



ORIGINAL ARTICLE

# Caries risk profiles in orthodontic patients: A 4-year follow-up study using the Cariogram model in governmental vs. private clinics

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## KEYWORDS

Risk assessment;  
Cariogram;  
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**Abstract Objectives:** To (1) analyze caries-related factors and (2) evaluate caries risk using the Cariogram model for governmental and private orthodontic patients at de-bonding and 4 years after de-bonding.

**Materials and methods:** Forty orthodontic patients with mean age of 26.4 years were recruited from a governmental (G) group (n = 20) and private (P) group (n = 20) and were examined at de-bonding (T1) and 4 years after de-bonding (T2). The examination included a questionnaire, plaque scoring, caries examination, bitewing radiographs, and assessment of salivary secretion rate, buffering capacity and cariogenic microorganisms. The data were entered into the Cariogram program to illustrate the caries risk profiles.

**Results:** The chance to avoid new cavities was higher in P-group compared to G-group at T1 (58% and 31%, respectively) ( $P < 0.01$ ) and T2 (77% and 52%, respectively) ( $P < 0.001$ ). Plaque index was significantly higher in G-group, and fluoride was used significantly more in P-group at T1 and T2 ( $P < 0.05$ ). The chance to avoid new cavities was higher at T2 compared to T1 (64% and 44%, respectively) ( $P < 0.001$ ). Saliva secretion rate and buffer capacity were significantly increased, and the plaque index was significantly decreased at T2 compared to T1 ( $P < 0.01$ ).

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*Conclusion:* According to the Cariogram, orthodontic patients were less likely to avoid new cavities at de-bonding and 4 years after de-bonding in government clinics compared to private clinics, and the caries risk significantly decreased 4 years after orthodontic treatment for all patients, regardless of the location of treatment.

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## 1. Introduction

Enamel demineralization associated with fixed orthodontic therapy can be a rapid process that is caused by a high and continuous cariogenic challenge in the plaque that develops adjacent to brackets and bands (Øgaard et al., 1988). Several studies in the literature have investigated the association between malocclusion and the development of dental caries. These studies showed contradicting results, with both positive (Gabris et al., 2006; Singh et al., 2011; Nalcaci et al., 2012; Buczkowska-Radlinska et al., 2012; Baskaradoss et al., 2013) and negative (Addy et al., 1988; Helm and Petersen, 1989; Stahl and Grabowski, 2004) relationships shown between malocclusion and the development of dental caries. However, a recent systematic review performed by Hafez et al. (2012); concluded that no evidence actually shows a positive relationship between crowding and the development of dental caries.

Though caries prevalence has declined in several countries (World Health Organization, 2003), it is still a problematic issue in many countries, such as the Kingdom of Saudi Arabia (KSA). Recently, a meta-analysis was performed on a Saudi population to evaluate dental caries, and they found that the mean of DMFT was 3.3 in the permanent dentition (Khan et al., 2013). In 2008, it was reported that the overall caries prevalence among preschool children in the KSA was approximately 75% and that the caries prevalence and severity were significantly higher among children from governmental preschools compared to those from private preschools (Wyne, 2008). Recently, Almosa et al. (2012), showed that orthodontic patients treated in government centers in KSA had a greater caries risk compared to patients treated in private clinics.

Dental caries has a multifactorial etiology and is caused by the interactions of several factors, including past caries experience, diet, fluoride use, extent of plaque, and bacterial and salivary activity, in addition to social and behavioral factors. All of these factors have been considered using a computer program developed by Bratthall et al., called the Cariogram (2013), which has been developed for caries risk assessment. Studies have shown that there is a correlation between the Cariogram results and the development of caries over time for both children and adults (Hansel Petersson et al., 2002; Hansel Petersson et al., 2003), and the validity of the Cariogram has been confirmed (Campus et al., 2012). The Cariogram, when used as a pedagogical tool in clinical practice, has been found to be promising in explaining the caries situation to patients, thus helping the patients improve their preventive measures (Petersson and Bratthall, 2000).

In 2009, a study was conducted to evaluate the caries risk using the Cariogram model in orthodontic patients. The caries-related factors between government and private groups

were compared at de-bonding (Almosa et al., 2012). The Cariogram risk profile showed that orthodontic patients treated in private centers had a low caries risk compared to patients treated in governmental centers. The aims of the present follow up study were (i) to analyze various caries-related factors and evaluate the caries risk for governmental and private orthodontic patients at de-bonding and 4 years after de-bonding, and (ii) to compare the caries-related factors and caries risk profile by using the Cariogram model for those patients over the 4-year period. It was hypothesized that caries risk is higher in patients treated in government clinics compared to those treated in private clinics 4 years after de-bonding and that the caries risk will decrease over time after de-bonding.

## 2. Materials and methods

### 2.1. Population and design

This prospective longitudinal study was approved by the Ethics Committee at King Saud University, College of Dentistry Research Centre, Riyadh, KSA (Reg. No. NF 2225). To estimate the sample size, a power analysis was performed based on the difference between the governmental (G) and private (P) groups in the Cariogram values, which was presented previously (Almosa et al., 2012). A minimum of 12 patients per group was required. To account for dropouts, we decided to recall 20 patients from each group (G and P) of the 89 patients who presented for the baseline study (Almosa et al., 2012). The number of patients, the group, the mean age, and the genders of the patients over the 4-year period are illustrated in Fig. 1. Informed consent was obtained prior to the start of the examination. The 40 the patients were treated with the same type of fixed orthodontic appliances in both jaws 4 years ago for 1.5–2 years (mean treatment time 21 months). After de-bonding, routine instructions were given to all patients in both groups, i.e. to brush their teeth with a fluoride toothpaste two times daily.

All patients in this follow-up study were interviewed and examined clinically for the presence of caries by the main author (N.A.) at de-bonding (T1) and 4 years after de-bonding (T2). The patients then underwent plaque scoring, saliva sampling, and bitewing radiographs to evaluate the interproximal surfaces for presence of caries.

### 2.2. Questionnaire

A standardized structured questionnaire according to the Cariogram manual (Cariogram, 2013) was used to elicit data about medical and dental history, dietary habits, and the use

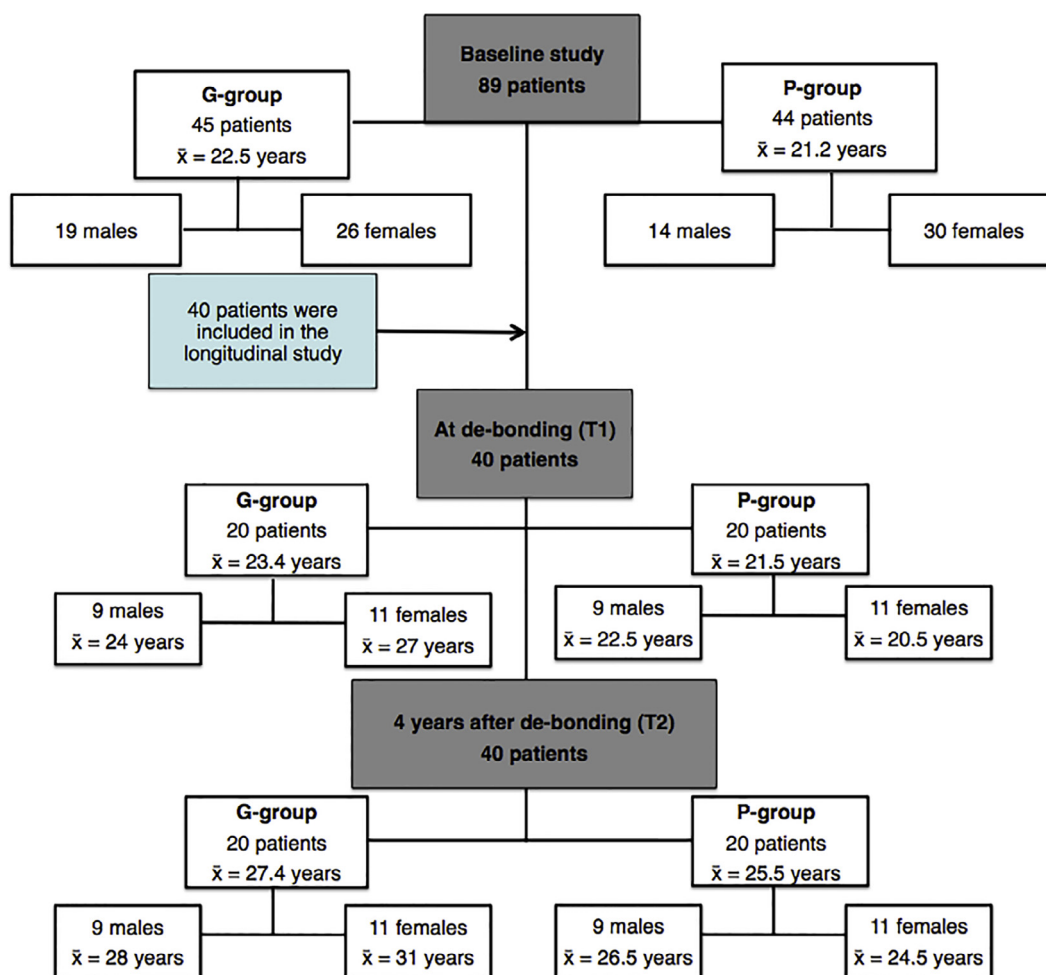


Fig. 1 Flowchart illustrating the study design.

of fluoride dentifrices, fluoride mouth rinse solutions, and fluoride tablets.

### 2.3. Clinical caries examination

The clinical examination was performed as previously described (Almosa et al., 2012). Dental caries was scored according to the World Health Organization criteria (World Health Organization, 1997). The numbers of decayed (D), missing (M) and filled (F) tooth surfaces (S) were scored for each individual and calculated as DMFS to evaluate the caries experience according to the Cariogram (Table 1). Molars and premolars were considered to have five surfaces, while canines and incisors were considered to have four surfaces. Third molars were not included in this study. Teeth with prosthodontic crowns were scored as 4/5 FS, and tooth surfaces affected with caries and filling were scored as DS. Premolars and molars that were extracted due to caries were scored as 5 MS. Extracted teeth due to orthodontic treatment and agenesis were not included as missing teeth. A number of 11 DMFS was set as the mean of past caries experience and considered to be normal for the age group. Patients with 0 DMFS were considered to be caries-free, and patients who had less or more than 11 DMFS were considered to be better or worse than normal,

respectively, in past caries experience according to the Cariogram. Bitewing radiographs were used to evaluate the presence of interproximal caries. White spot lesions were excluded because only frank lesions are considered in the “caries experience” according to the Cariogram (2013).

### 2.4. Plaque index

Before professional cleaning and saliva sampling, the plaque Index (PI) was recorded according to Silness and Loe (1964) (Table 1). Four sites (buccal, lingual and proximal surfaces) on 6 representative teeth (16, 12, 24, 36, 32 and 44) were scored; if any of these teeth were missing, the neighboring tooth was scored.

### 2.5. Salivary and microbiological tests

Paraffin-stimulated saliva was collected for 5 min, and the secretion rate was expressed as ml/min. The saliva was analyzed in terms of buffer capacity and the number of mutans streptococci (MS) and lactobacilli (LB) using chair-side tests (Dentocult SM Strip mutans, Dentocult LB and Dentobuff strip, Orion Diagnostica, Espoo, Finland). The MS, LB, and buffer capacity were scored in classes Table 1, according to

**Table 1** Caries-Related Factors according to the Cariogram.

Factor <sup>a</sup>	Information and data collected	Cariogram scores
Caries experience	Past caries experience, including cavities, fillings and missing surfaces due to caries; data from dental examination and bitewing radiographs.	0: Caries-free and no fillings 1: Better than normal 2: Normal for age group 3: Worse than normal
Related diseases	General diseases or conditions associated to dental caries; medical history, medications; data from interviews and questionnaire results.	0: no disease, healthy 1: a general disease, indirectly influence the caries process to a mild degree 2: a general disease, indirectly influence the caries process to a high degree
Diet, frequency	Estimation of number of meals and snacks per day, mean for 'normal days'; data from questionnaire results.	0: maximum 3 meals per day 1: 4–5 meals per day 2: 6–7 meals per day 3: > 7 meals per day
Fluoride program	Estimation of the extent of fluoride available in the oral cavity; data from questionnaire results.	0: fluoride supplements frequently 1: fluoride supplements infrequently 2: only fluoride toothpaste 3: Not using fluoride toothpaste
Plaque amount	Estimation of hygiene by scoring Plaque Index according to Silness and Løe.	0: No plaque 1: Seen by probe or disclosing agent only 2: Moderate seen by naked eye on tooth and gingival margin 3: Severe film around tooth and in gingival pocket
Saliva secretion	Estimation of flow rate of paraffin-stimulated saliva, as millimeter saliva per minute.	0: Normal, more than 1.1 ml/min 1: Low, from 0.9 to less than 1.1 ml/min. 2: Low, from 0.5 to less than 0.9 ml/min. 3: Very low, less than 0.5 ml/min.
Diet, contents	Lactobacillus counts (Dentocult) used as a measure of cariogenic diet.	0: 0–10 <sup>3</sup> CFU <sup>b</sup> 1: 10 <sup>3</sup> –10 <sup>4</sup> CFU 2: 10 <sup>4</sup> –10 <sup>5</sup> CFU 3: > 10 <sup>5</sup> CFU
Mutans streptococci	Estimation of levels of mutans streptococci in saliva, using Strip mutans test, the strip was cultivated for 48 h at 37 °C	0: 0–10 <sup>3</sup> CFU 1: 10 <sup>3</sup> –10 <sup>4</sup> CFU 2: 10 <sup>4</sup> –10 <sup>5</sup> CFU 3: > 10 <sup>5</sup> CFU
Saliva buffering capacity	Estimation of capacity of saliva, using the Dentobuff test	0: pH ≥ 6.0, adequate (blue) 1: pH 4.5–5.5, medium (green) 2: pH ≤ 4.0, low (yellow)

<sup>a</sup> For each factor, the examiner has to gather information by interviewing and examining the patient, including saliva tests. The result is then given a score on a scale ranging from 0 to 3 (0–2 for some factors) according to predetermined criteria. A score of 0 is the most favorable value, and the maximum score of 3 (or 2) indicates a high, unfavorable risk value.

<sup>b</sup> CFU = Colony-forming units.

the manufacturer's model chart. To determine the buffer capacity of saliva, a drop of saliva was left on the Dentobuff Strip for 5 min, and the pH was then determined by the color presented on the strip in accordance with the manual provided by the manufacturer. All saliva tests were checked and agreed upon by the first author and the laboratory technician.

## 2.6. Caries risk profile (Cariogram)

The Cariogram computer program evaluates the caries risk profile of an individual (Cariogram, 2013). The data of nine caries-related factors Table 1 were scored and entered into the program to produce a graphic image that illustrated the "chance of avoiding new cavities" as a percentage value. The tenth factor "clinical judgment" was given a score of 1 in all patients, which means that the caries risk was evaluated according to the other scores entered. The individual caries profile was estimated and presented in a pie chart with five

sectors, expressed as percentages: (i) "Diet," based on a combination of sugar intake and the number of lactobacilli (dark blue sector); (ii) "Bacteria," which is a combination of the plaque score and the number of mutans streptococci (red sector); (iii) "Susceptibility," including the fluoride program, salivary secretion rate and buffer capacity (light blue sector); (iv) "Circumstances," the past caries experience and general diseases (yellow sector); and (v) "the actual chance of avoiding new cavities" (green sector).

## 2.7. Statistical analysis

All data were analyzed using SPSS (version 18.0, Chicago, IL, USA). Descriptive statistics, including the means and standard deviations of numerical variables, were calculated for all individuals in the G and P groups. A two-sample *t*-test was applied to determine the statistically significant differences between the two main groups (G vs. P), and a paired *t*-test was applied to

**Table 2** Mean values  $\pm$  S.D of numerical variables included in the Cariogram model as caries-related factors in the G-group and the P-group at T1, T2, and over 4-year period (T2-T1).

Factor	T1			T2			T2-T1					
	G-group (n = 20)		P value	P-group (n = 20)		P value	G12-GT1		P12-P11			
	Mean	S.D		Mean	S.D		Mean	P value	Mean	P value		
DMFS	15.0	15.6	8.5	8.6	16.8	15.7	10.8	8.9	1.8	NS <sup>a</sup>	2.3	NS <sup>a</sup>
Saliva secretion rate/min	0.9	0.9	0.9	0.5	1.6	0.9	2.0	0.9	0.7	NS <sup>a</sup>	1.1	$P < 0.001$
ACAN <sup>b</sup> (%)	31	25	58	31	52	22	77	16	21	$P < 0.001$	19	$P < 0.01$

<sup>a</sup> NS not significant.<sup>b</sup> Actual chance to avoid new cavities.

determine the statistically significant differences for the same individuals over time (T2-T1). Fisher's exact test was used to compare the scores between the two different groups (G vs. P). In all tests, the significance level was  $P < 0.05$ . The median values of the green sector of the Cariogram for the G and P groups were calculated for illustrative purposes.

### 3. Results

All patients in the G and P groups were free of any diseases or conditions that might be associated with dental caries. There was no statistically significant difference between the G and P groups with regard to age, gender, diet frequency, DMFS, saliva secretion rate, LB counts, and buffer capacity at either T1 or T2. The caries-related factors included in the Cariogram model for the G and P groups at T1 and T2 are presented in Tables 2 and 3.

#### 3.1. Differences at T1

There was a statistically significant difference between the G- and P- groups with regard to fluoride use and plaque around teeth ( $P < 0.05$ ) Table 3. Approximately 10% of the G-group vs. 25% of the P-group used extra fluoride products, such as fluoride tablets or fluoride mouth-rinses, while 90% of the G-group vs. 75% of the P-group used fluoride toothpaste only. Although there was no statistically significant difference in the other caries-related factors Tables 2 and 3, the mean of "the actual chance to avoid new cavities" according to the Cariogram was almost double in the P-group compared to the G-group (58% vs. 31%) Table 2, Fig. 2) ( $P < 0.01$ ).

#### 3.2. Differences at T2

There was a statistically significant difference between the G- and P- groups with regard to fluoride use ( $P < 0.05$ ) Table 3. Fluoride use shows that 10% of the G-group vs. 30% of the P-group used extra fluoride products such as fluoride tablets or fluoride mouth-rinses. Fluoride toothpaste only was used by 85% of the G-group and 70% of the P-group. The remaining 5% of the G-group used no fluoride product at all. A statistically significant difference ( $P < 0.05$ ) was observed between the G- and P- groups in the number of MS and plaque around teeth Table 3. The mean of "the actual chance to avoid new cavities" according to the Cariogram was higher in the P-group compared to the G-group (77% vs. 52%) Table 2, Fig. 2 ( $P < 0.001$ ).

#### 3.3. Caries risk profile over a 4-year period (T2-T1)

There was no statistically significant difference over the 4-year period with regard to diet frequency, fluoride use, MS counts, and LB counts in either the G- or P-group. Statistically significant differences were observed over the 4-year period in the other caries-related factors, including saliva secretion rate, plaque score, and buffer capacity Tables 2 and 3, "T2-T1"). Although the mean of DMFS increased more in the P-group compared to the G-group over 4 years after de-bonding Table 2, the mean difference of DMFS (1.8 vs. 2.3) at T2-T1 for the P-group vs. the G-group was not statistically

**Table 3** Frequency distribution of categorical caries-related factors according to the cariogram score of the total number of individuals in the G-group and P-group at T1, T2 and the significant differences are shown over 4-year period (T2–T1): a Fisher's exact test was used to calculate the differences between G vs. P groups (T1 and T2), whereas paired *t*-test was used to calculate the differences for the same group (G or P) over time (T2–T1).

Factor	Cariogram score	T1		<i>P</i> value	T2		<i>P</i> value	T2–T1		
		G-group (n = 20)	P-group (n = 20)		G-group (n = 20)	P-group (n = 20)		<i>P</i> value	G <sub>T2</sub> –G <sub>T1</sub>	<i>P</i> value
<i>Caries experience</i>										
Caries-free and no fillings	0	0	3	NS	0	2	NS	NS		NS
Better than normal	1	11	11		9	11				
Normal for age group	2	0	1		0	1				
Worse than normal	3	9	5		11	6				
<i>Diet frequency</i>										
Maximum 3 meals per day	0	14	7	NS	10	14	NS			NS
4–5 meals per day	1	6	12		10	5		NS		
6–7 meals per day	2	0	1		0	1				
> 7 meals per day	3	0	0		0	0				
<i>Fluoride program</i>										
Fluoride supplements frequently	0	1	3	<i>P</i> < 0.05	0	2	<i>P</i> < 0.05	NS		NS
Fluoride supplements infrequently	1	1	2		2	4				
Only fluoride toothpaste	2	18	15		17	14				
Not using fluoride toothpaste	3	0	0		1	0				
<i>Plaque index</i>										
No plaque	0	1	5	<i>P</i> < 0.05	3	15	<i>P</i> < 0.001	<i>P</i> < 0.001		<i>P</i> < 0.001
Seen by probe or disclosing agent only	1	5	10		13	5				
Moderate	2	9	5		4	0				
Severe	3	5	0		0	0				
<i>Saliva secretion</i>										
Normal, more than 1.1 ml/min	0	3	9	NS	13	12	NS	<i>P</i> < 0.001		<i>P</i> < 0.001
Low, from 0.9 to less than 1.1 ml/min	1	2	1		3	4				
Low, from 0.5 to less than 0.9 ml/min	2	10	3		3	4				
Very low, less than 0.5 ml/min	3	5	7		1	0				
<i>Lactobacillus score (CFU/mL)</i>										
0–10 <sup>3</sup>	0	3	6	NS	5	7	NS	NS		NS
10 <sup>3</sup> –10 <sup>4</sup>	1	2	5		6	6				
10 <sup>4</sup> –10 <sup>5</sup>	2	11	6		4	4				
> 10 <sup>5</sup>	3	4	3		5	3				
<i>Mutans streptococcus (CFU/mL)</i>										
0–10 <sup>3</sup>	0	4	6	NS	3	7	<i>P</i> < 0.05	NS		NS
10 <sup>3</sup> –10 <sup>4</sup>	1	2	5		3	8				
10 <sup>4</sup> –10 <sup>5</sup>	2	5	7		10	4				
> 10 <sup>5</sup>	3	9	2		4	1				
<i>Buffer capacity (pH)</i>										
≥6.0, 'adequate'	0	5	8	NS	13	17	NS	<i>P</i> < 0.01		<i>P</i> < 0.001
4.5–5.5, 'medium'	1	8	7		3	2				
≤4.0, 'low'	2	7	5		4	1				



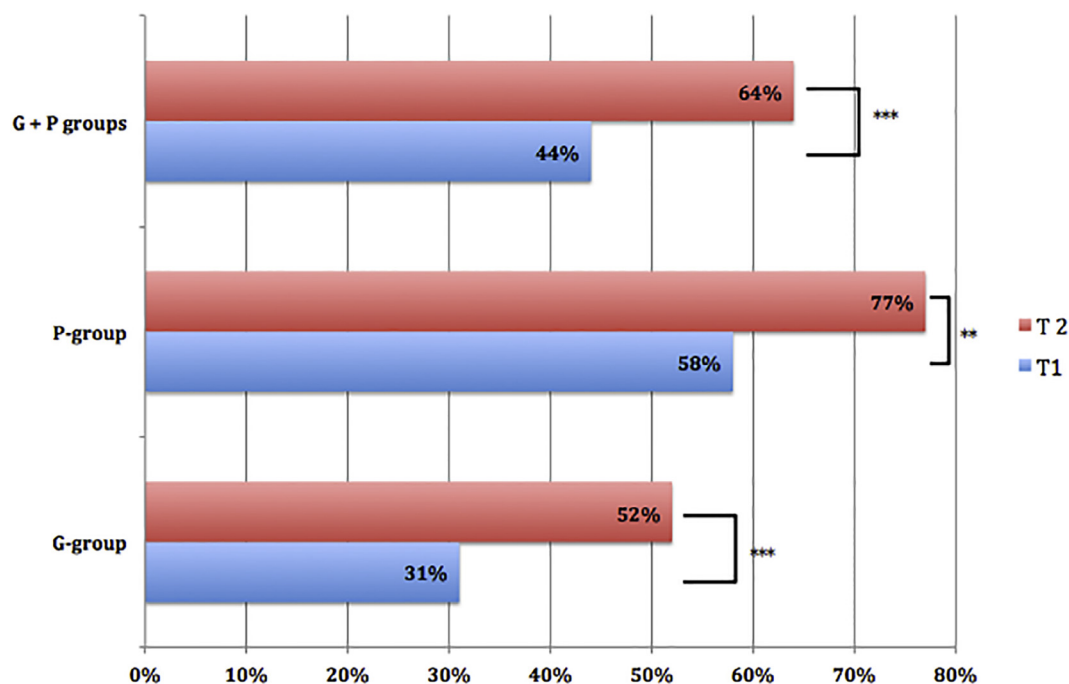


Fig. 2 The mean of actual chance to avoid new cavities at de-bonding (T1) and 4 years after de-bonding (T2) for the all patients merged together, and for the G and P groups' separately.

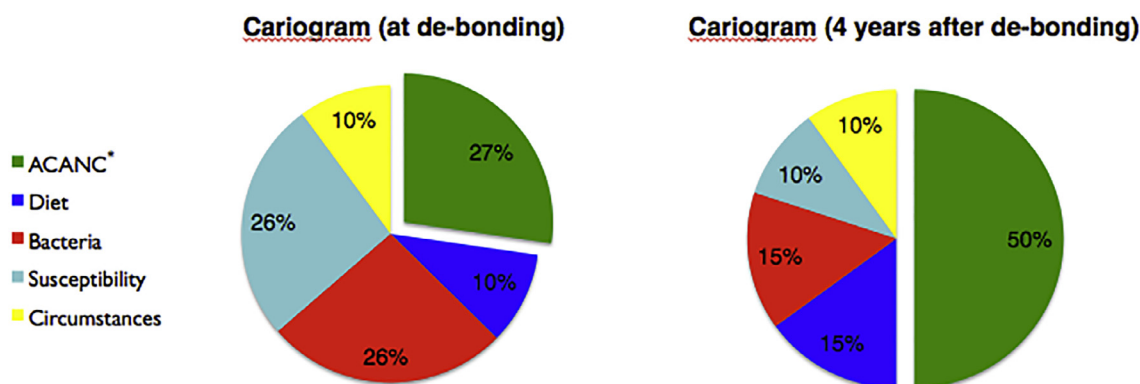


Fig. 3 Two Cariograms for patient in the governmental group based on the median value of \* Actual Chance to Avoid New Cavities at de-bonding and 4 years after de-bonding.

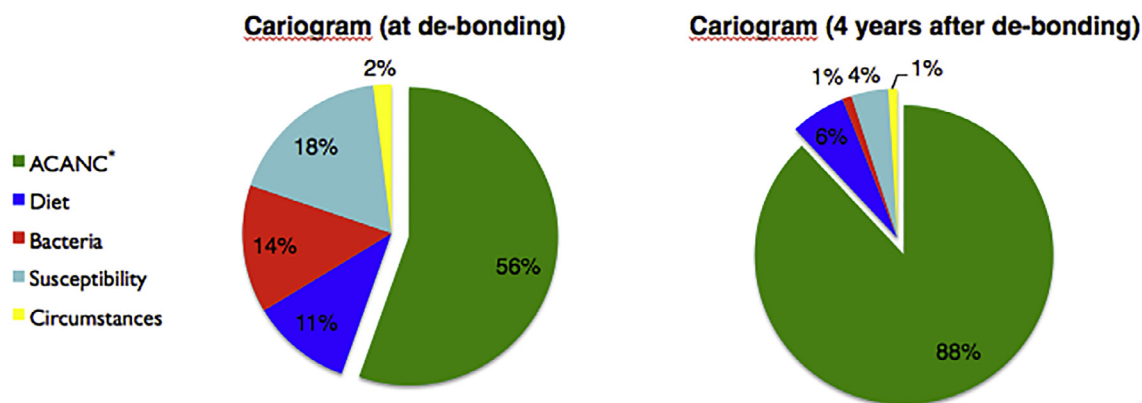
significant. Fig. 2 shows the improvement in “the actual chance to avoid new cavities” from T1 to T2 for the whole sample, pooling the G- and P-groups together (G + P), as well as for the G- and P- groups separately. Figs. 3 and 4 illustrate the changes in the Cariogram model 4 years after de-bonding based on the median value of “the actual chance to avoid new cavities” at T1 for the G and P groups, respectively.

4. Discussion

The results of this study reveal that the caries risk in the G-group was higher compared to the P-group at T1 and T2 based on the Cariogram model. In addition, the current study shows that the caries risk decreased 4 years after de-bonding according to the Cariogram model.

There were no statistically significant differences with regard to the mean of “the actual chance to avoid new cavities” between the 89 patients investigated at baseline (T1) and the 40 patients investigated at both T1 and T2, meaning that the 40 patients included in this study comprised a representative sample for follow-up investigation. It has already been shown in our earlier study that the G-group had greater risk to develop caries compared to the P-group at T1 (Almosa et al., 2012), but in the present study, we investigated whether the difference would remain when the number of patients decreased from 89 to 40 patients.

According to the Cariogram manual (Cariogram, 2013), the “caries experience” is evaluated using the mean DMFS of a certain population. Because no epidemiological study has been performed on the Saudi population for the same age group as in this study, the mean DMFS was calculated from the



**Fig. 4** Two Cariograms for patient in the private group based on the median value of \* Actual Chance to Avoid New Cavities at de-bonding and 4 years after de-bonding.

baseline study (Almosa et al., 2012) and was evaluated to be 11. A limitation with the Cariogram (Cariogram, 2013) is that white spot lesions (WSLs) are not included in the “caries experience.” This seems to be a disadvantage of the Cariogram model, especially for orthodontic patients, because WSLs constitute a frequent side effect of orthodontic treatment (Øgaard et al., 1988). This disadvantage should be incorporated into the Cariogram model in the future if an updated version is planned.

In the present study, we found that fluoride use and plaque index were the most significant indicators for caries risk according to the Cariogram when the G- and P-groups were compared at T1 and T2 Table 3. The differences could be associated with the socio-economic status of the patients. In the KSA, patients receive orthodontic treatment in governmental centers for free, while patients in private centers must pay the full fee for orthodontic treatment. Various explanations for the differences in caries risk profiles between the G- and P-groups have been described previously (Almosa et al., 2012). These findings show the importance of instructing the adolescents to improve preventive measures, including routine oral hygiene with fluoride toothpaste during orthodontic treatment, especially for the patients treated in governmental centers. Use of the modified fluoride toothpaste technique, as described by Al Mulla et al. (2010), has been shown to reduce the incidence of new carious lesions in orthodontic patients. Although the mean DMFS was much higher in the G-group compared to the P-group at T1 and T2 Table 2, there was no statistically significant difference between the two groups. This lack of difference could be due to a large value of standard deviation and a small follow-up sample size.

The current investigation shows that higher salivary secretion rate and buffer capacity at T2 compared to T1 had probably decreased caries risk according to the Cariogram model. The significant decrease in stimulated saliva at T1 compared to T2 is confusing, but it might be explained by the difficulty of chewing paraffin wax in the presence of fixed appliances. A second explanation may be related to methodological error, where the patients were unfamiliar with chewing paraffin tablets for the first time at T1, as observed in another study (Al Mulla et al., 2010). This finding contrasts other investigations claiming that orthodontic appliances increase the salivary

secretion rate (Chang et al., 1999; Li et al., 2009; Mummolo et al., 2013). However, another study proved that there were no significant differences in salivary flow rate and buffer capacity before, during, and after orthodontic treatment (Sanpei et al., 2010). These divergent findings indicate the need for further investigations.

The significantly lower plaque index found at T2 is explained by the fact that brackets and arch wires were present at T1. This could be the main reason why “the actual chance to avoid new cavities” was decreased 4 years after de-bonding, reflecting the increased risk for developing caries during orthodontic treatment. This finding, in agreement with other studies, confirmed that fixed orthodontic appliances are associated with increased plaque accumulation (Chang et al., 1999; Mummolo et al., 2013; Chatterjee and Kleinberg, 1979).

In the baseline study (Almosa et al., 2012), we found a trend that the more cariogenic microorganisms pooled from saliva, reflected by MS and LB counts led to a higher DMFS. It has been shown in another study that there are significant correlations between the mean values of DMFS and salivary microbiological counts (Gabris et al., 1999). The present study shows no statistically significant differences in the number of cariogenic microorganisms, pooled from saliva, at T1 and T2. This finding may explain the fact that there was no significant increase in the number of DMFS at T2 compared to T1 for both the G- and P-groups although the plaque index was significantly less at T2. Mannaa et al. showed that no significant relationships between the bacterial counts pooled from dental plaque and the caries experience (Mannaa et al., 2013). Moreover, the reason of having no significant difference in number of MS and LB over time could be explained by a study performed by Peros et al. (2011), showing that the period from the 6th to 12th week of orthodontic therapy is the peak time for intensive intraoral growth of MS and LB; the amount of MS and LB decreased afterward, which support our findings as we collected the saliva for MS and LB at de-bonding i.e. 1.5–2 years after bonding and 4 years after de-bonding.

## 5. Conclusions

According to the Cariogram model,



- the alternative hypothesis was accepted. The caries risk in orthodontic patients at de-bonding and 4 years after de-bonding was greater in the patients treated at government clinics compared to those treated at private clinics.
- the caries risk decreased dramatically 4 years after orthodontic treatment for all orthodontic patients, regardless of whether the treatment center was governmental or private.
- fluoride use and plaque index are the most significant indicators for caries risk when the government and private groups were compared.
- increased salivary secretion rate, decreased plaque amount, and the improvement of buffer capacity were the most significant factors in decreasing caries risk 4 years after de-bonding.

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