

The Impact of Fixed Orthodontic Ligatures on Periodontal Health

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Abstract

Introduction: Dental plaque is a primary etiological factor in the development of dental caries and periodontal disease. Orthodontic appliances can complicate oral hygiene, increasing plaque retention. This study aimed to evaluate the impact of elastic versus wire ligatures on periodontal health in patients with fixed orthodontic appliances.

Materials and Methods: A total of 24 patients aged 13–18 years participated. All received fixed appliances, with elastic ligatures applied to the right side of the jaw and wire ligatures to the left. Periodontal status was assessed using the Plaque Index (Silness and Løe) and Gingival Index (Løe and Silness) at three intervals: T1 – before appliance placement; T2 – one-week post-placement; and T3 – three months post-placement.

Results: At T3, a significant increase in plaque accumulation, gingival inflammation, and bleeding was observed on the side with elastic ligatures compared to the side with wire ligatures, which showed a reduction in these parameters over time.

Conclusion: Ligature type significantly affects periodontal health in orthodontic patients. Wire ligatures were associated with better periodontal outcomes than elastic ligatures. These findings highlight the importance of choosing appropriate ligation methods and emphasize the need for rigorous oral hygiene to mitigate adverse periodontal effects during fixed orthodontic treatment.

Keywords: Fixed orthodontic appliances, ligatures, plaque index, gingival index, periodontal health, oral hygiene

Introduction

Dental plaque is a complex biofilm that adheres to the surface of teeth or other hard surfaces in the oral cavity and is considered the primary factor in the development of dental caries and periodontal disease. It consists of bacteria embedded in a matrix mainly composed of extracellular bacterial polymers and byproducts of saliva and/or gingival exudates. Gingival disease induced by plaque formation results from the interaction between the microorganisms

in the dental plaque biofilm and the host's tissues and inflammatory cells [1].

During orthodontic treatment with fixed appliances, the risk of periodontal inflammation rises, and enamel demineralization becomes more likely due to decreased natural self-cleaning. This occurs because plaque buildup on orthodontic surfaces—such as brackets, tubes, bands, ligatures, and wires—increases. Therefore, monitoring dental plaque accumulation is crucial for assessing oral hygiene in patients with fixed orthodontic appliances [2]

According to the literature, some studies suggest that periodontal changes resulting from orthodontic appliances are temporary and do not lead to permanent loss of periodontal support [3].

This study aims to evaluate the impact of various orthodontic bracket ligation methods on the periodontal health of patients undergoing treatment with fixed orthodontic appliances. Specifically, the study aims to determine the effect of elastic versus wire ligatures on dental plaque accumulation and gingival inflammation one week and three months after the placement of the orthodontic appliance.

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Materials and Methods

To achieve the stated objectives, the study was conducted on 24 patients, aged 13–18 years, of both sexes, treated at the Orthodontic Clinic at the JZY University Dental Clinical Center, St. Pantelejmon, Skopje. Fixed orthodontic appliances were placed on all patients, including all necessary components. Elastic ligatures were applied to the right side of the jaw, and wire ligatures to the left side.

From each respondent, swabs were taken from selected areas—specifically the maxillary premolars and mandibular incisors on both sides. Sampling was conducted at the Clinic for Periodontal and Oral Diseases. The following indices were used to evaluate periodontal status: The dental plaque index (IDP) according to Silness and Loe, which measures the amount of plaque on the teeth, and the gingival index by Loe and Silness, which assesses the degree of gingival inflammation.

1. Dental plaque index (IDP) according to Silness and Loe[4]

In this index, as a ratio, the width of the dental plaque was taken into consideration along the length of the gingival edge, which is connected to the inflammation:

- 0 - No dental plaque
- 1 - A very small amount of plaque, visible only during careful probing,
- 2 - A moderate amount of plaque alongside the gingival edge is visible with the bare eye, and the interdental spaces are free.
- 3 - A large amount of plaque is present alongside the gingival edge, and the interdental spaces are filled with plaque.



Figure 1 Fixed orthodontic apparatus, on the right half, elastic ligatures are placed, and on the left half, wired ligatures.

2. Gingival index by Loe and Silness [4]

The gingival index, according to Loe and Silness, gives data for the degree of gingival inflammation:

- 0 - Normal gingiva, no inflammation, no change in color, no bleeding
- 1 - Mild inflammation, light change in color, and the surface of the gingiva, and no bleeding during probing,

- 2 - Moderate inflammation, redness, and swelling of the gingiva, bleeding during probing,
- 3 - A very strong inflammation, considerable redness and swelling of the gingival, and spontaneous bleeding.[4, 5, 6]

On each of the respondents, the swab taking and the determination of the index values were done in three-time intervals:

- T1-the first time, before starting the orthodontic therapy,
- T2-the second time, one week after placing the fixed apparatuses,
- T3-the third time, three months after placing the fixed apparatuses.

Results:

1. Elastic ligatures

1. Dental plaque index (IDP) by Silness and Loe[5, 6]

Table 1 provides a descriptive overview of the dental plaque values in relation to T1, T2, and T3, highlighting a significant difference in the dental plaque levels across the analyzed time points.

Variable	Average Rank	Sum of Ranks	Mean	Std.Dev.
IDP-T1	1,40	33,50	0,63	0,49
IDP-T2	2,08	50,00	1,21	0,41
IDP-T3	2,52	60,50	1,58	0,50

Table 1. Descriptive overview of the dental plaque values in relation to T1, T2, and T3,

Seven days after the placement of the elastic ligatures (T2), the dental plaque value for $Z=3.18$ and $p<0,01$ ($p=0.001$) is significantly higher than the value before the start of orthodontic therapy (T1) (Tab. 2).

Païrofvariables	Valid	T	Z	p-Values
IDP-T1&IDP-T2	24	0,00	3,18	0,001

Table 2. Seven days after the placement of the elastic ligatures, statistical correlation

Three months after the placement of the elastic ligatures (T3), the value of the dental plaque for $Z=2.67$ and $p<0,01$ ($p=0.008$) is significantly bigger than the value of the dental plaque for seven days after the placement of the elastic ligatures (T2) (Tab.3).

Païrofvariables	Valid	T	Z	p-Values
IDP-T2&IDP-T3	24	0,00	2,67	0,008

Table 3. Three months after the placement of the elastic ligatures, statistical correlation

Three months after the placement of the elastic ligatures (T3), the dental plaque value for $Z=3.52$ and $p < 0.001$ ($p = 0.000$) is significantly higher than the dental plaque value before the start of orthodontic therapy (T1) (Tab. 4).

Païrofvariables	Valid	T	Z	p -Values
IDP-T1&IDP-T3	24	0,00	3,52	0,000

Table 4. Three months after the placement of the elastic ligatures, before the start of orthodontic therapy, statistical correlation

2. Gingival index (IGI) by Loe and Silness

The differences in the values of the gingival index in relation to T1, T2, and T3 are presented in Table 5, indicating a significant difference in the values of the gingival index in the analyzed relation. (Tab. 5).

Variable	Average Rank	Sum of Mean Ranks	Std.Dev.
IGI-T1	1,33	32,00	0,38
IGI-T2	2,06	49,50	0,96
IGI-T3	2,60	62,50	1,42

Table 5. The differences in the values of the gingival index, and statistical correlation

Seven days after the placement of elastic ligatures (T2), the gingival index value for $Z=3.30$ and $p < 0.001$ ($p=0.000$) is significantly higher than the value of the gingival index before the start of orthodontic therapy (T1) (Tab. 6).

Païrofvariables	Valid	T	Z	p-values
IGI-T1&IGI-T2	24	0,00	3,30	0,000

Table 6. Seven days after the placement of elastic ligatures the value of the gingival index before the start of orthodontic therapy statistical correlation

Three months after the placement of elastic ligatures (T3), the value of the gingival index for $Z=2.69$ and $p < 0.01$ ($p=0.007$) is significantly higher than the value of the gingival index for seven days after the placement of the elastic ligatures (T2) (Tab. 7).

Païrofvariables	Valid	T	Z	p - values
IGI-T2&IGI-T3	24	7,00	2,69	0,007

Table 7. Three months after the placement of elastic ligatures the value of the gingival index before the start of orthodontic therapy statistical correlation

Three months after the placement of elastic ligatures (T3), the value of the gingival index for $Z=3.66$ and $p < 0.001$ ($p=0.000$) is significantly higher than the value of the gingival index before the start of orthodontic therapy (T1) (Tab. 8).

Païrofvariables	Valid	T	Z	p-level
IGI-T1&IGI-T3	24	7,00	3,66	0,000

Table 8. Three months after the placement of elastic ligatures, the value of the gingival index before the start of orthodontic therapy, and the statistical correlation

II. Wire ligatures

1. Dental plaque index (IDP) by Silness and Loe

The differences between the values of the dental plaque in relation to T1, T2, T3. As shown in Table 9, there is a significant difference between the values of dental plaque in the analyzed relation. (Tab. 9).

Variable	Average Rank	Sum of Mean Ranks	Std.Dev.
IDP-T1	1,58	38,00	0,63
IDP-T2	2,38	57,00	1,21
IDP-T3	2,04	49,00	0,96

Table 9. The differences between the values of the dental plaque in relation to T1, T2, T3.

Seven days after the placement of wired ligatures (T2), the value of the dental plaque for $Z=2.89$ and $p < 0.01$ ($p=0.004$) is significantly bigger than the value of the dental plaque before the start of the orthodontic therapy (T1) (Tab.10).

Païrofvariables	Valid	T	Z	p-Values
IDP-T1&IDP-T2	24	6,50	2,89	0,004

Table 10. Seven days after the placement of wired ligatures

Three months after the placement of wired ligatures (T3), the value of the dental plaque for $Z=1.89$ and $p > 0.05$ ($p=0.06$) was insignificantly smaller than the value of the dental plaque for seven days after the placement of the wired ligatures (T2) (Tab. 11).

Païrofvariables	Valid	T	Z	p-Values
IDP-T2&IDP-T3	24	4,50	1,89	0,06

Table 11. Three months after the placement of wired ligatures

Three months after the placement of wired ligatures (T3), the value of the dental plaque for $Z=2.52$ and $p < 0.05$ ($p=0.01$) is significantly bigger than the value of the dental plaque before the start of the orthodontic therapy (T1) (Tab. 12).

Païrofvariables	Valid	T	Z	p-Values
IDP-T1&IDP-T3	24	0,00	2,52	0,01

Table 12. Three months after the placement of wired ligatures before the start of the orthodontic therapy

2. Gingival index (IGI) by Loe and Silness

The differences between the values of the gingival index in relation to T1, T2, and T3 are shown in Table 13, with no significant difference between the values of the gingival index in the analyzed relation. (Tab. 13).

Variable	Average Rank	Sum of Ranks	Mean Ranks	Std.Dev.
IGI-T1	1,96	47,00	0,33	0,48
IGI-T2	2,08	50,00	0,42	0,50
IGI-T3	1,96	47,00	0,33	0,48

Table 13. The differences between the values of the gingival index in relation to T1, T2, and T3

Seven days after the placement of wired ligatures (T2), the value of the gingival index for $Z=0,63$ and $p>0,05$ ($p=0,53$) is insignificantly bigger than the value of the gingival index before the start of the orthodontic therapy (T1) (Tab. 14).

Païrofvariables	Valid	T	Z	p-Values
IGI-T1&IGI-T2	24	13,50	0,63	0,53

Table 14. Seven days after the placement of wired ligatures

Three months after the placement of wired ligatures (T3), the value of the gingival index for $Z=0,73$ and $p>0,05$ ($p=0,46$) is insignificantly bigger than the value of the gingival index before the placement of the wired ligatures (T2) (table 15).

Païrofvariables	Valid	T	Z	p-Values
IGI-T2&IGI-T3	24	7,00	0,73	0,46

Table 15. Three months after the placement of wired ligatures

Three months after the placement of wired ligatures (T3), the value of the gingival index for $Z=0,00$ and $p>0,05$ ($p=1,00$) is equal to the value of the gingival index before the start of the orthodontic therapy (T1) (Tab.16).

Païrofvariables	Valid	T	Z	p-Values
IGI-T2&IGI-T3	24	39,00	0,00	1.00

Table 15. Three months after the placement of wired ligatures the gingival index before the start of the orthodontic therapy

Discussion

The development of dental plaque in humans is influenced by several factors, including dietary habits, oral hygiene, age, sex, saliva quality, and the composition of the oral microflora according Forsberg et al.[7], and Islam et al.,[8] Orthodontic malocclusions, as well as the type of orthodontic appliance used, can influence the degree of dental plaque accumulation. Fixed appliances, with their numerous components, increase the likelihood of plaque retention and raise the risk of tooth decay and inflammatory reactions in the gingival tissue.

Furthermore, the type of brackets and their method of ligation, the duration of orthodontic treatment, and the frequency of orthodontic check-ups are all factors that affect plaque accumulation according Hamp et al.,[9]; Boyd & Baumrind, [10]; Türkkahraman et al., [11]; Ogaard et al., [12]; Souza et al., [13]; Al-Jewair et al., [14]

Research has shown that ceramic brackets, due to their larger size and the tendency to retain moisture, are more prone to accumulating plaque compared to metal brackets according Anhoury et al.,[15].

A significant increase in dental plaque was observed on the side of the jaw where brackets were ligated with elastic ligatures, especially with the extended use of the appliance. The highest values were recorded three months after the appliance was placed. On the side with wire ligatures, an increase in plaque accumulation was observed only during the first week, most likely due to reduced oral hygiene caused by initial discomfort or pain during the early phase of orthodontic therapy.

Three months after placement, plaque levels on the wire-ligated side had decreased and were lower than those recorded after the first week.

These findings are consistent with those of de Souza et al. [13], Ristic et al. [16], and Karkhanechi et al. [17] who documented similar changes, and are contrary to the findings of Türkkahraman et al. [11], who found no significant differences in plaque accumulation.

The adverse effect of fixed orthodontic appliances on plaque accumulation was also confirmed by studies conducted by Cantekin et al. [18] These authors demonstrated a positive correlation between plaque accumulation and fixed appliances, concluding that patients undergoing fixed orthodontic therapy must adhere to stricter oral hygiene protocols.

The gingival index, indicating the degree of gingival inflammation, significantly increased one week and three months after appliance placement on the side with elastic ligatures. In contrast, no significant changes were found on the side with wire ligatures during the same periods.

These findings also align with studies by Forsberg et al. [7] Ristic et al. [16], deSouza et al. [13], (2011), and Karkhanechi et al.[17], and contrast with those of Türkkahraman et al. [11].

The results of this study highlight the importance of ligating orthodontic brackets with wire ligatures as a

necessary measure for maintaining periodontal health in patients undergoing fixed orthodontic therapy. A strong correlation was observed between the use of elastic ligatures and an increase in dental plaque and inflammation. Elastic ligatures, particularly in patients with inadequate oral hygiene, significantly enhance microbial accumulation on tooth surfaces around brackets—an important predisposing factor for caries and gingival inflammation.

Conclusions

Based on the results obtained from the analysis of patients with fixed orthodontic appliances using different bracket ligation methods, the following conclusions can be drawn:

The amount of dental plaque and inflammation was elevated on both sides of the jaw seven days after bracket placement, compared to baseline values prior to treatment.

The increased index values are likely due to poor oral hygiene resulting from the pain and discomfort experienced during the first week of appliance placement.

Three months after appliance placement, index values for plaque and inflammation significantly increased on the side with elastic ligatures and decreased on the side with wire ligatures.

Analysis of the differences between the two sides showed significantly higher plaque and inflammation indices on the side with elastic ligatures seven days after placement compared to the side with wire ligatures.

The findings of this study highlight the significance of bracket ligation as a crucial factor in maintaining periodontal health during fixed orthodontic therapy.

To prevent or reduce undesirable inflammatory effects, in addition to recommending wire ligatures, proper oral hygiene instructions and regular follow-ups with a specialist in periodontal and oral diseases are also necessary before and during orthodontic treatment.

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