Original Article

Assessment of dental caries and salivary characteristics among type 1 diabetic Saudi children

Sami Abdoh Assiri a, Omar Abd El Sadek El Meligy b, c*, Ibtesam Omar Alzain b, Nada Othman Bamashmous b

a Dental Department, Hera General Hospital, Makkah, Saudi Arabia
b Pediatric Dentistry Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
c Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Alexandria University, Alexandria, Egypt

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Abstract  Background/purpose: Type 1 diabetes mellitus (DM1) is considered the most common chronic disease in childhood. This study aimed to assess dental caries and salivary characteristics among a group of Saudi children with DM1.

Materials and methods: Forty children with DM1 and 40 age— and gender—matched healthy controls were enrolled. A saliva sample was obtained to measure flow rate of saliva, buffering capacity, potential of hydrogen (pH), and bacterial counts. Oral examination and dental caries were recorded using Decayed, Missing, and Filled Teeth (dmft/DMFT) indices for primary/permanent teeth.

Results: Children with DM1 showed higher DMFT scores with a mean of 3.5 compared to 2.8 in healthy children. The differences between both groups were not statistically significant (P = 0.14). Regarding dmft score, children with DM1 showed a significantly lower mean score of 4.5 compared to 6.5 in healthy children (P = 0.019). The flow rate of saliva showed a non—significant reduction in children with DM1 compared to healthy children with a mean of 0.86 and 0.96, respectively (P = 0.24). The mean salivary pH was found to be higher in the healthy group, but this was statistically non—significant (P = 0.118). The buffering capacity was significantly lower in children with DM1 compared to healthy children (P = 0.013). Mutans streptococci (MS) and Lactobacilli counts were found to be not significantly different between both groups (P = 0.422, P = 0.118 respectively).

* Corresponding author. Pediatric Dentistry Department, Faculty of Dentistry, King Abdulaziz University, PO Box 80209, Jeddah 21589, Saudi Arabia. Fax: +966126403316.
E-mail address: omeligy@kau.edu.sa (O.A.E.S. El Meligy).

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Introduction

Diabetes mellitus (DM) is defined as a metabolic disorder that leads to improper metabolism of carbohydrates, fats, and proteins. This improper metabolism is associated with hyperglycaemia due to insufficient or absence of insulin hormones or defects in its action. Multiple etiological factors can be identified and linked to the incidence of DM. The worldwide increased prevalence of uncontrolled DM cases has led to an expanding global health burden due to diabetes complications. In 2019, almost 9% of the world population (463 million) were diagnosed as having DM, and 578 and 700 million are predicted to have DM by 2030 and 2045, respectively. Complications of uncontrolled DM affect most of the body system, but the predominant long–term complications are heart failure and coronary heart disease (CHD). In addition, DM patients have a significant prevalence of oral diseases such as an abnormal function of taste buds, periodontal disease, sensory problems, and salivary gland dysfunction, along with oral infections. Furthermore, deficiency in insulin hormones in patients with diabetes leads to alterations in salivary quantity and composition, leading to hyposalivation and high glucose concentration in the saliva. Patients with DM have a higher chance of developing dental caries because of changes in their oral environment; nevertheless, the evidence for a link between dental caries and type 1 DM (DM1) is ambiguous.

Some countries do not pay attention to non–infectious diseases like DM, especially in the Arab world, where there is a high prevalence of this disease. Saudi Arabia ranks in second place in the Middle East countries and seventh in the World according to World Health Organization (WHO). Saudi Arabia’s Ministry of Health (MOH) reported that approximately 900,000 individuals had DM in 1992, that increased to 2.5 million individuals by 2010. This increase in incidence represents 2.7 times more than what was recorded two decades earlier.

Data regarding the oral health condition of children with DM1 are very limited in Saudi Arabia. Al–Badr et al. studied the salivary pH and Mutans streptococci (MS) and lactobacilli levels in children with DM1. However, no studies measuring the salivary flow rate in type 1 DM have been done in Saudi Arabia.

This study aimed to assess dental caries and salivary characteristics among a group of Saudi children with DM1.

Materials and methods

Study design

This is a non–experimental case–control study.

Ethical approval

Ethical approval was obtained from the Research Ethics Committee (REC), Faculty of Dentistry (approval no. 106–06–19), King Abdulaziz University (KAU) and the Unit of Biomedical Ethics, Faculty of Medicine (reference no. 522–19), KAU, Jeddah, Saudi Arabia. Written consent was obtained from the parent.

Study sample

All children of ages 6–12 years with DM1 for at least three years, did not have any medical conditions other than DM1, and did not use any medication other than for the treatment of DM1 and who were treated in the Department of Endocrinology at King Abdulaziz University Hospital (KAUH) during the period 2016–2019 were identified through the information technology (IT) department. The controls were recruited from patients who attended King Abdulaziz University Dental Hospital (KAUDH) clinics for dental treatment. The controls were healthy children who matched the test group in age and gender, who were not on any medications, and with no history of any oral surgery or orthodontic treatment that might affect the oral environment and results. One examiner who was not blinded to both groups carried out the dental examination at KAUDH pediatric clinics, which included dmft, DMFT, buffering capacity, salivary flow rate, potential of hydrogen (pH), and bacterial level assessment.

Sample size calculation

According to Ismail et al. and Orbak et al., a sample of 32 participants in each group was estimated to be sufficient by using sample size calculations with a type 1 error of 5% and type 2 error of 20%, using G*Power software version 3.1.7.

Data collection

The data was collected by one examiner and were categorized into three sections (A, B and C). Section A covered demographic information (file number, age and gender). Section B comprised five questions regarding medical history data (does your child have DM1, when was your child diagnosed, what are the last two results of hemoglobin A1c (HbA1c), does your child have any medical condition other than DM1 and does your child take medication). Section C included the patient’s clinical examination findings (dental caries, buffering capacity, bacterial counts, pH and flow rate of saliva).
Caries index

In a dental clinic setting, prophylaxis was done to remove any food debris on the surface of the teeth, after which a clinical examination was conducted using WHO dental explorer and a mirror under dental chair light, recording Decayed, Missing, and Filled Teeth (dmft/DMFT) indices according to WHO criteria. The DMFT and dmft indices indicate Decayed, Missing, and Filled Teeth for primary and permanent teeth, respectively. The examination was done by systematic order using the World Dental Federation (FDI) tooth numbering system. The examination was performed by one investigator.

Salivary flow rate

Once the participant arrived at the clinic and before the clinical examination of dental caries was carried out, unflavoured paraffin wax was provided to the child to chew for 5 minutes to stimulate the salivary glands, and the saliva secreted via this stimulation was collected in a sterile plastic container. The saliva sample was transferred into a sterile syringe. The number marking the amount of saliva in the syringe was recorded and divided by five to obtain the flow rate of saliva per minute.

Buffering capacity

The buffering capacity was measured in the clinic by using the Caries Risk Test (CRT) buffer kit (Ivoclar Vivadent Clinical, Schaan, Liechtenstein), using the micropipette provided with the CRT kit. Following the manufacturing instructions, saliva drops were applied to cover the test field in the buffer strip and left for 5 minutes. The colour of the strip would then change into either blue, green, or yellow, which indicated either a high, medium or low buffering capacity, respectively.

pH

The pH of the saliva samples was measured using a pH meter (Thermo Scientific™ Orion Star A214 pH/ISE Benchtop Meter, Waltham, MA, United States). Before assessing the pH of the samples, calibration of the pH meter was carried out using the standard buffer solution. Then the measurement was performed by immersing the measuring electrode inside the collected saliva sample and the pH was recorded.

Bacterial level assessment

The CRT bacteria kit (Ivoclar Vivadent Clinical) was adopted to measure the amount of MS and lactobacilli in the collected saliva samples. The agar carrier was removed from the test vial and the NaHCO₃ tablet was placed at the base of the vial. After that, the protective foil of the two agar surfaces was removed carefully to avoid touching the agar surface. Then, both agar surfaces were wet thoroughly by saliva using a micropipette while holding the agar carrier surface in a slightly oblique direction to allow the excess saliva to drip off. The agar carrier was inserted back into the vial and closed tightly. The test vial was placed in the incubator (Memmert GmbH + Co. KG, Schwabach, Germany) in an upright direction for 48 hours at 37 °C. After 48 hours, the bacterial level in the saliva was measured in colony-forming units per milliliter (CFU mL⁻¹). The number of bacteria was assessed after removal of the agar carrier from the incubator into two categories: low category, which is less than 10⁵ CFU mL⁻¹ bacterial count, and the high category, which is more or equal to 10⁵ CFU mL⁻¹ bacterial count according to the manufacturer chart included in CRT kit.

Statistical analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, United States). The significance level for the statistical analysis was set at P < 0.05, with a 95% confidence level. A t-test was used to examine the variation in DMFT, dmft, salivary flow rate, and pH between case and control groups. Monte Carlo exact test was used to test the differences in buffering capacity between the studied groups. The chi-square test was used to test the differences in bacterial levels between the studied groups.

Results

Demographic characteristics

This study included a total of 80 individuals (40 case group and 40 control group) in the age range 6—12 years. For the case group, the mean age was 9.75 ± 1.9 years. Of those patients, 18 were males and 22 were females, representing 45% and 55% of the case group population. The recent results of the HbA1c level showed that the mean of HbA1c was 9.31 ± 2.1 mmol/mol. For the control group, the mean age was 9.6 ± 1.7 years. Of those patients, 18 were males and 22 were females, representing 45% and 55% of the control group population.

Caries index

Concerning mean DMFT, there was no statistically significant difference between both groups (P = 0.14). Regarding mean dmft, there was a statistically significant between both groups (P = 0.019) (Table 1).

| Variable | Group | Mean | SD  | t-test  | P-value |
|----------|-------|------|-----|---------|---------|
| DMFT     | Case  | 3.55 | 2.45| 1.488   | 0.145   |
|          | Control | 2.83 | 1.83|         |         |
| dmft     | Case  | 4.5  | 4.54| 2.393   | 0.019*  |
|          | Control | 6.52 | 4.21|         |         |

DMFT: Decayed, Missing, and Filled Teeth for permanent teeth; dmft: Decayed, Missing, and Filled Teeth for primary teeth. *Statistically significant at P < 0.05.
Salivary flow rate and pH

The mean flow rate was lower in the case group compared to the control group and this difference was not statistically significant \( (P = 0.247) \) (Table 2). Regarding pH, the difference between both groups was not statistically significant \( (P = 0.118) \) (Table 2).

Salivary buffering capacity

Regarding buffering capacity, the difference between both groups was statistically significant \( (P = 0.013) \) (Table 3).

Bacterial level assessment

Concerning MS level, the variation between both groups was not statistically significant \( (P = 0.422) \). As for lactobacilli level, the variation between both groups was not statistically significant \( (P = 1.00) \) (Table 4).

Association between HbA1c, DMFT, dmft, salivary flow rate, and pH

No statistically significant association was found \( (P = 0.726, P = 0.807, P = 0.830, P = 0.975 \) respectively) (Table 5).

Association between DMFT, salivary flow rate, and pH

There was no statistically significant correlation in both groups (Table 6).

Association between dmft, salivary flow rate, and pH

No statistically significant correlation was found in the case group. In the control group, there was a significant correlation between dmft level and salivary flow rate \( (P = 0.029) \) (Table 7).

Discussion

The effect of DM1 and its link with dental caries experience and alterations in saliva characteristics remains debatable. Three studies to date have addressed dental caries in children with DM1 in Saudi Arabia, all of which were in Riyadh city.\(^\text{12,16,17}\) The present study was the first study to investigate the stimulated salivary flow rate in children with DM1 in Saudi Arabia.

### Table 2

| Variable                  | Group | Mean   | SD     | t-value | P-value |
|---------------------------|-------|--------|--------|---------|---------|
| Salivary flow rate        | Case  | 0.86   | 0.306  | −1.175  | 0.247   |
|                           | Control| 0.96   | 0.476  |         |         |
| Salivary pH               | Case  | 7.42   | 0.551  | −1.582  | 0.118   |
|                           | Control| 7.60   | 0.442  |         |         |

\( \text{pH: potential of hydrogen. Statistically significant at } P < 0.05. \)

### Table 3

| Variable                  | Group | Case (n) | Control (n) | P-value |
|---------------------------|-------|----------|-------------|---------|
| Buffering capacity        | Low   | 12.5%    | 7.5%        | 0.013*  |
|                           | Medium| 22.5%    | 15%         |         |
|                           | High  | 65%      | 77.5%       |         |
|                           | Total | 100%     | 100%        |         |

\*Statistically significant at \( P < 0.05 \) using Monte Carlo test.

### Table 4

| Variable                  | Group | Case (n)% | Control (n)% | P-value |
|---------------------------|-------|-----------|--------------|---------|
| MS level                  | Low   | 17.5%     | 27.5%        | 0.422   |
|                           | High  | 82.5%     | 72.5%        |         |
|                           | Total | 100%      | 100%         |         |
| Lactobacilli level        | Low   | 45%       | 47.5%        | 1.000   |
|                           | High  | 55%       | 52.5%        |         |
|                           | Total | 100%      | 100%         |         |

**MS:** *Mutans streptococci; Low: \(< 10^5 \text{ CFU/mL}; \) High: \( \geq 10^5 \text{ CFU/mL}.\)

Statistically significant at \( P < 0.05 \) using chi-square test.

### Table 5

| Variable                  | Type of test | DMFT | dmft | Salivary flow rate | Salivary pH |
|---------------------------|--------------|------|------|-------------------|-------------|
| HbA1c level               | Pearson      | 0.057| −0.039| −0.034            | 0.005       |
|                           | Sig. (2-tailed) | 0.726| 0.807| 0.830             | 0.975       |

HbA1c: hemoglobin A1c; DMFT: Decayed, Missing, and Filled Teeth for permanent teeth.

dmft: Decayed, Missing, and Filled Teeth for primary teeth; pH: potential of hydrogen.

Pearson correlation is significant at < 0.05 level (2-tailed).

### Table 6

| Group         | Type of test | Salivary flow rate | Salivary pH |
|---------------|--------------|--------------------|-------------|
| DMFT Case     | Pearson      | 0.201              | 0.036       |
|               | Sig. (2-tailed) | 0.213              | 0.827       |
| DMFT Control  | Pearson      | −0.018             | −0.309      |
|               | Sig. (2-tailed) | 0.910              | 0.0524      |

DMFT: Decayed, Missing, and Filled Teeth for permanent teeth; pH: potential of hydrogen.

Pearson correlation is significant at < 0.05 level (2-tailed).
The DMFT finding in the current study had close similarities to two studies conducted in Saudi Arabia by Al–Badr et al. and AlMutairi et al. However, an earlier study in Saudi Arabia by Wyne et al. found statistically higher DMFT scores in children with DM1. A plausible reason for the variation in findings could be attributed to the larger sample size in Wyne et al. study.

Regarding the dmft index, our results were similar to Wyne et al., where caries experience in the primary teeth of children with DM1 was lower than in healthy children. The results of the current study are not in agreement with Al–Badr et al., where the dmft index was not different between children with DM1 and healthy children. This could be due to that in Al–Badr et al.’s study, the healthy controls were recruited from schools, while in the current study and Wyne et al.’s study, they were recruited from dental clinics implying that they already had some caries activity. Also, this could be rationalized by the theory that the diet of the younger children with DM1 is under the strict control of their parents, hence, they did not experience dental caries caused by the consumption of high levels of sugar, compared to healthy children. In addition, Siudikiene et al. found that the DMFT in children with DM1 and healthy children was not significantly different at baseline or after a two-year follow-up. However, these findings could not be generalized to other countries due to the diverse populations and multiple caries-associated risk factors. The degree of metabolic control could be an essential factor for the high caries incidence in patients with DM1. Numerous researchers have indicated that dental caries are more frequent in children with DM1 who have poor metabolic control than in children with DM1 who have good metabolic control. However, Edblad et al. could not find any link between the degree of glycaemic control and caries experience.

The stimulated salivary flow rate in the current study was relatively equal in both groups, with no significant reduction in children with DM1, indicating that DM1 did not impact the salivary flow rate. This result was consistent with other five studies in the literature that supported this finding. Unfortunately, there were no previous studies on stimulated salivary flow rate in children with DM1 in Saudi Arabia to which our results could be compared. The salivary flow rate was anticipated to be reduced in children with DM1 compared to healthy children, based on the information collected from previous studies, most of which had findings that supported the decreased salivary flow in children with DM1.

The salivary pH of diabetic and healthy groups was statistically identical, with a non—significant relationship between both groups, which was consistent with the results of previous studies. However, few studies found a low salivary pH in children with DM1. Different populations in research can affect the results. However, the extent of metabolic control directly impacts the composition of saliva, which can lead to low pH.

In the present study, MS counts were not significantly different between children with DM1 and healthy children. This result was consistent with the majority of previous studies but contradicts Swanljung et al. who reported that MS was higher in patients with DM1. What is important to note is that the method of measuring bacterial counts was not the same in all studies, which may explain these differences.

The results of the current study showed no difference in lactobacilli counts between children with DM1 and healthy children, which agree with other studies. However, some studies found a higher count of lactobacilli in children with DM1. Furthermore, Twetman et al. reported that lactobacilli levels were lower in saliva of children with DM1. This outcome suggests that dietary control of young insulin dependent diabetics can reduce lactobacilli in their saliva.

The outcome of the present study may be limited in scope because of small sample size, hence, data collected may not have been diverse enough. The selected participants were recruited from only one centre and shared certain behaviours and routines. Data on socioeconomic status and parent education were not collected nor assessed, which could have helped to understand the variations between the groups and the nature of the outcomes. Additionally, the metabolic and diet control status was not investigated, which could be essential in linking some of the results. Furthermore, the examiner was not blinded regarding case and control groups, which has the potential for bias.

Children with DM1 showed remarkably lower caries experience in primary teeth and lower buffering capacity compared to healthy children.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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