Effects of orthodontic ligation—using elastomeric and stainless steel ligatures—on periodontal health

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Abstract

Objective: This study aimed to conduct a clinical evaluation of the periodontal conditions of a test group and a control group using three periodontal indexing systems, namely: dental biofilm index (DBI), bleeding index (BI) and pocket probing depth (PPD). **Methods:** The test group consisted of 20 subjects with a mean age of 13.5 years undergoing fixed orthodontic treatment involving the use of two types of ligature: elastomeric ligature (EL) and stainless steel ligature (SSL). The results were compared with a control group without prior orthodontic treatment, comprising 15 subjects with a mean age of 15.3 years. The measurements were performed prior to orthodontic treatment (T1) and six months after placement of a fixed orthodontic appliance (T2); and in the control group, six months after the initial measurement (T2). Both groups were instructed about oral hygiene, according to the Bass technique, before treatment. **Results and Conclusions:** Dental surfaces showed a statistically significant increase in levels of biofilm (P=0.000), gingival bleeding (P=0.000) and probing depth (P=0.000), when T1 and T2 and the groups were compared, however, no statistically significant differences were found between EL and SSL in terms of these periodontal indexes.

Keywords: Orthodontic appliances. Periodontal diseases. Biofilms.

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INTRODUCTION AND LITERATURE REVIEW

The link between orthodontics and periodontics has been studied over the years, be it to address the role of orthodontic attachments as biofilm retainers and obstacles to proper oral hygiene,[2,3,4,5,9,10,11,13,14,16,20,22,23,26,28,29] be it to address tooth positioning as a means to retain dental plaque, protect the gingival papilla or allow the proper delivery of forces to the periodontum.[7,12,15,25,27]

Studies on periodontal changes caused by orthodontic treatment have yielded mixed results. The literature associates orthodontic appliances with mild gingival inflammation, even in patients with perfect health. Proximal and buccal areas are the most affected.[29] Moreover, some authors claim they did not observe significant changes in dental biofilm index (DBI) or in dental hygiene throughout a whole year of orthodontic treatment.[18]

Comparison between a group of women with and without fixed orthodontic appliances showed similar DBI and gingival inflammation index (GI) between groups, unlike pocket probing depth (PPD).[27]

In another study, however, DBI and GI were higher in groups using orthodontic appliances when compared to the control group, but both within adequate hygiene levels.[9]

It is known that after removal of orthodontic attachments gingival health improves significantly with a reduction in PPD, which suggests that periodontal changes are transient and no permanent damage is caused to oral tissues.[16,21,29]

Although few studies in the literature have compared elastomeric (EL) and stainless steel (SSL) ligatures, most of them used electron microscopy.

Measurement of the quantity of microorganisms accumulated on the teeth, as well as variations in the quantity of these microorganisms in saliva, in patients using EL and SSL showed that the former had the highest number of microorganisms in all samples and there was an increase in the number of Streptococcus mutans and lactobacilli in saliva.

But this is not reflected in an increase or decrease in bacterial colonization with either EL or SSL.[10]

Electron microscopy analyses of premolars extracted from patients undergoing orthodontic treatment with brackets bonded with composite resin using EL on one side and SSL on the opposite side disclosed no bacterial differences, although mature biofilms were observed in the resin, due to its rough exterior, as well as in the resin-enamel interface.[26]

In another electron microscopy study, it was found that neither the application of stannous fluoride nor the use of these ligation materials (EL or SSL) affect the number of Streptococcus mutans colonies around the brackets.[5]

The aim of this study was to evaluate clinically the periodontal health of patients with total fixed orthodontic appliances using two ligation methods: elastomeric (EL) and stainless steel (SSL), which were compared with a control group. Periodontal evaluation criteria were based on: dental biofilm index (DBI), bleeding index (BI) and pocket probing depth (PPD), measured before and six months after placement of fixed orthodontic appliances. Both the test and control groups were instructed on oral hygiene using the Bass technique and dental flossing. This study was submitted to and approved by the Ethics Committee of UFJF.

MATERIAL AND METHODS

This study evaluated clinically the periodontal conditions of a test group, submitted to orthodontic treatment, using two ligation methods: elastomeric ligature (EL) and stainless steel ligature (SSL), whose results were compared with a control group, using the following periodontal indexes:
» Dental Biofilm Index (DBI).[24]
» Bleeding Index (BI).[1]
» Pocket Probing Depth (PPD).[19]
The mesial, distal, buccal and lingual surfaces of all permanent teeth in the test and control groups were examined, except the second and third molars,

using a clinical mirror, artificial light, explorer and graduated periodontal probe (Newmar, São Paulo/SP, Brazil), Glickman No. 26, 10 mm.

The criteria for sample selection were: To be enrolled for treatment at the clinic of the Specialization Course in Orthodontics, School of Dentistry, UFJF; not using systemic medication for chronic diseases nor local or general antimicrobial medication; not undergoing periodontal treatment nor having a family history of periodontal disease; not smoking; not being pregnant.

The test group consisted of 20 Brazilian subjects, 9 males and 11 females, between 9 and 16 years with a mean age of 13.5 years. Periodontal evaluation was carried out prior to orthodontic treatment (T1) and six months after placement of the total fixed orthodontic appliances, using metal Standard Edgewise (Morelli, Sorocaba/SP, Brazil) and Roth (Abzil, São José do Rio Preto/SP, Brazil) brackets (T2). In this sample, T1 and T2 evaluations were performed in the upper and lower arches of 5 patients, in the upper arch of 9 patients and in the lower arch of 6 patients. This difference in the number of upper and lower arches that were assessed is due to the fact that some patients had fixed appliances installed in only one arch. Either that, or the appliance had been installed less than six months earlier.

Ligature types were alternated in each quadrant and maintained in such position throughout all consultations. In some patients the first quadrant was ligated with EL and in others, with SSL. In this manner, it was ensured that both types of ligature were alternately used in the second quadrant, since all participants in the test group were right-handed and subjects tend to brush best the buccal surfaces of the quadrant opposite to the hand holding the brush, especially in the maxillary arch.[8]

All stainless steel ligatures (Uniden, Sorocaba/SP, Brazil) were from the same manufacturing lot, size 0.010" (0.25 mm). Elastomeric ligatures (Uniden, Sorocaba/SP, Brazil) were also from the same production lot and in the gray color. Each tooth was individually ligated.

The control group consisted of 15 patients who had never undergone orthodontic treatment, 10 females and 5 males, aged between 9 and 22 years with a mean age of 15.3 years. Evaluation was performed initially (T1) and then six months after the initial measurement (T2).

All participants and their parents were instructed about oral hygiene according to the Bass technique and flossing before treatment. They were given toothbrushes (Condor, São Bento do Sul/SC, Brazil), soft bristle, No. 30, all from the same manufacturing lot.

All participants in this study, or their legal guardians, signed a consent term, pursuant to UFJF Ethics Committee regulations.

Statistical analysis

Periodontal evaluation was performed by a single, properly calibrated professional. Statistical analysis provided a concordance index of Kappa = 1 for DBI, an index of agreement of Kappa = 0.974 for BI, and Student's t-test yielded P = 0.140 for PPD.

DBI results were statistically analyzed using the Wilcoxon test (comparison between T1 and T2), the nonparametric Mann-Whitney (comparison between groups) and chi-square test (comparison between groups and between ligatures).

BI results were statistically analyzed using the Wilcoxon test (comparison between T1 and T2) and chi-square test (comparison between groups and between ligatures).

PPD values were subjected to statistical analysis by Student's t-test for paired samples (comparison between T1 and T2) and t-test for unpaired samples (comparison between groups and between ligatures).

RESULTS

The measurements obtained in this study are displayed in tables with a view to comparing

DBI, BI and PPD. For each index, comparisons were made between the initial and final measurements (T1 and T2), the test and control groups, and EL x SSL.

Dental Biofilm Index (DBI)

In analyzing this index, only the scores 0 (no plaque), 1 (biofilm attached on the free gingival margin and adjacent tooth surfaces, and identified using a probe) and 2 (moderate accumulation of clinically visible biofilm) were observed. Score 3 (abundant biofilm located both above and beneath the gums) was intentionally omitted and is therefore not expressed in the following tables.

In the test group, at T1, 9.3% of the surfaces exhibited score 1 or 2, and at T2, this percentage increased to 23.8%, with a statistically significant difference (P=0.000). In the control group at T1, 5.8% of the surfaces displayed score 1 or 2, and at T2, this percentage increased to 7.0%. This increase was also statistically significant (P=0.000), although in this group variations were not as pronounced as in the test group. Comparison between groups was statistically significant (P=0.000) (Table 1).

Comparison of DBI variations showed that most surfaces remained unchanged in the test group (73.5%) and even more so in the control group (90.4%). In the test group, 4.4% and 1.5% of the surfaces improved their scores 2 and 1, respectively. This improvement was also noted in the control group in 0.8% and 3.2% of the surfaces. An increase in scores 1 and 2 was observed in 6.9% and 13.7% of the surfaces examined in the test group. This increase was more moderate in the control group, affecting 1.7% and 3.9% of the surfaces with score 1 and 2, respectively. Comparison of DBI variations between groups proved statistically significant (P=0.000) (Table 2).

Comparison of DBI variations showed that most of the surfaces tied with EL remained unchanged (75%), and likewise with SSL (72%). Surfaces tied with EL showed improvement in

scores 2 and 1, of 3.9% and 0.7%, respectively. This improvement was also observed in 4.9% and 2.3% of surfaces tied with SSL. Increases in scores 1 and 2 were observed in 6.5% and 13.9% of EL surfaces and in 7.4% and 13.4% of SSL surfaces. No statistically significant difference was found in DBI variations between the surfaces tied with EL and SSL (P=0.242) (Table 2).

Bleeding Index

In the test group, at T1, 1.2% of the surfaces exhibited gingival bleeding, and at T2, this percentage increased to 5.8%, with a statistically significant difference (P=0.000). In the control group the surfaces with gingival bleeding displayed percentages of 1.1% and 2.8% at T1 and T2, respectively. This change was also statistically significant (P=0.001), although variations were not as pronounced as in the test group. Comparison between groups was statistically significant (P=0.000) (Table 3).

Variations in BI were classified thus: worse (no bleeding at T1 and then bleeding at T2), improved (bleeding at T1 and then no bleeding at T2) and unchanged (no changes in bleeding at T1 and T2) (Table 4).

The values show that most of the surfaces examined in this study had the same BI at T1 and T2, both in the test (93.6%) and control (96.9%) groups. Some slight improvement was noted in

TABLE 1 - Frequency, mean (M) and standard deviation (SD) of the sites where biofilm was present at T1 and T2 in the test and control groups

	Score	Test (N=1068)		Control (N=1296)	
		T1	T2	T1	T2
Biofilm	0	90.7%	76.2%	94.2%	93%
	1	1.9%	6.9%	3.8%	1.5%
	2	7.4%	16.9%	2.0%	5.5%
	M	0.17	0.41	0.08	0.12
	SD	±0.536	±0.761	±0.335	±0.467
	P	*0.000		*0.000	
		*0.000			

* Statistically significant at the level of P ≤0.05.

TABLE 2 - Frequency of variations in DBI scores between the two measurements (T1 and T2) in the test and control groups

Variation in Dental biofilm index (DBI) (T2-T1)	Test						Control	
	Total (%)		**EL (%)		***SSL (%)		Total (%)	
-2	4.4	5.9	3.9	4.6	4.9	7.2	0.8	4.0
-1	1.5		0.7		2.3		3.2	
0	73.5		75		72		90.4	
1	6.9	20.6	6.5	20.4	7.4	20.8	1.7	5.6
2	13.7		13.9		13.4		3.9	
Total	100		100		100		100	
P		0.242						
		*0.000						

* Statistically significant at the level of P≤0.05.
** EL = Elastomeric ligatures.
*** SSL = Stainless steel ligatures.

TABLE 3 - Frequency of sites with and without gingival bleeding at T1 and T2 in the test and control groups.

	Score	Test (N=1060)		Control (N=1296)	
		T1	T2	T1	T2
Gingival bleeding (%)	**-	98.8	94.2	98.9	97.2
	***+	1.2	5.8	1.1	2.8
	Total	100	100	100	100
	P	*0.000		*0.001	
		*0.000			

* Statistically significant at the level of P≤0.05.
** - = Without bleeding.
*** + = With bleeding.

TABLE 4 - Frequency of variations in DBI scores between the two measurements (T1 and T2) in the test and control groups.

Variation in bleeding index (BI) (T2-T1)	Test (%)			Control (%)
	Total	EL	SSL	Total
Improved	0.9	1.1	0.9	0.7
Unchanged	93.6	93.1	93.6	96.9
Worse	5.5	5.8	5.5	2.4
Total	100	100	100	100
P		0.788		
		*0.000		

* Statistically significant at the level of P≤0.05.
** EL = Elastomeric ligatures.
***SSL = Stainless steel ligatures.

0.9% and 0.7% of the surfaces in the test and control groups, respectively. However, BI worsened in 5.5% of the test group surfaces, which also occurred in the control group, although not significantly (2.4%). Comparison of BI variations between groups proved statistically significant (P=0.000) (Table 4).

Most of the surfaces showed the same BI at T1 and T2, both in the EL (93.1%) and SSL (93.6%) groups. Some minor improvement was noted in 1.1% and 0.9% of the surfaces in the EL and SSL groups, respectively. However, BI worsened in 5.8% and 5.5% of the faces in the EL and SSL groups, respectively. No statistically significant difference was found in BI variations between the surfaces tied with EL and SSL (P=0.788) (Table 4).

Pocket Probing Depth (PPD)

In the test group, at T1, the mean linear PPD was 1.555 mm with ±0.625 mm standard deviation, and at T2, 2.017 mm with ±0.797 mm standard deviation, with a mean increase of 0.462 mm, which was statistically significant (P=0.000). In the control group at T1, the mean linear PPD was 1.500 mm with ±0.585 mm standard deviation, and at T2, 1.639 mm with
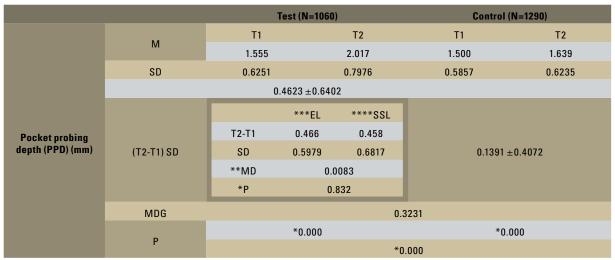
TABLE 5 - Mean (M), standard deviation (SD), mean difference between T1 and T2 (T2-T1) and mean difference between test and control groups (MDG) in terms of total PPD.

		Test (N=1060)		Control (N=1290)	
		T1	T2	T1	T2
Pocket probing depth (PPD) (mm)	M	1.555	2.017	1.500	1.639
	SD	0.6251	0.7976	0.5857	0.6235
		0.4623 ±0.6402			
	(T2-T1) SD		***EL	****SSL	
		T2-T1	0.466	0.458	
		SD	0.5979	0.6817	0.1391 ±0.4072
		**MD	0.0083		
		*P	0.832		
	MDG	0.3231			
	P	*0.000		*0.000	
		*0.000			

   * Statistically significant at the level of P<=0.05.
  ** MD: Mean difference between elastomeric ligatures (EL) and stainless steel ligatures (SSL).
 *** EL: Elastomeric ligatures.
**** SSL: Stainless steel ligatures.

±0.623 mm standard deviation, and a mean increase of 0.139 mm, which was statistically significant (P=0.000). The mean difference between groups was 0.323 mm, which was statistically significant (P=0.000) (Table 5).

Variation between the two measurements (T2-T1) of the mean linear PPD in the EL group was 0.466 mm with ±0.597 mm standard deviation. This variation, although more modest, was also noted in the SSL group, resulting in a mean of 0.458 mm with ±0.681 mm standard deviation. Given that the PPD mean was 0.008 mm, no statistically significant difference was found between the EL and SSL groups (P=0.788) (Table 5).

DISCUSSION

In the initial analysis (T1), the test group showed a mean DBI index of 0.17±0.536, which rose to 0.41±0.761 at T2. The control group showed mean values of 0.08±0.335 and 0.12±0.467 at T1 and T2, respectively. These variations between T1 and T2 and between groups were statistically significant.

In a previous study, the DBI mean in the ex-

perimental group was 0.49±0.41, initially, dropping to 0.43±0.34 during treatment, probably due to the implementation of an oral hygiene program after the initial measurement, which was reinforced during consultations, in addition to the prescription of fluoride rinsing. The control group was measured once and displayed a mean of 0.68±0.61.[29]

In another analysis, the measurement of DBI in patients undergoing orthodontic treatment showed an initial mean of 0.40, and after one year, 0.36, also demonstrating a high standard of DBI control thanks to the intensive oral health program.[18]

Higher scores were noted in DBI analysis in a group with fixed orthodontic appliances. It was 0.76 initially, but increased to 0.78 one month later. The control group showed an average of 0.52 and 0.51, in the initial analysis and after one month, respectively.[9]

In the present study, the percentages of DBI in T1 show that 90.7% of the surfaces examined in the test group had score zero and 9.3%, scores 1 and 2; and at T2, these values were 76.2% and

23.8% respectively. In the control group at T1, the values were 94.2% for score zero and 5.8% for scores 1 and 2, and at T2, 93% and 7.0%.

However, in a previous study with no oral hygiene support, 27.8% of surfaces in the test group showed score zero and 72.2% had scores of 1 and 2; and in the control group, 20% and 80% respectively, which showed, according to the authors, few differences between the groups.[27]

The total BI in the test group showed that, initially, 1.2% of the surfaces had bleeding, and at T2, this percentage increased to 5.8%. The control group showed bleeding in 1.1% of the surfaces at T1 and 2.8% of the surfaces at T2. These results were statistically significant when comparing T1 and T2 and in a comparison between the groups.

Previous studies also showed an increase in BI values in the group undergoing orthodontic treatment, even with an oral hygiene program in place, as well as the development of moderate gingivitis in the first two months of treatment.[29]

In another study, the measurement of gingival index exhibited an initial mean of 0.25, and after one year of orthodontic treatment it increased to 0.37.[18]

However, in another analysis of this index, the group with fixed orthodontic appliance had an initial mean of 0.75, which decreased to 0.70 after one month. The control group showed an average of 0.20 and 0.23 in the initial analysis and after one month, respectively. Thus, although the initial results and the results found after one month remained virtually unchanged in both groups, comparison between groups showed a statistically significant difference.[9]

Moreover, the authors noted bleeding in 42.2% and 40.6% of the areas measured in the test and control groups, respectively, but these differences were minor and clinically insignificant.[27]

The PPD measurements obtained in this study showed a mean value of 1.555 mm at T1 and 2.017 mm at T2, reflecting an increase of 0.462 mm in the test group. The control group showed an initial PPD of 1,500 mm, very similar to the test group, and at T2, 1.639 mm, also demonstrating an increase in PPD, albeit more modest (0.139 mm). PPD variations were statistically significant when comparing T1 and T2, as well as the two groups (P=0.000).

Previous PPD evaluations also showed initial values that were lower than those obtained during orthodontic treatment,[29] in addition to test group means that were higher than in the control group.[27]

In this study, radiographs were not performed to assess the bone level, nor were orthodontic appliances removed to observe changes in the gingiva, which makes it difficult to determine whether the increase in PPD during treatment was due to a loss of gingival attachment or to gingival hypertrophy, as reported,[2,16,21,29] although this increase was observed clinically.

Comparative studies between the use of elastomeric ligatures (EL) and stainless steel ligatures (SSL) are scarce in the literature and the few that can be found are often associated with electron microscopy.

This study compared elastomeric ligatures with stainless steel ligatures and found no statistically significant differences in dental biofilm index (P=0.242), gingival bleeding index (P=0.788) and pocket probing depth (P=0.832).

These results corroborate those found with the aid of electron microscopy,[5,26] but disagree with another study which showed that elastomeric ligatures held a higher number of microorganisms when compared to SSL.[10]

The results obtained in this study after comparing the two ligation methods suggest that other variables can play a role in affecting the periodontal health of patients undergoing orthodontic treatment, such as the use of brackets and bands, bonding technique and material used in bracket manufacture.[4,13,14]

Although the dental biofilm index (DBI) and bleeding index (BI) showed a significant increase at T2, both were within adequate hygiene standards.[6]

Likewise, pocket probing depth (PPD) showed a significant increase, but within normal standards.[17] Based on these findings, the need to implement an oral hygiene program geared to patients undergoing orthodontic treatment is hereby underscored with a view to preserving periodontal health.[2,7,9,16,18,28,29]

CONCLUSIONS

After clinical evaluation of the periodontal condition of patients undergoing fixed orthodontic treatment with elastomeric and stainless steel ligatures, using the dental biofilm index (DBI), bleeding index (BI) and examination of pocket probing depth (PPD), comparing them to a control group, assessed prior to orthodontic treatment (T1) and six months after placement of a fixed orthodontic appliance (T2), while the control group was assessed six months after the initial measurement (T2), the following results were found:

» A significant increase in DBI when comparing T1 and T2, as well as when comparing the test group with the control group.

» A significant increase in BI when comparing T1 and T2, as well as when comparing the test group with the control group.

» A significant increase in PPD when comparing T1 and T2, as well as when comparing the test group with the control group.

» No significant difference between the use of elastomeric ligatures and stainless steel ligatures after assessment of DBI, BI and PPD.

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