



Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl



Dental caries, cariogenic microorganisms and salivary properties of allergic rhinitis children

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ARTICLE INFO

Article history:

Received 26 December 2013

Received in revised form 28 February 2014

Accepted 3 March 2014

Available online xxx

Keywords:

Allergic rhinitis

Caries risk

Salivary properties

Mutans streptococci

Lactobacilli

ABSTRACT

Objectives: The aim of this study was to observe the caries activities of allergic rhinitis patients in relation to salivary properties, salivary levels of mutans streptococci (MS) and lactobacillus (LB), oral hygiene and dietary habits.

Methods: The study groups composed of 40 allergic rhinitis children and 40 healthy controls aged between 6 and 13 years old. Demographic data, oral hygiene practices and dietary habits were recorded by questionnaire. For permanent teeth, caries experience was expressed as DMFT (D = decayed; M = missing; F = filled; T = teeth) index. The dmft (d = decayed; m = missing; f = filling; t = teeth) index was used for caries prevalence in primary teeth. Unstimulated salivary flow rate, salivary buffering capacity, and salivary MS and LB were also determined in children with allergic rhinitis and controls.

Results: There were no significant differences in combined DMFT/dmft, salivary flow rate, buffer capacity of saliva, salivary LB levels, and sugary food consumption between cases and controls ($p > 0.05$). However, higher salivary MS levels were observed in allergic rhinitis patients, compared to controls ($P < 0.05$).

Conclusions: Our results demonstrated that patients with allergic rhinitis had an increase in the level of salivary MS.

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1. Introduction

Dental caries is one of the most common chronic diseases affecting millions of people globally [1]. One of the causative factors for the disease is dental biofilm, which is the bacterial deposit that forms continuously on the tooth surfaces [2]. Risk factors of the disease compose of inadequate salivary flow, low quality of salivary buffer capacity (BC), high levels of cariogenic bacteria, insufficient fluoride exposure, and frequency consumption of sugar [3].

Mutans streptococci (MS), a group of cariogenic bacteria, are involved in the initiation of dental caries [4]. In addition to MS, lactobacillus (LB) is another group of bacteria that is important in the development of caries. LB does not avidly colonize on the tooth surface, but it may be transiently found in the oral cavity including

the dorsum of the tongue [5]. LB is not important in dental caries formation; however, LB is likely to play an important role in the caries progression [2,6]. Due to the positive association between salivary levels of MS and LB with caries and the linkage of this association to carbohydrate consumption, counts of MB and LB may, potentially, serve not only as a caries risk predictor but also as an indicator of carbohydrate consumption [7].

Salivary flow rate and BC are the important modifying factors in the caries process. Low flow rate and BC of saliva are usually associated with high caries development [8].

The caries process usually progresses rather slowly because of alternating de- and remineralization episode in the dental biofilm. However, if the local environment changes for example, in response to frequent sugar intake or low salivary secretion combined with insufficient oral hygiene, the equilibrium between the de-remineralization episodes may favor a mineral loss (demineralization) [9].

Medications may play a role with regard to hyposalivation. At present, there are more than 500 drugs which have been reported to cause xerostomia or salivary hypofunction as an adverse effect [10].

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Allergic rhinitis (AR) is a common disease affecting nearly one-third of the general population [11]. This disease is also commonly found in Thai people. Previous studies using The International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire showed that prevalence for AR in Thai children were 28.5–38.7% [12–14].

Treatment with intranasal corticosteroids and antihistamine drugs are the choices recommended in AR patients. Patients receiving antihistamines had a lower salivary flow rate than that of healthy people [15]. Since low salivary secretion is one of the risk factors of dental caries, therefore, it has been suggested that patients suffering from AR may contribute to dental caries development. Some authors found that drugs used in chronic diseases, such as asthma were related to high caries risk [16], however, other authors did not observed the same results [17].

There are a few studies that evaluated the association between AR and dental caries. Moreover, because of controversies in the literature about medication use and dental caries, we investigated the potential relationship between AR including pharmacotherapy and dental caries in Thai patients.

2. Materials and methods

2.1. Subjects

This observational study was approved by the Ethics Committee of Thammasat University. The parents of the children received detailed information about the study and agreed to the participation of the present study by signing a free informed consent form. For the sample size calculation we consider the work of Elad et al. [15] who reported the difference in salivary flow rate between AR patients treated with fexofenadine and healthy individuals. To detect a difference of this magnitude, with alpha and beta error respectively of 0.05 and 0.20, it was estimated that 38 subjects were needed per group. Therefore, this study was conducted with 40 children in AR group and 40 in the control group. The sample size was determined using PASS 2002 software.

AR patients were recruited from allergy clinic, Thammasat university hospital. The diagnosis of AR is based on history, physical examination and positive skin-prick test to at least 1 of 7 aeroallergens (house dust mite, cockroach, grass pollens, cat, dog, molds and kapok). Clinical history and physical examination were used to diagnose allergic rhinitis comorbidities, such as asthma and allergic conjunctivitis.

The cases selected as AR were children, having previous allergic rhinitis, including persistent or intermittent allergic rhinitis and/or allergic conjunctivitis. The children forming the control group, were matched for age and socioeconomic status to the case group, and were randomly selected from a public school in Prathumthani province. Control subjects should not meet diagnostic AR criteria after applying the ISAAC phase I questionnaire regarding allergic symptoms (nasal congestion, rhinorrhea, sneezing, snoring and itchy/watery eyes). This questionnaire was used for national survey of childhood with AR in Thailand [12–14]. Both case and control groups should not have any other systemic diseases and were not using any other medication that could modify the salivary parameters at least 30 days before the study.

2.2. Diagnosis of allergic rhinitis

Information recorded for all participants included demographic data, duration of the AR, medication, family history of the disease, allergic comorbidities (asthma, atopic dermatitis, and allergic rhino conjunctivitis), smoking and sleep problems. Patients who were diagnosed to have AR were classified as intermittent or persistent rhinitis in according with the Allergic Rhinitis and its Impact on Asthma (ARIA) guideline [18].

2.3. Dental examination

Each child received a dental examination by one dentist at Faculty of Dentistry, Thammasat University. Diagnosis of dental caries was made according to the criterion recommended by the World Health Organization (WHO) [19]. Caries was determined visually with optimal illumination of the oral cavity, in which the detection of an apparent carious on visual inspection was defined as a carious lesion. Dental caries of permanent teeth was recorded as the decayed (D), missing (M), and filled (F) teeth. For primary teeth, the prevalence of caries was calculated by determining the number of decayed (d), missing (m), and filled (f) teeth. Notably, teeth that were lost because of trauma or exfoliation were excluded from the relevant calculation. Accordingly, the frequency of caries was assessed based on the DMFT score for permanent teeth and the dmft score for primary teeth.

2.4. Oral hygiene and dietary habits

In connection with the dental examination, a semi-structure interview was performed. Personal data regarding to oral hygiene practices included tooth-brushing frequency and fluoride use, were collected using questionnaires completed by the parents.

To assess dietary habit, parents completed at home a 3-day dietary diary for their child. Written instructions were attached to the diary aiming to encourage them to record everything that their child had eaten or drunk over a 3-day period (including a weekend day), together with the time of eating. Frequencies of diet including sugary snacks and beverage consumption between meals were calculated as described by Rugg-Gunn et al. [20]. An intake was considered separate if the time of consumption was at least 30 min after the previous intake of a meal, or at least 15 min after the previous eating of a snack. These separate intakes were called events. The number of events per day was calculated for all foods and drinks (total event). Sugary snack and soft drink consumption between meals was also recorded.

2.5. Salivary and microbiological analyses

Saliva collections were carried out between 9 AM and 12 PM to reduce variations caused by changes in circadian rhythm. Subjects were instructed to refrain from eating, drinking, and tooth brushing for a minimum of 90 min before saliva collection. Unstimulated whole saliva was collected by expectoration into a 10-ml sterile plastic tube for 5 min and its flow rate was calculated using gravimetric methods (assuming a specific gravity of saliva of 1.0) and expressed as ml/min [21]. The salivary flow rate was classified in accordance with [8], in which unstimulated salivary flow was considered normal for values ≥ 0.3 ml/min. Less than 0.3 ml/min was considered low flow rate for unstimulated saliva.

Paraffin-stimulated whole saliva was collected for caries activity tests. The buffering capacity was estimated by using the Dentobuff strip test (Orion Diagnostica, Espoo, Finland) and expressed according to the manufacturer's instructions as high (blue), medium (green) or low (yellow).

The salivary level of *Lactobacillus* spp. was determined with Dentocult[®] LB dip-slide test (Orion Diagnostica). The colony density of lactobacilli was estimated by comparing the slide with a density chart provided by the manufacturer. The colony density was expressed as a score of 0, 1, 2, or 3 corresponding to the counts of 10^3 , 10^4 , 10^5 , and 10^6 colony forming unit (CFU/ml), respectively.

The specific selective medium, mitis-salivarius bacitracin agar (MSB), was used for determining of MS [22]. The count of MS was expressed as CFU/ml of saliva. The count was interpreted according to the criteria described by Kohler and Bratthall [23]. Three groups

were classified: low caries risk = $0\text{--}10^4$ CFU of MS/ml; moderate caries risk = $10^5\text{--}10^6$ CFU of MS/ml and high caries risk = $>10^6$ CFU of MS/ml.

For statistical analyses, we combined the scores of LB into 2 categories, which were low level ($<10^5$ CFU/ml: score = 0 and 1) and high level ($\geq 10^5$ CFU/ml: score = 2 and 3) [24]. The level of MS in saliva was also grouped into low level ($<10^5$ CFU of MS/ml) and high level ($\geq 10^5$ CFU of MS/ml) [25]. Dental caries were classified as “low caries risk” (combined DMFT/dmft, dmft + DMFT < 4) and those with combined DMFT/dmft ≥ 4 were classified as “high caries risk”. The reason for choosing a DMFT/dmft value of 4 as the cut-off point was that the average (median) of the combined DMFT and dmft scores for all participants was 4 [26].

2.6. Statistical analyses

Data were analyzed using The Statistical Package for Social Science (SPSS) software Version 22 (SPSS Inc., Chicago, IL). Sample size and power of test were calculated by using PASS software. Descriptive statistics including the frequency, mean, median, standard deviation and range was used to describe variables. Fisher's exact test and Pearson Chi-square test were applied to test the association or comparison between categorical variables. Student's unpaired *t*-test for normally distributed quantitative variables or Mann–Whitney *U*-test for variables with skewed distribution was used to determine the significance between unpaired two groups. Logistic regression analysis was carried out to simultaneously evaluate the correlation of each variable. The critical level for statistical significance was *P* value ≤ 0.05 , with a confidence interval of 95%.

3. Results

3.1. Demographic characteristics

The study included 40 AR and 40 healthy children. The average age (median) of AR (25 males and 15 female) was 8 years (range 6–13 years). The average age (median) of the control (16 male and 24 female) was 9 years. There were no statistical differences in age (*P* = 0.56, Mann–Whitney *U*-test) and sex (*P* = 0.73, Fisher's exact test) between cases and controls. The demographic and clinical characteristics of the patients are summarized in Table 1.

Among 40 patients tested, 23 patients have a positive test to single allergen while the remaining patients were noted to react to 2 or more allergens. House dust mite was the most common allergen in our AR patients. House dust mite positivity accounted for 19 (47.5%) patients. Grass pollens and cockroaches were positive in 3 (7.5%) and 1 (2.5%) patients, respectively.

According to ARIA classification, mild and moderate/severe persistent were observed in 7 (17.5%) and 33 (82.55%) patients, respectively. AR co-exists with asthma in as many as 42.5% of patients. With regard to treatments for AR, all patients were prescribed a second- or third-generation (non-sedating) antihistamine; 13 (32.5%) were received antihistamines combined with a leukotrienes receptor antagonist (Montelukast). The use of intranasal steroids was more frequent in the patients. The average duration of AR was 3.5 years ranged with 1–10 years. Forty percent were exposed to household smoking. About half of children had parents with a history of AR.

3.2. Dental caries experience

Medians of combined DMFT/dmft of AR and the control groups were 3.0 (range, 0–13) and 4.0 (range, 0–13), respectively. There was no significant difference of the combined DMFT/dmft between both groups (*P* = 0.20, Mann–Whitney *U* test). Of these, high caries

Table 1

Demographic and clinical characteristics of patients (*n* = 40).

Characteristics	
ARIA classification	
Mild persistent, <i>n</i> (%)	7 (17.5)
Moderate/severe persistent, <i>n</i> (%)	33 (82.5)
Comorbidities	
AR, <i>n</i> (%)	18 (45.0)
AR and asthma, <i>n</i> (%)	17 (42.5)
AR and conjunctivitis, <i>n</i> (%)	7 (17.5)
AR, allergic conjunctivitis, and asthma, <i>n</i> (%)	2 (5.0)
Medication	
Antihistamine	
2nd or 3rd generation, <i>n</i> (%)	27 (67.5)
2nd or 3rd generation and Montelukast, <i>n</i> (%)	13 (32.5)
Steroids	
Intranasal steroids	39 (97.5)
Inhaled steroids	17 (42.5)
Positive skin-prick test	
House dust mite, <i>n</i> (%)	19 (47.5)
Grass pollens, <i>n</i> (%)	3 (7.5)
Cockroach, <i>n</i> (%)	1 (2.5)
House dust mite + Cockroach, <i>n</i> (%)	3 (7.5)
+ Cat, <i>n</i> (%)	3 (7.5)
+ Dog, <i>n</i> (%)	1 (2.5)
+ Molds, <i>n</i> (%)	1 (2.5)
+ Grass pollens, <i>n</i> (%)	1 (2.5)
+ Cockroach, cat, <i>n</i> (%)	2 (5.0)
+ Cockroach, grass pollens, <i>n</i> (%)	2 (5.0)
+ Cat, grass pollens, <i>n</i> (%)	1 (2.5)
+ Cockroach, molds, grass pollens, <i>n</i> (%)	1 (2.5)
+ Cockroach, molds, dog, <i>n</i> (%)	1 (2.5)
+ Cockroach, cat, dog, <i>n</i> (%)	1 (2.5)
Symptom duration, years [median (min–max)]	3.5 (1–10)
Household smoking, <i>n</i> (%)	
Mother	0 (0)
Father	10 (25.0)
Other	6 (15.0)
Animal exposure, <i>n</i> (%)	16 (40.0)
Family history of AR, <i>n</i> (%)	
Father with AR	11 (27.5)
Mother with AR	7 (17.5)
Mother with AR and asthma	2 (5.0)

risk (combined DMFT/dmft ≥ 4) was observed in 52.5% and 55% in cases and controls, respectively (*P* = 0.50, Fisher's exact test).

3.3. Salivary properties

Salivary flow rate and buffer capacity of the children studied are given in Table 2. Unstimulated salivary flow rate of children with AR was between 0.1–2.4 ml/min (median = 0.50 ml/min). It was between 0.25 and 1.71 ml/min in the control with a median salivary flow rate of 0.76 ml/min. The difference was not statistically significant (*P* = 0.10, Mann–Whitney *U* test). Six

Table 2

Flow rate and buffer capacity of saliva.

Variable	AR	Control	<i>P</i> -value
Salivary flow rate			
Low, <i>n</i> (%)	6 (15.0)	2 (5.0)	0.26 ^a
Normal, <i>n</i> (%)	34 (85.0)	38 (95.0)	
Salivary buffering capacity (BC)			
Low, <i>n</i> (%)	13 (32.5)	13 (32.5)	0.69 ^b
Medium, <i>n</i> (%)	16 (40.0)	19 (47.5)	
High, <i>n</i> (%)	11 (27.5)	8 (20.0)	

^a Fisher's exact test.

^b Pearson Chi-square test.

(15%) children with AR had low salivary flow rate (<0.3 ml/min) where as in the control, low salivary flow rate was observed in 2 (5%) children ($P = 0.26$, Fisher's exact test). There was no statistical difference in salivary flow rate between AR who used intranasal steroids and those who did not use the drugs ($P = 0.49$, Fisher's exact test). Severity of AR did not affect on salivary flow rate ($P = 0.28$, Fisher's exact test). However, Eta coefficient (0.28) indicated that there was weak correlation between symptom duration and salivary flow rate in AR patients.

Majority of children had medium salivary BC, followed by low salivary BC and high salivary BC in AR and control groups. No significant difference was observed in children with and without AR, respect to salivary BC ($P = 0.69$, Pearson Chi-square test).

3.4. Cariogenic bacteria

The median number of salivary MS was 11×10^5 and 3×10^5 CFU/ml in the AR and control groups, respectively. A statistically significant increase in the level of salivary MS was found in AR children compared with the controls ($P < 0.05$, Mann Whitney U test). The AR group had a significantly higher percentage (57.5%) of children with a high level of salivary MS than the control group (5%) (Table 3) ($P = 0.01$, Fisher's exact test). However, there were no significant differences in the percentage of children with high and low levels of salivary LB between the two groups ($P = 1.0$, Fisher's exact test). Low association between salivary MS and LB was observed in the studied population (Pearson Chi-square, $P = 0.01$, Cramer' $V = 0.28$).

3.5. Oral hygiene and dietary habits

Table 4 shows that the majority of children with and without AR brushed their teeth at least twice daily. Approximately 88% of patients used fluoride toothpastes whereas 92.5% was observed in the controls. No significant difference was found with regard to oral hygiene practices between AR and control groups.

AR children had more frequent main meals per day (5.35 ± 1.51) compared to that of the controls (4.39 ± 1.16) ($P = 0.01$, Unpaired t test). However, there were no significant differences in snack ($P = 0.78$) and beverage ($P = 0.26$) consumptions between the two groups.

Furthermore, to confirm the association between AR and cariogenic bacteria, the logistic regression analysis was carried out. In this study AR and salivary flow rate were included in logistic regression model. The study had events-per-variables more than 10. Therefore logistic regression model was valid [27,28]. For salivary MS but not LB, the logistic regression analysis of all participants revealed that AR was an important risk factor (Table 5). To validate our logistic regression model, power of test was calculated by using PASS software. We calculated P_0 , P_1 and R^2 from our logistic regression model. It was found that power of test was 0.98 where P_0 , P_1 , and R^2 were 0.148, 0.567 and 0.028, respectively.

Table 3
The level of MS and LB of patients and controls.

Variable	AR	Control	P-value
Salivary MS			
Low ($<10^5$ CFU/ml), n (%)	17 (42.5)	35 (87.5)	0.01
High ($\geq 10^5$ CFU/ml), n (%)	23 (57.5)	5 (5.0)	
Salivary LB			
Low ($<10^5$ CFU/ml), n (%)	34 (85.0)	34 (85.0)	1.0
High ($\geq 10^5$ CFU/ml), n (%)	6 (15.0)	6 (15.0)	

Fisher's exact test.

Table 4

Oral hygiene practices and dietary habits of patients and controls.

Variable	AR	Control	P-value
Tooth brushing frequency			
1/day, n (%)	32 (80.0)	11 (27.5)	0.6 ^a
≥ 2 /day, n (%)	8 (20.0)	29 (72.5)	
Fluoridated toothpaste			
Use, n (%)	35 (87.5)	37 (92.5)	0.71 ^a
No use, n (%)	5 (12.5)	3 (7.5)	
Meals per day, mean $\pm$ SD	5.35 $\pm$ 1.51	4.39 $\pm$ 1.16	0.01 ^b
Sweet snacks, n (%)			
≤ 1 /day	9 (22.5)	7 (17.5)	0.78 ^a
> 1 /day	31 (77.5)	33 (82.5)	
Carbonated drinks, n (%)			
≤ 1 /day	23 (57.5)	17 (42.5)	0.26 ^a
> 1 /day	17 (42.5)	23 (57.5)	

^a Fisher's exact test.

^b Unpaired t test.

Table 5

Logistic regression analysis of salivary MS.

Variable	Odds ratio	SE	95% CI	P-value
Allergic rhinitis	2.23	0.58	2.98–28.95	0.01
Salivary flow rate	–0.21	0.83	0.16–4.14	0.80

Note: $R^2 = .21$ (Cox and Snell), .29 (Nagelkerke).

Model χ^2 (2) = 18.96, $P = 0.01$.

4. Discussion

Our results indicated that 57.5% patients tested positive to at least 1 allergen. Results of other studies have varied from 24.9 to 81.6% [29,30]. Diversity of populations tested with regard to urban or rural lifestyles, and their mobility accounted for the wide variation in numbers. We found that house dust mites were the most common allergens in our AR patients. Our findings are in agreement with the previous reports performed in patients with allergic rhinitis in Thailand, [31] and Singapore [32].

The diagnosed of asthma in AR patients in this study was relatively high. However, the prevalence of AR coexists with asthma in our patients was in the range reported in the previous study in Thailand [33].

There is some controversy in the reports about the relationship between allergic disorders and dental caries [34]. Most studies have reported the relationship between asthma and dental caries, whereas a few studies have investigated the association between AR and dental caries. It has been suggested that AR itself was not considered a risk factor for dental caries. Medication used for AR treatment may play an important role for caries development and it is mainly due to a decrease of salivary flow [15].

Some evidence from the literature suggests that poor oral health could be linked to asthma [35,36]. However, a previous study demonstrated that asthmatic children 4–10 years of age at all severity levels had more or less the same dmft and DMFT as the healthy children. In addition, no association was found between cumulative exposure of xerostomatic drugs and the prevalence of dental caries either in the primary (dmft) or permanent (DMFT) dentition [37]. In the present study, we demonstrated that there was no difference in caries experience between AR and the control groups. Our findings are agreement with previous studies in AR [38,39] and asthmatic patients [37].

We found that the median value of the unstimulated salivary flow for the children with AR was 0.50 ml/min. Therefore, our

patients had normal salivary flow rate [8]. Moreover, no difference in salivary flow rate was recorded between AR and the control groups. This implies that AR *per se* and/or the drug treatment in AR has not affected the salivary flow. The findings were not different from that of our expectations because in this study, all patients had been prescribed non-sedating antihistamines (desloratadine, loratadine, fexofenadine and cetirizine). This new generation antihistamines had a lesser degree of anti-cholinergic effects than that of the first-generation antihistamines [40,41]. However, it is surprising that our findings differed from a study by Elad et al. [15]. The authors reported that AR patients treated with fexofenadine or loratadine had a lower salivary flow rate than the healthy control group. We are unable to offer a satisfactory explanation for these conflicting reports.

There are even fewer studies, which in addition to asthma consider the effect of AR on salivary BC. Paganini et al. [42] did not detect any difference in salivary BC between asthmatic and healthy while others have found a decrease of salivary BC in asthmatics [43]. Our study is in agreement with the study of Paganini et al. We showed no significant difference in salivary BC between AR and the control groups. Interestingly we observed that 32.5% of the children in the control group had low salivary BC. The reasons for this may be due to extrinsic factors such as dietary habit, as well as intrinsic factor such as bicarbonate content [44]. Taken together, our findings from the saliva analysis suggest that salivary characteristics are not overtly associated with AR.

Despite the importance of the salivary MS and LB in caries risk assessment, we could not find any study related to cariogenic bacteria in children with AR in the literature. Many previous studies have evaluated the association between the number of MS and LB in saliva and caries experience in asthmatics. However, there are conflicting reports regarding the cariogenic bacteria of individuals with asthma in comparison to controls [34]. In the present study, we found a higher level of salivary MS in children with AR compared with controls. However, there was not a significant difference in salivary LB between AR and control groups. Our findings are in agreement with the work of Botelho et al. [45] who reported an increased level of salivary MS but not LB in asthmatics. A possible reason for the results could be that MS is generally found on tooth surfaces and carious lesions, whereas LB is found not only on the tooth surfaces but also on oral mucosa and dorsum of tongues [7]. Therefore by taking saliva it is possible to detect more LB compared to MS even though there may be no association to caries lesions.

In this study, there was a significant relationship between salivary MS and LB in all participants; confirming results obtained by previous studies [46]. Although it is unclear about this association, it is likely that interaction between the two bacteria enhances their growth in the dental biofilm [47]. However, the correlation obtained in our study was low. Therefore, it is possible that other factors may affect the result of this analysis. In addition, our findings have shown that all participants tend to consume fermentable carbohydrates and this could explain the non-significant difference in salivary LB between AR and control groups [48].

This study demonstrated that despite AR children showing an increase in salivary MS, they had similar dental caries prevalence when compared with the healthy children. One explanation for these results may be the multifactorial characteristics of dental caries. Some studies found a significant association between salivary MS and caries experience, however, other studies revealed no clear-cut association between them [8,49]. On the other hand, it is also possible that AR and healthy children who participated in our study had proper oral hygiene practices, as shown in evidence by non-significant difference in tooth brushing and fluoride use.

Analysis of questionnaire data did not reveal major difference in the reports of this study population as concerns their dietary habits. We found that children with AR had more meals per day compared to the controls. However the total daily intakes of food were not involved in the level of cariogenic bacteria and caries experience [50]. It was also suggested that 4–5 meals or snacks per day as found in our study population appear to be “safe” when the teeth are cleaned with fluoride toothpastes twice or more daily [51,52]. The present study has confirmed that the effect of sugar consumption on caries development depends partly on the cleanliness of tooth [48].

Our logistic regression analysis indicated that AR was positively related to salivary MS independently of the other variables. This finding confirms that AR increases the risk for an increase of certain cariogenic bacteria as mentioned above.

Taken together, our results revealed that AR was not significantly associated with caries experience. Although a high level of salivary MS was observed in children with AR but the physiologic changes resulting from the disease and/or medication use may not strongly affect the caries process, especially in children who have regular oral hygiene maintenance.

5. Conclusions

In summary, our studies show conclusively for the first time that children with AR have a higher level of salivary MS than healthy children although; combined DMFT/dmft, saliva properties, oral hygiene habit and frequency consumption of sweet snacks and drinks were not significantly different between children with and without AR.

Conflict of interest statement

The authors declare that there is no potential conflict of interest as none of the authors have any personal or financial relationship that might introduce bias or affect their judgment.

Acknowledgements

The authors thank all parents and children involved in the study and gratefully acknowledge the funding for this project by Thammasat University. We also thank Paopanga Monthanapisut and Napaporn Pattanacharoenchai for technical assistance, and Sira Nanatapisal for his suggestions.

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