Original Article

Caries Risk Profiles in Orthodontic Patients at Follow-Up Using Cariogram

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ABSTRACT

Objective: To analyze caries-related factors shortly after orthodontic treatment and to use the Cariogram computer program to describe caries risk profiles at follow-up in these patients.

Materials and Methods: One hundred orthodontic patients age 12–29 years, with a mean age of 17.5 years, were included in the study. They were divided into two groups (50 in each) based on their prebonding decayed, filled surfaces index (DFS). High ($5 \geq$ DFS) and low ($2 \leq$ DFS) groups were created. All patients were examined after debonding in the following order: interview, plaque score, caries examination, saliva samples, bitewing radiographs, panoramic radiographs, and intra-oral digital photos. All types of carious lesions in both the enamel and dentine were diagnosed clinically and radiographically and included in the DFS index. A paraffin-stimulated whole saliva sample was collected for estimations of secretion rate, buffer capacity, and number of mutans streptococci and lactobacilli.

Results: The low caries group ($2 \leq$ DFS) displayed a statistically significant difference and low values for the following factors, DFS ($P < .001$), lactobacilli ($P < .001$), mutans streptococci ($P < .001$), and high Cariogram percent ($P < .001$). The plaque index displayed very close significance ($P = .051$).

Conclusions: Patients with high ($5 \geq$ DFS) numbers before orthodontic treatment ran a higher risk of developing caries. They had significantly higher numbers of mutans streptococci and lactobacilli and had less chance of avoiding new cavities according to the Cariogram. (*Angle Orthod.* 2008;79:323–330.)

KEY WORDS: Caries lesions; Saudi Arabia

INTRODUCTION

It is well known that orthodontic treatment has the potential to cause damage to the hard and soft tissues.[1–2] Patients undergoing fixed appliance treatment often have high salivary and plaque counts of mutans streptococci due to a favorable environment for the accumulation of microorganisms and food particles,[3] which increases the caries risk.[4] The use of conventional oral hygiene procedures in orthodontic patients for plaque removal is more difficult, and, adjacent to the brackets, the clearance of plaque and carbohydrates by saliva is also reduced.[5] This may lead to caries lesions in the enamel that can occur within a month, irrespective of mechanical plaque control and the use of fluoridated dentifrice.[6–8]

The caries prevalence in teenagers and adolescents in the Kingdom of Saudi Arabia (KSA) is high.[9] This also applies to preschool children.[10] In 300 military school children (6–7 years old) examined for caries, 288 (96%) of the children were diagnosed with decay, while only 4% were clinically caries free.[11] The differences found in the oral health behavior of Saudi Arabian and Irish 15-year-old children is obvious with respect to the intake of sweet foods and drinks.[12] In 1994, it was reported that 90% of 5-year-old children, from preschool nurseries in Al-Kharj, KSA, had heavy plaque on their teeth and one-third never brushed their teeth, while two-thirds had never been to a dentist.[13]

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Table 1. Caries-Related Factors and the Data Needed to Create a Cariogram According to Bratthall and Hänsel Petersson (2005)

Factor[a]	Comment	Information/Data Needed
Caries experience	Past caries experience, including cavities, fillings, and missing teeth because of caries. Several new cavities definitely appearing during preceding year should give a high score even if number of fillings is low.	DMFT (decayed missed filled teeth), DMFS (decayed missed filled surfaces), new caries experience in the past 1 year
Related disease	General disease or conditions associated with dental caries.	Medical history, medications
Diet, contents	Estimation of the cariogenicity of the food, in particular, sugar contents.	Diet history, lactobacillus test count
Diet, frequency	Estimation of number of meals and snacks per day, mean for ''normal days.''	Questionnaire results, 24-hour recall or dietary recall (3 days)
Plaque amount	Estimation of hygiene, for example, according to Silness-Löe plaque index (PI). Crowded teeth leading to difficulties in removing plaque interproximally should be taken into account.	Plaque index
Mutans streptococci	Estimation of levels of mutans streptococci (*Streptococcus mutans, Streptococcus sobrinus*) in saliva, for example, using Strip mutans test.	Strip mutans test or other laboratory tests giving comparable results
Fluoride program	Estimation of to what extent fluoride is available in the oral cavity over the coming period of time.	Fluoride exposure, interview patient
Saliva secretion	Estimation of amount of saliva, for example using paraffin-stimulated secretion and expressing results, as millimeter saliva per minute.	Stimulated saliva test – secretion rate
Saliva buffer capacity	Estimation of capacity to buffer acids, for example using the Dentobuff test.	Dentobuff test or other laboratory tests giving comparable results

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

Different methods have been used in the Scandinavian countries to evaluate the ''caries risk''. Krasse introduced this terminology more than 20 years ago.[14–15] A computer-based program, called the ''Cariogram,'' has been developed by Petersson and Bratthall[16] to illustrate caries risk assessment in adolescents. It is an interactive program for caries risk evaluation, illustrating the various caries-related factors expressing the ''actual chance of avoiding new cavities.''

Since teenagers easily develop caries due to newly erupted teeth,[17] it is very interesting to study in greater detail whether orthodontic treatment increases the caries risk. The aims of the present investigations were to analyze caries-related factors shortly after orthodontic treatment and to use the Cariogram computer program to describe caries risk profiles at follow-up in these patients.

MATERIALS AND METHODS

Subjects

The study consisted of 100 patients, age 12–29 years, with a mean age of 17.5 years. They were recruited consecutively during a 6-month period in a well-known orthodontic clinic in Riyadh, KSA. The patients' pre-orthodontic examination charts, panoramic radiographs, and intra-oral photos were examined. The patients were divided into two groups (50 in each), based on their prebonding decayed, filled surfaces index (DFS). A high ($5 \geq$ DFS) and a low ($2 \leq$ DFS) caries group were created; individuals with DFS between 2 and 5 were excluded. All patients were treated with fixed orthodontic appliances in both jaws for 1–2 years (mean treatment duration 18 months). Synergy brackets were used (Rocky Mountain Orthodontics, Denver, Colo), bonded with Reliance light bond material (Reliance Orthodontic Product Corporate, Itasca, Ill). After bonding, routine clinic instructions were given to all patients to brush their teeth three times a day and to rinse with a fluoridated mouth rinse solution once a day.

Examination

The same dentist examined all patients (Dr Mulla). Before bonding, the records, intra-oral photos, and the orthopantomographic radiographs were checked carefully for caries lesions (DFS). After debonding, the patients were examined in the following order: data collection, plaque score, caries examination, saliva samples, bitewings and panoramic radiographs, and intra-oral digital photos. The kappa value for caries recording based on 20% of the patients was estimated to be 0.84.

Data Collection

A standardized form was used to collect all the data needed for the Cariogram (Table 1). Each of the nine parameters was ranked from 0–2 or 0–3, according to the manual.[18] All data were then inserted into the com-

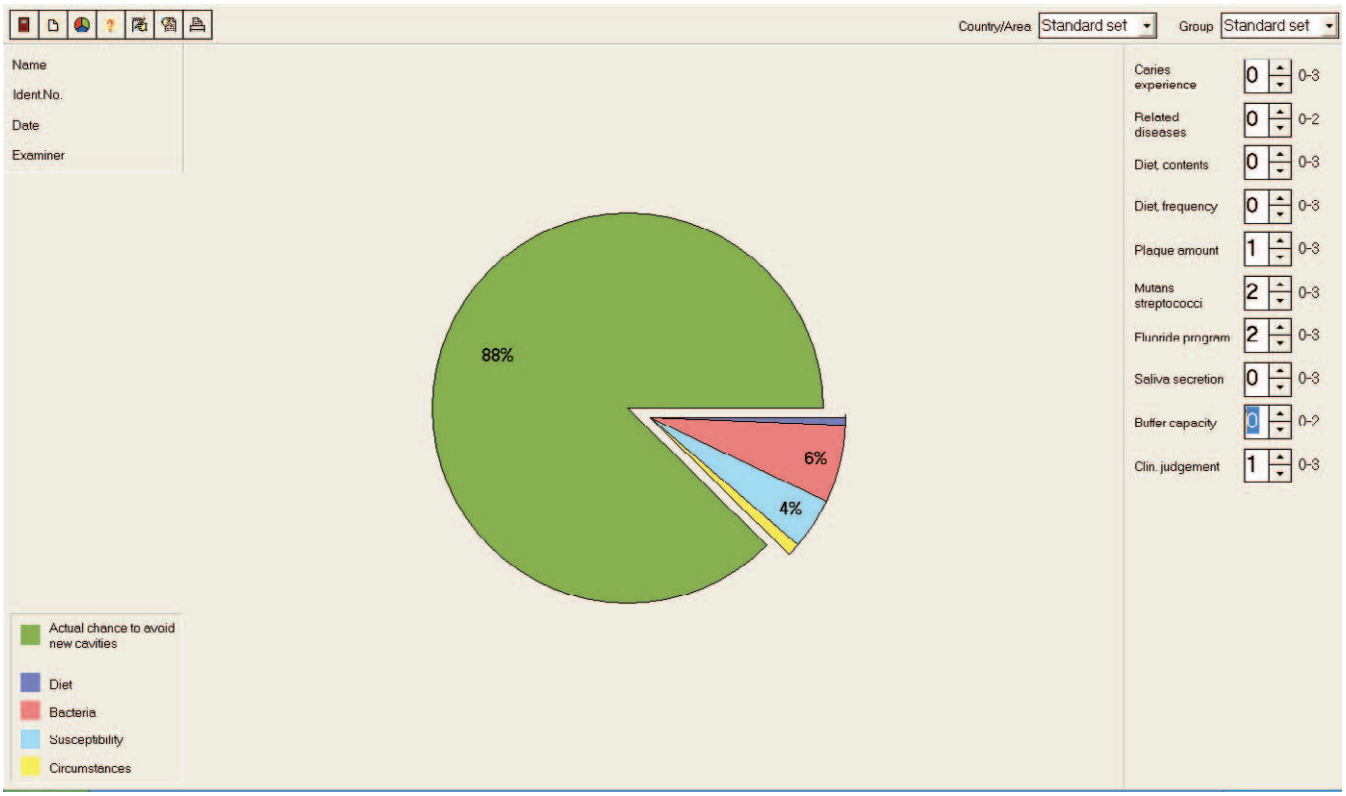

Figure 1. A Cariogram (as it appears in the computer) showing a low-risk patient with a high percentage (88%) of ''actual chance of avoiding new cavities'' (green sector). On the right, all nine factors plus clinical judgment are giving a score from 0 to 2–3. On the lower left, the five Cariogram sectors are explained in different colors.

puter program to produce a graphic image (Cariogram) that illustrates the chance of avoiding caries as a percentage value[15] (Figures 1 and 2).

Plaque Scoring

Four different scores were used according to the Cariogram manual[19]: (0) no plaque; (1) film of plaque adhering to the free gingival margin and adjacent area of the tooth; (2) moderate accumulation of soft deposits in the gingival pocket, or on tooth gingival margin; and (3) abundance of soft matter within the gingival pocket and/or on the tooth gingival margins.

Clinical and Radiographic Caries Registration

Prophylaxis and flossing were performed before the registration. Using optimal light, a mirror, and an explorer, all kinds of carious lesions, in both enamel and dentine, diagnosed clinically (except white spots) and radiographically (four bitewings), were included in the DFS index. White spot lesions were excluded in the present study because they are difficult to score and have been discussed previously in detail in the literature.[20–23] Moreover, only cavities are included in the ''caries experience'' according to the Cariogram.[24]

Salivary and Microbiological Factors

Paraffin-stimulated whole saliva was collected for 3 minutes, and the salivary secretion rate was expressed as mL/min. The patient during collection was placed in an upright position. The fresh saliva sample was then used for culturing on selective media and for estimation of buffer capacity in the following way. Chair-side tests (Dentocult SM Strip Mutans and Dentocult LB, Orion Diagnostica, Espoo, Finland) were used to evaluate both mutans streptococcus (MS) and lactobacillus (LB) counts, respectively. The MS and LB were scored in four classes according to the provided model chart (1, 2, 3 and 4). Score 1 is the lowest number of microorganisms. The buffer capacity of the stimulated whole saliva was determined using Dentobuff Strip (Buffer Strip, Orion Diagnostica). Three colors were obtained: blue (pH $>$ 5.5), green (4.5 $<$ pH $<$ 5.5), and yellow (pH $<$ 4.5).

Statistical Analysis

SPSS 13.0 (Lead Tech, Chicago, Ill) was used for the statistical analysis of the determined measurements. For the descriptive statistics, the mean values with standard deviations were calculated, as well as

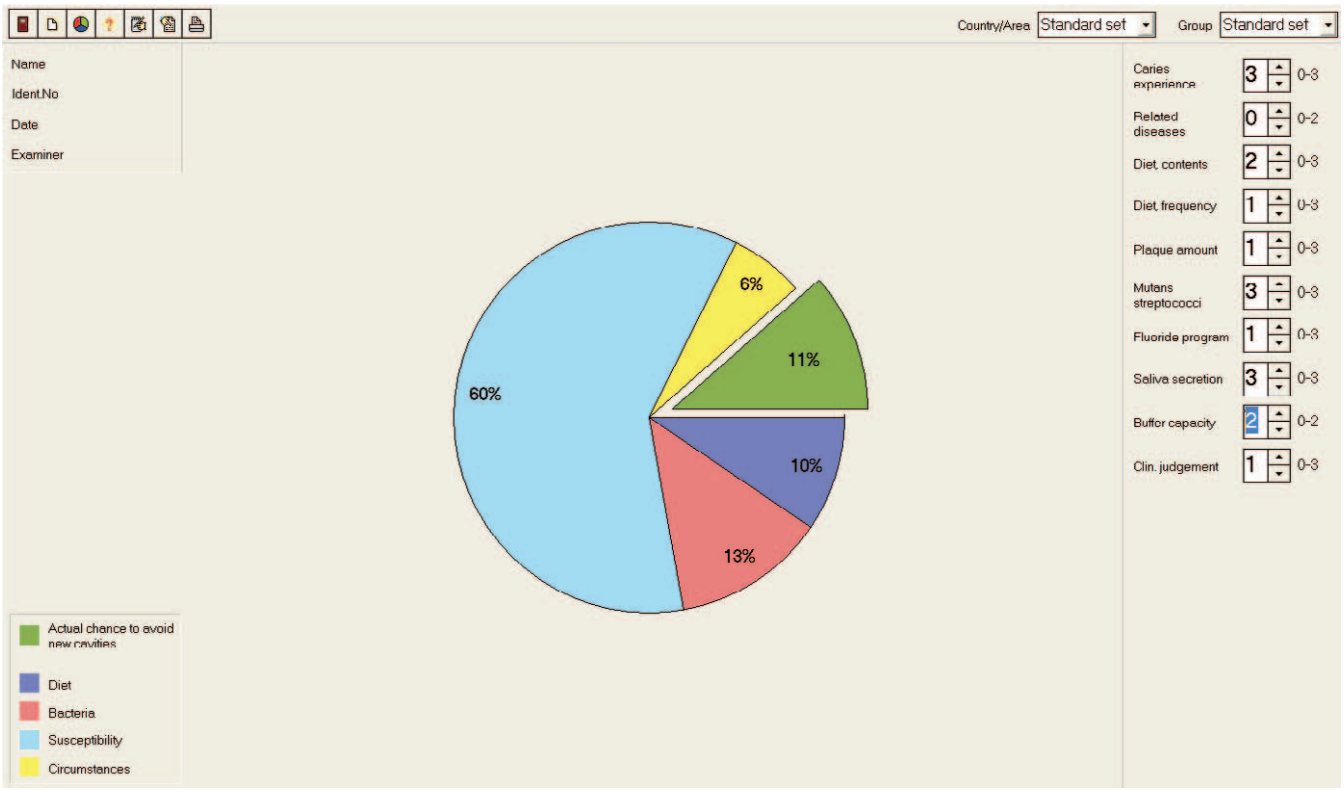

Figure 2. A Cariogram (as it appears in the computer) showing a high-risk patient with a low percentage (11%) of "actual chance of avoiding new cavities" (green sector). On the right, all nine factors plus clinical judgment are giving a score from 0 to 2–3. On the lower left, the five Cariogram sectors are explained in different colors.

the minimum and maximum. To determine statistically significant differences between the groups, the independent sample *t*-test was applied to the two main groups, while the analysis of variance (ANOVA) was applied when three groups or more were analyzed. In all tests, the significance levels were $P < .05$, $P < .01$, and $P < .001$.

RESULTS

The various caries-related factors that were compared between the two groups are shown in Table 2. The DFS in the high caries group was more than four times higher than that in the low caries group. The following factors differed significantly between the two groups: decayed surfaces (DS), filled surfaces (FS), LB, and MS. The plaque index was almost significant ($P = .051$). Regarding the Cariogram values, the "chance of avoiding new cavities" was 75% in the low caries group and 42% in the high caries group ($P < .001$).

In Table 3, the 10 individuals with the lowest DFS and the 10 with the highest DFS are shown with respect to the same variables as in Table 2 (matched by age). The group with the highest DFS had a DS that was more than 6 times higher, an FS that was more than 5 times higher, and a DFS that was more than 12 times higher in comparison with the group with the lowest DFS. The Cariogram value (actual chance to avoid new cavities) was 2.5 times higher in the lowest DFS group.

The distribution of carious lesions in the 100 patients and their locations are shown in Table 4. Occlusal caries (n = 137) and recurrent caries (n = 55) constituted more than half of the total number of lesions (n = 285). Palatal/lingual caries were less common.

The relationship between the DFS and the number of cariogenic microorganisms in the 100 patients is illustrated in Figures 3 and 4. Patients with LB scores of 3 and 4 compared with patients with a score of 1 had three (9.5 vs 3.5) and four (12.6 vs 3.5) times more DFS, respectively. The corresponding values compared with an LB score of 2 were 2 (9.5 vs 5.0) and 2.5 (12.6 vs 5.0) times higher. When it came to the MS score, the DFS values were almost the same in scores of 3 and 4. The two highest scores were significant in comparison to both scores 1 and 2. There was also a statistically significant difference between scores 1 and 2.

The Cariogram data (ie, actual chance of avoiding new cavities) were divided into three classes: (1) low

Table 2. Mean Values ± SD and Range of Various Factors in the Low Caries Group (n = 50) and the High Caries Group (n = 50) (the Significant Differences Between the Two Groups Are Also Shown)

Factor	Low Caries Group (n = 50)			High Caries Group (n = 50)			Significance
	Mean	±SD	Range	Mean	±SD	Range	
Age, years	17.2	4.9	12–29	17.8	2.9	12–24	
Decayed surfaces (DS)	1.48	2.15	0–9	4.22	3.19	0–12	$P < .001$
Filled surfaces (FS)	0.96	1.31	0–4	5.72	3.70	0–16	$P < .001$
Decayed, filled surfaces (DFS)	2.44	2.70	0–11	9.94	2.92	6–19	$P < .001$
Plaque index	1.46	0.58	1–3	1.72	0.73	1–3	$P = .051$
Lactobacilli, log CFU/mL	3.56	0.61	3–5	4.64	0.75	3–6	$P < .001$
Mutans streptococci, log CFU/mL	4.52	0.63	4–7	5.74	0.73	5–7	$P < .001$
Saliva secretion, mL/min	0.91	0.26	0.3–1.1	0.88	0.30	0.3–1.1	NS[a]
Buffer capacity (pH)	5.7	0.51	4–6	5.6	0.58	4–6	NS[a]
Cariogram[b], %	75	16	16–99	42	19	6–72	$P < .001$

[a] NS indicates not significant.
[b] Actual chance to avoid new cavities.

Table 3. Mean values ± SD and Range of Various Factors in Those With the Lowest and Highest DFS (n = 10), Matched by Age (the Significant Differences Between the Two Groups Are Also Shown)

Factor	Lowest DFS (n = 10)			Highest DFS (n = 10)			Significance
	Mean	±SD	Range	Mean	±SD	Range	
Age, years	16	1.6	14–18	16	1.6	14–18	
Decayed surfaces (DS)	0.1	0.32	0–1	6.9	4.0	1–12	$P < .001$
Filled surfaces (FS)	0.3	0.7	0–2	5.6	4.1	0–11	$P < .001$
Decayed, filled surfaces (DFS)	0.4	0.7	0–2	12.5	1.9	10–16	$P < .001$
Plaque index	1.6	0.52	1–2	1.9	0.74	1–3	NS[a]
Lactobacilli, log CFU/mL	3.6	0.7	3–5	5.1	0.74	4–6	$P < .001$
Mutans streptococci, log CFU/mL	4.7	0.5	4–6	5.9	0.8	5–7	$P < .001$
Saliva secretion, mL/min	1	0.2	0.5–1.1	0.8	0.3	0.3–1.1	NS[a]
Buffer capacity (pH)	5.8	0.4	5–6	5.4	0.7	4–6	NS[a]
Cariogram[b], %	86	7	76–99	33	20	6–71	$P < .001$

[a] NS indicates not significant.
[b] Actual chance to avoid new cavities.

(0%–40%), (2) medium (41%–60%), and (3) high (61%–100%). The DFS values in these categories are illustrated in Figure 5. Patients with a low or intermediate chance of avoiding new cavities (≤60%) had 2–3 times more DFS compared with the group with high chance values (>60%; $P < .001$).

DISCUSSION

The findings in the present study demonstrate the importance of caries risk assessment in orthodontic patients. Saudi children have a high caries prevalence and high sweet intake.[9–11,13,25] In combination with many newly erupted teeth and a lack of proper oral hygiene, this constitutes a major caries risk. These children need proper information, especially as orthodontic treatment is becoming a common procedure in KSA and is gaining in popularity. The use of oral preventive programs, including fluoride and informative oral hygiene knowledge, is currently being implemented in state-run and private schools in KSA; it has to be mentioned that these programs are still being developed.

Most orthodontists agree that patients seeking orthodontic treatment run a high risk of developing caries,[26,27] but the question is how this risk should be estimated. In this study, at debonding, we have used an advanced caries risk assessment (Cariogram), which has previously been used in both children and adults[28,29] but never on orthodontic patients. The experience from the present investigation indicates that it is a very useful tool and easy to use. The results reveal a very clear difference between the high and low groups. The Cariogram is a practical pedagogic tool to illustrate the actual chance of patients avoiding new cavities (Figures 1 and 2).

When evaluating the nine caries-risk indicators, three appear to be of great importance, ie, DFS, MS, and LB. The number of DFS the patient has before orthodontic treatment is a strong predictive factor of his/her caries risk. Many studies reveal that patient ex-

Table 4. Distribution of Caries Lesions[a] (DS) on Various Tooth Surfaces According to Groups of Teeth in All 100 Patients

Teeth	Mesial	Occlusal	Distal	Lingual	Buccal	Total
Maxillary teeth						
Incisors and canines	2	0	2	3	0	7
Premolars	1	12	19	0	5	37
Molars	6	62	2	0	4	74
Mandibular teeth						
Incisors and canines	2	0	0	1	1	4
Premolars	3	10	13	0	5	31
Molars	8	53	6	0	10	77
Total	22	137	42	4	25	230

[a] Total number of caries lesions (n = 230) plus recurrent lesions (n = 55) = 285 DS.

posure to caries and fillings puts these patients in a higher risk group.[1–5] When checking the MS and LB scores, both appear to have a strong effect on DFS and the caries risk. We therefore believe that a chairside saliva test is very worthwhile in order to reduce a patient's caries risk. In the choice between MS and LB, we are in favor of LB because it is easier to read, but both LB and MS are useful. The importance of plaque amount as a factor for estimating caries risk was, however, shown to have a fairly weak association with caries (Tables 2 and 3).

There have been many publications about caries risk in orthodontic patients.[6–8] These authors have discussed multiple factors in relation to orthodontic treatment, caries development, plaque accumulation, effect of fluoride, and demineralization. Bratthall[15] has pointed out that "The complexity of the issue is highlighted, and it is concluded that there is not one single factor explaining the changes observed. Thus, in one and the same population, different explanations may be relevant for different individuals, for different age groups, for different teeth and for different periods of time." The data from the present investigation in orthodontic patients support this statement.

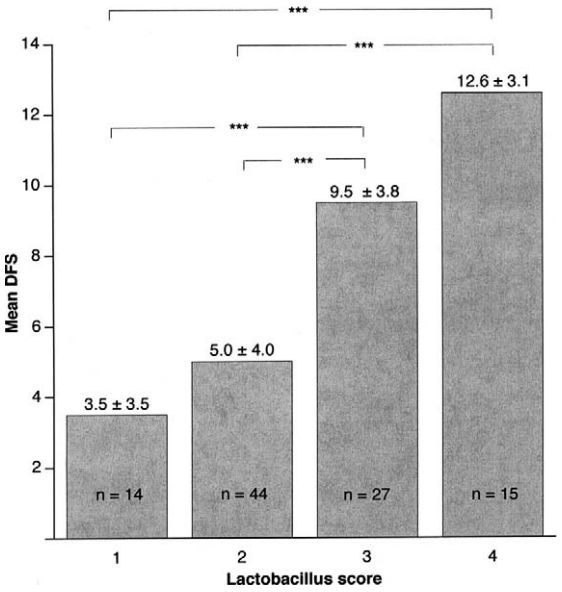

Figure 3. Mean value ± SD of DFS at follow-up in all 100 patients divided into four different LB scores (1, 2, 3, and 4). The number of patients is given within each column. Significant differences between the groups are also shown (***$P < .001$).

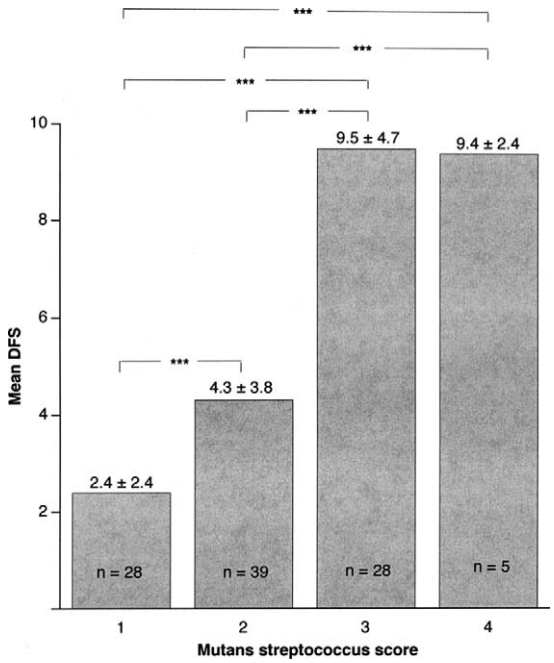

Figure 4. Mean value ± SD of DFS at follow-up in all 100 patients divided into four different MS scores (1, 2, 3, and 4). The number of patients is given within each column. Significant differences between the groups are also shown (*** $P < .001$).

The number of occlusal caries lesions in our population was high (n = 137). The diagnosis of occlusal decay is challenging and its inherent uncertainties lead to differing diagnoses.[30–32] The population in KSA do not normally seek dental treatment until they experience pain.[33] Patients' poor oral hygiene and the lack of regular visits will increase their chance of developing decay, especially on the occlusal surfaces. Although they were aware of their caries activity before, their interest in orthodontic treatment alone and the importance of reducing payments made them ignore the appropriate oral hygiene and the use of fluoride. Proximal caries lesions are very common in this age group, 12–29 years, and are missed easily, especially when bitewing radiographs are not taken. One important observation in the present study was the high level of proximal caries, which causes lesions in premolars and molars (n = 64[22+42]).

The importance of taking bitewing radiographs, saliva samples and Cariogram-related factors before orthodontic treatment appears to be significant when it

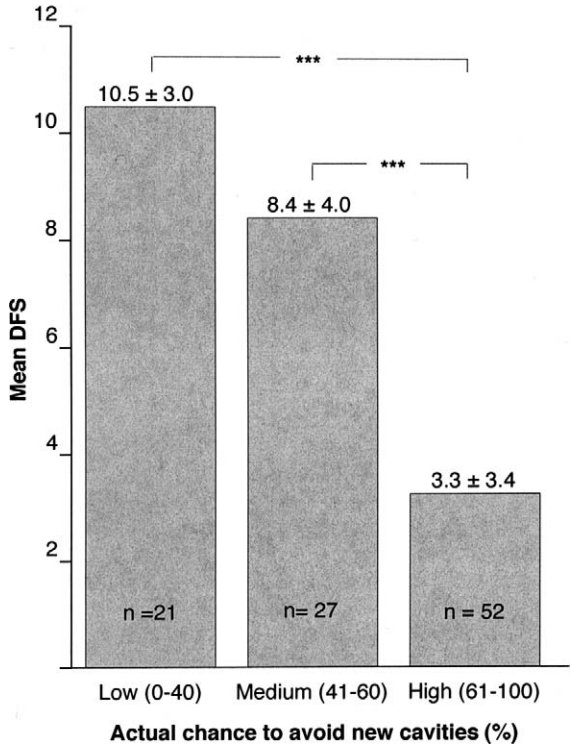

Figure 5. Mean value ± SD of DFS in all 100 patients of "actual chance of avoiding new cavities" (%) according to a Cariogram divided into three different groups, ie, 0–40%, 41–60%, and 61–100%.

comes to making a proper caries risk assessment. In our opinion, the extra 10 minutes it takes to collect Cariogram-relevant data are, therefore, of great importance to make a better diagnosis and to give the patient customized advice to reduce the risk of caries.

CONCLUSIONS

- The higher the number of DFS a patient has before orthodontic treatment, the higher the number of mutans streptococci and lactobacilli he/she has. This then increases his/her caries risk throughout orthodontic treatment.
- The "Cariogram" is a very useful and practical program. Patients with high numbers of DFS before orthodontic treatment often displayed a low percentage in their "actual chance of avoiding new cavities".

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