Acta Odontologica Scandinavica. 2014; 72: 721–728

informa
healthcare

ORIGINAL ARTICLE

Does caries risk assessment predict the incidence of caries for special needs patients requiring general anesthesia?

JUHEA CHANG[1] & HAE-YOUNG KIM[2]

[1]*Clinic for Persons with Disabilities, Seoul National University Dental Hospital, Dental Research Institute, School of Dentistry, Seoul National University, Seoul, Korea, and* [2]*Department of Dental Laboratory Science and Engineering, College of Health Science & Department of Public Health Sciences, Graduate School & BK21+ Program in Public Health Sciences, Korea University, Seoul, Korea*

Abstract

Objectives. The aim of this study was to correlate the caries-related variables of special needs patients to the incidence of new caries. ***Materials and methods.*** Data for socio-demographic information and dental and general health status were obtained from 110 patients treated under general anesthesia because of their insufficient co-operation. The Cariogram program was used for risk assessment and other caries-related variables were also analyzed. Within a defined follow-up period (16.3 ± 9.5 months), 64 patients received dental examinations to assess newly developed caries. ***Results.*** At baseline, the mean (SD) values of the DMFT (decayed, missing and filled teeth) and DT (decayed teeth) for the total patients were 9.2 (6.5) and 5.8 (5.3), respectively. During the follow-up period, new caries occurred in 48.4% of the patients and the mean value (SD) of the increased DMFT (iDMFT) was 2.1 (4.2). The patients with a higher increment of caries (iDMFT ≥3) showed significantly different caries risk profiles compared to the other patients (iDMFT <2) ($p < 0.05$). Close correlations existed between the caries increment and several caries-related variables; baseline DMFT, insufficient self-tooth-brushing and malocclusion were greatly associated with new caries development. ***Conclusions.*** Caries risk assessment could predict the incidence of future caries in hospital-based dentistry. Past caries experience and inadequate oral hygiene maintenance were largely related to caries development in special needs patients.

Key Words: *caries risk assessment, special needs patient, cariogram, general anesthesia, intellectual disabilities, DMFT*

Introduction

People with special needs are susceptible to dental caries due to various reasons: limited oral healthcare, difficult access to dental services, inadequate diet, xerostomia-causing medication, etc. [1]. Despite the high demand for restorative intervention, many special needs patients with severe intellectual disabilities lack the co-operation necessary for routine treatments, requiring general anesthesia. Even when extensive carious lesions are involved throughout a whole dentition, the limitation of time and cost is imposed on the dental treatment under general anesthesia (G/A treatment). Hence, it is challenging for dental practitioners to establish a treatment plan that is most suitable for a patient widely affected with caries. Furthermore, adequate post-operative care is hardly achievable in patients with severe disabilities, resulting in the development of new caries and restoration failures. It necessitates another dental treatment under general anesthesia, which is a large burden not only to the patients and caregivers but also to the dental healthcare providers [2]. Therefore, there is a strong need for a strategic approach to caries management in special needs cases.

Caries risk assessment has been applied to identify caries-susceptible individuals and to provide appropriate preventive and treatment measures for the disease [3]. One of the multivariate assessment tools, the Cariogram program has been used to screen high-risk populations. There have been a few longitudinal studies for caries prediction using the Cariogram, which were conducted on young and elderly groups in low risk areas [4–6]. In our previous cross-sectional

Correspondence: Juhea Chang, Clinic for Persons with Disabilities, Seoul National University Dental Hospital, 101 Daehak-no, Jongno-gu, Seoul, 110-768, Korea. Tel: +82 2 2072 3831. Fax: +82 2 2072 2854. E-mail: juhchang@snu.ac.kr

(Received 29 October 2013; accepted 4 February 2014)

ISSN 0001-6357 print/ISSN 1502-3850 online
DOI: 10.3109/00016357.2014.898788

study based on the Cariogram [7], adolescent and adult patients with the G/A treatment had more unfavorable caries risk profiles compared to patients with conventional dental treatment. Another question was whether the variables indicative of high risk would result in an actual increase of caries. In this study, we aimed to perform caries risk assessment for special needs patients under G/A treatment and determine the caries-predictable factors. We first hypothesized that high risk patients would be more likely to develop new caries. Second, we hypothesized that there would be risk factors contributing to the development of new caries in the special needs patients.

Materials and methods

Study population

This study included a total of 110 patients [mean age (SD) = 23.7 (9.3)] who received dental treatment by one of the authors (J.C.) at the Clinic of Persons with Disabilities, Seoul National University Dental Hospital from April 2010 through April 2012. The Seoul National University Dental Hospital Institutional Review Board approved this study (CRI No.11030 and 12014). Non-probability consecutive sampling was performed with the following inclusion criteria: (1) age older than 11 years, (2) received restorative treatments under general anesthesia due to deficient co-operation and (3) received caries risk assessment using the Cariogram. After dental treatments under general anesthesia, follow-up examinations were given to 64 of the 110 patients by the same dentist (J.C) until September 2013 [mean follow-up period (SD) = 16.3 (9.5) months]. The other 46 patients neither attended a follow-up appointment nor co-operated with an intra-oral examination at an attendance. The demographic characteristics of the study population are presented in Table I.

Collecting information on the patients

Information on the socio-demographic background and general health condition of each patient was collected from interviews with the patients or their primary caregivers. Additional data were obtained using a questionnaire based on the Cariogram manual. The scoring system for caries risk factors in the Cariogram and the levels of oral hygiene maintenance followed the protocols in our previous study [8]. For the factor of related general diseases, patients who were taking medication on a long-term basis or had insufficient self-brushing skills were scored as 1.

Caries examination

For scoring of DMFT (decayed, missing and filled teeth), only carious lesions requiring restorative intervention were counted; i.e. cavitated or actively-progressing lesions were included, while white spots, arrested lesions and inactive lesions were excluded from the scoring. For the caries risk assessment, one of four scores was assigned to the caries experience factor: (0) caries free, DMFT 0; (1) better than average, DMFT 1–4; (2) average, DMFT 5–7; (3) worse than average, DMFT ≥8. The reference DMFT value was taken from the Korean National Oral Health Survey 2010, in which the mean DMFT index was 6.06 for 18–24 years olds and 6.55 for 25–29-year olds [9].

Other dental examination

For plaque scoring in the Cariogram, the Silness-Löe plaque index was used: (0) no plaque; (1) film of plaque adhering to the free gingival margin and adjacent area of the tooth; (2) moderate accumulation of soft deposits in the gingival pocket or on the gingival margins; (3) abundance of soft matter within the gingival pocket and/or on the gingival margins. For an assessment of periodontal disease and malocclusion, the WHO criteria [10] and Dental Aesthetic Index (DAI) [11] were applied, respectively. Tooth defects were categorized as fracture, attrition (combined with or without abrasion) or erosion and scored as 'yes' when at least one segment of dentition was involved.

Salivary and microbiological tests

Salivary buffering capacity and mutans streptococcus (MS) counts were measured during the G/A treatment. Unswallowed saliva was collected from the patients' oral cavities immediately after anesthetic induction. The salivary buffering capacity was scored based on the color of the strip as follows: (0) blue, pH >6.0; (1) green, 4.5< pH <5.5; (2) yellow, pH <4.0. 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 bacterial count strip (Dentocult SM Strip Mutans, Orion Diagnostica, Espoo, Finland). When the amount of plaque was too small to be visible, the strip was pressed on the tongue surface and soaked with saliva and used for the test.

Caries risk assessment using the cariogram

Information relevant to each caries-related factor was inserted into the Cariogram. The simplified Cariogram was performed without inclusion of the Lactobacilli counts and salivary secretion rates [8]. The Diet sector was analyzed based on diet frequency and content. The Bacteria sector was based on the plaque amount and MS counts. The Susceptibility sector was based on fluoride exposure and salivary

Table I. Demographic characteristics of the special needs patients with or without follow-up after G/A treatment.

Demographic variables		Total patients (n = 110), n (%)	Patients with follow-up (n = 64), n (%)	Patients without follow-up (n = 46), n (%)	p-value*
Gender	Male	74 (67.3)	45 (70.3)	29 (63.0)	0.423
	Female	36 (32.7)	19 (29.7)	17 (37.0)	
Age (years)	≤20	50 (45.5)	27 (42.2)	23 (50.0)	0.081
	21–30	41 (37.3)	29 (45.3)	12 (26.1)	
	≥31	19 (17.2)	8 (12.5)	11 (23.9)	
	Mean (SD)/ range	23.7 (9.3)/12–66	22.7 (7.3)/12–43	25.1 (11.6)/13–66	
Disabilities[a]	Mental retardation	71 (64.5)	40 (62.5)	31 (67.4)	0.786
	Developmental disorders	20 (18.2)	13 (20.3)	7 (15.2)	
	Neurological disorders	12 (10.9)	8 (12.5)	4 (8.7)	
	Dental phobia	3 (2.7)	2 (3.1)	1 (2.2)	
	Alzheimer's disease	2 (1.8)	0 (0)	2 (4.3)	
	Others	2 (1.8)	1 (1.6)	1 (2.2)	
Medication	None	51 (46.4)	31 (49.2)	20 (43.5)	0.758
	Anticonvulsant	28 (25.5)	17 (27.0)	11 (23.9)	
	Antipsychotic	19 (17.3)	9 (14.3)	10 (21.7)	
	Others	11 (10)	6 (9.5)	5 (10.9)	
Past G/A history	None	44 (40)	23 (35.9)	21 (45.7)	0.497
	Medical	31 (28.2)	17 (26.6)	14 (30.4)	
	Dental	18 (16.4)	12 (18.8)	6 (13)	
	Both	17 (15.5)	12 (18.8)	5 (10.9)	
Residency	Home	70 (63.6)	49 (76.6)	21 (45.7)	*0.001*
	Institution	40 (26.4)	15 (23.4)	25 (54.3)	
Primary caregiver[b]	Parents	88 (80)	57 (89.1)	31 (67.4)	*0.005*
	Family	6 (5.5)	1 (1.6)	5 (10.9)	
	(spouse/siblings/children)	2 (1.8)	0 (0)	2 (4.3)	
	Relatives	13 (11.8)	6 (9.4)	7 (15.2)	
	Professional	1 (0.9)	0 (0)	1 (2.2)	
	Self				
Meal types	Normal	84 (76.4)	49 (76.6)	35 (76.1)	0.954
	Soft	26 (23.6)	15 (23.4)	11 (23.9)	
Tooth brushing types	Self	40 (36.4)	24 (37.5)	16 (34.8)	0.626
	Self + assisted	22 (20)	15 (23.4)	7 (15.2)	
	Assisted	39 (35.5)	20 (31.2)	19 (41.3)	
	Rarely done	9 (8.2)	5 (7.8)	4 (8.7)	
Cooperation during dental treatment[c]	Normal	1 (0.9)	1 (1.6)	0 (0)	0.070
	Low[d]	12 (10.9)	10 (15.6)	2 (4.3)	
	Very low[e]	69 (62.7)	40 (62.5)	29 (63)	
	None[f]	28 (25.5)	13 (20.3)	15 (32.6)	

*p-value obtained by the Chi-square test.
In statistical testing, some categories were collapsed to avoid small expected frequencies;
[a]Categories of Neurological disorders, Dental phobia, Alzheimer's disease and Others were collapsed;
[b]Categories of Family, Relatives and Self were collapsed;
[c]Categories of Normal and Low were collapsed.
Co-operation levels were categorized as follows:
[d]Low: only simple dental treatment was possible without using engine-driven cutting instruments;
[e]Very low: only oral examination was possible without any virtual treatment; and
[f]None: neither clinical nor radiographic examination was obtainable,

buffering capacity. The Circumstance sector was based on past caries experience and related diseases. The remaining percentile portion was represented as the chance of avoiding caries.

Statistical analysis

Descriptive statistics were expressed as either frequency and percentage or mean and standard deviation (SD) according to the characteristics of the variables. Because the distribution of the quantitative variables may be non-normal referring to the Shapiro-Wilk's test ($p < 0.05$), non-parametric tests were applied. In the comparison of two group means the Wilcoxon rank-sum test was implemented and, for three or more groups, the Kruskal-Wallis test was used. The non-parametric version of analysis of covariance (ANCOVA) using ranked values was

applied to control different follow-up periods. The Pearson chi-square test was used to assess associations between categorical variables. SPSS (v. 20.0, SPSS Inc., Chicago, IL, USA) was used for the analysis and a type one error rate 0.05 was applied to determine a statistical significance.

Results

The characteristics of the patients with G/A treatment are summarized in Table I. No significant differences existed between each group of patients with or without follow-up after the G/A treatment, except in the categories of residency and primary caregiver ($p < 0.05$). Table II presents the frequency and duration of the G/A treatment and the dental conditions of the patients. There were no significant differences in the dental status between the two groups ($p > 0.05$). No significant differences existed between the two groups in DMFT, DT, MT and FT at baseline ($p > 0.05$). The mean (SD) values of the DMFT and DT were 9.2 (6.4) and 5.5 (4.9) for the patients with follow-up. The outcomes of the Cariogram (Chance of avoiding caries, Diet, Bacteria,

Table II. Dental status of the special needs patients with G/A treatment.

Dental status		Total patients (n = 110), n (%)	Patients with follow-up (n = 64), n (%)	Patients without follow-up (n = 46), n (%)	p-value
GA frequency*	0	1 (0.9)	0	1 (2.2)	0.885
	1	76 (69.1)	44 (68.8)	32 (69.6)	
	2	24 (21.8)	15 (23.4)	9 (19.6)	
	3	9 (8.2)	5 (7.8)	4 (8.7)	
	Mean (SD)/range	1.37 (0.65)/ 0–3	1.39 (0.63)	1.35 (0.67)	
G/A duration (min)	0–120	18 (16.4)	11 (17.2)	7 (15.2)	0.973
	121–240	42 (38.2)	25 (39.1)	17 (37)	
	241–360	22 (20)	12 (18.8)	10 (21.7)	
	361–840	28 (25.5)	16 (25)	12 (26.1)	
	Mean (SD)/range	280.5 (162.6)/60–840	274 (151.6)	289.3 (178)	
DMFT (baseline)	0	8 (7.3)	5 (7.8)	3 (6.5)	0.734
	1–4	19 (17.3)	11 (17.2)	8 (17.4)	
	5–7	22 (20)	10 (15.6)	12 (26.1)	
	8–15	44 (40)	27 (42.2)	17 (37)	
	16–28	17 (15.5)	11 (17.2)	6 (13)	
	Mean (SD)/range	2.4 (1.2)/0–28	2.4 (1.2)	2.3 (1.1)	
DT	0	8 (7.3)	5 (7.8)	3 (6.5)	0.097
	1–4	19 (17.3)	11 (17.2)	8 (17.4)	
	5–7	22 (20)	10 (15.6)	12 (26.1)	
	8–15	44 (40)	27 (42.2)	17 (37)	
	16–28	17 (15.5)	11 (17.2)	6 (13)	
	Mean (SD)/range	2.4 (1.2)/0–28	2.4 (1.2)	2.3 (1.1)	
MT	0	85 (77.3)	49 (76.6)	36 (78.3)	0.407
	1–9	25 (22.7)	15 (23.4)	10 (21.7)	
	Mean (SD)/range	0.6 (1.5)/0 ~ 9	0.7 (1.6)/0 ~ 6	0.6 (1.4)/0 ~ 9	
FT	0	45 (40.9)	30 (46.9)	15 (32.6)	0.419
	1–17	65 (59.1)	34 (53.1)	31 (67.4)	
	Mean(SD)/range	2.8 (3.8)/0 ~ 17	2.7 (3.7)/0 ~ 14	3.1 (3.9)/0 ~ 17	
Malocclusion	minor or none	71 (64.5)	37 (57.8)	34 (73.9)	0.089
	definite	14 (12.7)	12 (18.8)	2 (4.3)	
	severe	12 (10.9)	9 (14.1)	3 (6.5)	
	handicapping	13 (11.8)	6 (9.4)	7 (15.2)	
Periodontal condition	healthy	15 (13.6)	6 (9.4)	9 (19.6)	0.293
	bleeding	40 (36.4)	24 (37.5)	16 (34.8)	
	calculus	46 (41.8)	30 (46.9)	16 (34.8)	
	pockets 4–5 mm	6 (5.5)	3 (4.7)	3 (6.5)	
	pockets ≥6 mm	3 (2.7)	1 (1.6)	2 (4.3)	
Tooth defects	none	75 (68.2)	40 (62.5)	35 (76.1)	0.249
	fracture	19 (17.3)	12 (18.8)	7 (15.2)	
	attrition	14 (12.7)	11 (17.2)	3 (6.5)	
	erosion	2 (1.8)	1 (1.6)	1 (2.2)	

*One patient was not able to receive general anesthesia as planned, due to medical circumstances. Instead, deep sedation was performed during dental treatment.

Table III. Comparison of the mean (SD) numbers of patients according to caries increment.

Caries increment		Patients with follow-up (n = 64), n (%)
iDMFT	0	33 (51.6)
(increased DMFT)	1–2	18 (28.1)
	3–6	8 (12.5)
	7–22	5 (7.8)
	Mean (SD)/range	2.2 (4.2)/0–22
iDT	0	33 (51.6)
	1–2	19 (29.7)
	3–6	7 (10.9)
	7–22	5 (7.8)
	Mean (SD)/range	2.1 (4.2)/0–22
iMT	0	64 (58.2)
	Mean (SD)/range	0
iFT	0	63 (57.3)
	3	1 (0.9)
	Mean (SD)/range	0.1 (0.4)/0–3
iDMFS	0	33 (51.6)
(increased DMFS)	1–2	11 (17.2)
	3–8	13 (20.3)
	9–62	7 (10.9)
	Mean (SD)/range	4.1 (9.7)/0–62
iDS	0	33 (51.6)
	1–2	12 (18.8)
	3–8	13 (20.3)
	9–62	6 (9.4)
	Mean (SD)/range	3.8 (9.6)/0–62
iMS	0	64 (58.2)
	Mean (SD)/range	0
iFS	0	63 (57.3)
	3	1 (0.9)
	Mean (SD)/range	0.1 (0.4)/0–3

Susceptibility and Circumstance) were not different between the two groups ($p > 0.05$). The mean (SD) value of the chance of avoiding caries for the patients with follow-up was 27.6% (22.2%). The mean value (SD) of the intervals between the G/A treatment and the final follow-up was 16.3 (9.5) months with the range of 6–40 months. During a follow-up period, new caries occurred in 48.4% of the patients (iDMFT >0) (Table III). The mean values (SD) of the newly-developed caries teeth (iDMFT) and caries surfaces (iDMFS) were 2.2 (4.2) and 4.1 (9.7), respectively. While the means (SD) of the iDMFT and iDMFS in the high caries risk group (Chance of avoiding caries ≤20%) were 2.97 (5.2) and 5.81 (11.97), those in the low caries risk group (Chance of avoiding caries >60%) were both 0.44 (0.7) (Table IV). When tooth brushing was not performed by the patients on their own, the incidence of new caries increased by 13.0–14.0-times, compared to the self-brushing group ($p < 0.05$) (Table V). When tooth brushing was rarely done because of a lack of co-operation, the incidence increased by 28.0-times ($p < 0.05$). For the patients with no co-operation, the incidence was 6.4 times higher than the patients with a low level of co-operation. For the patients with a high DMFT score (≥8), the incidence was 7.0–8.0-times higher than the patients with no caries experience (baseline DMFT = 0). For the patients with severe-to-handicapping malocclusion, the incidence increased by 4.87-times compared to the patients with no or minor malocclusion ($p < 0.05$).

Discussion

The first aim of this study was to validate the caries risk assessment conducted on patients highly susceptible to caries, who cannot tolerate routine dental treatments without G/A administration. Just a few clinical studies have been published on caries management under G/A, because of the limited accessibility of dental professionals to special needs patients. Although a variety of caries risk assessments have been applied to dissimilar populations in different areas, no such group with a disadvantaged oral health environment has been evaluated as in this study. Within a narrow frame of time and cost under a G/A setting, a screening process for highly caries-susceptible patients is requisite for effective management of the disease. For high risk patients, costive and elaborate restorative options need to be re-considered. On the other hand, for low risk patients, restoration of untreated carious teeth could have relatively more viable options.

We first obtained information that was inserted into the Cariogram and also collected other caries-related factors from clinical records and questionnaires. Because of limited co-operation from the patients, we had to simplify the Cariogram procedures, omitting the two least available steps: the salivary

Table IV. The mean (SD) values of caries increment according to the chance of avoiding caries in the Cariogram.

	Chance of avoiding caries (%)					
	0–20 (high risk) (n = 37)	21–40 (n = 7)	41–60 (n = 11)	61–100 (low risk) (n = 9)	p-value (un)	p-value (adj)
iDMFT	2.97 (5.2)	1.28 (1.5)	1.36 (2.2)	0.44 (0.7)	0.433	0.433
iDMFS	5.81 (11.97)	1.28 (1.5)	3.27 (6.8)	0.44 (0.7)	0.291	0.475

p-value (un), unadjusted p-value by the Kruskal-Wallis test; p-value (adj): p-value under adjustment for follow-up periods obtained by the non-parametric version of analysis of covariance (ANCOVA) method.

Table V. Bivariate associations of demographic factors with caries increment among the patients with G/A treatment.

		Caries increment (iDMFT >0)	
Demographic factors		Odds ratio (95% CI)	*p*-value
Age	≤20 (ref)	1.0	—
	21–30	1.01 (0.35 ~ 2.87)	0.992
	31 ≥	0.65 (0.13 ~ 3.26)	0.597
Gender	Male (ref)	1.0	—
	Female	1.03 (0.35 ~ 3.01)	0.959
Medication	None	1.0	—
	Anticonvulsant	0.95 (0.29 ~ 3.10)	0.930
	Antipsychotic	0.85 (0.19 ~ 3.79)	0.835
	Others	0.53 (0.09 ~ 3.35)	0.503
Disabilities	Mental retardation	1.0	—
	Developmental disorders	0.63 (0.17 ~ 2.24)	0.471
	Neurological disorders	1.00 (0.22 ~ 4.56)	1.000
	Others	0.50 (0.04 ~ 5.99)	0.584
Residency	Home	1.0	—
	Other than home	1.40 (0.44 ~ 4.48)	0.568
Primary caregiver	Parents	1.0	—
	Other than parents	—*	—*
Meal types	Normal	1.0	—
	Soft	2.90 (0.86 ~ 9.78)	0.086
Tooth brushing types	Self	1.0	
	Self + assisted	14.0 (2.78 ~ 70.56)	*0.001*
	Assisted	13.0 (2.85 ~ 59.39)	0.001
	Rarely done	28.0 (2.29 ~ 342.15)	0.009
Cooperation during dental treatment	Low	1.0	—
	Very low	3.62 (0.68 ~ 19.21)	0.131
	None	6.40 (0.95 ~ 43.23)	0.057
DMFT (baseline)	0	1.0	—
	1–4	1.50 (0.12 ~ 19.44)	0.756
	5–7	0.44 (0.022 ~ 9.03)	0.598
	8–15	8.00 (0.78 ~ 82.46)	0.081
	16–28	7.00 (0.67 ~ 86.32)	0.129
Malocclusion	minor or none	1.0	—
	definite	1.26 (0.33 ~ 5.00)	0.731
	severe/handicapping	4.87 (1.29 ~ 18.42)	*0.020*
Periodontal condition	healthy	1.0	—
	bleeding	4.00 (0.40 ~ 41.23)	0.244
	calculus	4.00 (0.40 ~ 40.11)	0.239
	pockets ≥4 mm	1.33 (0.06 ~ 31.12)	0.858
Tooth defects	none	1.0	—
	fracture	0.79 (0.21 ~ 2.91)	0.723
	attrition & erosion	1.11 (0.30 ~ 4.02)	0.879
Chance of avoiding caries (%)	0–20	1.0	—
	21–40	1.13 (0.22 ~ 7.79)	0.880
	41–60	0.49 (0.12 ~ 1.95)	0.308
	61–100	0.24 (0.04 ~ 1.33)	0.103

*Patients in this category showed no newly-developed caries during the follow-up period.

secretion measurement and Lactobacilli cultures using secreted saliva. Our previous study confirmed that the simplified Cariogram without the two above factors produced similar risk profiles to those from the original Cariogram [8]. The next difficult part, due to their complicated situation and insufficient compliance, was to follow-up the patients for post-operative evaluation (normally a 6-month follow-up was scheduled). We tried to compare the two groups, with follow-up (58%) and without follow-up (42%), to determine any underlining causes hindering their visits. Based on our results, only the types of residency and primary caregivers were counted; patients with home-living and parental care were more likely approachable to follow-up examination. Otherwise, other demographic variables, dental status and

caries-risk profiles did not significantly differ between the two groups ($p > 0.05$). Even with a varied length of follow-up periods (6–40 months), longer follow-up periods were significantly associated with more decayed teeth. The effects of different follow-up periods were statistically controlled for in the outcomes (Table IV). As we hypothesized, the overall tendency of the caries increment was according to the level of individual caries risk; more newly developed decayed teeth were seen in the patients with high caries risk compared to those with low caries risk, although this result was not statistically significant. It could be because of the large variances in the data, resulting in the mean values (SD) of the iDMFT and the Chance of avoiding caries (%) being 2.2 (4.2) and 27.6 (22.2), respectively.

The second aim of this study was to define the contributing factors of the high incidence of caries. Most patients had severe intellectual and developmental disabilities, except for only a few having an extreme fear of dental treatment or excessive gag reflex (Table I). Even for patients without disabilities, it is not easy to incorporate multiple factors into caries risk assessment at a routine clinical practice. It would be desirable that clinical variables easily attainable from dental examinations, questionnaires or interviews were valid for the prediction of future caries. In this study, no specific intervention was conducted after the G/A treatment other than comprehensive oral healthcare, which included the following: instructions on tooth brushing using fluoride-containing toothpaste, diet consultation and regular dental check-ups. In general, incorrigible habits against caries prevention prevailed among the patients with severe intellectual- and developmental-disabilities, such as cognitive and masticatory dysfunction, frequent consumption of fermentable carbohydrate-rich snacks, neglect of regular tooth brushing, etc. In particular, individual patterns of tooth brushing using fluoride-containing toothpaste may have manifold implications: cariogenic biofilm formation, fluoride exposure, awareness of the significance of oral health, etc. [12]. Our previous study, performed with the same study population, showed that insufficient oral hygiene maintenance was closely associated with high caries risk [7]. This finding was further substantiated by the present study; when tooth brushing was rarely done by patients or caregivers, then new caries was highly likely to occur (Table V). Additionally, a severe degree of malocclusion could hamper proper oral hygiene maintenance, which was shown to have a large relation to the increment of caries.

Many studies have a good consensus on past caries experience being the best caries predictor throughout various age groups [13–15]. For special needs patients, their caries experiences more clearly demonstrate how they have been coping with the disease with very limited interventions. We attempted to correlate the baseline DMFT scores and the new caries increment (iDMFT) of the patients. A high score for the DMFT (≥8) was greatly associated with the development of new caries (Table V). The level of co-operation of the patients was shown to be another variable indicative of caries development. When the patients were unco-operative and combative against unwanted disciplinary procedures, it would be challenging to persuade them into any activities related to home- and professional-dental care. The consequence of their lack of co-operation combined with a high caries risk could result in the quick development of multiple active lesions.

There is no standard rule for treatment in hospital-based dentistry, with only the most practical and beneficial options for individual circumstances being used [2,16]. Therefore, dental practitioners should be fully informed of the patients' conditions and be prepared to provide the best diagnosis and treatment plans. Additionally, practitioners need to determine time and facilities necessary for the G/A treatment. There is a wide array of treatment options for teeth largely affected by caries: i.e. minimal to full-coverage restoration, endodontic treatment or extraction. Individual risk assessment could provide information that guides the decision-making for restorative needs. Furthermore, application of intensified preventive protocols for an extremely high risk group is as important as restorative treatment in itself. We need to pursue more effective and relevant strategies for the least approachable patients.

In conclusion, caries risk assessed by the Cariogram had a similar tendency to the incidence of future caries in the special needs patients requiring G/A treatment. Other caries-related factors such as past caries experience, oral hygiene maintenance, malocclusion and co-operation levels were largely associated with the caries increment.

***Declaration of interest*:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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