires are intended to align teeth using light and consistent forces. These forces may reduce the possibility of patient discomfort, tissue hyalinization, and bone resorption. When such forces are applied, the arch wire should behave elastically for several weeks to months. There are four major orthodontic arch wire alloys available: Nickel–Titanium (NI-TI), Copper Titanium (CU-Niti), beta-titanium, stainless steel, and cobalt chromium-nickel arch wires. Each arch wire alloy system has its own set of characteristics [6].

The hypothesis of this study is to prove that self-ligating brackets preserve the healthy periodontium more than conventional brackets.

2. Subjects and methods

The present study was done on 14 patients with a split-mouth design, according to a previous study by Bergamo et al. (2018) [7].

The patients were selected from the Orthodontic Clinic, Faculty of Dental Medicine for Girls, Al-Azhar University. This study obtained ethical approval from the Ethical Committee at the Faculty of Dental Medicine of Al-Azhar University, Cairo, Egypt, under the number (P-OR-21-03). The study follows a Single-center randomized clinical trial with a parallel design where the participants needed relief from crowding in the mandibular arch ranging from mild to moderate stages. The study follows a design of Single-center randomized clinical trial with a parallel design where the participants needed relief from crowding in lower arch ranging from mild to moderate stages. The selected patients fulfilled the following criteria: a) female outpatients in the clinic of the university 18–25 years old, b) Mild to moderate dental irregularity (2–6 mm), c) good oral hygiene and periodontal health, d) Presence of all permanent teeth. The exclusion criteria: a) if the patient need orthognathic surgery to correct skeletal malocclusion, b)requiring extraction treatment, c) if the patient taking drugs like nonsteroidal inflammatory drugs, d) cleft lip or palate, e) hypodontia or hyperdontia, f) any autoimmune disease [7].

2.1. The study groups

Participants were divided into three groups, group I: conventional Foresta-dent in five patients as split-mouth design, group II: Foresta-dent self-ligating brackets; and group III: Ortho-pro self-ligating brackets. The study design was Split-mouth techniques, where Foresta-dent self-ligating brackets were on the mandibular right side and Ortho-pro self-ligating brackets were on the mandibular left side in nine patients. The foremost phase of teeth alignment and levelling was completed by a sequence of 0.014, 0.016, and 0.018 CU-Niti arch wires [8,9].

2.2. Bonding protocol

The patients were instructed on proper oral hygiene measures, including tooth brushing, and using mouthwash. By periodontal probe the length of any pocket was measured if present and the most healthy site (pocket ranging from 0 to 2 mm) was the site for taking the pre and post samples for measuring IL 1 and TNFα (after 60 days from the treatment beginning) for measuring IL-1 and TNFα(by absorbing paper point (number 30))then froze at −80 C until the end of treatment. Bonding the brackets was done by using Green glue (Oramco, California, USA). Using an LED curing unit (Led B, wireless, Woodpecker, Guilin, China). The levelling and alignment stage began with 0.014, 0.016, and 0.018 CU-Niti arch wires (Foresta-dent copper Niti arch wires), which have been tested by a universal testing machine.

3. Results

The amount of TNF-α and IL-1 found in GCF were measured by Enzyme-Linked Immunoassay (ELISA). Data management and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) version 18. The data were checked for normality using the data distribution and the Kolmogorov–Smirnov and Shapiro–Wilk tests.

3.1. Intergroup comparison of pre- and post-values of TNF and Interleukin-1

Regarding the TNF Pretreatment, the highest mean value was recorded in Ortho_pro self-ligating,

followed by Foresta self-ligating, with the lowest mean value recorded in control group. ANOVA test and post hoc test revealed a significantly higher value in Ortho_pro self-ligating group in comparison to control ($P = 0.013$). However, post-treatment, the highest mean value was observed in control, then Foresta self-ligating, with the lowest mean value recorded in Ortho_pro self-ligating group. ANOVA test revealed no significant variance between groups ($P = 0.655$) (Table 1).

Regarding Interleukin-1(IL-1), in the pretreatment, the highest mean value was recorded in Ortho-pro self-ligating, followed by control, with the lowest mean value recorded in Foresta self-ligating group. ANOVA test revealed statistically nonsignificant variance between groups ($P = 0.825$). In the post-treatment, the highest mean value was recorded in control, followed by Foresta self-ligating, with the lowest mean value recorded in Ortho_pro self-ligating group. ANOVA test and post hoc test revealed no significant difference between Foresta and Ortho-pro groups. The two experimental groups recorded a significantly lower value in comparison to control ($P = 0.00$) (Table 1).

3.2. Intragroup comparison of pre- and post-values of TNF and Interleukin-1

Regarding the TNF, in control conventional Foresta group, a significantly higher value was recorded post-treatment ($P = 0.02$). In Foresta self-ligating group, there was no significant difference between the pre- and post-values ($P = 0.942$). According to Ortho-pro self-ligating group, a significantly lower value was recorded post-treatment ($P = 0.02$) Table 2 (Fig. 1),

Regarding Interleukin-1(IL-1), In control group, a significant value was recorded after treatment ($P = 0.019$). In Foresta self-ligating group, there was no significant difference between the pre- and post-values ($P = 0.117$). In Ortho-pro self-ligating group, a lower value was recorded post-treatment, however, this difference did not reach the level of statistical significance ($P = 0.126$) Table 2 (Fig. 1).

(1) Intragroup comparison of pre- and post-values of TNF and Interleukin-1.
Results are summarized in Table 2.

(a) TNF

In control group, a significant higher value was recorded after treatment ($P = 0.02$). In Foresta self-ligating group, there was no significant difference between pre- and post-values ($P = 0.942$). According to Ortho-pro self-ligating group, a significantly lower value was recorded post-treatment ($P = 0.02$).

(b) Interleukin-1(IL-1)

In control group, a significant higher value was recorded after treatment ($P = 0.019$). In Foresta self-ligating group, there was no significant difference between the pre- and post-values ($P = 0.117$). According to Ortho-pro self-ligating group, a lower value was recorded post-treatment, however this difference is not statistically significance ($P = 0.126$).

4. Discussion

Orthodontic treatment shows a variety of metabolic changes that permit tooth movement. Bone

Table 1. Descriptive statistics and comparison between groups (intergroup) regarding pre- and -values of TNF and Interleukin-I (ng/l), (ANOVA test).

	Mean	S-D	95% Confidence interval for mean		Min	Max	F	P
			Lower bound	Upper bound				
TNF Pre								
Control	230.6[b]	50.84	191.52	269.68	167.06	318.64	5.219	0.013*
Foresta SL	266.64[a,b]	36.83	238.33	294.95	219.18	337.42		
Ortho-Pro SL	287.25[a]	17.66	273.68	300.83	256.55	311.29		
TNF Post								
Control	266.85	36.10	239.10	294.60	220.33	331.74	0.431	0.655ns
Foresta SL	264.01	87.73	196.57	331.44	158.18	471.48		
Ortho-Pro SL	242.48	46.16	206.99	277.96	175.92	316.78		
Il-1 Pre								
Control	80.71	6.02	76.08	85.34	70.94	92.39	0.193	0.825ns
Foresta SL	78.54	9.03	71.60	85.48	66.76	97.69		
Ortho-Pro SL	81.83	16.53	69.13	94.54	65.45	116.33		
Il-1. Post								
Control	83.83[x]	6.56	78.79	88.87	72.38	94.72	12.773	0.000*
Foresta SL	72.41[y]	3.97	69.36	75.47	68.28	79.91		
Ortho-Pro SL	71.85[y]	6.15	67.12	76.58	63.13	84.72		

Significance level $P \leq 0.05$.
* significant, ns = nonsignificant.
Post hoc test: Within the same comparison, means sharing the same superscript character are not significantly different (a,b) or (x,y).

Table 2. Comparison of TNF and Interleukin-1 pre- and post-values (ng/l) in the same group (intragroup) (paired t-test).

Groups	Mean	S-D	Difference				*t*	*P*
			Mean	Std. Dev	C.I. lower	C.I. lower		
Control								
TNF.pre	230.60	50.84	−36.25	37.68	−65.21	−7.29	−2.89	0.02*
TNF.post	266.85	36.10						
Il-1.pre	80.71	6.02	−3.12	3.18	−5.56	−0.68	−2.94	0.019*
Il-1.post	83.83	6.56						
Foresta self-ligating								
TNF.pre	266.64	36.83	2.63	105.55	−78.50	83.76	0.075	0.942ns
TNF.post	264.01	87.73						
Il-1.pre	78.54	9.03	6.13	10.45	−1.91	14.16	1.76	0.117ns
Il-1.post	72.41	3.97						
Ortho_proself ligating								
TNF.pre	287.25	17.66	44.78	46.26	9.22	80.33	2.904	0.02*
TNF.post	242.48	46.16						
Il-1.pre	81.83	16.53	9.98	17.53	−3.49	23.46	1.708	0.126ns
Il-1.post	71.85	6.15						

Significance level $P \leq 0.05$.
* significant, ns = nonsignificant.
C.I., 95% Confidence Interval for Mean.

remodeling of the alveolar bone is crucial for successful orthodontic tooth movement. When minor force is being applied for an extended period of time, inflammatory responses typically begin, resulting in osteoclastic activity and tooth movement [10].

Forces resulting from orthodontic appliances stimulate periodontal cells to secrete substances including cytokines and enzymes that are involved in connective tissue remodeling and osteoclastic process. Tracking changes in the GCF during tooth movement can be used to assess these substances [11]. Tooth movement results in inflammatory reactions like increased vascular permeability, increasing leukocyte and macrophage counts, and immune system involvement. Interferons and growth factors, as well as cytokines including IL, RANKL, and TNFs, play an important role in controlling connective tissue and bone turnover [12].

Cytokines are proteins in nature that have a role in the activation of lymphocytes and macrophage production in order to regulate the other cells [13]. It has a role in bone resorption in response to orthodontic treatment, particularly bone remodeling, in periodontal diseases. Since early tooth movement, it has been linked to the alveolar bone as well as periodontal cell activity [11,13,14].

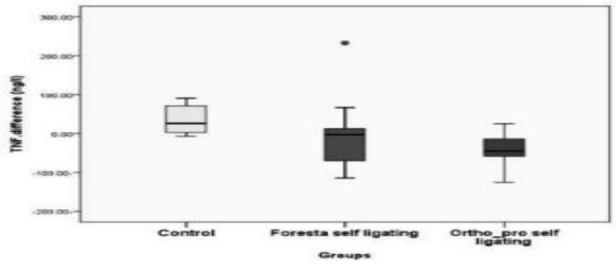

Fig. 1. Box plot illustrating median and interquartile range of value of TNF difference (ng/l) after treatment.

IL-1 and TNF are pre-inflammatory cytokines activated by macrophages; they play a significant role in inflammation and induction of systemic chronic-phase reactions [13].

Orthodontic forces are responsible for the rapid release of TNF-α, IL-1, and IL-8 during tooth movement, which can be inspected with the increase in GCF.

The diverse range of brackets, wires, and ligatures has provided clinicians with a wide scale of combinations for use at different stages of orthodontic treatment [15].

This study determined the leveling and alignment stage, where a comparison between the effect of two self-ligating systems (Foresta-dent and Ortho-pro self-ligating brackets) were done in terms of inflammatory mediators found in GCF during tooth movement and mechanical deterioration in Cu-Niti wires after using each wire sequence (0.014, 0.016, and 0.018, respectively). The split-mouth design was chosen to reduce individual biologic variability.

The efficient force for orthodontic tooth movement is the lightest force that produces tooth movement without adversely affecting the periodontium, so the current study compared passive self-ligating brackets with conventional brackets.

Passive self-ligating brackets are preferred in delivering an appropriate amount of force for producing tooth movement, particularly during the leveling and alignment stage, which was confirmed in our literature as TNF and IL-1 have been reduced

after treatment with self-ligating brackets compared to the control group, resulting in a healthier periodontium. The primary advantage of using self-ligating brackets over conventional brackets, is the claim of reduced friction. That is due to absence of the steel or elastomeric ligatures, and it is claimed that passive designs generate even less friction than active ones. A significant reduction in the force level required for the self-ligating bracket when compared to elastomeric and steel-tie ligation in different types of bracket systems and come to the conclusion that the self-ligating bracket requires less force to produce tooth movement by decreasing the friction [16].

Through comparison of the percentage intragroup analysis of TNF-α pre- and post-treatment, the current study found that there was a reduction in post readings than pre ones, which is due to gingivitis found in some patients prior to orthodontic treatment, and it was reduced in turn by following proper oral hygiene measures and using self-ligating brackets.

Finally, these findings could imply that passive self-ligating brackets are more favorable in keeping healthy periodontium after leveling and alignment stage. But also needed many sequences of CU-Niti wires to achieve the same result achieved by conventional brackets, which in turn used few sequences of wire.

4.1. Conclusions

In TNF-α, there was no significant difference between groups that show ($P = 0.655$), according to IL-1. The two experimental groups recorded a significantly lower value in comparison to control ($P = 0.00$).

4.2. Recommendation

More studies should be done to evaluate the outcome of using self-ligating brackets during the alignment stage by a large number of samples and according to other cytokines in leveling and during en-mass retraction in different malocclusion types. Also, more research is needed to prove their clinical effectiveness over conventional ligation systems.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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