Original Article

Caries Risk Factors in Children under Treatment with Sectional Brackets

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ABSTRACT

Objective: To longitudinally investigate the caries risk levels in children undergoing orthodontic treatment with sectional brackets.

Materials and Methods: A total of 42 children scheduled for orthodontic treatment with sectional orthodontic appliances participated in this study. They were divided into two groups based on decayed, missing, and filled permanent and deciduous teeth (DMFT/dmft) scores and counts of mutans streptococci (MS) prior to treatment. One was the low caries risk group (n = 26) and the other was the high caries risk group (n = 16). Paraffin-stimulated whole saliva was collected for examination of salivary flow rate, buffer capacity, and MS and lactobacilli (LB) levels before treatment, 2 and 4 months after appliance placement, and 2, 4, and 8 months after appliance removal.

Results: The pretreatment salivary flow rates, buffer capacity, and MS levels remained statistically unchanged during and after active orthodontic treatment in both groups. The levels of LB in the high caries risk group were significantly elevated by appliance placement, but upon appliance removal started to fall significantly and came a little short of the pretreatment levels. In the low caries risk group, the pretreatment levels of LB remained statistically unchanged during and after treatment. There were no significant differences in salivary flow rate or buffer capacity, but there were significant differences in MS and LB scores between the two groups at every measurement time.

Conclusions: In children undergoing orthodontic treatment with sectional brackets, LB levels are an important part in making caries risk assessment. (*Angle Orthod.* 2010;80:509–514.)

KEY WORDS: Caries risk; Sectional brackets; Orthodontic treatment; Saliva

INTRODUCTION

It is thought that fixed orthodontic appliances play a role in increasing the probability of incidence of enamel demineralization and white spot formation because of an increased chance of dental plaque accumulating around brackets.[1] The placement of fixed orthodontic appliances increases retention sites for dental plaque, and gives rise to an increase in the levels of mutans streptococci (MS) and lactobacilli (LB) in dental plaque and saliva,[2–6] and then organic acids produced by increased MS and LB cause enamel demineralization. Patients with large numbers of decayed and filled tooth surfaces (DFSs) before orthodontic treatment have significantly larger numbers of MS and LB after debonding of appliances and have less chance of avoiding new cavities than those with a small number of DFSs.[7] A knowledge of caries-related factors in patients before, during, and after active orthodontic treatment helps to determine the caries risk levels and work out appropriate preventive measures individually.

Saliva is one of the most important modifying factors in the caries process.[2] The salivary conditions associated with caries risk are the salivary flow rate and buffer capacity.[8] Cariogenic microorganisms gain prominence at the expense of noncariogenic microorganisms in concert with an extremely low salivary flow rate.[9] The high salivary buffer capacity, which is maintained by a high salivary pH, is unfavorable to the growth of MS, thus resulting in a low incidence of caries.[10] The higher the salivary flow rate, the higher

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Accepted: September 2009. Submitted: July 2009.

the salivary pH and the higher the bicarbonate content.[8] There are controversial findings on the association between salivary conditions and placement of orthodontic appliances. Some researchers reported that there were significant increases in salivary flow rate and buffer capacity during active orthodontic treatment.[2] Another report showed that the salivary flow rate significantly increased, but the buffer capacity remained unchanged during active orthodontic treatment.[11]

Different methods are available to evaluate an individual caries risk level. A caries risk test should be a very useful tool and easy to use.[3] The test involves salivary flow rate, buffer capacity, and salivary colony-forming units per mL of saliva (CFUs/mL) for MS and LB counts.[2,3,11] In most studies using various caries risk tests, subjects are orthodontic patients with permanent dentition or extensive brackets and bands.[2–6] Sectional brackets are used for early orthodontic treatment of dental (functional) anterior crossbites, maxillary incisor crowding, and impacted (unerupted) maxillary incisors in the early mixed dentition.[12,13] A majority of patients undergoing early orthodontic treatment are less than 10 years of age. Presumably their compliance with dentists' instructions in plaque control and caries prevention may be poor. The purpose of this study was to longitudinally investigate the caries risk factors in children undergoing the orthodontic treatment using sectional brackets.

MATERIALS AND METHODS

Subjects

All participants gave their informed consent after receiving thorough information. Our protocol was reviewed and approved by the local Committee of Ethics. Forty-seven children were selected as the subjects from orthodontic patients who visited our clinics of the Nippon Dental University Niigata Hospital (Niigata, Japan). All subjects underwent the caries risk tests before the start of active orthodontic treatment. However, two of the children dropped out and three did not come regularly to our hospital for orthodontic treatment. Eventually, a total of 42 children (16 boys and 26 girls) participated in this study. They were divided into low and high caries risk groups based on the total number of decayed, missing, and filled permanent and deciduous teeth (DMFT and dmft) and MS counts before the start of treatment. The low caries risk group consisted of 26 children (10 boys and 16 girls) with $<10^5$ CFUs/mL for the MS counts and <4 for the combined DMFT and dmft scores. The high caries risk group consisted of 16 children (6 boys and 10 girls) with $\geq 10^5$ CFUs/mL for the MS counts and ≥ 4 for the combined DMFT and dmft scores. The reason behind having 4 DMFT/dmft as the border between the high and low groups is that the mean of the combined DMFT and dmft scores was 3.21 (SD, 2.51) in 42 children. The mean age was 8 years and 8 months (SD, 9 months) before the start of active orthodontic treatment in the high caries risk group, and 8 years and 8 months (SD, 11 months) in the low caries risk group.

All children were treated for maxillary incisor crowding with sectional orthodontic appliances. The sectional orthodontic appliance used in this study was composed of four brackets (0.018 $\times$ 0.022 inches, Tomy International Inc, Tokyo, Japan) and two buccal tubes (0.018 $\times$ 0.022 inches, Tomy) bonded to the maxillary permanent incisors and first molars (or deciduous second molars) with an adhesive system (Transbond XT, 3M Unitek, Monrovia, Calif) and without bands. In the high caries risk group, the placement of appliance was performed after the plaque control record (PCR) rate decreased to 20%—the target we expected the children to attain after toothbrushing instructions. After active orthodontic treatment, Hawley retainers were used in the maxillary arch. Information about the results of caries risk tests, tooth brushing instructions, and professional mechanical tooth cleaning (PMTC) were also given to all subjects in both groups during and after active orthodontic treatment. All children were instructed to brush the teeth, especially around the attachments, at contact points between teeth, and in the gingival regions, for a minimum of 3 minutes three times a day after meals and once before bedtime. The PMTC was performed once a month using a fluoride-containing pumice.

Caries Risk Tests

Prior to clinical examinations of caries experiences, each tooth crown was cleansed with a mixture of water and pumice in a rubber prophylactic cup and a dental floss, rinsed with a water spray, and dried with an oil-free air drier. The DMFT and dmft scores were used to assess caries experiences. The examinations were performed using a mouth mirror, a dental explorer, and a full-mouth set (10 films) of periapical radiographs.

Fresh whole saliva was collected from each subject for 5 minutes during which salivation was being stimulated by a masticatory method with a piece of paraffin wax as a stimulant. The stimulated saliva sample thus collected was used to determine the salivary flow rate, buffer capacity, and MS and LB counts according to the manufacturer's instructions.

The salivary flow rate was measured from the collected saliva volume within 5 minutes and expressed as mL/min. The salivary flow rates were scored from 0 to 3: 0, >1.1 mL/min; 1, from 0.9 to 1.1 mL/min; 2, from 0.5 to 0.9 mL/min; and 3, <0.5 mL/min.

Table 1. The DMFT and dmft Scores of the Two Groups at Each Measurement Time[ab]

	Low Caries Risk Group (n = 26)						High Caries Risk Group (n = 16)							
	DMFT		dmft		DMFT+dmft		DMFT		dmft		DMFT+dmft			Two-way ANOVA / *P* value (Power)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Source	DMFT / dmft / DMFT+dmft
T1	0.13	0.32	2.25	2.27	2.38	2.36	0.45	0.67	4.08	2.48	4.53	2.81	Caries groups	.002 (.888) / .010 (.733) / .003 (.862)
T4	0.13	0.32	2.21	2.19	2.33	2.28	0.50	0.64	3.91	2.44	4.41	2.70	Measurement times	.952 (.057) / .947 (.058) / .991 (.051)
T6	0.13	0.32	2.21	2.19	2.33	2.28	0.50	0.64	3.91	2.44	4.41	2.70	Interaction	.952 (.057) / .966 (.055) / .997 (.050)

[a] DMFT indicates decayed, missing, and filled permanent teeth; dmft, decayed, missing, and filled deciduous teeth.

[b] T1 indicates before the start of active orthodontic treatment; T4, 2 months after the removal of appliances; and T6, 8 months after the removal of appliances.

The buffer capacity of saliva was determined by the use of Dentobuff Strip (Orion Diagnostica, Espoo, Finland). A drop of saliva was left on the Dentobuff Strip for 5 minutes, and the pH was then determined by the color presented by the strip in accordance with the manual provided by the manufacturer. The buffer capacity was scored from 0 to 3: 0, $\geq$6 for immediate pH; 1, $\geq$6 for final pH; 2, from 4.5 to 5.5 for final pH; and 3, $\leq$4.0 for final pH. When the strips turned to blue immediately and within 5 minutes after a drop of saliva, the scores were 0 and 1, respectively.

The MS and LB counts were determined with Dentocult SM Strip (Orion Diagnostica) and Dentocult LB (Orion Diagnostica), respectively. The growth density of bacteria from the saliva samples was assessed according to the manufacturer's instructions. The MS scores ranged from 0 to 3: 0, not detected; 1, $<10^5$ CFUs/mL; 2, from 10^5 to 10^6 CFUs/mL; and 3, $>10^6$ CFUs/mL. The LB scores ranged from 0 to 3: 0, not detected or 10^3 CFUs/mL; 1, 10^4 CFUs/mL; 2, 10^5 CFUs/mL; and 3, 10^6 CFUs/mL.

The scores of salivary flow rate, buffer capacity, MS, and LB were worked out six times by one examiner: T1, before the start of active orthodontic treatment; T2, 2 months after the placement of orthodontic appliances; T3, 4 months after the placement of appliances; T4, 2 months after the removal of appliances; T5, 4 months after the removal of appliances; and T6, 8 months after the removal of appliances. The DMFT and dmft scores were examined before the start of active orthodontic treatment (T1), and 2 and 8 months after appliance removal (T4, T6) by the same investigator. The mean lengths of time required for active treatment in the low and high caries risk groups were 4.9 months and 5.4 months, respectively.

Statistical Analysis

Statistical analyses were performed by use of the SPSS for Mac version 17.0J (SPSS Japan Inc, Tokyo, Japan). For the descriptive statistics, means and standard deviations were calculated. A two-way analysis of variance (ANOVA) was used to test the main effects of the caries groups and the measurement times on the DMFT, dmft, and combined DMFT and dmft scores. The Kruskal-Wallis test was used to determine whether the changes in the distribution of children with different scores of the caries risk tests such as the salivary flow rate, buffer capacity, and MS and LB counts occurred between the measurement times in each group. The Friedman test was used to determine whether there were any significant differences in the scores of the caries risk tests between the measurement times in each group. If any significant difference was recognized, the Bonferroni test was used to identify at which measurement times differences in scores were observed. The Mann-Whitney *U*-test was used to compare the scores of the caries risk tests between the caries groups at each measurement time. All statistical tests were performed at $P < .05$ level of significance.

RESULTS

As shown in Table 1, the two-way ANOVA demonstrated significant differences in mean DMFT, dmft, and combined DMFT and dmft scores between the two groups, but no significant differences between the measurement times, and no significant interactions between these two variables. The mean combined DMFT and dmft score in the two groups decreased at T4 and T6, thus being caused by the exfoliation of dmf deciduous teeth throughout the period of study.

As shown in Tables 2 through 5, the Kruskal-Wallis test demonstrated no significant differences in the distribution of children with the scores of salivary flow rate, buffer capacity, or MS or BL between the measurement times in each group.

As shown in Tables 2 through 4, the Friedman test demonstrated no significant differences in the scores of salivary flow rate, buffer capacity, or MS between the measurement times in each group. Table 5 showed that the Friedman and the Bonferroni tests demonstrated significant differences in LB scores between T1 and other measurement times, between T2 and T4, between T2 and T5, and between T3 and T4 in the high caries risk group, while in the low caries risk group no significant differences were noted

Table 2. Salivary Flow Rate Scores of the Two Groups at Each Measurement Time[a]

	Low Caries Risk Group (n = 26)						High Caries Risk Group (n = 16)						Mann-Whitney
	0	1	2	3	Mean	SD	0	1	2	3	Mean	SD	*U* / *P* value
T1	8	12	6	0	0.92	0.74	5	5	5	1	1.13	0.96	.527
T2	6	17	3	0	0.88	0.59	4	6	5	1	1.19	0.91	.257
T3	9	14	3	0	0.77	0.65	4	6	6	0	1.13	0.81	.137
T4	8	16	2	0	0.77	0.59	6	4	5	1	1.06	1.00	.384
T5	8	15	3	0	0.81	0.63	3	8	5	0	1.13	0.72	.147
T6	9	15	2	0	0.73	0.60	4	9	2	1	1.00	0.82	.313
	Kruskal-Wallis / *P* value .420				Friedman / *P* value .976		Kruskal-Wallis / *P* value .988				Friedman / *P* value .704		

[a] T1 indicates before the start of active orthodontic treatment; T2, 2 months after the placement of orthodontic appliances; T3, 4 months after the placement of appliances; T4, 2 months after the removal of appliances; T5, 4 months after the removal of appliances; and T6, 8 months after the removal of appliances.

between the measurement times. Bonferroni test showed the significant difference between T4 and T5 but no significant difference between T4 and T6, while T5 and T6 have the same mean LB scores (1.75), thus resulting from the difference in SDs between T5 and T6.

The Mann-Whitney *U*-test demonstrated no significant differences in the scores of salivary flow rate or buffer capacity, and demonstrated significant differences in the MS and BL scores between the two groups at every measurement time, as shown in Tables 2 through 5.

The scores of caries risk tests used in this study are nonparametric data. Therefore, the means and SDs for all the measurements of caries risk tests were shown as supplements without statistical comparisons to express ordinal scales in Tables 2 through 5.

DISCUSSION

A few published studies on the association between the orthodontic treatment and the salivary flow rate and salivary buffer capacity were available in a PubMed search on the Internet.[2,11,14] Our results showed that changes in salivary flow rate were statistically insignificant throughout the period of study in each caries group. These results were inconsistent with those by Chang et al,[2] Ulukapi et al,[11] and Cheng et al,[14] who reported that the salivary flow rate significantly increased after the placement of orthodontic appliance. The probable reason for these different results may be due to differences in the number of orthodontic attachments. All the children in this study had six attachments bonded, whereas Chang et al[2] placed 16 attachments on average.

Our results that the buffer capacity remained statistically unchanged during the duration of the study in each caries group were in agreement with those by Chang et al, Ulukapi et al, and Cheng et al, who reported that the salivary pH demonstrated no significant changes until 1 month[2] or 4 months[11,14] after appliance placement, although Chang et al[2] showed a significant increase after 3 months of placement. Significant increases in salivary flow rate and no significant changes in buffer capacity in previous studies may suggest that the salivary flow rate is more sensitive to the placement of orthodontic appliances than buffer capacity.[2,11,14]

Table 3. The Dentobuff Strip Scores of the Two Groups at Each Measurement Time[a]

	Low Caries Risk Group (n = 26)						High Caries Risk Group (n = 16)						Mann-Whitney
	0	1	2	3	Mean	SD	0	1	2	3	Mean	SD	*U* / *P* value
T1	2	21	2	1	1.08	0.56	1	10	3	2	1.38	0.81	.169
T2	2	19	5	0	1.12	0.52	1	11	1	3	1.38	0.89	.494
T3	2	20	3	1	1.12	0.59	1	12	2	1	1.19	0.66	.741
T4	2	19	4	1	1.15	0.61	1	12	1	2	1.25	0.77	.867
T5	2	21	2	1	1.08	0.56	1	11	2	2	1.31	0.79	.306
T6	2	20	4	0	1.08	0.48	1	11	2	2	1.31	0.79	.401
	Kruskal-Wallis / *P* value .987				Friedman / *P* value 1.000		Kruskal-Wallis / *P* value .985				Friedman / *P* value .704		

[a] T1 indicates before the start of active orthodontic treatment; T2, 2 months after the placement of orthodontic appliances; T3, 4 months after the placement of appliances; T4, 2 months after the removal of appliances; T5, 4 months after the removal of appliances; and T6, 8 months after the removal of appliances.

Table 4. Mutans Streptococci Scores of the Two Groups at Each Measurement Time[a]

	Low Caries Risk Group (n = 26)						High Caries Risk Group (n = 16)						Mann-Whitney *U* / *P* value
	0	1	2	3	Mean	SD	0	1	2	3	Mean	SD	
T1	13	13	0	0	0.50	0.51	0	0	7	9	2.56	0.51	<.001
T2	8	14	4	0	0.85	0.67	0	0	9	7	2.44	0.51	<.001
T3	8	13	5	0	0.88	0.71	0	0	7	9	2.56	0.51	<.001
T4	12	10	4	0	0.69	0.74	0	0	8	8	2.50	0.52	<.001
T5	12	12	2	0	0.62	0.64	0	0	8	8	2.50	0.52	<.001
T6	13	12	1	0	0.54	0.58	0	1	8	7	2.38	0.62	<.001
	Kruskal-Wallis / *P* value .233				Friedman / *P* value .976		Kruskal-Wallis / *P* value .940				Friedman / *P* value .180		

[a] T1 indicates before the start of active orthodontic treatment; T2, 2 months after the placement of orthodontic appliances; T3, 4 months after the placement of appliances; T4, 2 months after the removal of appliances; T5, 4 months after the removal of appliances; and T6, 8 months after the removal of appliances.

No significant difference was noted in salivary flow rate and buffer capacity between the low and high caries risk groups from beginning to end in this study. These results supported those by Al Mulla et al,[7] who reported that patients with a large number of DFSs had no significant difference in salivary flow rate or buffer capacity compared with those patients with a small number of DFSs. In view of our findings about the salivary flow rate and buffer capacity, these tests may be regarded as less helpful in making a caries risk assessment in children undergoing orthodontic treatment using sectional brackets than the microbial measurement for LB.

Our results showed that the pretreatment levels of salivary MS remained statistically unchanged during and after active orthodontic treatment in either the low or high caries risk group. These results were inconsistent with several previous studies, in which the elevated levels of salivary MS were confirmed in patients under active orthodontic treatment.[2–4,6,14] The differences in the levels of MS between our study and others may be caused by the differences in the number of orthodontic attachments. Scheie et al[4] reported that the salivary levels of MS significantly increased in patients with extensive attachments but not in those with only two to four attachments. However, Chang et al[2] found that patients with fewer attachments did not show a lesser rise in the level of MS. The association between the elevated levels of salivary MS and the number of attachments still remains unclear and should be studied further. On the other hand, Ulukapi et al[11] showed no increase in MS and LB counts during active orthodontic treatment, as evidenced in this study, although they did not mention the number of attachments used.

In this study, the levels of salivary LB were significantly elevated by the placement of orthodontic appliances, but significantly decreased upon appliance removal and eventually came near to the pretreatment level in the high caries risk group. In the low caries risk group, the pretreatment levels of salivary LB remained statistically unchanged during and after active ortho-

Table 5. Lactobacilli Scores of the Two Groups at Each Measurement Time[a]

	Low Caries Risk Group (n = 26)						High Caries Risk Group (n = 16)						Mann-Whitney *U* / *P* value
	0	1	2	3	Mean	SD	0	1	2	3	Mean	SD	
T1	15	9	2	0	0.50	0.65	4	5	4	3	1.38	1.09	<.01
T2	8	16	2	0	0.77	0.59	0	2	11	3	2.06	0.57	<.001
T3	6	14	2	4	1.15	0.97	0	4	7	5	2.06	0.77	<.01
T4	10	16	0	0	0.62	0.50	1	6	7	2	1.63	0.81	<.001
T5	10	14	2	0	0.69	0.62	0	7	6	3	1.75	0.77	<.001
T6	12	12	2	0	0.62	0.64	1	5	7	3	1.75	0.86	<.001
	Kruskal-Wallis / *P* value .080				Friedman / *P* value .847		Kruskal-Wallis / *P* value .217				Friedman / *P* value <.001 Bonferroni T1 vs T2, T1 vs T3, T1 vs T4, T1 vs T5 T1 vs T6, T2 vs T4, T2 vs T5, T3 vs T4		

[a] T1 indicates before the start of active orthodontic treatment; T2, 2 months after the placement of orthodontic appliances; T3, 4 months after the placement of appliances; T4, 2 months after the removal of appliances; T5, 4 months after the removal of appliances; and T6, 8 months after the removal of appliances.

dontic treatment. Our findings that the levels of LB in the high caries risk group were elevated after the placement of orthodontic brackets were consistent with the results of Chang et al,[2] Sari and Birinci,[6] and Cheng et al,[14] who showed that the LB levels significantly increased after appliance placement, and inconsistent with those by Ulukapi et al.[11] LB was strongly associated with further development of dental caries, while MS was mainly associated with the onset of caries.[8] Our high caries group consisted of children with high MS levels and high DMFT/dmft scores before the start of treatment. Therefore, it may be speculated that LB increased significantly as secondary invaders in the development of dental caries after appliance placement following the initiation of MS. The placement of appliances resulted in newly increased levels of LB and the maintenance of the already increased levels of MS in the high caries risk group, thus meeting the necessary microbiologic conditions for developing dental caries, although the DMFT or dmft scores did not change significantly throughout the period of study. Moreover, the removal of appliances caused a significant decrease in LB levels which had been elevated significantly by appliance placement in this study. These significant changes in LB levels may suggest that LB is more suitable than MS for the assessment of caries risk in patients undergoing orthodontic treatment using sectional brackets, although both LB and MS are useful.[7]

In our subjects, the PMTC and toothbrushing were performed once a month and four times a day, respectively. However, there were statistically significant differences in the levels of MS and LB between the low and high caries risk groups throughout the duration of this trial. These results suggest that the conventional oral hygiene procedures are less useful for the purpose of removing the harbored cariogenic microorganisms from the oral cavity and inhibiting the multiplication of them during orthodontic treatment.

CONCLUSION

- Among the caries risk tests, LB levels are an important part in making caries risk assessment in patients undergoing orthodontic treatment with sectional brackets.

ACKNOWLEDGMENT

Part of this study was supported by a Grant-in-Aid for Research Promotion from Nippon Dental University (NDUF-05-12, NDUF-08-09).

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