Original Article

Archwire Ligation Techniques, Microbial Colonization, and Periodontal Status in Orthodontically Treated Patients

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Abstract: Fixed or removable orthodontic appliances impede the maintenance of oral hygiene and result in plaque accumulation. Plaque retention surrounding orthodontic appliances leads to enamel demineralization caused by organic acids produced by bacteria in the dental plaque. Many studies have evaluated the effects of fixed orthodontic appliances on microbial flora and periodontal status, but only a few have evaluated the method of ligation as an additional factor. The aim of this study was to determine the changes in microbial flora and periodontal status after orthodontic bonding and to determine whether two different archwire ligation techniques affect these changes. A total of 21 orthodontic patients scheduled for fixed orthodontic treatment were selected for this split-mouth study. Two commonly used auxiliaries (elastomeric rings and ligature wires) for tying archwires were tested. Microbial and periodontal records were obtained before bonding (T0), one week later (T1), and five weeks after bonding (T2). Paired *t*-test and Wilcoxon signed rank test were used to compare the groups statistically. Although, teeth ligated with elastomeric rings exhibited slightly greater numbers of microorganisms than teeth ligated with steel ligature wires, the differences were not statistically significant and could be ignored. The two archwire ligation techniques showed no significant differences in the gingival index, bonded bracket plaque index, or pocket depths of the bonded teeth. However, teeth ligated with elastomeric rings were more prone to bleeding. Therefore, elastomeric ring use is not recommended in patients with poor oral hygiene. (*Angle Orthod* 2005;75:231–236.)

Key Words: Elastomeric rings; Lactobacilli; Orthodontic appliances; *Streptococcus mutans*

INTRODUCTION

The development of dental plaque has been associated with several environmental and individual factors including diet composition,[1,2] oral hygiene,[1] fluoride exposure,[3] the quality of saliva, the composition of the oral microflora, and immune factors.[4,5] Fixed or removable orthodontic appliances also impede the maintenance of oral hygiene, resulting in plaque accumulation.[5,6] Plaque retention surrounding orthodontic appliances leads to enamel demineralization caused by organic acids produced by bacteria in the dental plaque.[7,8] Recently, fluoride-releasing elastomeric modules[9–11] and chlorhexidine varnish[12] were suggested for reducing plaque accumulation and decalcification.

Fixed orthodontic appliances create new retention areas, which are suitable for bacterial colonization and lead to an increase in the absolute number and percentage of *Streptococcus mutans* and lactobacilli.[4,13–24] A lot of studies have evaluated the effect of fixed orthodontic appliances on microbial flora and periodontal status,[13–15,17,20,22,24–27] but only a few studies evaluated the method of ligation as an additional factor.[4,28] However, their sample sizes were relatively low, and no additional periodontal evaluation was performed.

The aim of this study was to determine changes in microbial flora and periodontal status after orthodontic bonding and to find out whether the two different archwire ligation techniques affect these changes.

MATERIALS AND METHODS

A total of 21 orthodontic patients (12 female and nine male subjects) scheduled for fixed orthodontic treatment in the Orthodontic Department of Suleyman Demirel Univer-

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TABLE 1. Statistical Comparison of Bacterial Counts of the Groups[a]

	T0					T1					T2				
	Elastomer		Ligature			Elastomer		Ligature			Elastomer		Ligature		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Total bacteria	6.06	0.29	5.74	0.44	NS	6.54	0.43	6.15	0.21	NS	7.34	1.64	6.88	0.56	NS
Anaerobe lactobacilli	4.19	0.48	4.06	0.36	NS	4.72	0.15	4.39	0.33	NS	5.31	0.25	4.89	0.36	NS
Aerobe lactobacilli	4.06	0.59	3.97	0.23	NS	4.51	0.28	4.16	0.34	NS	4.76	0.34	4.49	0.25	NS
Streptococcus mutans	5.07	0.19	4.55	0.60	NS	5.26	0.22	4.79	0.51	NS	5.73	0.39	5.28	0.52	NS

[a] NS indicates nonsignificant.

sity were randomly selected for this study. The mean age of the sample was 15.37 ± 3.76 years (minimum = 11.60 and maximum = 25.07). Informed consent was obtained from all subjects. All patients were in the permanent dentition, free of dental plaque, and motivated for good oral hygiene. Subjects who had used antibiotics during the three-month period before the study were excluded. Patients were supplied with standardized toothpaste and asked to refrain from any other oral hygiene products for the duration of the trial.

The investigation was designed as a split-mouth study. Two commonly used auxiliaries (elastomeric rings and ligature wires) for tying archwires were tested. Straight wire appliances (0.018 × 0.025 inch) were bonded to the upper teeth from first molar to contralateral first molar, and a 0.014-inch nitinol archwire was used for initial leveling. Brackets on the right side of the patient were ligated with elastomeric rings, and brackets on the left side were ligated with conventional stainless steel ligature wires. Microbial and periodontal records were obtained before bonding (T0), one week later (T1), and five weeks after bonding (T2).

At each appointment, the ligatures, elastomeric rings, and archwires were carefully removed. Microbial samples taken from the labial surfaces of the upper second premolars were cultivated and analyzed by the same examiner in the Department of Clinical Microbiology. The plaque sample was placed in four mL Stuart transport medium. Serial 10-fold dilutions of the transport medium with the sample of plaque were prepared to 10^{-4}, and 0.1-mL samples were inoculated on blood agar for numbers of total bacteria and Mitis-Salivarius agar (Difco Laboratories Inc., Detroit, MI, USA) containing 0.001% Chapman Tellurite solution (Difco), 150 g sucrose, and 3.33 mg bacitracin (Sigma Diagnostics, St. Louis, MO, USA) per liter agar for number of *S mutans*. The agar plates were incubated for 48 hours at 37°C in anaerobic jars. Subsequently, colonies were counted under a stereomicroscope. Also, serial 10-fold dilutions were prepared to 10^{-3}, and 0.1-mL samples were inoculated on two Rogosas agar plates for number of lactobacilli. Both plates were incubated for 48 hours at 37°C, one plate in aerobic conditions and the other in an anaerobic jar. The number of colonies were then determined under a stereomicroscope. Results are expressed as colony-forming units per milliliter.

Periodontal measurements were recorded from all bonded maxillary teeth, but only the scores of the second premolars were taken into consideration. The same examiner, who calibrated before the study, evaluated the periodontal status with a Williams periodontal probe. The gingival index (GI),[29] bonded bracket plaque index (BBPI),[30] bleeding on probing (BOP) values,[31] and pocket depth (PD) values were used for periodontal evaluation.

Two groups were formed according to ligation technique:

- The elastomer group was evaluated by microbial counts and periodontal measurements of 21 premolars ligated with elastomeric rings.
- The ligature group was evaluated by microbial counts and periodontal measurements of 21 premolars ligated with steel ligature wires.

Statistical method

All bacterial counts were divided by 10^5 for ease of statistical calculations. The mean and standard deviations of the bacterial counts, GI, BBPI, and PD values were calculated for both groups. Paired *t*-test was used to compare the mean bacterial counts and PDs of the groups statistically. Wilcoxon signed rank test was used to compare GI and BBPI values of the groups. To determine the longitudinal changes that occurred in the microbial flora and periodontal status, all bacterial counts, GI, BBPI, and PD values of both groups were pooled. Paired *t*-test for bacterial counts and PDs and Wilcoxon signed rank test for GI and BBPI scores were used to evaluate the results statistically. A P value of $<.05$ was considered significant. All tests were performed by SPSS v11.0 (SPSS, Inc., Chicago, Ill).

RESULTS

Amount of microbial colonization

No significant difference between the bacterial counts of the groups was found at any time point (Table 1). Although all microbial counts were slightly higher in the elastomer group, the differences were not statistically significant (Figure 1).

Statistically significant increases in total bacteria and *S. mutans*, anaerobe, and aerobe lactobacilli counts were determined at all time intervals ($P < .001$) (Table 2).

TABLE 2. Longitudinal Changes in Bacterial Counts of Bonded Teeth

	T0		T1		T2		Significance Between		
	Mean	SD	Mean	SD	Mean	SD	T0-T1	T0-T2	T1-T2
Total bacteria	5.90	0.40	6.35	0.39	7.11	1.23	***	***	***
Anaerobe lactobacilli	4.13	0.42	4.58	0.30	5.14	0.34	***	***	***
Aerobe lactobacilli	4.01	0.44	4.43	0.23	4.68	0.31	***	***	***
Streptococcus mutans	4.81	0.51	5.06	0.44	5.54	0.32	***	***	***

*** $P < .001$.

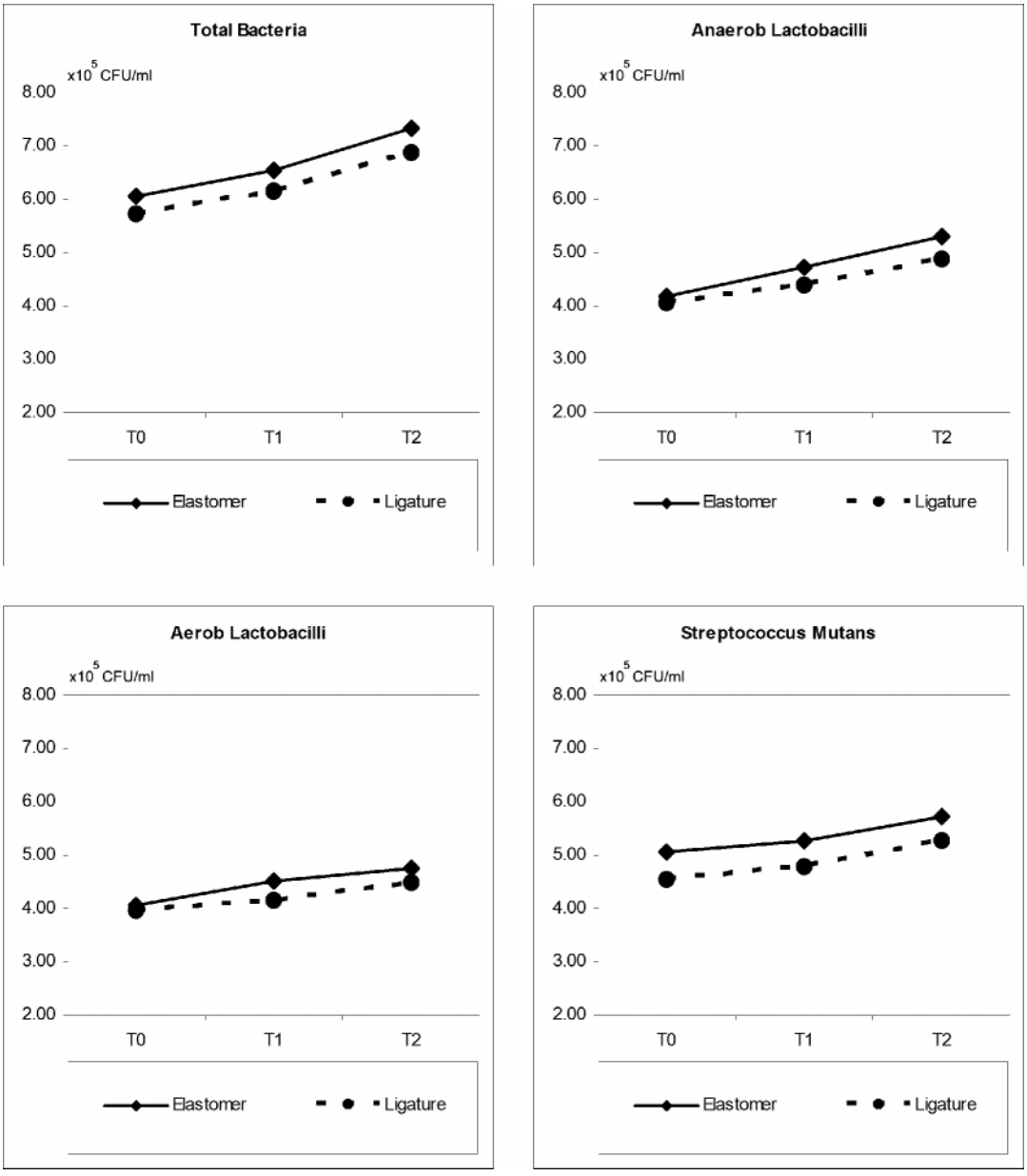

FIGURE 1. Mean numbers of bacteria in T0, T1, and T2.

TABLE 3. Statistical Comparison of Periodontal Measurements of the Groups[a]

	T0					T1					T2				
	Elastomer		Ligature			Elastomer		Ligature			Elastomer		Ligature		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Gingival index	0.23	0.37	0.29	0.43	NS	0.20	0.50	0.25	0.39	NS	0.42	0.51	0.46	0.47	NS
Bonded bracket plaque index	0.17	0.25	0.19	0.28	NS	0.58	0.20	0.64	0.30	NS	0.52	0.21	0.61	0.22	NS
Pocket depth	1.48	0.36	1.48	0.38	NS	1.43	0.41	1.57	0.42	NS	1.33	0.37	1.42	0.47	NS

[a] NS indicates nonsignificant.

TABLE 4. Longitudinal Changes in Periodontal Measurements of Bonded Teeth[a]

	T0		T1		T2		Significance Between		
	Mean	SD	Mean	SD	Mean	SD	T0-T1	T0-T2	T1-T2
Gingival index	0.26	0.40	0.23	0.44	0.44	0.48	NS	NS	**
Bonded bracket plaque index	0.18	0.27	0.61	0.25	0.56	0.22	***	***	NS
Pocket depth	1.48	0.36	1.50	0.41	1.37	0.42	NS	NS	NS

[a] NS indicates nonsignificant.
** $P < .01$, *** $P < .001$.

Gingival index

No significant difference was found at any time point between the GI values of the groups (Table 3).

A statistically significant increase in the GI was determined between T1 and T2 ($P < .01$) (Table 4).

Bonded bracket plaque index

No significant difference was found between the BBPI values of the groups (Table 3). A statistically significant increase in BBPI values was determined between T0-T1 and T0-T2 ($P < .001$) (Table 4).

Pocket depth

No significant difference was found at any time point between the PD values of the groups (Table 3).

No statistically significant difference in PD values was determined between the time intervals (Table 4).

Bleeding on probing

In T0 and T1, the number of teeth that exhibited BOP was similar for both groups. However, in T2, significantly more teeth exhibited bleeding in the elastomeric group (Figure 2).

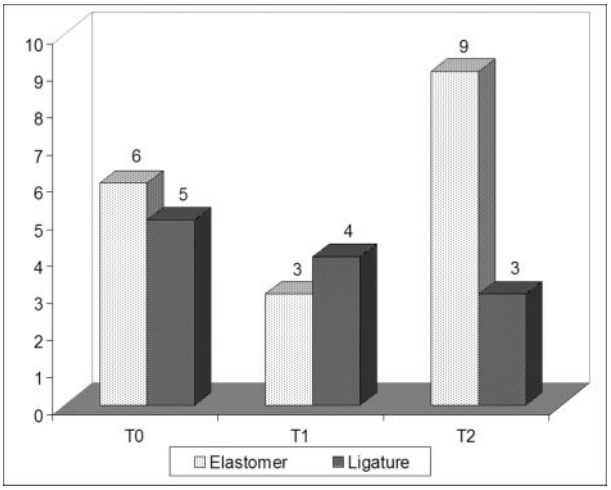

FIGURE 2. Number of teeth that exhibited BOP.

DISCUSSION

The literature clearly demonstrates that fixed orthodontic appliances increase plaque accumulation, bacterial colonization, and resultant enamel decalcification.[13–15,17,20,22,24,26] However, the contribution of ligation materials to this increase has only been evaluated in a few studies.[4,28]

Forsberg et al[4] evaluated microbial colonization of 12 patients treated by fixed orthodontic appliances and reported that the lateral incisor attached to the archwire with an elastomeric ring exhibited a greater number of microorganisms in the plaque than teeth ligated with steel wire. They also reported a significant increase in the number of *S. mutans* and lactobacilli in the saliva after the insertion of fixed appliances. They recommended that the use of elastomeric ligation rings should be avoided in patients with inadequate oral hygiene because elastomeric ligation rings will significantly increase microbial accumulation on tooth surfaces adjacent to the brackets, leading to a predisposition for the development of dental caries and gingivitis.

On the other hand, Sukontapatipark et al[28] used scanning electron microscopy to evaluate bacterial colonization associated with fixed orthodontic appliances and reported that the method of ligation did not appear to influence the bacterial morphotypes on either composite or enamel surfaces.

However, the archwire was not ligated into the bracket because the experimental design included only one bonded tooth in each quadrant.

In the present study, upper second premolars were selected as the donor site for microbial samples because posterior teeth are more prone to plaque accumulation. In addition, not all the anterior teeth were bonded at the beginning of the treatment. Bacterial sampling was performed before bonding (T0), one week later (T1), and five weeks after bonding (T2). The second occasion (T1) was performed one week after bonding (T0) because Sukontapatipark et al[28] detected abundant plaque on bonded teeth within one week. The third occasion (T2) was performed four weeks after the second one (T1), which was equivalent to the average duration between orthodontic appointments. The study was terminated on the fifth week because longer periods of observation may affect the results because cooperation, motivation for oral hygiene, and dietary habits can change.

Our study revealed that although teeth ligated with elastomeric rings exhibited slightly greater numbers of microorganisms than teeth ligated with steel ligature ties, the differences were not statistically significant and could be ignored. This result is in contrast with the study of Forsberg et al,[4] who found a statistically significant difference between elastomers and ligatures. A feasible explanation may be the differences in sample size, sample teeth, registration times, statistical methods, or study design.

Fixed orthodontic appliances create new retention areas suitable for bacterial colonization.[4,13–24] Our results also demonstrated a significant increase in the number of *S. mutans* and lactobacilli in dental plaque.

A certain deterioration of the gingival and periodontal status was reported in orthodontically treated children.[24,26,27,32] To prevent detrimental effects of orthodontic treatment on periodontal and gingival tissues, oral hygiene programs before orthodontic treatment were strongly recommended.[32,33] In our study, all patients received oral hygiene education before treatment. The results of the periodontal evaluation revealed a significant increase in GI value between T1 and T2, but the final GI values were still within the boundaries of mild inflammation.

BBPI values of bonded teeth increased significantly between T0-T1 and T0-T2. The increase is in agreement with the results of numerous studies that suggest that fixed orthodontic appliances lead to an increase in plaque volume.[24,26,28] Huser et al[26] evaluated the effects of placement of orthodontic bands on the gingival tissues. They performed the clinical examinations before the beginning of treatment and five, seven, 47, 72, and 90 days after placement of the orthodontic appliances. They reported that the plaque index increased significantly on banded teeth as compared with control sites.

In the present study, no significant difference in PDs of bonded teeth was determined. Huser et al[26] also reported that probing depth remained within normal values for both test and control groups.

An increase in bleeding scores of bonded teeth is also reported.[26,27] Glans et al[27] reported that the gingival bleeding index improved significantly from 12 weeks after bonding to debonding in the patients with crowded dentitions. Huser et al[26] also found a significant increase in bleeding scores of banded teeth. However, in our sample, no significant differences in bleeding scores were detected. The number of teeth exhibiting bleeding in our study decreased slightly one week after bonding (T1), but returned to its original level four weeks after. This may be attributed to the relatively short period of our study.

All GI, BBPI, and PD values recorded from the elastomeric and ligature sides were similar at all occasions. The only difference between the groups was in the number of teeth that exhibited BOP five weeks after bonding (T2). Teeth ligated with elastomeric rings exhibited more bleeding than teeth ligated with ligature wires. One feasible explanation is that bleeding may be induced by the quality and the quantity of plaque around elastomeric rings. The differences in surface characteristics of elastomers and steel ligature wires may also be a factor.

CONCLUSIONS

- Fixed orthodontic appliances significantly increase the colonization of *S. mutans* and lactobacilli.
- Plaque volume and gingivitis also increase with treatment, whereas bleeding and PDs remain the same for the first five weeks of treatment.
- Although teeth ligated with elastomeric rings exhibited a slightly greater number of microorganisms than teeth ligated with steel ligature wires, the differences were not statistically significant and could be ignored.
- No significant effect of archwire ligation technique was determined in the GI, BBPI, and PDs of bonded teeth. However, the teeth ligated with elastomeric rings were more prone to bleeding. Therefore, the use of elastomeric rings is not recommended in patients with poor oral hygiene.

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