치의학박사 학위논문

Effectiveness of simplified Cariogram models for caries risk assessment

치아우식 위험도 분석에 있어 간소화한 Cariogram 모델의 유효성 평가

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서울대학교 대학원
치의과학과 치과보존학 전공
이 정 현

Abstract

Effectiveness of simplified Cariogram models for caries risk assessment

Jung-Hyun Lee
Department of Dental Science
The Graduate School
Seoul National University
(Directed by Professor Ho-Hyun Son, D.D.S., M.S.D., Ph.D.)

Objectives

Modification and correction of individual caries risk factors is essential for dental caries management. The risk assessment models should be simple to apply and be acceptable and convenient for patients.

The objectives of this study were to assess the caries risk among young adult dental patients and to compare the caries risk profiles obtained from the simplified Cariogram models and the conventional Cariogram model.

Material and Methods

Data required for a caries risk assessment with the Cariogram were collected from 80 young adult patients (mean: 23 ± 3.3 years old). Three different simplified Cariogram

models were produced with exclusion of either or both salivary secretion rate and *lactobacilli* count: group 1, conventional model; group 2, both salivary secretion rate and *lactobacilli* count excluded; group 3, salivary secretion rate excluded; group 4, *lactobacilli* count excluded.

Results

With conventional Cariogram model, the mean chance of avoiding caries was 55.5%, and the susceptibility sector was 13.5%, the diet sector was 13.3%, the bacteria sector was 11.8%, the circumstance sector was 5.7%. The mean chance of avoiding caries in group 1 (55.5%) was not significantly different from those in groups 2 and 3. Also four caries-related sectors of the Cariogram (diet, bacteria, susceptibility and circumstance) in group 1 were not significantly different than in groups 2 and 3. Group 4 showed significant differences from group 1 in the mean chance of avoiding caries, and the diet, susceptibility and circumstance sectors ($p < 0.05$). Significant correlations were detected between all risk factors and their corresponding risk sectors ($p < 0.05$). Also there were significant correlations between each risk factor and the chance of avoiding caries, except for the amount of plaque, in groups 1, 2, and 3 ($p < 0.05$).

Conclusions

Dental patients in this study had a medium risk of caries and the dominant sector was the susceptibility sector. The simplified Cariogram model without salivary secretion rate and *lactobacilli* count did not significantly change the outcome produced from the

conventional model. However, single exclusion of *lactobacilli* count noticeably changed the caries risk profile.

Key Words: Caries risk assessment, Cariogram, *lactobacilli*, Salivary secretion

Student number: 2011-30668

목 차

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Jung-Hyun Lee
Department of Dental Science
The Graduate School
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I. Introduction

A caries risk assessment (CRA) is the evaluation of unique individual disease indicators, risk factors, and protective factors to determine the presence of current and the risk of future dental caries [1]. A CRA involves gathering evidence relevant to the diagnosis of dental caries and decision making with regard to appropriate therapeutic intervention in the early stages of disease. Therefore, caries management based on a CRA can enhance health- and cost-effectiveness, and facilitate the application of a customized treatment modality for individual patients [2].

A computer-based model, the Cariogram, has been developed for the practical application of a CRA (Figure I). The Cariogram was first launched in 1997, in Swedish version. It has been developed into version 3.0 and translated into the English version.

The program is free and can be downloaded from the online (http://www.mah.se/fakulteter-och-omraden/Odontologiska-fakulteten/Avdelning-och-kansli/Cariologi/Cariogram/). The program takes into account interactions among individually-assessed risk factors (Table I) and evaluates the factors in a weighted way [3, 4]. The Cariogram expresses the extent to which different etiological factors of caries affect the caries risk of a particular individual and provides targeted strategies for the individual.

In order to run the Cariogram, clinical examination and subsequent tests are needed and data should be collected for nine factors of direct relevance for caries. Nine factors are scored based on the Cariogram manual and put into the program [5]. According to its built–in formula, the program presents the outcome, a pie diagram where 'bacteria' appears as a red sector, 'diet' as a dark blue sector, 'susceptibility' as a light blue sector and 'circumstances' is presented as a yellow sector. The diet sector is based on a combination of diet contents and diet frequency, the bacteria sector is based on a combination of the amount of plaque and *mutans streptococci* (MS), the susceptibility sector is based on a combination of the fluoride program, saliva secretion, and saliva buffer capacity, and the circumstances sector is based on a combination of past caries experience and related diseases. The four sectors take their shares as percentage and what is left appears as green sector and represents the 'chance of avoiding caries' (Figure I). Total nine caries-related factors are put into the program, but with a minimum seven factors, the Cariogram can still provide its outcomes. The computer algorithm estimates a hypothetical value using a weighted formula based on the combination of collected

variables. Therefore, missing a certain risk factor with a relatively lower weight may not significantly affect the overall assessment outcome [6].

Some risk factors, such as past caries experience, plaque amount, and fluoride availability can be easily determined during a routine clinical examination and a patient interview. However, some factors require additional cost and time for measurement. Moreover, patient compliance is an important consideration when attempting to establish a routine series of assessment procedures [3, 6]. During the measurement of salivary secretion rate, patients must continue to chew the paraffin wax, and spit the accumulated saliva in to a measuring glass continuously for five minute. So it can be uncomfortable for some patients. Without the collection of secreted saliva, *lactobacilli* (LB) count cannot be obtained, since the saliva is used to inoculate the media used for LB culture. Furthermore, this technique is not suitable in young children or people with special needs. Many previous studies have examined the weight of each risk factor included in the Cariogram [7-9], but few studies have sought to determine whether the absence of some factors in the Cariogram would affect the overall profile of caries risk. Petersson et al. [6] compared a total set of the Cariogram-factors with a reduced set of factors lacking MS count, salivary secretion rate, and buffer capacity, as a prediction model for 10- to 11-year old adolescent. They found that the accuracy of the risk assessment significantly decreased when all three factors were omitted. In the present study, we assessed the caries risks of adolescent and young adult patients, using conventional Cariogram model and three simplified Cariogram models, in which either or both of the following two factors, salivary secretion rate and LB count, were excluded. We compared the caries risk profiles obtained using the conventional Cariogram and those from the simplified models. Null

hypothesis was that there would be no difference in the caries risk profiles between the conventional Cariogram model and the simplified models.

II. Materials and methods

Study population

Participants in the study were recruited from among individuals who visited Seoul National University Dental Hospital, Department of Conservative Dentistry between December 2011 and February 2012. The inclusion criteria were: 1) 15-30 years of age and 2) in need of caries and/or root canal treatments. And the exclusion criteria were those who have signs of general disease related to caries, take medication on a regular basis, and suffer from symptoms suggestive of hyposalivation. The study population consisted of 80 individuals with 41 women and 39 men [mean age ± standard deviation (SD), 23.0 ± 3.3]. The study was approved by the Seoul National University Dental Hospital Institutional Review Board (CRI11034) and informed consent was obtained from all participants or their parents.

Questionnaire

Modified questionnaire based on the Cariogram manual was made in order to reflect the characteristics of Korean dental patients (Figures II and III) [5]. Each participant was interviewed using a modified questionnaire written in Korean. Information was obtained from the patients on their general health and oral hygiene maintenance. The dietary factor was scored on four levels according to the contents ranging from a very cariogenic diet

(foods with high fermentable carbohydrates and a sticky consistency) to a less cariogenic diet (foods with low fermentable carbohydrates and a flowing consistency), and the frequency of diet was also determined. The fluoride factor was scored on four levels according to the availability of supplemental fluoride. Since no participants with any systemic diseases related to caries susceptibility were included, all cases were assigned a score of 0 for the related general disease factor of the Cariogram model.

The level of oral hygiene maintenance was assessed by using a three-point scoring system based on self-reported brushing time as follows: 0, normal (> 3 min); 1, insufficient (1-3 min); 2, very insufficient, (< 1 min). In addition, a high frequency of brushing (more than two times a day) had one point subtracted from the original score to provide a more favorable outcome in the Cariogram (when the original score was 0, the final score was still the same).

Clinical and radiographic caries assessments

The clinical examination and subsequent tests were conducted by a single examiner (J.H.L). Using an optimal light, a mirror, and an explorer, caries lesions were examined both clinically and radiographically (if available). We defined established caries lesions in a pit or a fissure or on a smooth surface as those with a distinct cavity, undermined enamel, loss of enamel continuity, or a detectably softened floor or wall [10]. Approximal caries lesions had a detectable cavity (visually or tactilely) or discontinuity on an approximal surface or a discolored marginal ridge. Radiolucency reaching the outer dentin was also used as a cut-off for established lesions [11]. White spots and arrested and inactive lesions were excluded from the study. The number of decayed, missing, and

filled teeth (DMFT index) was recorded. The reference DMFT value was taken from the Korean National Oral Health Survey 2010 [12], in which the mean DMFT index was 6.06 for 18- to 24-year olds and 6.55 for 25- to 29-year olds. Consequently, caries experience factor was rated on a four-point scale, that is, with 0 indicating caries free (DMFT = 0); 1, better than normal (DMFT = 1-4); 2, normal (DMFT = 5-7); 3, worse than normal (DMFT $\geq$ 8).

Plaque scoring

The Silness-Löe plaque index was assessed: with 0 indicating 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 the tooth gingival margin; 3, abundance of soft matter within the gingival pocket and/or on the tooth gingival margins [13].

Salivary and microbiological tests

For an assessment of MS count, plaque was obtained using a microbrush (Applicator Tips, Dentsply DeTrey BmbH, Konstanz, Germany) from the tooth surfaces and spread thoroughly on the rough surface of a strip (Dentocult SM Strip Mutans, Orion Diagnostica, Espoo, Finland). When the amount of plaque was insufficient for collection, an alternative method was used according to the manufacturer's directions. Briefly after the participant chewed paraffin pellets for one minute, the rough surface of the strip was pressed against the saliva remaining on the participant's tongue [14]. The strip was put into the culture vial, then incubated for 48 hours at 36℃. Participants were classified into

one of four classes based on their MS and LB scores according to the Cariogram manual, the lowest class had a score of 0 [5]. Salivary secretion rates were measured in ml/min, while paraffin-stimulated whole saliva was collected for 5 minutes with the participants in an upright position. The fresh saliva sample was then used to inoculate selective LB culture media (Dentocult LB, Orion Diagnostica). The buffer capacity of the saliva was also determined using a buffer strip (Dentobuff Strip, Orion Diagnostica). The scoring of the salivary buffer capacity was determined by the color of the strip as follows: 0, blue (pH > 6.0); 1, green (4.5 < pH < 5.5); 2, yellow (pH < 4.0).

Risk assessment using the Cariogram

Information based on each caries-related factor was collected and entered into the Cariogram (Table I). Each factor has a score ranging from 0 to 2 (or 3) with 0 being the most favorable score. The “clinical judgment” factor was set to 1 (normal setting). In the Cariogram, an individual caries risk profile is generated for each of five sectors (chance of avoiding caries, diet, bacteria, susceptibility, circumstances) expressed with a percentage value. In the simplified Cariogram models, either or both the salivary secretion rate and *lactobacilli* count were excluded. The following four groups were recognized: group 1, conventional model; group 2 (simplified_SL), both salivary secretion rate and LB count excluded; group 3 (simplified_S), salivary secretion rate excluded; group 4 (simplified_L), LB count excluded (Table II).

Statistical methods

Descriptive statistics were expressed as either a mean (SD) or frequency (percentage),

as appropriate. The distribution of chance of avoiding caries was approximately symmetric (|skewness|<0.5). Repeated measures analysis of variance (ANOVA) was applied to determine whether there were statistically significant differences in risk avoidance (%), diet (%), bacteria (%), susceptibility (%), and circumstances (%) among the four models. Since the assumption of sphericity was rejected ($p < 0.001$) and the Greenhouse-Geisser epsilon was below 0.7, the Greenhouse-Geisser adjustment was applied to modify the obtained *p*-values (0.05). Spearman correlation coefficient analysis was used to assess the degree of correlation between the risk factors and the corresponding risk sectors, and between the risk factors and the chance of avoiding caries. The type one error rate of 0.05 was applied to determine the statistical significance. SPSS version 12.0 (SPSS Inc., Chicago, IL, USA) was used for the analysis.

III. Results

Most patients had a medium risk of caries, with a 55.5% mean chance of avoiding future caries. The dominant sector was the susceptibility sector with 13.5% risk, followed by the diet sector (13.3%), the bacteria sector (11.8%), and the circumstances sector (5.7%).

According to the median value of the chance of avoiding caries, the lower and the higher half of the participants (40 in each) were subjected to the higher risk and the lower risk groups, respectively. The various caries-related factors that were compared between the two groups are shown in Table III. The DMFT of the higher risk group was more than four times higher than that of the lower risk group. LB score, MS score and oral hygiene maintenance differed significantly between two groups. Regarding the Cariogram values,

the “chance of avoiding caries” was 65.2% in the lower caries risk group and 46.5% in the higher caries risk group, and the difference was statistically significant ($p < 0.001$).

Figure IV shows the distribution of the caries risk groups according to the level of oral hygiene maintenance. Of the total patients, 44 (55.0%) belonged to the normal maintenance group, 34 (42.5%) were in the insufficient maintenance group, and two (2.5%) were in the very insufficient group.

There was no significant difference in the chance of avoiding caries between age groups [divided based on the mean age (23.0) of participants, 15-23 years and 24-30 years] or between males and females (Table IV). However, for oral hygiene maintenance, the insufficient and very insufficient groups had lower chances of avoiding caries than the normal group over all the different Cariogram settings ($p < 0.05$).

The mean chance of avoiding caries in the conventional Cariogram model (group 1) was 55.5% (Table V). In the simplified_SL model (group 2) and the simplified_S model (group 3), the chances of avoiding caries were 55.4% and 54.0%, respectively. The three groups were not significantly different. The simplified_L model (group 4) showed a significant difference in the chance of avoiding caries (57.0%) compared to group 1 ($p < 0.05$). In the dietary sector, group 4 was significantly different from group 1 ($p < 0.05$). In the bacteria sector, no significant difference was detected among all the groups. In the susceptibility sector, group 4 significantly differed from group 1 ($p < 0.05$). In the circumstances sector, group 4 was significantly different from the other three groups ($p < 0.05$). Significant correlations were detected between each risk factor and its corresponding risk sector (Table VI). All risk factors and the chance of avoiding caries

were also significantly correlated, except for the amount of plaque in all the groups and MS count in group 4 (Table VII).

IV. Discussion

Performing a CRA in an efficient and practical way is crucial not only in public health screenings, but also in ordinary clinical practices [3]. Determining the risk level of an individual patient can inform the selection of treatment options and prediction of prognosis to establish a definitive treatment plan and post-care program. The application of assessment models should not have usage barriers for clinicians, and data collection systems need to be simple and inexpensive with a limited armamentarium [15]. More importantly, the procedures should be acceptable and convenient for patients. Among the risk parameters included in the Cariogram, saliva secretion rates may be the least attainable in clinical settings, because the measurement procedure deviates from the routine examination and requires special patient guidance. After measurement, the collected saliva sample is used to inoculate LB culture media, while MS can be alternatively gathered from plaque on the tooth surfaces. We speculated that the saliva collection procedure could be excluded from the Cariogram without significant changes in the caries risk profile generated by the program.

In groups 2 and 3, the chance of avoiding caries was not significantly different from the control group (group 1, Table V). In group 4, however, the chance of avoiding caries differed significantly compared to the values in the other three groups. In the diet sector, group 4 showed a significant difference from the other three groups. Considering the fact that a high level of LB correlated with increased sugar consumption [16], the role of

fermentable carbohydrates might have been underestimated in the high sugar-intake group, when only dietary questionnaires were included in the diet sector. When salivary secretion rate and LB count were both excluded (group 2), the disparity between the simplified model and the conventional model seemed to decrease, resulting in no significant difference between the two groups in the diet sector. The questionnaire results were highly correlated (0.72–0.82) with the diet sector in all groups, and the correlation coefficients were similar to those generated by the analysis of the questionnaire results and LB count combined (0.74–0.81, Table VI). There was no significant difference among all four groups in the bacteria sector. This was an intuitive outcome because no variables belonging to the bacteria sector were excluded. In the susceptibility and the circumstances sector, group 4 showed significantly different values compared to the other groups. Additionally, a certain individual factor (MS count) was inconsistently correlated with future caries risk of group 4 compared to the other groups. Overall, among the three simplified Cariogram models, only the single omission of LB count noticeably altered the risk profiles. Therefore, null hypothesis was rejected, except in the group that LB count was excluded.

Our statistical analysis was performed after adjusting for age, gender, and oral hygiene maintenance. Age and gender did not affect the risk of future caries throughout the four different settings of the Cariogram. The three-point scoring system for oral hygiene maintenance was based on self-reports (normal, insufficient, and very insufficient). There were conflicting reports with regard to the direct influence of tooth brushing habits on the degree of caries risk [17-19]. And, the plaque amount factor was not significantly correlated with the future caries risk in this study (Table VII). However, extended

duration of brushing can induce intra-oral fluoride retention, and in addition, it implies good oral hygiene maintenance [20]. In the present study, we intended to relate a CRA to patients' self-awareness of oral hygiene, because a CRA can be an educating and explanatory tool for patients along with clinical intervention. We evaluated an adolescent and young adult population (mean age: 23.0 ± 3.3 years) that visited the dental hospital for caries and/or root canal treatments. Since information based on CRA studies in children or the elderly is abundant, evidence-based caries management protocols for these groups have been widely proposed. In other way, adults almost never encounter school-based preventive programs and are prone to neglecting their potential caries risk. Among the participants, 4% reported that they spent less than three minutes for tooth brushing per each brushing session. This self-defined status of oral hygiene maintenance was significantly correlated with future caries risk (-0.32 to -0.28, $p < 0.05$, Table IV). A remarkably higher proportion of participants among the normal-maintenance group belonged to the low caries risk group, while the opposite trend was noted among the insufficient and very insufficient maintenance group (Figure IV). The participants commonly sought treatments related to past or current caries lesions, or endodontic problems. A recent study [21] showed that the lower the chance of avoiding new caries was, the higher the percentage of recurrent caries would be. According to another study on the survival of teeth with extensive restorations [22], failed teeth and surviving teeth differed with regard to some caries-related factors, such as bacterial levels, dietary frequency per day, and salivary buffer capacity. When the level of risk is adequately evaluated, clinicians can work with patients to modify the contributing risk factors, which will then enhance the preservation of tooth structure and longevity of the restorations.

There are some restrictions to the interpretation of our results. First, the outcome of this study may be valid only for young adults with uncompromised saliva-secretory function. The results would likely be different in an elderly group with an increased prevalence of hyposalivation. Second, the Cariogram serves as both a prediction model and a risk model [3], and the present study focused on the latter function of the program. We attempted to evaluate the patients' current risk factors to allocate them into various risk groups in an everyday practice setting. As Petersson et al. have already emphasized [6], it is more important to proceed with a CRA incorporating the best available evidence than not to attempt it due to a lack of firm evidence. Future studies involving longitudinal observations and linear regression analysis could facilitate the development of simpler CRA models with greater accuracy and accessibility for both clinicians and patients.

In conclusion, dental patients in the present study had a medium risk of caries. Within the limitations of the present study, our findings indicate that the simplified Cariogram with the exclusion of two risk factors (i.e. saliva secretion rates and LB count) may be used in the clinical practice, when a full inclusion of risk factors is not achievable. The Cariogram can be used to determine individual risk profiles of patients in need of preventive and/or restorative dentistry.

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Figures

Figure I. Examplary diagram from the Cariogram denotes the ‘chance of avoiding caries (new cavities)’ as 14% indicating a high caries risk.

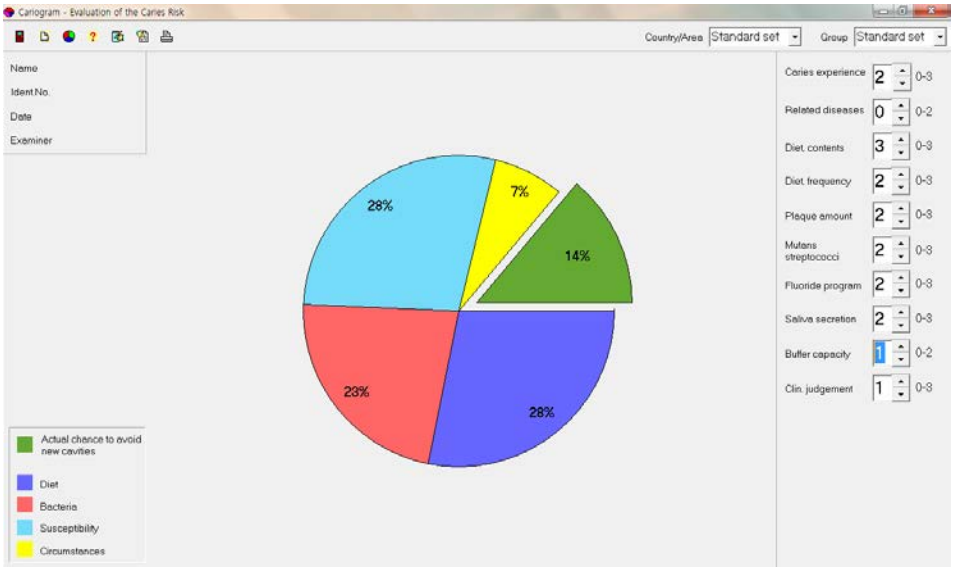


Figure II. Modified questionnaire based on the Cariogram manual (in Korean) [5]

✧ 다음은 **치아 우식 (충치) 발생 위험도 검사**에 관련된 질문입니다.

1. 하루에 간식을 얼마나 자주 먹나요?
1) 전혀 먹지 않음 2) 1일 1-2 회 3) 1일 3-4 회 4) 1일 5회 이상

2. 간식을 먹는 다면 주로 어떤 종류의 음식물인가요?
1) 과일, 달지 않은 음료수
(예: 과일 간 것, 미수 가루 같은 것)
2) 단 맛이 있고, 삼키고 나면 입안에 남지 않는 음식물
(예: 커피, 음료수, 아이스크림 등)
3) 단 맛은 없지만, 먹고 나서 입안에 남기 쉬운 음식물
(예: 새우깡, 뻥튀기, 옥수수 등)
4) 단 맛이 있고, 먹고 나서 입안에 남기 쉬운 음식물
(예: 케익, 캬라멜, 쿠키, 달콤한 스낵 등)

3. 하루 칫솔질은 얼마나 오래, 자주 하나요?
1) 하루 3회 이상, 매회 3분 이상
2) 하루 3회 이상, 매회 1-2 분 미만으로 짧게
3) 닦기는 하나 불규칙한 편임
4) 거의 닦을 수가 없음

4. 치과에서 불소 양치나 불소 도포를 받은 적이 있나요?
1) 정기적으로 받고 있는 편이다
2) 정기적이지는 않지만 받은 적은 있다 (언제:)
3) 받아 본 적이 없다

Figure III. Modified questionnaire based on the Cariogram manual (in English) [5]

✧ These are questions for caries risk assessment.

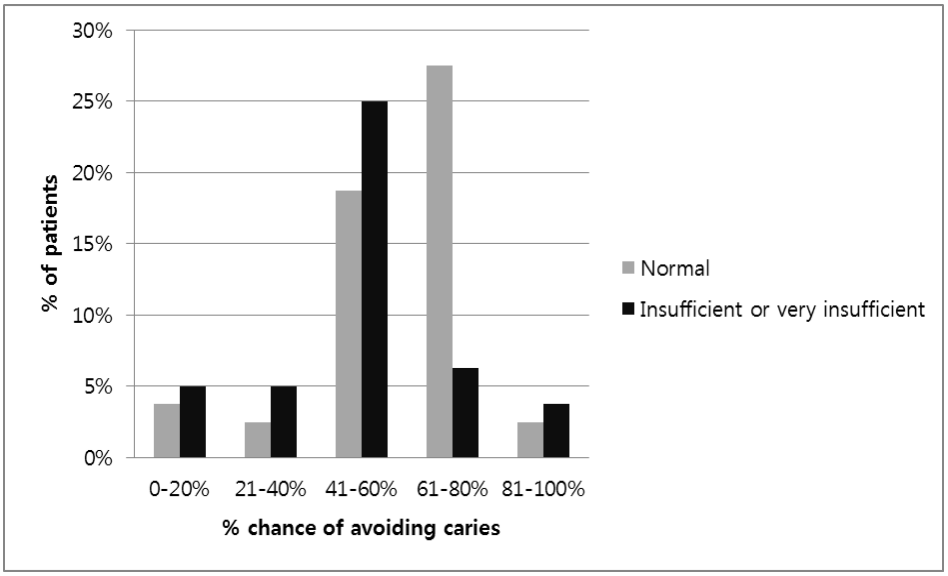
1. How often do you eat snacks in a day?
1) Do not eat at all 2) 1-2 times per day 3) 3-4 times per day 4) More than 5 times per day

2. If you eat snacks, what kind food do you eat?
1) Fruits, non sweet drinks
(i.e. Fruit juices, grains)
2) Sweet, but not sticky snacks
(i.e. Coffee, ice cream)
3) Non sweet, but sticky snacks
(i.e. Popcorn, potato snacks)
4) Sweet and sticky snacks
(i.e. Cake, cookie, caramel)

3. How often do you brush your teeth in a day? And how long does it take?
1) More than 3 times per day, more than 3 minutes each time
2) More than 3 times per day, 1-2 minutes each time
3) Brushing, but irregular
4) Rarely brushing my teeth

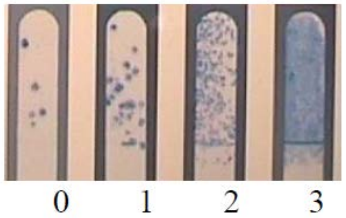
4. Have you ever taken topical fluorides or fluoride mouth rinses in dental clinic?
1) Yes, periodically.
2) Yes, but not periodically. (when:)
3) No, I've never taken any topical fluorides.

Figure IV. Distribution of caries risk groups according to the level of oral hygiene maintenance: normal, brushing time > 3 min; insufficient, brushing time 1-3 min; very insufficient, brushing time < 1 min.



Tables

Table I. Caries-related factors included in the Cariogram*

Factors	Cariogram information	Collection methods	Score
Diet (content)	A. Consumption of fermentable carbohydrates B. *lactobacillus* (LB) test	A. Questionnaire B. Dip-slide LB test (Dentocult LB)	0 : Fruits, non sweet drinks 1 : Sweet, but not sticky snack 2 : Non sweet, but sticky snack 3 : Sweet and sticky snack * If LB score is 3, one point is added to original score.
Diet (frequency)	Frequency of daily dietary intake	Questionnaire	0 : No snack per day 1 : 1-2 snacks per day 2 : 3-4 snacks per day 3 : More than 5 snacks per day
Plaque amount	Plaque Index (PI)#	Clinical examination	0 : No plaque 1 : Film of plaque 2 : Moderate accumulation of soft deposition 3 : Abundance of soft matter
***mutans streptococci* (MS)**	MS count	Strip Mutans test (Dentocult SM)	

Fluoride	Availability of fluoride	Questionnaire	0 : Regular F program + F tooth paste 1 : Infrequent F program + F tooth paste 2 : F tooth paste only 3 : No fluoride
Saliva secretion rate	Secretion rate on stimulated saliva	Paraffin & measuring cup	0 : > 1.1 ml stimulated saliva per minute 1 : 0.9-1.1 ml stimulated saliva per minute 2 : 0.5-0.9 ml stimulated saliva per minute 3 : < 0.5 ml stimulated saliva per minute
Salivary buffering	Buffering capacity of saliva	pH indicator kit (Dentobuff Strip)	0 : Adequate, Dentobuff blue 1 : Reduced, Dentobuff green 2 : Low, Dentobuff yellow
Caries experience	DMFT (decayed, missing, and filled teeth)	Clinical examination, Radiography	0 : DMFT = 0 1 : DMFT = 1-4 2 : DMFT = 5-7 3: DMFT ≥ 8
Related disease	General disease, medication	Questionnaire	0 : No disease 1 : Mild degree, contributing to higher caries risk 2 : Severe degree, affecting the saliva secretion
Clinical judgement	Opinion of dental examiner		Set to 1 (Normal setting)

[*] According to the Cariogram manual [5]

[#] According to Silness-Löe plaque index [3]

Table II. Caries-related factors included in the conventional and the simplified Cariogram models

Sectors	Cariogram models			
	Conventional, Group 1	**Simplified_SL, Group 2**	**Simplified_S, Group 3**	**Simplified_L, Group 4**
Diet	Contents Frequency LB count	Contents Frequency	Contents Frequency LB count	Contents Frequency
Bacteria	Plaque amount MS count	Plaque amount MS count	Plaque amount MS count	Plaque amount MS count
Susceptibility	Fluoride Salivary secretion Saliva buffer	Fluoride Saliva buffer	Fluoride Saliva buffer	Fluoride Salivary secretion Saliva buffer
Circumstance	Caries experience Related disease	Caries experience Related disease	Caries experience Related disease	Caries experience Related disease

Abbreviations: Simplified_SL, salivary secretion rate and LB count were excluded; Simplified_S, salivary secretion rate was excluded; Simplified_L, LB count was excluded.

Table III. Mean values (SD) of various factors in the lower caries risk group (n = 40)* and the higher caries risk group (n = 40)*

Factor	**Lower risk group (n = 40)**	**Higher risk group (n = 40)**	***p*-value**
DMFT index	2.44 (0.70)	9.94 (2.92)	0.001
Plaque index	1.46 (0.58)	1.72 (0.73)	0.051
***lactobacilli* (score)**	1.16 (0.61)	2.35 (1.31)	< 0.001
***mutans streptococci* (score)**	0.89 (0.35)	2.02 (0.94)	< 0.001
Diet content (score)	1.71 (0.58)	1.96 (0.83)	0.094
Diet frequency (score)	1.14 (0.30)	1.35 (0.52)	0.078
Saliva secretion (ml/min)	0.91 (0.26)	1.02 (0.32)	0.137
Buffer capacity (score)	0.72 (0.31)	0.61 (0.24)	0.108
Oral hygiene maintenance (score)	0.89 (0.47)	1.95 (0.75)	< 0.001
Chance of avoiding caries (%)	65.2 (26.7)	46.5 (19.6)	< 0.001

Values are number (score or index).

* According to the median value of the chance of avoiding caries

Table IV. Comparisons of the chance of avoiding caries according to age, gender, and oral hygiene maintenance among the conventional and the simplified Cariogram models

Models	Age			Gender			Oral hygiene maintenance		
	15-23 y	24-30 y	*p*-value	Male	Female	*p*-value	Normal	Insufficient or very insufficient	*p*-value
Conventional, group 1	57.4 (20.0)	52.8 (20.7)	0.321	57.7 (20.0)	53.5 (20.6)	0.360	60.1 (19.9)	49.9 (19.6)	0.024
Simplified_SL, group 2	53.1 (19.2)	57.0 (18.2)	0.363	58.4 (17.2)	52.6 (19.6)	0.162	59.5 (18.0)	50.5 (18.4)	0.030
Simplified_S, group 3	55.6 (18.6)	51.6 (18.5)	0.347	56.9 (17.7)	51.3 (19.0)	0.173	58.2 (17.7)	49.0 (18.5)	0.026
Simplified_L, group 4	58.8 (19.8)	54.2 (21.4)	0.327	59.2 (19.8)	54.8 (20.1)	0.345	61.4 (20.2)	51.5 (19.7)	0.029

Values are number [%, (SD)].

Abbreviations: Simplified_SL, salivary secretion rate and LB count were excluded; Simplified_S, salivary secretion rate was excluded; Simplified_L, LB count was excluded.

Table V. Mean values of the chance of avoiding caries and the sectors of diet, bacteria, susceptibility, and circumstance (%) obtained with the conventional and the simplified Cariogram models

Models	**Chance of avoiding caries**	**Diet**	**Bacteria**	**Susceptibility**	**Circumstance**
Conventional, group 1	55.5 (20.3)[ab*]	13.3 (7.9)[b]	11.8 (7.1)[a]	13.5 (8.2)[bc]	5.7 (3.0)[b]
Simplified_SL, group 2	55.4 (18.6)[ab]	12.5 (7.7)[ab]	11.8 (6.6)[a]	14.5 (5.8)[c]	5.8 (3.0)[b]
Simplified_S, group 3	54.0 (18.5)[a]	13.3 (7.6)[b]	12.0 (6.6)[a]	14.8 (5.7)[c]	5.9 (3.1)[b]
Simplified_L, group 4	57.0 (20.4)[c]	12.4 (7.9)[a]	11.6 (7.1)[a]	13.3 (8.2)[a]	5.6 (2.9)[a]
***p*-value**[#]	0.004	0.005	0.109	0.011	0.001

Values are number [%, (SD)].

Abbreviations: Simplified_SL, salivary secretion rate and LB count were excluded; Simplified_S, salivary secretion rate was excluded; Simplified_L, LB count was excluded.

[*] Different alphabetic superscripts represent a statistical difference at a type one error rate of 0.05.

[#] *p*-values obtained after adjusting for age, gender, and oral hygiene status.

Table VI. Spearman correlations coefficient between the risk sectors and the risk factors in the conventional and the simplified Cariogram models

Sectors	Factors	Cariogram models			
		Conventional	**Simplified_SL**	**Simplified_S**	**Simplified_L**
		Group 1	**Group 2**	**Group 3**	**Group 4**
Diet	Diet contents (questionnaire)	0.72	0.82	0.80	0.75
	Diet contents (questionnaire + LB count)	0.74	-	0.81	-
	Diet frequency	0.41	0.47	0.40	0.46
Bacteria	Plaque amount	0.49	0.57	0.57	0.49
	MS count	0.69	0.69	0.69	0.69
Susceptibility	Fluoride	0.41	0.55	0.56	0.41
	Saliva secretion	0.65	-	-	0.65
	Salivary buffer	0.51	0.65	0.64	0.51
Circumstances	Caries experience	0.87	0.90	0.90	0.87
	Related disease*	-	-	-	-

Values are number (Spearman correlation coefficient).

Abbreviations: Simplified_SL, salivary secretion rate and LB count were excluded; Simplified_S, salivary secretion rate was excluded; Simplified_L, LB count was excluded; LB, *lactobacilli*; MS, *mutans streptococci*.

p-values of all correlation coefficients were below 0.001.

* The general disease factor was scored as 0 for all cases.

Table VII. Spearman correlations coefficient between the caries-related factors and the chance of avoiding caries in the conventional and the simplified Cariogram models

Factors	**Cariogram models**			
	Conventional	**Simplified_SL**	**Simplified_S**	**Simplified_L**
	Group 1	**Group 2**	**Group 3**	**Group 4**
Oral hygiene maintenance	-0.32	-0.28	-0.30	0.30
Diet contents(questionnaire)	-0.32	-0.43	-0.40	-0.38
Diet contents(questionnaire + LB count)	-0.34	-	-0.41	-
Diet frequency	-0.31	-0.40	-0.40	-0.40
Plaque amount	-0.19*	-0.20*	-0.17*	-0.05*
MS count	-0.49	-0.51	-0.53	-0.04*
Fluoride	-0.34	-0.33	-0.33	-0.27
Saliva secretion	-0.42	-	-	-0.49
Salivary buffer	-0.42	-0.39	-0.37	-0.38
Caries experience	-0.40	-0.40	-0.41	-0.41

Values are number (Spearman correlation coefficient).

Abbreviations: Simplified_SL, salivary secretion rate and LB count were excluded; Simplified_S, salivary secretion rate was excluded; Simplified_L, LB count was excluded; LB, *lactobacilli*; MS, *mutans streptococci*.

* *p*-values of the denoted figures were above 0.05. Other figures had the *p*-values below 0.05.

국문초록

치아우식 위험도 분석에 있어 간소화한 Cariogram 모델의 유효성 평가

이 정 현

서울대학교 대학원 치의과학과

치과 보존학 전공

(지도교수 손 호 현)

목 적

치아우식 위험도 분석을 통해 개인의 치아우식 위험 인자를 변화시키고 교정하는 것은 치아우식 관리에 있어서 필수적이다. 따라서 치아우식 위험도 분석은 적용이 간단해야 하며, 과정이 환자에게 큰 불편함 없이 받아들여질 수 있어야 한다.

본 연구의 목적은 서울대학교 치과병원에 내원한 치과 환자의 치아우식 위험도 특성을 분석하고, 일부의 측정항목을 배제하여 간소화한 Cariogram 모델을 이용하여 얻어진 치아 우식 위험도 특성을 종래의 Cariogram 모델의 결과와 비교하여 간소화한 Cariogram 모델의 유효성을 평가하는 것이다.

방 법

서울대학교 치과병원 임상시험심사위원회의 승인 하에 (CRI11034) 80명의 젊은 성인 환자를 대상으로 설문조사, 임상적/방사선학적 평가, 미생물학적 평가 및 타액검사 등을 통해 Cariogram을 이용한 치아 우식 위험도 분석을 위해 필요한 자료를 수집하였다. 타액분비율과 젖산균 수치를 제외하는 방법으로 세 개의 간소화한 Cariogram 모델을 제작하였다. 1군, 종래의 Cariogram 모델; 2군, 타액분비율과 젖산균 수치를 제외; 3군, 타액분비율 제외; 4군, 젖산균 수치 제외. Cariogram을 이용하여 각 군의 치아 우식 회피 가능성, 식이요소, 세균요소, 감수성요소, 환경요소를 산출하고 ANOVA를 이용하여 군간에 유의한 차이가 있는지 분석하였다.

결 과

1군의 평균 치아우식 회피 가능성(55.5%)은 2군과 3군의 결과와 유의한 차이가 없었다. 또한 1군의 치아우식 발생과 연관된 4가지 요소 (식이, 세균, 감수성 및 환경) 또한 2군, 3군과 유의한 차이가 없었다. 4군의 평균 치아우식 회피 가능성, 식이, 감수성, 환경 요소는 1군과 유의한 차이를 나타내었다 ($p < 0.05$). 모든 위험인자와 거기에 상응하는 위험요소 사이에 유의한 연관성이 관찰되었다 ($p < 0.05$). 또한 1군, 2군, 3군에서 치태의 양을 제외한 각각의 위험 인자와 평균 치아우식 회피 가능성 사이에서 유의한 연관성이 있었다($p < 0.05$).

결 론

본 연구에서 모집한 치과 환자는 중등도의 치아우식 위험도를 나타냈으며, 가장 우세한 위험요소는 감수성이었다. 타액분비율과 젖산균 수치를 모두 제외한 간소화한 Cariogram 모델의 결과는 종래의 Cariogram 모델의 결과와 유의한 차이가 없었다. 하지만 젖산균 수치만을 제외한 모델은 치아우식 위험도 특성을 현저히 변화시켰다.

주요어: 치아우식 위험도 분석, Cariogram, 젖산균, 타액분비

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