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Root caries and risk profiles using the Cariogram in different periodontal disease severity groups

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Abstract

Objectives. To study root caries and risk profiles using the Cariogram in relation to periodontal disease severity and to analyse indicators associated with high caries risk. ***Material and methods.*** A cross-sectional examination was carried out on 112 patients with periodontal disease from two government clinics in Saudi Arabia. The investigation comprised a questionnaire, bitewing radiographs, measurement of salivary secretion rate, buffering capacity and cariogenic microorganisms, and registration of periodontal status, plaque amount and coronal and root caries/fillings (DFT and RDFT). The data were then entered into the Cariogram pedagogic model to illustrate the caries risk profiles. ***Results.*** Patients were grouped according to periodontal disease severity into one of three groups: (1) gingivitis ($n = 44$); (2) mild-to-moderate periodontitis ($n = 33$); and (3) severe periodontitis ($n = 35$). The prevalence of RDFT in the total sample was 17%. There were no statistically significant differences between the three groups in number of root lesions or mean 'Actual Chance to Avoid New Cavities' (Chance-AC) according to the Cariogram. Of the total sample, 22% displayed high caries risk (Chance-AC ≤40%). The most significant risk indicators in high caries risk patients were infrequent use of fluoride and unfavourable salivary and microbial parameters. ***Conclusions.*** Root surface lesions and high caries risk were present in about one-fifth of the patients referred for periodontal treatment. A combination of risk indicators rather than a single one contributed to the increased risk. Caries and risk profiles were not significantly correlated with periodontal disease severity.

Key Words: *periodontal disease, risk assessment, root caries, Saudi Arabia*

Introduction

Occurrence of root surface caries in patients with periodontal disease, those undergoing periodontal treatment or maintenance and those eventually receiving prosthodontic reconstructions has been a frequent problem for periodontists and clinicians in general [1–9]. Over a 12-year observational period, root caries developed in ≈90% of patients treated for advanced periodontal disease [7]. Studies correlating caries with different severity levels of periodontal disease are rare. A single report [10] investigated the caries experience in relation to different forms of periodontal disease and observed that, in adults, chronic forms of periodontitis were associated with higher caries prevalence than more aggressive forms.

Ravald et al. [11] utilized the Octagon pedagogic model to illustrate the caries risk in patients who had undergone periodontal treatment 8 years earlier. The authors also analysed possible caries-related factors. Positive correlations with past root caries experience in addition to several other factors were found. More recently, a user-friendly computer program, the 'Cariogram', was introduced by Bratthall et al. [12] by taking into account a number of caries-related factors. This pedagogic model has been validated for predicting future coronal and root caries

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[13,14]. However, there are no studies that have used the Cariogram in patients with periodontal disease.

The aims of this investigation were to study root caries and risk profiles using the Cariogram computer program in relation to periodontal disease severity, and to further analyse indicators associated with high caries risk.

Material and methods

Study sample

This cross-sectional study, which was approved and registered by the King Saud University College of Dentistry Research Centre Ethics Committee (Reg. No. NF 2050), comprised a consecutive sample of 112 patients. Patients were recruited from those referred for treatment of various forms of periodontal disease at the Periodontics Clinic, College of Dentistry, King Saud University (KSU) in Riyadh, and at the Periodontics Division of the Dental Centre, King Fahd Armed Forces Hospital (KFAFH) in Jeddah. Waiting lists of patients referred for treatment at each centre were obtained. Consecutive patients meeting the inclusion criteria were invited to participate in the study. Only untreated referred patients were included. Patients who had at any time received specialist periodontal treatment or regular treatment from a dental hygienist were excluded. Similarly, patients with no signs of periodontal disease, or with only localized conditions, were not included. Patients who had fewer than 20 teeth were also excluded.

Interview

One-hour interviews were conducted with each subject by one and the same examiner (H. F.). The participants were informed about the nature of the study and were asked to sign an informed consent form. The patients then answered a questionnaire about their general health, oral cleaning habits, use of fluoride, diet and smoking before undergoing a clinical examination. At the end of the visit, patients were advised regarding the need for any treatment.

Salivary sampling

Stimulated whole saliva samples were collected after chewing on a piece of paraffin wax for 5 min. The stimulated salivary secretion rate (SR) was recorded per minute and the salivary buffer capacity (BC) was determined by means of a chair-side test (CRT® Buffer; Vivacare, Schaan, Lichtenstein). Counts of salivary mutans *Streptococci* (MS) and *Lactobacilli* (LB) were determined with dip-slide kits (CRT® Bacteria; Vivacare) for the growth of MS on a mitis-salivarius-bacitracin agar [15] and LB on Rogosa selective LB agar [16]. According to the manufacturer's instructions, $NaHCO_3$ tablets were placed in the test vials in order to release CO_2 when coming into contact with moisture, thereby creating favourable conditions for bacterial growth. The test vials were then incubated for 48 h at 37°C. Counts were determined by comparing the visible colonies with those shown in the attached manufacturer'sguide [17]. For practical reasons, saliva samples were not taken from two patients known to be suffering from infectious diseases.

Clinical examination

Examinations were carried out using an optimal light source, a dental mouth mirror and a graded periodontal probe. Clinical measurements included registration of the plaque index (PI) from six representative teeth [18], marginal gingival bleeding [19], gingival recessions, probing pocket depths and bleeding on probing.

In accordance with the WHO criteria [20], coronal caries was present when a lesion in a pit or fissure or on a smooth tooth surface had an unmistakable cavity, undermined enamel or a detectably softened floor or wall. No differentiation was made regarding caries activity of the lesion. The numbers of teeth with coronal caries (DT) or restorations (FT) were registered. The number of missing teeth was also recorded (MT). Root surface caries was defined as "a cavitation or softened area in the root surface which might or might not involve adjacent enamel or existing restorations" [1]. A root surface was considered to be restored if a filling was strictly confined to the root surface, or if a coronal restoration clearly extended beyond the cemento–enamel junction [8]. The term 'root lesion' was a collective expression indicating the presence of root caries or a filling [8]. In addition, the number of teeth with decayed or filled roots (RDFT) was determined.

A set of periapical radiographs was available for most patients with generalized periodontal conditions. Right and left horizontal bitewing radiographs were taken for each patient. Additional radiographs were taken on a selective basis. Radiographic radiolucent areas on crown or root surfaces were re-checked clinically to confirm or reject a caries diagnosis.

Readings of interproximal radiographic caries in 20% of the sample were assessed on two different occasions for reproducibility; the intra-examiner agreement was 0.86.

Caries risk illustration

Caries risk profiles were obtained by entering the collected data into the Cariogram computer program, i.e. caries experience, systemic condition, number of

daily meals, LB and MS counts, PI, use of fluoride, salivary SR and BC. According to the Cariogram manual, caries experience was determined by approximating the DFT of the current sample to that of a large and recent epidemiological investigation in the same geographical area [21].

An illustrated risk profile of a sample case using the Cariogram is shown in Figures 1 and 2. Case details and additional information about the Cariogram are mentioned in the legends to the Figures.

Data analysis

In order to investigate any correlation between root caries and risk profiles with periodontal disease severity, all individuals were sub-categorized based on clinical and radiographic findings into the following three periodontal disease groups (modifications of Hugoson & Jordan [22]).

Gingivitis group (G). Normal alveolar bone height and >12 bleeding gingival units upon probing in the molar–premolar regions.

Mild-to-moderate periodontitis group (MP). Alveolar bone loss around the majority of the teeth reaching up to two-thirds of the length of the roots, in the presence of generalized bleeding on probing.

Figure 1. Intra-oral frontal view and bitewing radiographs of a 25-year-old female patient with severe periodontitis who is medically healthy, has never smoked and does not have more than three meals a day. Oral hygiene is fair. However, she does not use any fluoride products. Salivary LB counts were moderate, while MS counts were high. Stimulated salivary SR was low and salivary BC was considered to be medium. DFT was 18. Gingival recessions were observed, but no root lesions were recorded.

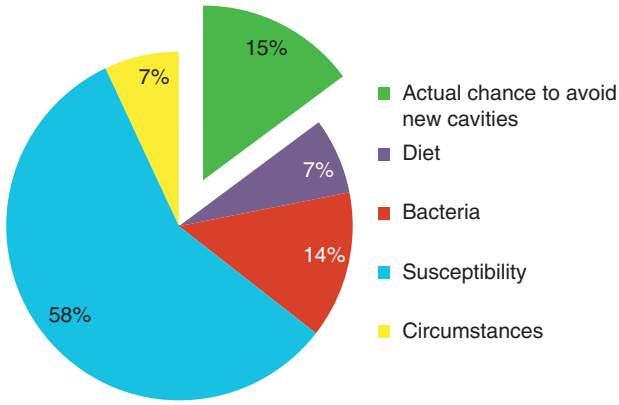

Figure 2. An illustration of the caries risk profile for the severe periodontitis patient shown in Figure 1 produced by the Cariogram suggested a high caries risk (Chance-AC = 15%). The pie chart shown here was generated after entering 10 specific caries risk indicators into the Cariogram computer program. The different coloured sectors represent combinations of the different entered indicators.

Severe periodontitis group (SP). Alveolar bone loss around the majority of the teeth exceeding two-thirds of the length of the roots, in the presence of generalized bleeding on probing.

A power analysis was carried out in order to determine the sufficient number of subjects for the detection of any significant differences between the groups. An assumed significance level of 5%, standard deviation of 2.0, least detectable difference of 1.5 and power for the detection of 80% were applied to the variable 'number of remaining teeth'. This suggested a sample size of ≈30 per group.

A further area of interest was to investigate caries risk indicators in high caries risk individuals from the studied sample. Initially, all individuals were classified according to caries risk into five subgroups: high, high–medium, moderate, low–medium and low risk categories [13,14]. At the time of analysis, a decision was taken to consider all individuals with 'Actual Chance to Avoid New Cavities' (Chance-AC) ≤40% as high-risk individuals, while those with Chance-AC >40% were considered as low-risk individuals. Accordingly, caries risk indicators in the two risk profile subgroups were assessed. In addition, the results for each of the different risk indicators were grouped into two scores instead of what was suggested and initially entered into the Cariogram, i.e. three- or four-scale scores.

ANOVA was used to compare means between periodontal disease groups and patients with high- and low-risk profiles. Categorical variables were analysed by means of Fisher's exact test. Multiple linear regression analysis was used to control for confounders and to assess the significant influence

of specific risk indicators while controlling for the others.

Results

Caries prevalence and periodontal disease severity

A description of the studied sample with regard to age, gender, smoking, number of remaining teeth, number of teeth with recession, coronal/root lesions and allocation of subjects to the different periodontal disease groups is presented in Table I.

The mean number of teeth with coronal lesions (DFT) was 9.1, while the mean number of teeth with root lesions (RDFT) was 0.7. No statistically significant differences were observed between the three groups with regard to DFT or RDFT. The prevalence of coronal lesions was 94% for the total sample, and was almost the same in the three periodontal disease groups. For root lesions in the G, MP and SP groups, the prevalence was 9%, 15% and 29%, respectively. These differences did not reach statistical significance (Table I).

Risk profiles and periodontal disease severity

The percentages of subjects with unfavourable scores in terms of caries risk indicators as entered into the Cariogram, as well as the different caries risk groups according to the Chance-AC, are presented for the total sample and the different periodontal disease groups in Table II. About half of the studied sample (51%) were suffering from one or more systemic conditions and were taking medications for various conditions, such as asthma, hypertension, hypothyroidism and diabetes.

No statistically significant differences were detected between the three groups with regard to the various caries risk indicators, apart from the presence of one or more systemic conditions, where the percentage of subjects with such conditions increased with increasing periodontal disease severity ($P < 0.05$) (Table II). However, when controlling for the confounders age, gender and smoking by means of a multiple linear regression model, the association with periodontal disease severity was no longer significant.

According to the Cariogram, the mean Chance-AC for the 110 patients from whom salivary samples were collected was 63%. For the G, MP and SP groups, the figures were 67%, 64% and 58%, respectively (P = NS). Twenty-two per cent of the total sample (24 patients) demonstrated high caries risk, with ≤40% Chance-AC (Table II).

When comparing patients with Chance-AC ≤40% with the rest of the sample in terms of suggested caries risk indicators, infrequent use of fluoride ($P < 0.0001$), increased plaque amount ($P = 0.0077$), low salivary SR ($P = 0.0064$), low salivary BC ($P = 0.0033$), high counts of salivary LB ($P = 0.0109$) and MS ($P = 0.0059$) and number of remaining teeth ($P = 0.0191$) were statistically significant (Figure 3). All these indicators, apart from plaque amount and number of remaining teeth, retained a significant influence on the increased caries risk among the 24 patients after controlling for other variables by means of regression analysis (Table III).

When expressed collectively as combinations of risk indicators by the Cariogram, all the factors, i.e. diet, bacterial susceptibility ($P < 0.0001$) and circumstances ($P = 0.0008$), were significantly associated with the higher risk of the 24 patients with Chance-AC ≤40%, as compared to the rest of the

Table I. Description of sample characteristics. The results relate to the total sample and the three periodontal disease groups.

Characteristic	G (n = 44)	MP (n = 33)	SP (n = 35)	Total (n = 112)
No. of females/males	10/34	14/19	12/23	36/76
No. of current (or past) smokers	8	8	4	20
Mean (SD) age (years)	25.8 (11)	41.9 (14)	49.7 (10)	38.0 (15)***
Mean (SD) no. of remaining teeth	26.8 (2)	26.7 (2)	24.0 (4)	25.8 (3)***
Mean (SD) no. of decayed teeth (DT)	4.6 (4)	4.3 (4)	3.3 (4)	5.0 (4)
Mean (SD) no. of filled teeth (FT)	4.4 (4)	4.1 (4)	3.7 (4)	4.1 (4)
Mean (SD) no. of teeth with root surface caries (RDT)	0.4 (2)	0.5 (1)	1.1 (2)	0.6 (2)
Mean (SD) no. of teeth with root surface fillings (RFT)	0.1 (0.3)	0 (0.2)	0.1 (1)	0.1 (0.4)
Mean (SD) Actual Chance to Avoid New Cavities (%)[a]	67 (23)	64 (27)	58 (25)	63 (25)
Prevalence (%) of coronal lesions (caries and/or fillings)	93	94	94	94
Prevalence (%) of gingival recession	23	55	71	43***
Prevalence (%) of root lesions (caries and/or fillings)	9	15	29	17

[a]The valid percentage is listed, with n = 43 for the G group, 32 for the MP group and 110 for the total sample.
***$P < 0.0001$.

Table II. Percentages of subjects relating to the different caries risk indicators and the five caries risk categories. The results relate to the total sample and the three periodontal disease groups.

	G (n = 44) (%)[a]	MP (n = 33) (%)[a]	SP (n = 35) (%)	Total (n = 112) (%)[a]
Coronal caries status (experience):				
Worse than normal for age group (Cariogram score 3)	84	85	88	86
Medical status:				
One or more systemic condition(s) and multiple medications (Cariogram scores 1&2)	36	55	66	51*
Diet content (*Lactobacilli* counts; CFU/ml):				
$>10^4$ (high) (Cariogram scores 2&3)	16	16	14	15
Diet frequency (no. of meals/day):				
>5 (Cariogram scores 2&3)	2	0	3	2
Plaque amount (oral hygiene; PI):				
Poor (Cariogram scores 2&3)	16	15	26	19
Mutans *Streptococci* counts (CFU/ml):				
$>10^4$ (high) (Cariogram scores 2&3)	23	16	11	18
Fluoride programme:				
Not using any fluoride products (Cariogram score 3)	11	21	29	20
Salivary secretion rate (ml/min):				
Low[b] (Cariogram scores 1–3)	19	25	29	24
Buffer capacity (pH):				
≤5.5 (inadequate) (Cariogram scores 1&2)	14	28	37	27
Actual Chance to Avoid New Cavities (%):				
0–20 (high caries risk)	0	12	8	6
21–40 (high–medium)	16	13	17	16
41–60 (moderate)	19	9	29	19
61–80 (low–medium)	21	25	20	22
81–100 (low)	44	41	26	37

[a]In results related to salivary sampling parameters and Actual Chance to Avoid New Cavities, the valid percentage is listed, with $n = 43$ for the G group, 32 for the MP group and 110 for the total sample.
[b]Salivary secretion rate is considered 'low' when it is <0.7 ml/min for children/adolescents and <1.1 ml/min for adults.
*$P < 0.05$.
CFU = colony-forming units.

sample (see Figure 4 for details on combination factors).

Discussion

In this study, the prevalence of root lesions was 17%, with no significant difference between the three periodontal disease groups. Although the prevalence reached as high as 29% in the SP group, this is still in contrast to much higher figures reported from other periodontal disease populations prior to periodontal treatment, which varied between 58% and 87% [1–4]. One possible explanation may be related to differences in fluoride habits and supplemental fluoride sources in the different populations examined, since 25 of the 35 severe periodontitis patients from the present sample regularly used fluoride toothpaste on a daily basis. In addition, the different regions in Saudi Arabia where the study was conducted have previously demonstrated extremes in terms of drinking-water fluoride levels [23–25] and, as both clinics from the current investigation are regarded as tertiary referral centres, it can only be speculated that some of the patients may have come from neighbouring areas with relatively high water-fluoride concentrations and consequently displayed a lower prevalence of root lesions. A third explanation may be the initial exclusion of patients with fewer than 20 teeth from the current investigation, who may also have exhibited root lesions in their remaining teeth.

No significant differences in caries risk as suggested by the Cariogram were observed between the three periodontal disease groups. In patients with Chance-AC ≤40% (n = 24), the infrequent use of fluoride, increased number of daily meals, low salivary SR, low BC and high counts of LB and MS were the most significant risk indicators. This is in contrast to the

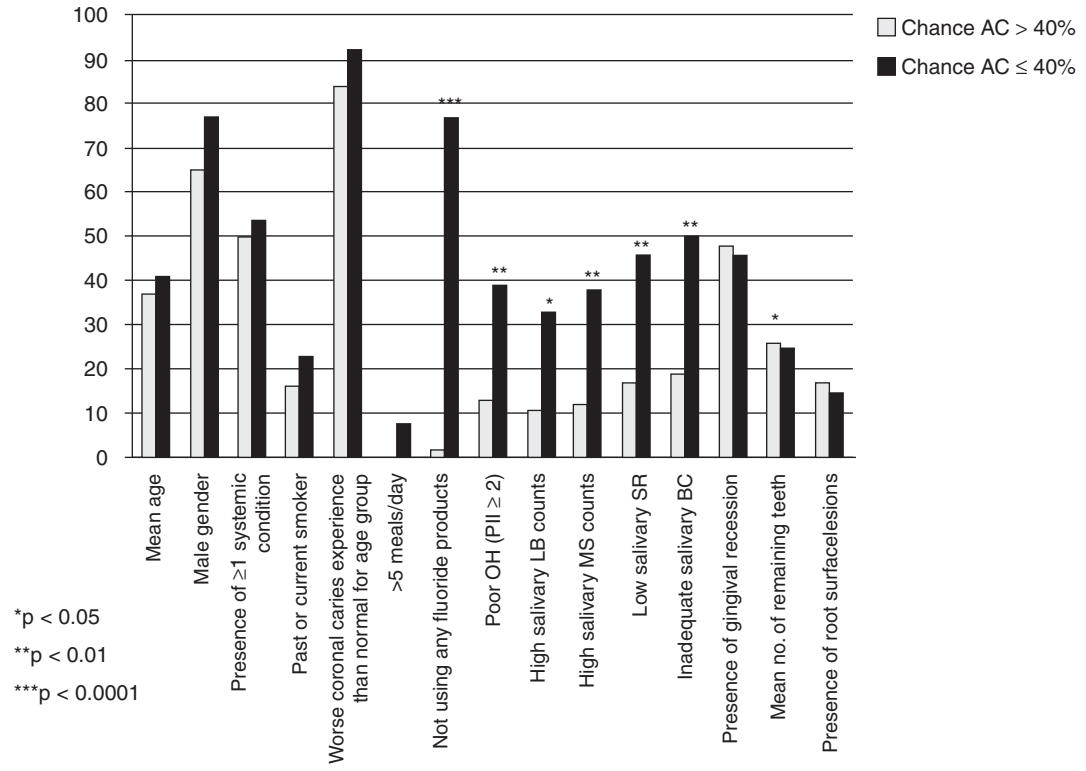

Figure 3. Bar chart representing the influence of the suggested caries risk indicators in the high-risk group (Chance-AC ≤40%; *n*=24) compared with the rest of the sample.

findings of Ravald et al. [11], who demonstrated that past root caries experience had the greatest impact on the incidence of root lesions, in addition to the other risk factors. An important fact that may in part explain these differences, in addition to the different populations studied and risk assessment tools utilized, is the cross-sectional nature of the present investigation, which does not allow for an appropriate comparison with the longitudinal study of Ravald et al. [11].

In the present study, the association of different risk indicators and the risk profiles increased when they were combined rather than when they were viewed separately. Combinations of parameters are represented by the different coloured sectors in the Cariogram. One interesting example is the non-significant individual effect of past coronal caries experience ($P = 0.3529$) and the presence of a systemic health condition ($P = 0.8242$) (Figure 3). When combined (expressed as 'Circumstances Factor'), the effect was statistically significant ($P < 0.001$) (Figure 4). This observation is in line with the

Table III. The significant influence of the suggested caries risk indicators in the high-risk group (Chance-AC ≤40%; $n = 24$) after controlling for the other risk indicators and the confounders age, gender and smoking by means of multiple linear regression analysis.

Suggested caries risk indicator	Contribution to overall risk (*P*-value)
Not using any fluoride products	<0.0001
Poor oral hygiene (PI ≥2)	0.2363*
Salivary LB counts $>10^4$ CFU/ml	<0.0001
Salivary MS counts $>10^4$ CFU/ml	<0.0001
Low SR	<0.0001
BC (pH) ≤5.5	<0.0001
Number of remaining teeth	0.3514*

*P = NS.
CFU = colony-forming units.

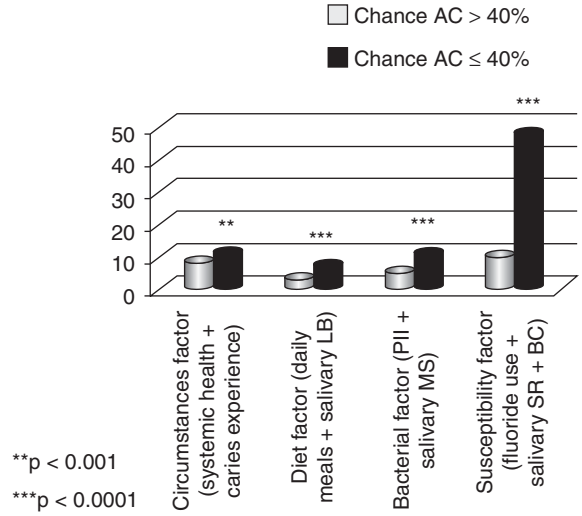

Figure 4. Bar chart representing the combined influence of the suggested caries risk indicators in the high-risk group (Chance-AC ≤40%; $n = 24$), displayed by the different sectors in the Cariogram, compared with the rest of the sample.

generally adopted opinion that a combination of variables with unfavourable values increases the possibility of the future development of dental caries, rather than the presence of a single variable alone [11].

To conclude, root surface lesions lesions and high caries risk were observed in about one-fifth of the untreated patients with periodontal disease. A combination of risk indicators rather than a single one influenced these observations. Severity of periodontal disease was not significantly associated with prevalence of coronal or root lesions, or with the 'Actual Chance to Avoid New Cavities' according to the Cariogram. The Cariogram may be a useful tool to illustrate caries risk profiles in periodontal disease patients. Caries prevention programs can be formulated based on such profiles during the course of periodontal therapy, irrespective of periodontal disease severity. However, further long-term validation of the Cariogram in patients with periodontal disease is needed.

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