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Risk profile and quality of dental restorations: A cross-sectional study

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Abstract

Objectives. The aims of the present study were (1) to evaluate the percentage of recurrent caries with respect to the estimated caries risk profile obtained with a Cariogram, (2) to evaluate the quality of restorations in a Saudi population with several restorations and (3) to determine the additional value of bite-wing radiographs as an aid to quality evaluation. ***Material and methods.*** A total of 803 restorations were examined in 100 adults according to the United States Public Health Service/Ryge criteria. Salivary and microbiological factors, dietary habits and plaque index were investigated. The Cariogram was used to evaluate the risk profiles. Class II bite-wing radiographs ($n = 281$) were taken to examine the marginal integrity and the anatomic form proximally. ***Results.*** The patients were categorized according to 'the chance of avoiding caries' into three risk groups: 0%–20% (n = 38), 21%–40% (n = 28) and 41%–100% (n = 34). ANOVA revealed statistically significant differences between the risk groups with respect to the recurrent caries ($P < 0.05$). A high percentage of the total restorations (56%) were diagnosed with recurrent caries. The quality of anatomic form and surface texture was unacceptable in the majority of cases. After adding the evaluations of class II bite-wings, the percentage of unacceptable restorations increased by 28% and 17% with regard to marginal integrity and anatomic form, respectively ($P < 0.001$). ***Conclusions.*** Recurrent caries was related to the percentage 'chance of avoiding caries' as estimated by the Cariogram. The importance of bite-wings was emphasized as an aid to quality evaluation.

Key Words: *Cariogram, dental restorations, quality evaluation, recurrent caries, Saudi Arabia*

Introduction

The approach of 'extension for prevention' as a means of caries management has been the cornerstone of 20th century dentistry. This approach is still being utilized by dentists, in both developed and developing countries. Unfortunately, this restorative approach has neither prevented caries nor addressed the complexity of restorative challenge. Several studies have demonstrated that restorations have a limited lifespan and that, once the tooth is restored, the restoration is likely to be replaced many times [1,2]. This may lead to repetitive restorative cycles with larger restorations, weaker teeth and an increased risk of more advanced treatment [2].

The success or failure of dental restorations in everyday clinical practice relies on several factors related to the dentist, the patient and the type of dental restoration used [3]. However, a number of studies have reported that recurrent caries is the most common reason for the replacement of amalgam, composite resin and glass ionomers [4–6]. Furthermore, placing a restoration does not reduce caries increment [7].

The population in the present study had been treated for caries with several dental restorations in the past. Our hypothesis was that the percentage of recurrent caries might be related to the population caries risk estimated by the Cariogram.

The aims of the present survey were: (1) to evaluate the percentage of recurrent caries with respect to the estimated caries risk profile obtained by the Cariogram, expressed as the 'chance of avoiding caries', (2) to evaluate the quality of dental restorations in an adult Saudi population with several dental restorations using the United States Public Health Service (USPHS)/Ryge criteria and (3) to determine the additional value of bite-wing radiographs as an aid to the quality evaluation of restorations.

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Material and methods

Study population

All adult patients visiting the Emergency Dental Clinic at the Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia from February to May 2006 were screened clinically for certain criteria. The inclusion criteria were (1) at least 20 teeth present, (2) a minimum of seven teeth with dental restorations (amalgams, composites, glass ionomers or crowns) and (3) being willing to participate in the study. One hundred patients [38 males, 62 females; mean (SD) age 29 (8.8) years] fulfilled the three inclusion criteria and were included in the study. Informed consent was obtained prior to the start of the examination and the local ethics committee approved the study (code number 29/1/1419).

Caries risk profile (Cariogram)

The main purpose of the Cariogram is to demonstrate the risk of caries graphically, expressed as the 'chance of avoiding new caries' in the near future [8–10]. It also illustrates the extent to which various caries-related factors affect this 'chance'. There are 10 factors that are relevant to caries in this model: (1) caries experience, (2) related diseases, (3) salivary flow rate, (4) salivary buffer capacity, (5) amount of plaque, (6) diet frequency, (7) diet content, (8) mutans Streptococcus count, (9) fluoride program and (10) clinical judgment. Since all the patients involved in the present study had several restorations (≥ 7), the 'caries experience' factor was given a score of 3, which represents 'worse status than normal for age group'. The 'clinical judgment'" factor was given a score of 1, which means that the risk will be evaluated according to the other values entered. All the data are entered according to predetermined scales. As a result, each patient has a pie chart with five colored sectors that represent (as percentages) the impact of various risk factors related to caries. The green sector represents the patient's estimated percentage 'chance of avoiding caries', which was used for the analysis in this study. The total population was categorized into three risk groups according to the percentage "chance of avoiding caries", as follows: 0–20%, 21–40% and 41–100%. The number of patients in each group was 38, 28 and 34, respectively. The following data were obtained for the Cariogram evaluation.

Questionnaire. All the patients were interviewed using a standardized structured questionnaire to elicit information on medical and dental history, dietary habits and the use of fluoride.

Plaque index. Before the professional cleaning and saliva sampling, the plaque index was recorded [11]. Four tooth surfaces were examined on the following teeth: 16, 12, 24, 36, 32 and 44.

Salivary and microbiological factors. Paraffin-stimulated whole saliva was collected and the secretion rate was expressed in milliliters per minute. A chair-side test (CRT Bacteria®; Ivoclar-Vivadent, Schaan, Liechtenstein) was used to evaluate mutans *Streptococcus* (MS) and *Lactobacillus* (LB) counts. The MS and LB counts were categorized into four classes according to the model chart provided. According to the Cariogram, the LB score is used for 'diet content' [12,13]. The buffer capacity of the stimulated saliva was determined using CRT Buffer® (Ivoclar-Vivadent). Three colors were obtained: (1) blue (pH >5.5), (2) green (pH 5.5–4.5) and (3) yellow (pH <4.5) [14].

Quality evaluation of restorations (clinical and radiographic)

The clinical examination was carried out by one of the authors (H. S.) in a dental chair under optimal light, using magnification glasses ($2.5\times$), an explorer and a dental mirror. Before the quality evaluation, the teeth were cleaned with a rubber cup and pumice, flossed and dried with compressed air. In all, 803 restorations were evaluated clinically, according to USPHS/Ryge criteria [15]. In the present study, some of the criteria were modified: the color of the margin was not evaluated and the surface texture and anatomic form were evaluated separately [16]. Each restoration was therefore evaluated in terms of the following criteria: (1) presence of recurrent caries, (2) marginal integrity, (3) anatomic form, (4) surface texture and (5) color match (Table I). Only frank carious lesions and/or decalcification at the margin of the restoration were registered and marginal staining was excluded. Each criterion was graded as A or B if clinically 'acceptable', and as C or D if 'unacceptable'. Only A, B, or C ratings were used for recurrent caries. Fifty-six of the 803 restorations were re-evaluated after 2 weeks; the kappa value was 0.89.

Bite-wing radiographs were taken to evaluate the proximal part of class II restorations with respect to (1) marginal integrity at the gingival wall, in which the presence or absence of 'radiolucency' was recorded, and (2) anatomic form, in which under-contour or over-hang restorations were identified. The radiographs were examined by one of the authors (H. S.) using a magnifying viewer and a light desk. In all the patients, the bite-wings were taken at the same time as the clinical examination. However, the radiograph evaluation was carried out approximately 4–6 months later. Furthermore, marginal integrity

Table I. The modified USPHS/Ryge criteria used for quality evaluation of the restorations. A = the restoration is of satisfactory quality and is expected to protect the tooth, B = the restoration is of acceptable quality but exhibits one or more features which deviate from the ideal, C = the restoration is of unacceptable quality and future damage to the tooth and/or the surrounding tissue is likely to occur, D = damage to the tooth and/or its surrounding is now occurring.

Criterion	Rating	Clinical evaluation criteria
Recurrent caries	A	No caries contiguous with the restoration.
	B	Evidence of decalcification contiguous with the restoration.
	C	Caries contiguous with the restoration, loss of tooth substance.
Marginal integrity	A	No visible evidence of ditching along the margin.
	B	Visible evidence of ditching along the margin, in which the explorer will penetrate or catch.
	C	Visible evidence of ditching along the margin, in which the explorer will penetrate; the dentin is exposed.
	D	Bottom of the cavity exposed. The restoration is movable or fractured or tooth structure fractured.
Anatomic form	A	The restoration is continuous with existing anatomic form (restores contours, cusps, planes, marginal ridges, and proximal contact).
	B	The restoration slightly under- or over-contoured or slightly deviated from normal or functional anatomy, or the material is not sufficient to expose dentin; neglectable or easily adjusted.
	C	The restoration is under- or over-contoured severely, sufficient material is lost to expose dentin, or some deviation from normal and/or functional anatomy; cannot be adjusted.
	D	Restoration is partially or totally missing.
Surface texture	A	Surface restoration is smooth.
	B	Surface restoration is slightly rough or pitted; can be refinished.
	C	Surface restoration is deeply pitted; cannot be refinished.
	D	Surface is flaking or there is fracture on the surface of the restoration.
Color match	A	No mismatch in color between restoration and adjacent tooth structure.
	B	Slight mismatch in color within the normal range of adjacent tooth structure.
	C	Mismatch in color outside the normal range of adjacent tooth structure.
	D	Severe mismatch in color, esthetically displeasing color.

and anatomic form were evaluated clinically alone and in addition to bite-wings.

Statistical analysis

All the data were analyzed using the SPSS statistical package (version 16.0; SPSS Inc., Chicago, IL, USA). The frequency distribution and the percentage of the quality ratings for the 803 restorations were calculated. The percentage of recurrent caries was obtained by dividing the number of restorations diagnosed with recurrent caries by the total number of restorations per patient. ANOVA was used to compare the mean percentage of recurrent caries between the risk groups. When evaluating the difference between clinical judgment alone and in addition to radiographs, the restoration was regarded as a unit and a paired Z-test was used. A power analysis with an assumed significance level of 1%, a standard deviation of 0.5 and a power of 80% to detect a difference of at least 0.15 was performed; a sample size of 260 paired observations was obtained. The level of significance was considered as $P < 0.05$.

Results

Figure 1 shows a bar chart of the mean percentage of recurrent caries for the three risk groups; the lower the likelihood of new caries being avoided in the near future, the higher the percentage of recurrent caries ($P < 0.05$). In the total study population, the mean (SD) percentage 'chance of avoiding caries' was 30.9% (19.41%).

The distributions of the quality rating according to USPHS/Ryge criteria are shown in Table II. The percentage distribution between ratings A, B, C and D was different for amalgam, composite and glass ionomer. Composite restorations had lower percentages of C and D ratings than amalgam and glass ionomer, with regard to anatomic form (25% +6% = 31%) and surface texture (17%+6% = 23%).

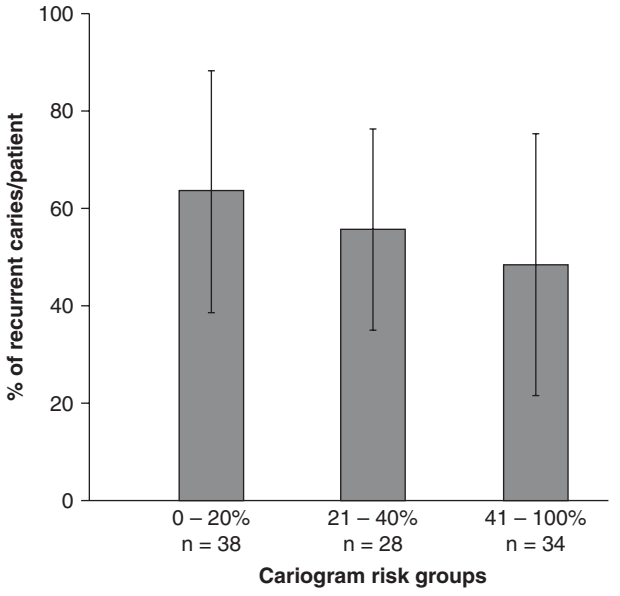

Figure 1. Bar chart representing the mean (SD) percentage of recurrent caries in the risk groups according to the Cariogram outcome.

The majority of glass ionomer restorations (76%) were diagnosed with recurrent caries (scores B and C). Regardless of the type of restoration, recurrent caries was diagnosed in 56% of the total restorations. The anatomic form and surface texture showed high percentages of unacceptable restorations (47% and 44%, respectively) while the marginal integrity was 26%.

Table III shows the frequency distribution and percentage of class II restorations (n = 281) in terms of marginal integrity and anatomic form, both clinically and radiographically. In overall terms, gingival marginal 'radiolucency' was detected in 125 (44%) of the class II restorations, while 101 (36%) had under/over-contour proximally. The frequency of clinically unacceptable restorations was 102 (36%) and 174 (62%) with regard to marginal integrity and anatomic form, respectively. However, when the bite-wing evaluation was added, the corresponding values increased to 180 (64%) and 221 (79%), respectively ($P < 0.001$) (data not shown).

Table II. Evaluation ratings of all 803 restorations according to the criteria described in Table I. Values are given as numbers of restorations, with percentages in parentheses.

Criterion/rating	Amalgam	Composite	Glass ionomer	Total
Recurrent caries				
A	98 (39)	220 (52)	32 (24)	350 (44)
B	74 (30)	119 (28)	37 (28)	230 (28)
C	77 (31)	83 (20)	63 (48)	223 (28)
Marginal integrity				
A	49 (20)	195 (46)	26 (20)	270 (34)
B	116 (47)	155 (37)	50 (38)	321 (40)
C	63 (25)	63 (15)	30 (23)	156 (19)
D	21 (8)	9 (2)	26 (20)	56 (7)
Anatomic form				
A	14 (6)	55 (13)	0 (0)	69 (8)
B	97 (39)	237 (56)	23 (17)	357 (45)
C	111 (45)	104 (25)	76 (58)	291 (36)
D	27 (11)	26 (6)	33 (25)	86 (11)
Surface texture				
A	5 (2)	63 (15)	2 (2)	70 (9)
B	75 (30)	263 (62)	38 (29)	376 (47)
C	124 (50)	73 (17)	51 (39)	248 (31)
D	45 (18)	23 (6)	41 (31)	109 (13)
Color match				
A		151(36)	0 (0)	151 (27)
B		189 (45)	7 (5)	196 (36)
C		63 (15)	65 (49)	128 (23)
D		19 (4)	60 (46)	79 (14)
Total	249	422	132	803

Table III. Frequency distribution of the 281 class II restorations, with regard to marginal integrity and anatomic form at both clinical and radiographic examinations. The data are presented as the number of restorations, with percentages in parentheses.

	Marginal integrity				Anatomic form			
	Clinical		Radiographic		Clinical		Radiographic	
Type of restoration	Acceptable	Un-acceptable	No-gingival radiolucency	Gingival radiolucency	Acceptable	Un-acceptable	Acceptable contour	Under/over contour
Amalgam (*N* = 110)	64 (58)	46 (42)	67 (61)	43 (39)	37 (34)	73 (66)	70 (64)	40 (36)
Composite (*N* = 112)	86 (77)	26 (23)	63 (56)	49 (44)	64 (57)	48 (43)	71 (63)	41 (37)
Glass ionomer (*N* = 59)	29 (49)	30 (51)	26 (44)	33 (56)	6 (10)	53 (90)	39 (66)	20 (34)
Total	179	102	156	125	107	174	180	101

Discussion

One important outcome of our study is that the lower the likelihood of new caries being avoided in the near future, the higher the percentage of recurrent caries. Regardless of the restoration material, recurrent caries was diagnosed in more than half the total restorations. Such a high percentage might indicate that these restorations were initially placed without any attempt to evaluate the patient's caries risk. Apparently, these restorations will be replaced for the same reason in the future. Mjör [6] reported that 50% of restorations in adults were replaced because of recurrent caries. In Saudi Arabia, where the caries prevalence has been reported to be high, the DFS has increased significantly in the past decade, in both primary and permanent teeth, in rural and urban areas [17–19]. The lack of preventive programs and the belief that placing restorations represents the definitive management of dental caries might be the reason for the observed high DFS. One recent study [20] has demonstrated that the likelihood of restoration failure due to caries could be improved in the long term by changing the level of overall caries risk factors. Consequently, the management of caries needs to be based on the patient's risk of developing caries in order to be most health- and cost-effective [21]. In this context, the Cariogram could be of great benefit in daily clinical work when it comes to evaluating the patient's caries profile and identifying the risk factors promoting caries development. This would preserve the tooth structure, increase the longevity of restorations and interrupt the restoration/replacement cycle due to caries.

In this context, it is important to emphasize that the high caries experience score of the studied population does not influence the resultant percentage 'chance of avoiding caries'. In the Cariogram, the caries experience factor is regarded as a risk marker that might indicate the increased probability of new caries, but it is not a part of the causal chain that lead to caries development. It therefore has far less weight than the other risk factors in the built-in algorithm [10]. This is probably due to the fact that the Cariogram model was originally developed to predict future caries lesions. This is in agreement with an earlier study of the same population, in which all the risk factors included in the Cariogram were discussed [22].

According to the present survey, the anatomic form and surface texture showed a high percentage of unacceptable restorations. However, composite restorations obtained more acceptable ratings for these two criteria than amalgam and glass ionomer. This is probably because the light-cured composite restoration can be adjusted and polished on the same day it is placed, in contrast to glass ionomer and amalgam. Moreover, glass ionomer restorations

showed the most unacceptable quality ratings in overall terms compared with amalgam and composite, particularly in class II restorations. Mjör et al. [23] reported that poor anatomic form was the primary reason for the failure of glass ionomer restorations, which confirms the present data. One interesting finding of our study is that the majority of glass ionomer restorations were diagnosed with recurrent caries, in spite of the release of fluoride *in vivo* [4,24]. For this reason, the fluoride-releasing property of glass ionomer should not be relied upon as a means of preventing caries, while ignoring other caries-related factors.

Bite-wing radiographs as an aid to clinical quality evaluation may be of value in class II restorations. In the present study, the unacceptable ratings for marginal integrity and anatomic form increased by 28% and 17%, respectively when restorations were evaluated in addition to bite-wing radiographs. The presence of radiolucency and/or failed anatomic form at the gingival wall of class II restorations is unlikely to be detected by clinical examination alone. However, the clinical interpretation of this radiolucency could be crucial. For example, it could be due to the failure of proper condensation with an amalgam, while, in a composite, a thick layer of adhesive could appear to be radiolucent in a radiograph, or it could be due to a recurrent caries lesion that was not observed in a clinical evaluation alone. Regardless of the cause, this 'radiolucency' is regarded as a potential factor for developing future caries, particularly in high-risk patients. Mjör [6] reported that the gingival wall in class II restorations is the most common site of recurrent caries. Furthermore, proximal overhangs, even minute ones, are predisposed to plaque accumulation and the development of recurrent caries [6,25]. A variety of studies have used bite-wing radiographs in the quality evaluation of restorations and their extra diagnostic value was emphasized [26–28]. The information from bite-wings could therefore refine the clinical quality evaluation of the restorations.

In conclusion, recurrent caries was related to the percentage 'chance of avoiding caries' estimated by the Cariogram. The main reason for the unacceptable rating for restorations was recurrent caries. As a result, pursuing caries risk assessments and thereby modifying the risk factors accordingly should be a rule of thumb in daily practice, particularly in a population with high caries prevalence, such as that of Saudi Arabia. The Cariogram could be a suitable model for risk-profile assessment in the dental clinic. In a high percentage of restorations, the quality of anatomic form and surface texture was unacceptable. The bite-wing radiograph was found to be an important aid when evaluating marginal integrity and anatomic form proximally.

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