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Original Article

Caries Risk Assessment in Adults Using the Cariogram

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Abstract

Introduction: This study identifies the caries risk in adult patients using the Swedish software product Cariogram. Early detection and timely management of risk factors for caries development are crucial for its prevention and non-operative preventative treatment.

Aim: To identify patients at high risk for caries and implement a prophylactic program aimed at the individual patient based on the assessment of the individual risk factors.

Materials and methods: The study included 59 women and 41 men aged 19–65 years. A detailed medical history was obtained from all patients who underwent thorough clinical examination, evaluation of saliva with Saliva-Check Buffer (GC) test and of *Streptococcus mutans* and *Lactobacillus* levels using the CRT Bacteria kit (Ivoclar Vivadent AG products), and assessment of the caries risk using the Cariogram software.

Results: The results showed that the most important risk factors were as follows: DMFT, (r_s [100] = 0.358, p<0.001), levels of *Lactobacilli* (r_s [100] = 0.321, p<0.001), levels of *Streptococcus mutans* (r_s [100] = 0.302, p<0.05), plaque amount (rs [100] = 0.291, p<0.05), food intake frequency (r_s [100] = 0.252, p<0.05), and diet content (r_s [100] = 0.220, p<0.05). Insignificant correlation coefficients in risk assessment were shown by the application of fluorides (r_s [100] = 0.114, p>0.05), saliva rate (r_s [100] = 0.018, p>0.05), and saliva buffer capacity (r_s [100] = 0.144, p>0.05).

Conclusions: Cariogram is a very useful method in clinical practice for evaluation of the caries risk and its preventive, non-operative management.

Keywords

caries risk factors, Cariogram, elderly, software risk evaluating, tooth decay

INTRODUCTION

Caries risk assessment has been the most successful strategy to control this dental disease for the last two decades. It is the basis for the creation of prevention programs by accurately determining the individual risk factors and the degree of risk of developing caries in each patient.

Dental caries is a multifactorial disease and as such it depends on various factors such as patient's general health, diet, the oral microbiome, saliva characteristics, and other local and general factors. Each individual has a different risk profile, and it is important that those with the highest caries risk are identified as early as possible.[1]

Caries risk assessment has great potential for improving preventative patient care and is the cornerstone of a minimally invasive treatment plan.[2]

It is crucial that we identify early the relevant factors affecting adult individuals that can increase the risk of developing caries. Two different approaches have been described for caries risk assessment models: the risk model and the prediction model.[3-6] The risk model evaluates the factors responsible for the development of caries, called risk factors. The prediction model estimates the risk of caries progression in the future.

Cariogram is an interactive computer program for caries risk assessment, based on nine different caries-related risk factors showing the "real chance of avoiding new caries", conceptualized by Bratthal[7] in 1997. The aim of Cariogram is to identify patients at high risk for caries and to provide for them appropriate preventative and treatment measures to stop the disease.[8,9] The program has been used in several countries and has demonstrated relatively high efficacy, good reliability and offers short recommendations to prevent the developing of caries in the near future.[10-12] It has been the subject of studies for caries prediction.[13-15] They show that the program predicts caries progression more accurately than any single factor model.[16]

Cariogram is used to predict caries mainly in children and adolescents, and the scientific evidence of its effectiveness in predicting caries is still disputed.[1,17,18] There are studies reporting a high predictive value of caries risk levels with Cariogram, while other studies find no relationship between the risk for caries and the factors included in this program. Although extensive studies have been conducted to evaluate the risk of caries in children, there is limited data on the risk assessment in adult patients.[19,20]

The lack of such data explains why dental practitioners have difficulties in applying models to assess the risk of dental caries in the adult population. The use of Cariogram in this population may be useful for evaluating the caries-related risk behaviours and for enhancing patient motivation.[7]

AIM

The aim of the study was to evaluate the risk of caries in adult patients using the Cariogram program and to investigate the impact of the risk factors on the development of caries included in the Cariogram model.

MATERIALS AND METHODS

One hundred participants (59 women and 41 men, aged 19–65 years) were recruited in the study. A detailed medical history was obtained from all patients. They underwent a thorough clinical examination, evaluation of the saliva with Saliva-Check Buffer (GC) test and of *Streptococcus mutans* and *Lactobacillus* levels using the CRT Bacteria kit (Ivoclar Vivadent AG products), and assessment of the caries risk using the Cariogram software.

The information for the overall health, diet, frequency of meals, and administration of fluorides was obtained from the medical history we took of every patient.

The clinical study included determination of the dental status using the D1MFT index (Klein & Palmer & Knutson) and the application of the International Caries Detection and Assessment System (ICDAS II) with registration of the earliest enamel caries lesions.

The level of oral hygiene was assessed using the simplified oral hygiene index of Greene & Vermillion – OHI-S (Simplified – 1964) and the GC Plaque Indicator test. The index is taken from the vestibular surface of teeth 16, 11, 24, 31 and the lingual surface of teeth 36 and 46.

The rate of salivary secretion, the number of *Streptococcus mutans* (SM) and *Lactobacilli* (LB) were determined by taking saliva samples. On the day of the study, participants consumed no food and liquids one hour before saliva sample collection. Salivation of the patient was stimulated with a sugar-free wax, which was chewed for 30 seconds. After that the patient collected saliva for 5 minutes in a sterile container graduated in millilitres (0 to 5 ml). The salivary secretion rate was registered in millilitres per minute (ml/min). The amount of saliva collected over this period of 5 minutes was recorded. According to the results obtained, determined by the manufacturer of the test, the salivary flow of the patient can be defined as normal if it is greater than 5 ml/5 min (1 ml/min), as slightly reduced if it is in the range from 5.0 to 3.5 ml/5 min (0.7 ml/min.), or weak if it is less than 3.5 ml/5 min (<0.7 ml/min).

Saliva pH was assessed using a litmus test strip (pH test strips) placed in the saliva from the container for 10 seconds, and the color of the test strip was compared with the samples of the scale provided by the manufacturer. The results were evaluated according to a table from 1 to 3: green color – normal saliva (pH 6.8–7.8); yellow color – acid saliva (pH 6.0–6.6); red color – very acidic saliva (pH 5.0–5.8).

Saliva's consistency was categorized as either watery or frothy or viscous saliva.

Saliva buffer capacity test was performed by pipetting from the collected saliva on the three fields of buffer capacity test strips. The test was inverted at 90° and after 2 minutes the color change of each field was scored, which was marked by a certain number of points, shown in the description of the test methodology: blue (green) – 4 points; gray-blue (green) – 3 points; bluish – 2 points; red – blue – 1 point; red – 0 points.

The assessment of cariesogenic microflora was evaluated by the Vivadent CRT test – CRT Bacteria kit (Ivoclar Vivadent AG products) for determination of *S. mutans* and *Lactobacillus spp.* levels. The test was used in patients with a higher risk of dental caries, but as required to work with Cariogram, it needs to be performed. Following the instructions for using the CRT test we cultivated the samples for 48-72 hours in a thermostat at 38°C **(Fig. 1)**.

Figure 1. Thermostat for saliva samplings.

The number of colonies was counted and the microbial number was determined. The bacterial count was measured according to the standard CRT Bacteria kit chart. The number of colony units per milliliter (CFU/ml) of saliva formed was categorized into four levels according to the table provided by the manufacturer. According to the CRT, scores of 0 to 3 indicate an MS level of $<10^4$, 10^4-10^5; 10^5-10^6, and $>10^6$, respectively, and for a LB level of 1 to 4 means level of $<10^4$; equal to or greater than 10^4; equal to or greater than 10^5 and $> 10^6$, respectively **(Fig. 2)**.

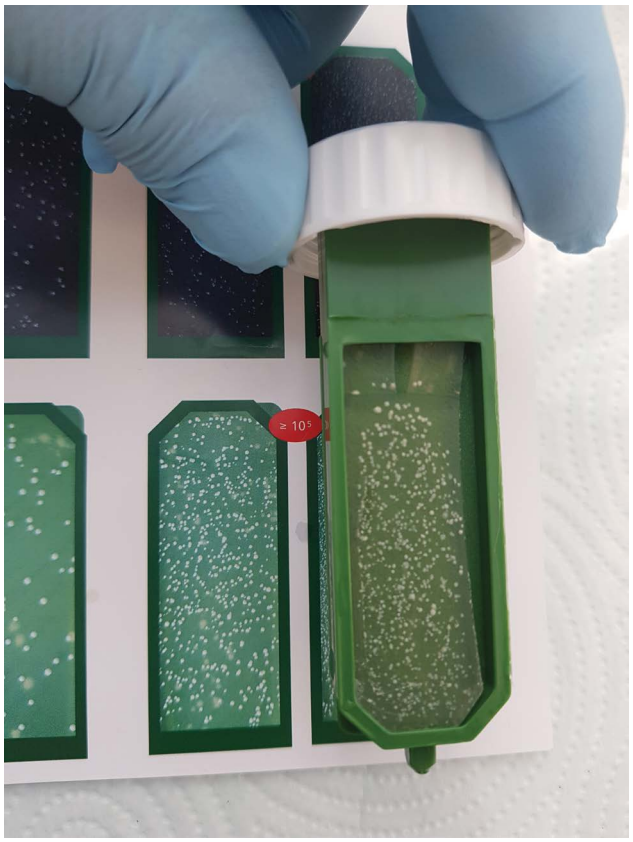

Figure 2. Colonies of salivary *Lactobacilli*.

Caries-risk profile

A caries risk profile of each individual was obtained using the Cariogram program. The original Cariogram employs 10 different parameters: (1) caries experience, (2) related diseases, (3) degree of saliva secretion, (4) saliva buffer capacity, (5) plaque amount, (6) diet frequency, (7) diet contents (LB count), (8) SM amount, (9) fluoride program, and (10) clinical evaluation. Nine parameters that were directly relevant to caries were used in the study (clinical evaluation was fixed at 1).

Cariogram calculates the data and presents the result in a pie chart illustrating the 'chance of avoiding caries' in the future. The sectors of the chart were as follows: "Bacteria" (amount of plaque and SM), "Diet" (*Lactobacilli* level and frequency of meals), "Susceptibility" (fluoride intake, saliva secretion and saliva buffer capacity) and "Circumstances" (previous caries experience and medical history). The participants were classified into five groups: very low risk: 81–100% chance of avoiding caries, low risk: 61–80% chance of avoiding caries, medium risk: 41–60% chance of avoiding caries, high risk: 21–40% chance of avoiding caries, very high risk: 0–20% chance of avoiding caries. In this study, each participant was classified as belonging to a group with low (0–33), medium (34–66), or high caries risk (> 67). Each participant in the study group was provided with a visual presentation and detailed information about the risk factors for caries according to the Cariogram. They were motivated for regular and careful oral hygiene and consulted on the carbohydrate diet.

Statistical analysis

The obtained data were exported to SPSS vers.19.0 for Windows (SPSS, Chicago, IL, USA) and statistically analyzed using descriptive statistics and Spearman-Brown correlations analyses.

RESULTS

The data received for each participant were entered into the Cariogram software which generated a colour-coded pie chart for each individual with red representing the relative share of bacteria, purple representing diet, light blue – susceptibility, yellow – circumstances, and the green sector showing an estimation of the chance of avoiding caries **(Fig. 3)**.

After completing the forms and summarizing the results for all variables, each participant was classified into a group with low (0–33), medium (34–66), or high caries risk (> 67) **(Fig. 4)**.

The average caries risk percentage based on the Cariogram model of all study participants is given in **Fig. 5**. The largest sector in the average caries risk profile is the caries "susceptibility" (16.24%), followed by the food sector (11.64%), bacteria (10.42%), and circumstances (6.14%).

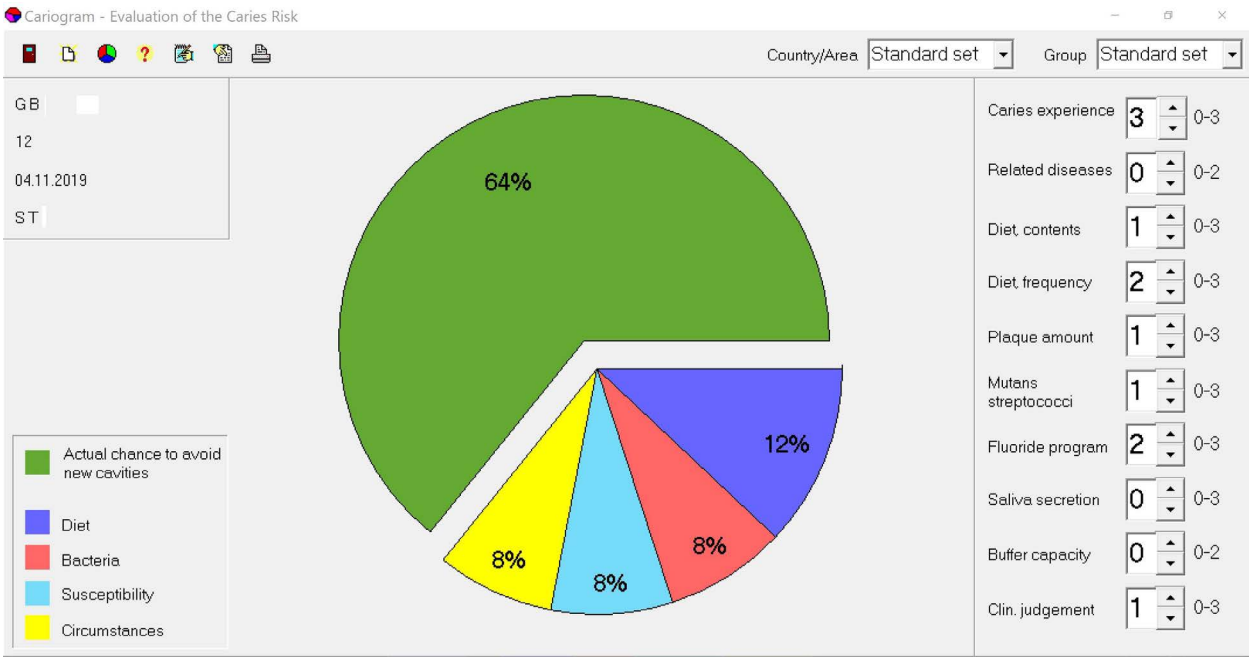

Figure 3. Cariogram individual graphic for "chance of avoiding new caries".

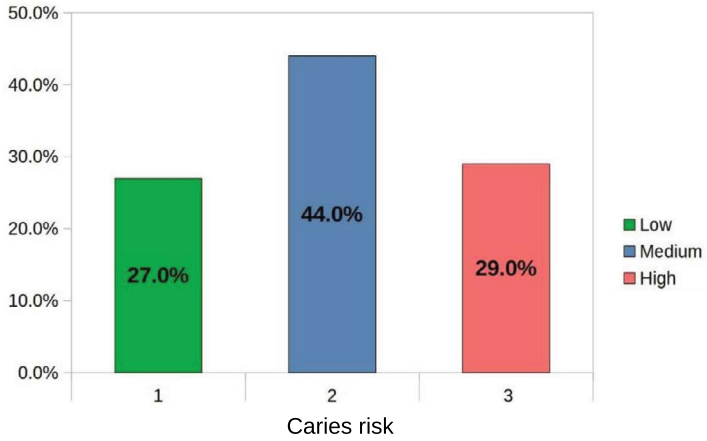

Figure 4. Patients' distributions by caries risk.

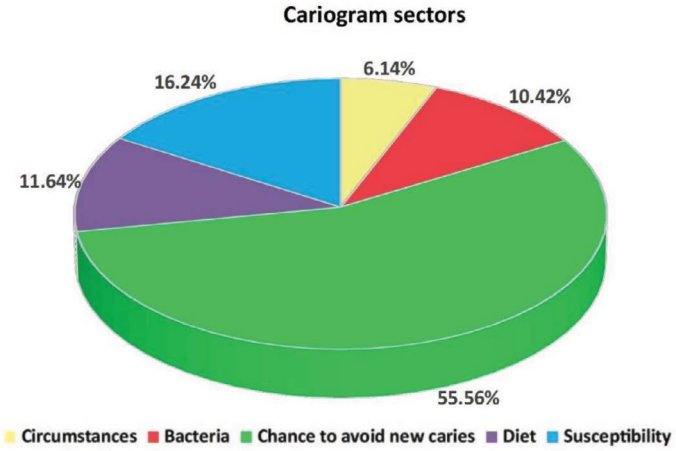

Figure 5. Average caries risk of study participants as assessed by the Cariogram model.

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The Cariogram model revealed a 55.56% chance of avoiding caries in the near future for the whole group. The total risk of caries was 44.44%.

A correlation analysis was performed to examine the relationship between caries risk and the factors that influence it in the Cariogram model **(Table 1)**.

Spearman's rank correlation results show that there is a significant positive relationship between caries risk and DMFT, (r_s [100] = 0.358, p<0.001), diet contents (r_s [100] = 0.220, p<0.05), diet frequency (r_s [100] = 0.252, p<0.05), LB (r_s [100] = 0.321, p<0.001), plaque amount (r_s [100] = 0.291, p<0.05), and SM (r_s [100] = 0.302, p<0.05). Correlation analysis revealed that SM, DMFT, LB, and plaque were with typical effect sizes and were associated with caries risk in this study. These factors could explain both the high caries status of the individuals and the probability of having a high risk of developing caries lesions in the future.

DISCUSSION

One of the modern tools for assessing caries risk is the Cariogram program which generates an individual's caries risk profile and presents it graphically to patients. This program is both a prediction model and a risk model, as it predicts who is at risk and identifies risk factors to determine the appropriate treatment and treatment plan.[7] Although Cariogram software includes certain parameters that are used in the tool's algorithm, many studies have excluded or modified these factors.[21]

The present study included all of the factors according to the Cariogram model because exclusion of saliva characteristics due to insufficient equipment (most often) does not account for one of the important components of caries risk – "Bacteria".[22]

Dou L et al. reported that in young individuals the exclusion of Cariogram saliva tests did not affect the predictive ability of the instrument.[23] This has been confirmed by other studies according to which bacterial count is an important risk factor, but not a unique and determining factor.[24] In our correlation analysis of the bacterial component of Cariogram, the amount of LB and SM levels were positively associated with the risk of caries.

In the literature reviewed, caries risk assessment studies typically use risk models that include both risk variables and predictive factors.[25]

Ruiz Miravet et al. reported that it was possible to develop regression models to determine caries risk based on the prognostic variables that most strongly correlate with the caries risk obtained through the Cariogram model.[26]

Zero et al. indicate that during the caries risk assessment the variety of ages have to take into account a number of risk factors related to caries risk models, developed for different ages.[27]

This was also confirmed in a study by Petersson et al., where 26.4% of the adult patients belonged to the group with the highest caries risk compared to 3.1% of children.[28]

In our study, diet contents, salivary secretion rate and amount of plaque were not strongly associated with the risk of caries in adults. In contrast, in a study by Kavvadia K et al., for example, the most significant caries-risk variable for Greek children 2 to 6 years old, determined by regression analysis (R (2) = 0.88), was the insufficient fluoride intake.[29] In contrast, in our study, fluoride intake was not associated with caries risk in individuals aged 19-65 (r_s [100] = 0.114, p>0.05).

Similar to our results are the results reported for Spanish young adults with a statistically significant relationship between the caries risk profile as determined by Cariogram and previous caries experience.[1,26]

Various caries related factors, such as previous caries experience and sugar consumption (LB), have been reported as dominant risk profile sectors in previous Cariogram studies.[19] According to the results of another study, the most important factors for caries risk are caries experience, fluoride programs and the number of *S. mutans* and *Lactobacillus*.[24]

Many factors such as age of participants, fluoride programs, nutrition, and many others should be considered in comparing the results of different caries risk studies.

CONCLUSIONS

The Cariogram software classifies patients according to low, medium, and high risk of caries patients, with predominance of patients in the medium risk group. The highest weighted impact on the caries risk was caused by the "Susceptibility" factor, followed by the factors "Diet" and "Bacteria". The results of the correlation analysis showed that caries experience (DMFT), oral hygiene, diet contents and LB levels were factors associated with caries risk of the studied patients. It is necessary to model the oral environment in order to increase the protective factors and reduce the risk factors. Further longitudinal studies are needed to evaluate the risk of caries in different age and risk groups. The

Table 1. Correlation between caries risk and Cariogram parameters (predictors)

Caries risk		DMFT	Diet contents	Diet frequency	LB	Plaque	SM	Fluoride	Saliva rate	Buffer capacity
	Spearman's rho	0.358**	0.220*	0.252*	0.321**	0.291**	0.302**	0.114	0.018	0.144
	p-value	<0.001	0.028	0.011	<0.001	0.004	0.002	0.258	0.858	0.153

****: size based on Cohen's coefficient 'r' and interpreted in values >0.70 for much higher than the typical risk; ***: values of 0.50-0.69 for high risk; **: values of 0.30–0.49 for mean or typical risk; *: values of 0.10–0.29 for low or lower than the typical risk

Cariogram is an interactive program for patient education and motivation.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Consent for publication

Written informed consents for publication of any associated data and accompanying images were obtained from all patients.

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Оценка риска кариеса среди пожилых людей с помощью программы „Cariogram“

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Резюме

Введение: Исследование выявило риск развития кариеса у пожилых пациентов с помощью шведского программного продукта „Cariogram“. Раннее выявление и своевременное лечение факторов риска развития кариеса имеют важное значение для его профилактики и безоперационного профилактического лечения.

Цель: Выявить пациентов с высоким риском кариеса и реализовать профилактическую программу, направленную на каждого отдельного пациента, на основе оценки индивидуальных факторов риска.

Материалы и методы: В исследование было включено 59 женщин и 41 мужчина в возрасте от 19 до 56 лет. Подробный медицинский анамнез был взят у всех пациентов, которые прошли подробное клиническое обследование, оценку слюны с помощью набора CRT Bacteria (продукты Ivoclar Vivadent AG) и оценку риска кариеса с помощью программного обеспечения „Cariogram“.

Результаты: Результаты показали, что наиболее важными факторами риска были следующие: индекс DMFT (r_s [100] = 0.358, p<0.001), уровни *Lactobacilli* (r_s [100] = 0.321, p<0.001), уровни *Streptococcus. mutans* (r_s [100] = 0.302, p<0.05), количество налёта (rs [100] = 0.291, p<0.05), частота приёма пищи (r_s [100] = 0.252, p<0.05) и тип режима питания (r_s [100] = 0.220, p<0.05). Незначительные коэффициенты корреляции в оценке риска были установлены с введением фторида (r_s [100] = 0.114, p>0.05), скоростью потока слюны (r_s [100] = 0.018, p>0.05) и буферной ёмкостью слюны (r_s [100] = 0.144, p>0.05).

Заключение: „Cariogram“ – очень полезный метод в клинической практике для оценки риска кариеса и его профилактического безоперационного лечения.

Ключевые слова

факторы риска кариеса, „Cariogram“, пожилые люди, программная оценка риска, кариес