

Changes in the oral environment during four stages of orthodontic treatment

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Objective: To identify clinical, salivary, and bacterial changes during orthodontic treatment with follow-up to 24 months. **Methods:** In 30 patients, clinical (decayed, missing, and filled surfaces [DMFS], O'Leary's plaque index, and plaque pH), salivary (unstimulated and stimulated saliva, buffer capacity, pH, and occult blood), and bacterial (*Streptococcus mutans* and *Lactobacillus*) markers were evaluated. A questionnaire was employed to evaluate their hygienic-dietary habits. Data were analyzed by ANOVA, logistic regression and Spearman's correlation. **Results:** DMFS increased significantly, whereas the plaque index diminished, plaque pH was more acidic ($p = 0.23$), and unstimulated salivary flow showed significant differences during the treatment ($p = 0.013$). Stimulated saliva flow increased in females after the placement of appliances; buffer capacity was diminished in males during the therapy; salivary pH remained at basal values. Bacterial levels and occult blood increased to high-risk levels and were not statistically significant different between genders ($p > 0.05$). Two major relationships were confirmed: initial plaque with use of dental aids ($r = 0.429$; $p = 0.018$) and final DMFS with unstimulated salivary flow ($r = -0.372$; $p = 0.043$). **Conclusions:** The increase in retentive surfaces increased the bacterial levels, plaque pH became acidified, and gingival damage was greater. Buffer capacity was altered but maintained a healthy salivary pH during the treatment. (*Korean J Orthod* 2010;40(2):95-105)

Key words: Dental plaque, Oral hygiene, Orthodontic, Saliva

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INTRODUCTION

The dental literature reports that orthodontic treatment induces changes in the oral environment by increasing the number of retentive surfaces for plaque, augmenting the bacterial levels of *Streptococcus mutans* (SM) and *Lactobacillus*; these modify the patient's salivary characteristics, for example, pH, buffer capacity, and salivary flow.¹⁻⁵ These alterations increase caries risk: some patients develop white spots on the enamel surface and generalized gingival alterations that appear at the completion of and even during orthodontic treatment.^{6,7}

Enamel demineralization after placing orthodontic appliances can affect more than 50% of patients,⁶ sometimes progressing rapidly. The process is found

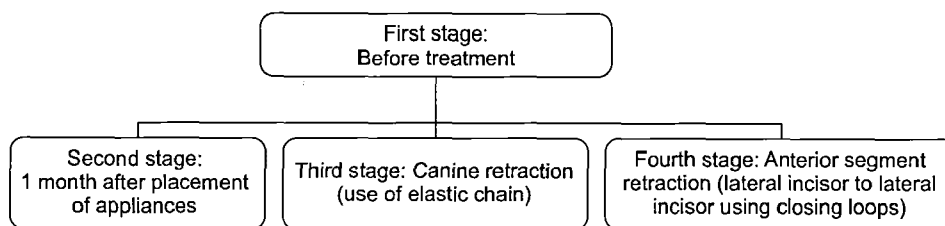


Fig 1. Diagram over four stages of study.

most frequently in cervical and middle thirds of the buccal surfaces of upper lateral incisors, lower canines, and first premolars.⁸ These changes in the oral environment can be worsened by the use of attachments such as elastic chains, loops, and springs. Nevertheless, the best way to minimize this problem is plaque control. Some studies recommend scrupulous oral cleanliness, suggesting the use of irrigators,⁹ electrical or ultrasonic brushes,¹⁰ rinsings,¹¹ and varnish,¹² but one of the most important requirements for oral health is the motivation of the patient.

Therefore, the aim of this study was to identify changes in the oral environment in hygienic-dietary habits, saliva, plaque, and bacterial counts during four different stages of orthodontic treatment.

MATERIAL AND METHODS

Patients who required treatment with fixed orthodontic appliances (straight wire technique) from the Orthodontic Clinic at the Research Center and Advanced Studies in Dentistry of the Autonomous University of the State of Mexico (UAEM) were studied. Thirty patients, including 11 males (mean age, 16.5 ± 3.7 years) and 19 females (mean age, 16.5 ± 5.5 years) participated. Patients having any systemic disease, using antibiotics within 15 days of enrolling in the study, having active caries, or being in the mixed dentition phase were excluded. Dental and skeletal diagnoses were made for each patient, defined by Angle's molar class and cephalometric angle ANB.

The Ethics Committee of the University approved this research. All patients or their guardians consented to participate after obtaining information about the study.

Not all patients started their orthodontic treatment at

the same time, so during 24 months, samples were taken from the same patients over four different stages of orthodontic treatment (Fig 1).

Patients were to avoid eating, drinking, and toothbrushing for 2 hours before sample processing. Two certified researchers performed all procedures, and the commercial kits were used according to the manufacturers' instructions. Intraexaminer reliability in using these kits and evaluating all markers was tested prior to the study using a group of orthodontic patients from one author's (NMMB) clinical practice.

Clinical markers

Caries status

Subjects were examined in the clinic area with the aid of a dental mouth mirror and periodontal probe, type E. The presence of caries was recorded using WHO¹³ DMFS criteria.

Plaque index

Plaque was disclosed with a chewable tablet (Viarden[®]; Viarden, Mexico City, Mexico) and its amount estimated using criteria according to O'Leary's plaque index.^{14,15} This index was evaluated before toothbrushing as routinely performed by the patients to verify whether the techniques they employed were effective for plaque removal.

Bacterial plaque pH

Plaque from the buccal surface of the upper first molar was collected with a Q-tip and evaluated with the aid of Cariostat^{®16,17} (Dentsply-Sankin KK, Tokyo,

Japan). The material was placed inside the culture and incubated at 37°C for 48 hours. The pH was determined according to the color: dark blue, pH = 6.1; green, pH = 5.4; greenish-yellow, pH = 4.7; and bright yellow, pH = 4.0.

Salivary markers

Unstimulated saliva

Unstimulated salivary flow was measured by the time of formation of small drops of saliva on the mucous membrane of the lower lip (Saliva Check[®], GC America Inc, Alsip, IL, USA). The results were expressed in seconds.¹⁸

Stimulated saliva

Stimulated salivary flow was obtained by chewing on an unflavored piece of wax for 5 minutes. The patient was asked to chew bilaterally in the usual way, as in chewing gum; the ensuing saliva was collected in a graduated cup. The volume was measured and the flow expressed in ml/min.¹⁸

Buffer capacity

Buffer capacity was determined by placing the saliva in a strip test (Saliva Check[®], GC America Inc, Alsip, IL, USA); after 2 minutes, the final result was obtained by adding the scores of 3 reactive zones: 5 points = very low; 6 - 9 points = low; ≥ 10 points = normal.¹⁸

Salivary pH

The reactive strip of the Saliva Check[®] kit was submerged in stimulated saliva for 10 seconds and the color obtained was compared with categorical levels in the chart: 5.0 - 5.8 = highly acidic; 6.0 - 6.6 = moderately acidic; and 6.8 - 7.8 = healthy saliva.¹⁸

Bacterial markers

Salivary counts of *S. mutans*

S. mutans was measured in stimulated saliva using a commercial technique, Dentocult-SM[®] (Orion Diagnostica, Espoo, Finland) according to Jensen and Brathall.^{19,20} The classification of test scores was 0 = negative or $< 10^4$ colony-forming units (CFU)/ml, 1 = 10^5 CFU/ml, 2 = 10^5 to 10^6 CFU/ml, and 3 = $> 10^6$ CFU/ml.

Salivary counts of *Lactobacillus* (LB)

Lactobacillus was measured using the Dentocult-LB[®] (Orion Diagnostica, Espoo, Finland) as described by Larmas.^{20,21} The classification of test scores was NC = no count, 0 = negative or 10^3 CFU/ml, 1 = 10^4 CFU/ml, 2 = 10^5 CFU/ml, and 3 = 10^6 CFU/ml.

Occult blood in saliva

To measure "occult blood in saliva," we used the Salivaster[®] reactive strip (Showa Yakuin Kako Co, Tokyo, Japan).²² The procedure involves dipping the test paper into the hematometric, stimulated saliva for 2 - 3 seconds and then judging by comparing it with the standard color-change chart. The color reaction is divided into three levels: no change = 0.0 mg of blood per ml of saliva (no periodontal disease), light-blue = 1.0 mg/ml (incipient periodontal disease), and dark-blue = 2.5 mg/ml (periodontal disease present).

Hygienic-dietary habits

The patients were asked to fill out a questionnaire stating their identification data and hygienic-dietary habits, both before treatment and at the last stage. This questionnaire included a series of questions regarding daily brushing and eating habits, focusing on behavioral risk factors for dental disease. The questions were the following: 1) When do you brush your teeth?, 2) How many times do you brush your teeth per day?, 3) Do you use some dental auxiliary for cleaning your mouth?, 4) How often do you change your tooth-

brush?, 5) Do you eat between meals?, 6) How many times per day do you eat food between meals?

Recommendations to avoid sticky, cariogenic, and hard foods during orthodontic treatment were provided verbally. We recommended that patients brush their teeth three times a day using the Bass modified technique with fluoridated toothpaste after the placement of appliances.

Statistical analysis

Clinical data (DMFS and plaque index) and hygienic-dietary habits were obtained only before treatment and at the final stage. The following statistical analyses were used: (a) a repeated-measures ANOVA model to analyze quantitative variables; (b) a logistic regression model for bimodal or multinomial response variables; and (c) a Spearman's correlation test to measure the association between the variables and the questionnaire. The information was analyzed using JMP 7.0.1 (SAS Institute Inc, Cary, NC, USA). The statistical level of significance was set at 0.05.

RESULTS

Fifteen patients had Class I molar relation, 10 had Class II, 4 had class III, and in 1 patient it was not possible to determine the relationship due to missing first molars. As for skeletal diagnosis, 13 were Class I, 16 were Class II, and 1 was Class III. When we analyzed skeletal diagnoses, we eliminated Class III because the sample size was too small. However, dental and skeletal diagnoses did not correlate with or determine the behavior of any of the studied variables ($p > 0.05$) (data not shown).

Clinical markers

The initial mean on the DMFS index was 5.7 (6.7 for females and 4.1 for males; $p = 0.407$). In the follow-up study, the DMFS increased slightly to 5.9 (7.0 for females and 4.2 for males, $p = 0.391$); we did not observe differences between the two stages ($p = 0.057$; Tables 1 and 2).

The initial plaque index was 43.9%. The average of the follow-up plaque index decreased by 39.9% (Table

Table 1. Mean and standard deviation of quantitative clinical and salivary markers (N = 30)

Markers	Stages of orthodontic treatment				<i>p</i>
	Initial	1 month after placement of appliances	Canine retraction*	Anterior segment retraction [†]	
Clinical markers					
DMFS	5.7 (8.3)	—	—	5.9 (8.3)	0.057
Plaque index	43.9 (22.9)	—	—	39.9 (15.7)	0.061
Plaque pH	5.7 (0.4)	5.6 (0.4)	5.5 (0.5)	5.3 (0.5)	0.230
Salivary markers					
Unstimulated saliva (seconds)	40.9 (18.4)	50.2 (19.4)	52.3 (19.0)	53.4 (20.4)	0.013
Stimulated saliva (ml/min)	1.4 (0.7)	1.5 (0.6)	1.4 (0.6)	1.4 (0.6)	0.255
Buffer capacity	7.7 (2.8)	10.8 (14.7)	7.4 (1.9)	7.2 (2.0)	0.548
Salivary pH	7.6 (0.3)	7.7 (0.1)	7.7 (0.1)	7.7 (0.2)	0.225

Data are shown as mean (standard deviation). Clinical markers DMFS (decayed, missing, and filled surfaces), and O'Leary's plaque index were only measured in the first and fourth stages. *Elastic chains; [†]closing loops. *p* value based on repeated-measures ANOVA for salivary markers.

Table 2. Distribution by gender of clinical and salivary markers in the follow-up study (N = 30)

Clinical markers	Gender		<i>p</i>	
	Male	Female		
DMFS In	4.1 (2.5)	6.7 (1.9)	0.407	
DMFS Fn	4.2 (2.5)	7.0 (1.9)	0.391	
Plaque In	53.5 (26.6)	38.3 (18.8)	0.079	
Plaque Fn	45.2 (17.1)	36.8 (14.5)	0.163	
	Initial	1 month after placement of appliances	Canine retraction*	Anterior segment retraction [†]
Plaque acidity (pH)				
Male	5.5 (0.4)	5.5 (0.3)	5.5 (0.5)	5.5 (0.5)
Female	5.9 (0.3)	5.6 (0.4)	5.5 (0.5)	5.3 (0.5)
<i>p</i>	0.004	0.507	0.787	0.315
Salivary markers				
Unstimulated saliva flow (seconds)				
Male	35.4 (18.4)	36.5 (14.5)	45.6 (15.3)	49.9 (19.8)
Female	44.1 (18.1)	58.1 (17.6)	56.2 (20.3)	55.4 (21.1)
<i>p</i>	0.218	0.002	0.142	0.430
Stimulated saliva flow (ml/min)				
Male	1.9 (0.7)	1.8 (0.8)	1.6 (0.6)	1.5 (0.5)
Female	1.1 (0.5)	1.4 (0.5)	1.3 (0.5)	1.3 (0.6)
<i>p</i>	0.001	0.121	0.197	0.307
Buffer capacity				
Male	9.1 (2.4)	8.7 (2.5)	8.2 (1.5)	8.0 (1.8)
Female	6.9 (2.8)	7.7 (1.6)	6.9 (2.0)	6.7 (2.0)
<i>p</i>	0.040	0.573	0.074	0.094
Salivary (pH)				
Male	7.7 (0.2)	7.7 (0.1)	7.8 (0.1)	7.8 (0.1)
Female	7.6 (0.4)	7.7 (0.1)	7.7 (0.2)	7.6 (0.3)
<i>p</i>	0.324	0.607	0.589	0.046

Data are shown as mean (standard deviation). In, Initial stage; Fn, final stage. Clinical markers DMFS (decayed, missing, and filled surfaces), and O'Leary's plaque index only were measured in the first and fourth stages. *Elastic chains; [†]closing loops. *p* value based on ANOVA.

1). The males showed a greater, but not statistically significant, decrease (53.5%) than females (38.3%) ($p = 0.079$; Table 2). At the final stage we observed a similar trend: males decreased by slightly more than females (45.2% vs. 36.8%; $p = 0.163$). The difference between the initial and final plaque indices in our total study population was not significant ($p = 0.061$).

The plaque acidity decreased during the orthodontic

treatment, though no significant differences were found ($p = 0.230$; Table 1). Initially only one patient showed parameters of high risk, and at the fourth sample, they were 8/30 with values of high risk. Only at the first stage did we find differences between genders ($p = 0.004$; Table 2).

Salivary markers

Using a repeated-measure analysis between the four unstimulated-saliva stages, we observed significant differences between all the samples ($p = 0.013$), indicating a diminution of unstimulated saliva flow (Table 1). On the basis of gender, we found the means were different only at the second stage ($p = 0.002$; Table 2).

The stimulated salivary flow rates were stable in the follow-up study ($p = 0.255$). The placement of orthodontic appliances promoted a slight increase in the stimulated salivary flow in females but not in males (Table 2). Significant differences between genders were observed only at the initial stage ($p = 0.001$).

The salivary buffering evaluation did not demonstrate significant differences during the treatment ($p = 0.548$; Table 1), although at the first stage there were differences between genders ($p = 0.040$). The salivary buffer capacity in males decreased during treatment, whereas it increased in females after the placement of appliances and later diminished (Table 2).

Salivary pH showed similar values throughout the study, with a slight decrease at the final stage in females. No significant differences were observed in the four stages of orthodontic treatment ($p = 0.225$; Table 1 and 2).

Bacterial markers

When we applied a multinomial logistic regression model for initial bacteria and occult blood in saliva fitted by *Streptococcus mutans* (SM), *Lactobacillus* (LB) and occult blood history during the follow-up, we

found significant differences in the distribution of SM at the second stage and marginal differences at the last stage (anterior segment retraction; Table 3). During treatment, changes in bacterial counts appeared; at the first stage, 13 of 30 (13/30) subjects had high-risk values for caries ($> 10^5$); at the second stage, there were 15/30, and at the third and fourth stages, there were 26/30 with high values (Table 4).

According to LB count, the first stage had 7/30 subjects at high risk for caries ($> 10^5$); the second stage had 17/30; and the third and fourth both showed 19/30 at high risk. The LB counts were different in all treatment stages at diverse levels of significance (Tables 3 and 4).

Occult blood in saliva

At the beginning of the study, 7/30 patients showed high-risk values, and at the final stage, 17/30 had an increased risk. A greater presence of blood derived from inflamed gingival tissue was found at the first and second stages of treatment. We then observed stabilization during the processes of canine retraction and anterior segment retraction (chi-square values of 0.07 and 0.08, respectively, by multinomial logistic regression analysis).

Statistically significant differences were not observed between genders ($p > 0.05$) in the distribution of bacterial markers or in occult blood in saliva (Tables 3 and 4).

Table 3. Significance levels obtained from three multinomial logistic regression models for initial bacterial markers and occult blood in saliva fitted by *Streptococcus mutans*, *Lactobacillus* and occult blood history during the follow-up

Model I		Model II		Model III	
<i>Streptococcus mutans</i>	Prob > ChiSq	<i>Lactobacillus</i>	Prob > ChiSq	Occult blood in saliva	Prob > ChiSq
2nd stage	0.009	2nd stage	0.006	2nd stage	0.037
3rd stage	0.132	3rd stage	0.001	3rd stage	0.076
4th stage	0.054	4th stage	0.019	4th stage	0.081

Prob > ChiSq is the observed significance probability, often called the p value, for the chi-square test. 2nd stage, 1 month after placement of appliances; 3rd stage, canine retraction; 4th stage, anterior segment retraction.

Table 4. Distribution frequencies of bacterial markers and occult blood in saliva by gender (N = 30)

Marker	Stages of orthodontic treatment							
	Initial		1 month after placement of appliances		Canine retraction		Anterior segment retraction	
	Male	Female	Male	Female	Male	Female	Male	Female
Bacterial								
<i>SM</i> (CFU/ml)								
< 10 ⁵	6	11	6	9	2	2	1	3
> 10 ⁵	5	8	5	10	9	17	10	16
<i>p</i>	0.852		0.575		0.743		0.867	
<i>Lactobacillus</i> (CFU/ml)								
< 10 ⁵	7	16	3	10	3	9	2	9
> 10 ⁵	4	3	8	9	8	10	9	10
<i>p</i>	0.412		0.702		0.428		0.420	
Occult blood in saliva (mg/dl)								
0.0	1	1	0	0	0	0	0	0
1.0	6	15	7	15	7	10	4	9
2.5	4	3	4	4	4	9	7	10
<i>p</i>	0.366		0.361		0.558		0.558	

SM, *Streptococcus Mutans*; < 10⁵, Low-risk; > 10⁵, high-risk. *p* values between genders based on repeated-measures analysis.

Hygienic–dietary habits

At the beginning of the study and at the time of taking the final sample (anterior segment retraction with closing loops), we queried the patients' hygienic and dietary habits with a questionnaire. We compared their responses with the experimental results to determine the influence hygienic-dietary habits may have had on the latter. Table 5 shows those statistically significant associations revealed by the correlation analysis. The salivary factors (pH, buffer capacity, stimulated and unstimulated salivary flow) were correlated with each other ($p < 0.0001$).

Several relationships were confirmed, for example initial plaque with use of dental aids ($r = 0.429$; $p = 0.018$); final DMFS with unstimulated salivary flow (third stage) ($r = -0.372$; $p = 0.043$); buffer capacity with *LB* (third stage) ($r = -0.419$; $p = 0.021$); and *Salivaster* (third stage) with frequency of toothbrushing ($r = 0.399$; $p = 0.029$).

DISCUSSION

In the present study we determined the changes in clinical, salivary, and bacterial markers that occur in the oral environment during four stages of orthodontic treatment with fixed appliances on permanent dentition. Actually, there exist few clinical studies that show the physiologic and biological characteristics of saliva, plaque and bacteria and their correlation. There are no reports relating these to the behavior of patients undergoing orthodontic therapy.

Among the clinical factors which were evaluated, the DMFS index increased slightly during orthodontic treatment, more in females than males, similar to previous reports on diverse cultures.²³ Probably because women have higher risk factors than men, differences have been attributed principally to less salivary production and to hormonal patterns in women.

With the reinforcement of oral hygiene, it is possible to avoid the associations reported in the literature,

Table 5. Correlations found between study markers and hygienic-dietary habits questionnaire

Variable	Per variable	<i>r</i>	<i>p</i>
Plaque (1st)	Dental aids use (1st)	0.429	0.018
DMFS (4th)	Unstimulated saliva (3rd)	-0.372	0.043
Unstimulated saliva (2nd)	Salivary pH (2nd)	-0.389	0.034
Unstimulated saliva (3rd)	Salivary pH (3rd)	-0.478	0.008
Unstimulated saliva (4th)	Unstimulated saliva (3rd)	0.471	0.009
Stimulated saliva (1st)	Frequency of brushed per day (1st)	0.406	0.026
Stimulated saliva (2nd)	Stimulated saliva (1st)	0.716	< 0.0001
Stimulated saliva (3rd)	Stimulated saliva (1st)	0.561	0.001
Stimulated saliva (3rd)	Stimulated saliva (2nd)	0.830	< 0.0001
Stimulated saliva (4th)	Stimulated saliva (1st)	0.405	0.026
Stimulated saliva (4th)	Stimulated saliva (2nd)	0.561	0.001
Stimulated saliva (4th)	Stimulated saliva (3rd)	0.738	< 0.0001
Buffer capacity (1st)	Frequency of brushing per day (1st)	0.383	0.037
Buffer capacity (1st)	Stimulated saliva (1st)	0.583	0.001
Buffer capacity (1st)	Salivary pH (1st)	0.673	< 0.0001
Buffer capacity (2nd)	Stimulated saliva (2nd)	0.709	< 0.0001
Buffer capacity (2nd)	Salivary pH (2nd)	0.449	0.013
Buffer capacity (3rd)	Buffer capacity (1st)	0.433	0.017
Buffer capacity (3rd)	Buffer capacity (2nd)	0.673	< 0.0001
Buffer capacity (3rd)	Stimulated saliva (3rd)	0.429	0.018
Buffer capacity (3rd)	LB (3rd)	-0.419	0.021
Buffer capacity (3rd)	Salivary pH (3rd)	0.388	0.034
Buffer capacity (4th)	Buffer capacity (3rd)	0.502	0.005
Buffer capacity (4th)	Stimulated saliva (4th)	0.516	0.004
Buffer capacity (4th)	Salivary pH (4th)	0.636	0.000
Salivary pH (1st)	Stimulated saliva (1st)	0.559	0.001
Salivary pH (2nd)	Salivary pH (1st)	0.415	0.023
Salivary pH (2nd)	Stimulated saliva (2nd)	0.510	0.004
Salivary pH (3rd)	Salivary pH (2nd)	0.534	0.002
Salivary pH (3rd)	Stimulated saliva (3rd)	0.560	0.001
Salivary pH (4th)	Salivary pH (2nd)	0.366	0.047
Salivary pH (4th)	Salivary pH (3rd)	0.529	0.003
Salivary pH (4th)	Stimulated saliva (4th)	0.645	0.000
SM (2nd)	Frequency of brushing per day (1st)	0.430	0.018
SM (2nd)	SM (1st)	0.502	0.005
SM (4th)	SM (3rd)	0.400	0.029
LB (1st)	Frequency of brushing per day (1st)	0.482	0.037
LB (4th)	LB (2nd)	0.381	0.046
LB (4th)	Plaque (4th)	0.459	0.012
Salivaster (2nd)	Salivaster (1st)	0.391	0.033
Salivaster (3rd)	Frequency of brushing per day (1st)	0.399	0.029
Salivaster (3rd)	Salivaster (1st)	0.363	0.049
Salivaster (4th)	Salivaster (1st)	0.402	0.028

1st, First stage; 2nd, second stage; 3rd, third stage; 4th, fourth stage. SM, *Streptococcus mutans*; LB, *Lactobacillus*; Salivaster, occult blood in saliva; *r*, Spearman's correlation coefficient. *p* value was set at 0.05.

as the frequency of toothbrushing positively influenced the results we obtained; this was demonstrated by the lower plaque index at the completion of the study than that at the beginning, indicating that patients can improve their hygiene habits, which is in contrast to Chang's findings.² A previous study²⁴ established that adequate use of the manual toothbrush can significantly reduce plaque during the first stages of orthodontic treatment. In this study we reported significant, positive correlations between plaque index and the use of dental aids. Plaque percentages were lower in females than in males, which agrees with a previous report.²⁵

In this study unstimulated salivary production diminished during orthodontic treatment, with statistically significant differences between genders, which is consistent with Percival et al.²⁶ The stimulated salivary flow findings also demonstrated significant differences between genders, as previously suggested,^{2,27,28} after the placement of orthodontic appliances. Salivary flow is known to be stimulated by foreign bodies in the mouth, which occurs after the placement of appliances; nevertheless, this study demonstrates that subjects become accustomed to the attachments, with resultant diminished salivary secretion, reaching basal parameters.

The salivary buffer capacity increased drastically after the placement of orthodontic appliances but diminished during treatment, consistent with the findings of Chang.² At one month of treatment, he found statistically significant differences, with no significant changes between the first and third month of his study.

Salivary buffer capacity is an important factor influencing the salivary pH and relating to the salivary flow.²⁸ This was verified in our study because all these factors were positively correlated. Patients with a high buffer capacity are often resistant to the caries process because a high host response can compensate for detrimental caries habits. If orthodontic patients at high caries risk can be identified at the beginning of treatment, preventive measures can be implemented with maximal effect.

The salivary pH did not demonstrate significant differences over four stages of orthodontic study. However, Chang² reported a significant increase 3 months after the placement of fixed orthodontic appliances. We

observed significant positive correlations of salivary pH with buffer capacity and with stimulated saliva production, which is why the subjects maintained basal salivary pH values during the treatment. The placement of orthodontic appliances altered the buffer capacity, but this salivary characteristic maintained the healthy salivary pH during the treatment.

On the other hand, as orthodontic therapy progressed, plaque became more acidic, most prominently in females, whereas the males maintained more steady plaque pH. The caries activity test Cariostat[®] (Dentsply-Sankin KK, Tokyo, Japan) was designed to measure the pH decrease caused by microorganisms in the dental plaque. Positive correlations between caries activity test score and the counts of *Streptococcus mutans* and *Lactobacillus* have been reported.²⁹ In our study, the bacterial counts increased, which might explain the plaque acidification.

The oral cavity is a complex ecosystem inhabited by more than 300 bacterial species, such that any external interference, such as fixed orthodontic appliances, can disturb the delicate balance between components of the microflora in this environment.³⁰ The presence of attachments in the mouth favors the increase of plaque which is difficult to remove, and which promotes the increase of bacteria.^{1,12} The findings of this study indicate that patients undergoing orthodontic treatment show a continuing increase of *SM* and *LB* levels at diverse degrees of significance. According to Rosenbloom¹ the highest levels of bacteria appear in the "active treatment" stage. Likewise, the positive correlation between toothbrushing frequency and plaque control demonstrates the importance of hygiene maintenance programs during orthodontic therapy.

The development of gingivitis and gingival hyperplasia are also recognized as problems associated with fixed orthodontic treatment.¹¹ Moreover, periodontal disease has been reported in subjects with malocclusion due to crowding, considered a primary etiologic factor in the development of periodontal injury.³¹

The presence of occult blood in saliva at the initial stages may be due to malocclusion. In addition, we observed that the risk of periodontal damage increased as orthodontic treatment advanced, with the introduction of elastic chains and closing loops. It should be de-

terminated whether occult blood in saliva disappears when the appliances are removed and the problem of dental malposition is eliminated.³²

CONCLUSION

Stimulated salivary flow initially increased after placing the appliances; subsequently, it diminished, returning to basal levels. The increase in retentive surfaces increased bacterial levels, leading to increased plaque acidity, and gingival damage rose, as evaluated by occult blood in saliva. The placement of orthodontic appliances altered the buffer capacity, but this salivary characteristic maintained the healthy salivary pH value during the treatment.

Plaque control in orthodontic patients is essential to support periodontal and dental health. We strongly recommend a program of home care for patients wearing fixed orthodontic appliances.

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- 국문초록 -

교정치료 4단계 동안의 구강 내 환경의 변화

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교정치료 중 구강 내 환경 변화를 파악하기 위하여 교정치료 시작 후 24개월까지의 임상적 구강위생지수 및 타액, 구강 내 미생물의 변화양상을 평가하였다. 30명의 환자를 대상으로 하여, 임상적 구강위생지수(DMFS [decayed, missing and filled surfaces], O'Leary's plaque index, plaque pH), 타액의 변화(비자극/자극시의 타액량, 완충능(buffer capacity), pH, 잠혈(occult blood)류량, 구강 내 미생물(*Streptococcus mutans*, *Lactobacillus*) 변화를 파악하였다. 추가적으로 설문지를 이용하여 구강위생관리 및 식습관을 평가하였다. 분산분석, 회귀분석 및 Spearman의 상관분석을 통해 데이터를 분석하였다. 교정치료 도중 DMFS 값은 유의성있게 증가한 반면, plaque index는 감소하였고, plaque pH는 산성을 나타내었다 ($p = 0.23$). 비자극 시 타액량은 치료 중

유의성있게 변화하였으며 ($p = 0.13$), 자극 시의 타액량은 여성에서 장치 부착 이후 증가하는 양상을 보였다. Buffer capacity는 남성에서 치료 도중 감소되었으며, 타액의 pH는 유지되었다. 구강 내 미생물 및 잠혈류량은 고위험 수준까지 증가하였으며 성별의 차이는 나타나지 않았다 ($p > 0.05$). 치료 전 plaque와 구강위생용품의 사용 ($r = 0.429$; $p = 0.018$), 최종 DMFS와 비자극 시의 타액량 ($r = -0.372$; $p = 0.043$) 간에 뚜렷한 상관관계가 확인되었다. 교정치료의 부착으로 인해 구강 내 미생물은 증가하고, plaque pH는 산성화되어 치주조직의 손상이 일어나게 되었다. 또한 Buffer capacity는 변하지만, 치료 기간중의 타액의 pH는 유지되었다.

주요 단어: 치태, 구강위생, 교정, 타액

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