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Oral Health in Young Children with Type 1 Diabetes Mellitus

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Abstract

Aims: Knowledge about the risk factors for oral pathology among children with Type 1 Diabetes Mellitus (T1DM) is essential for establishing appropriate preventive and therapeutic strategies. We compared the oral health of youngsters with T1DM with that of non-diabetic children according to dietary and hygiene habits, dental caries history, gingival health, saliva secretion, saliva composition and number of mutant's streptococci (MS, pathognomonic for early childhood caries) colonies in the saliva. We also examined a possible association between glycemic control and oral health among T1DM children.

Methods: The T1DM children were examined by pediatric dentists who scored their oral health status using three indices: decayed (D), missing (M) or filled (F) teeth ("DMFT" for permanent dentitions and "dmft" for primary dentitions) for caries parameters, and the plaque index (PI) and gingival index (GI) for periodontal parameters. Age-matched siblings and friends of the study children comprised the control group.

Results: The T1DM children (n=24, age 8.2 ± 2.4 yr) had higher MS levels, a higher prevalence of caries, and significantly higher salivary Na levels compared to the controls (n=30, age 6.4 ± 2.7 yr). Caries history, evidence of current periodontal disease, oral health-related behaviors, PI and GI findings, and other salivary parameters were similar for both groups. Glycemic control did not influence oral health status.

Conclusions: T1DM children may bear potential compromised oral conditions, making early identification of those at high risk essential for preventing oral complications. Salivary MS counts may be a useful tool to identify T1DM children at increased risk for developing caries.

Keywords: Dental Caries; Diabetes Control; Periodontal Disease; Type 1 Diabetesoral Health

Introduction

Oral and systemic health are closely related. Abnormalities in the oral cavity can affect the systemic health, growth, and development of children, and systemic conditions can affect the health of the oral cavity. Oral health is mainly defined by the status of dental caries and periodontal disease. In the dental literature, Decayed (D), Missing (M) or Filled (F) Teeth (T) Indices ("DMFT" for permanent dentitions and "dmft" for primary dentitions) have been used for the measurement of caries [1], while the Plaque Index (PI) [2] and the Gingival Index (GI) [3] are used as periodontal parameters. The association between diabetes and periodontal diseases is well established in adults with type 2 diabetes mellitus. Diabetes is a recognized risk factor for periodontal disease, with diabetic adults exhibiting an increased prevalence, extent and severity of gingivitis and periodontitis compared to non-diabetic

adults [4]. Patients with poorly controlled diabetes are reportedly at risk for severe periodontitis, which results in the destruction of oral connective tissue and generalized bone loss, ultimately leading to tooth loss [5]. The relationship between Type 1 Diabetes Mellitus (T1DM) as an underlying disease and various aspects of oral health has been investigated by a number of studies worldwide. Even though some associations have been confirmed, others are still being discussed, and the results of individual studies are often controversial due to methodology differences as well as to the multifactorial etiologies of most oral pathologies. Reported oral pathologies related to T1DM among adults include many aspects of oral health, such as a decrease in salivary flow rate, pH and buffer capacity and an increase in the levels of glucose, magnesium and calcium in saliva [6], a higher incidence of chronic gingivitis that increases with age [7], and an increased risk of severe periodontal disease related to poor metabolic control of diabetes together with smoking and inadequate oral hygiene [8]. A few studies examined oral health of children with T1DM. Orbak et al. reported that the mean GI value was higher in a group of children with T1DM than in healthy children [9]. Other studies confirmed higher PI levels and a higher incidence of chronic gingivitis in both adults and in children with T1DM [10,11]. Although juvenile periodontitis is rare among both healthy subjects and those with T1DM, some studies demonstrated differences in oral microflora in children with T1DM and documented the impact of metabolic control of diabetes on periodontal health, indicating a higher risk of periodontitis in children with T1DM [5,11]. The results of studies on the association of diabetes and dental caries are inconsistent [7,12], and studies that examined various aspects of oral health among pre-pubertal children with T1DM are scarce. The aim of the present study was to compare the oral health of young children with T1DM with that of non-diabetic children according to the following parameters: dietary and hygiene habits, dental caries, gingival health, saliva secretion, saliva composition and number of Mutants Streptococci (MS) colonies in the saliva. Our second objective was to examine a possible association between glycemic control and oral health among children with T1DM.

Research Design and Methods

This observational cross-sectional study assessed nutritional and oral hygiene habits and oral health status of young children with T1DM and compared the results with those of selected nondiabetic children. The study protocol was approved by the Research Ethics Committees of the E. Wolfson Medical Center, Holon and the Assaf HaRofeh Medical Center, Tzrifin, Israel. The parents of the participants signed a consent form. Following the children's clinical examinations, the parents were informed of the oral health needs of their children and referred them for treatment when indicated. The study was carried out at the Pediatric Endocrinology and Diabetes Clinic in the E. Wolfson Medical Center and the Assaf Harofeh Medical Center. The researchers contacted the parents of children with T1DM by regular mail and by telephone, and two appointments were scheduled. Twenty-four children with T1DM aged 2 to 11 years (13 males) were recruited from among the patients being followed-up at the two participating medical centers. The 30 non-diabetic children (14 males) in the same age range who comprised the control group were siblings or close friends of the children with the T1DM in order to ensure similar lifestyle patterns within the study cohort. The following information was collected from the medical records of the T1DM children: age at diagnosis, duration of diabetes, mode of treatment (multiple daily injections or insulin pump), and recent HbA1c measurement. Inclusion criteria were diagnosis of T1DM with diabetes duration of more than 3 months who received at least two daily insulin injections or were treated with an insulin pump. Exclusion criteria were the use of any medication that would affect the mouth flora, the immune system or the inflammatory response, or failure to cooperate with the oral clinical examination. The children with T1DM were stratified into two groups: those with good metabolic control [HbA1c <7.5% (<58mmol/mol)] and those with suboptimal control [HbA1c ≥7.5% (≥58mmol/mol)].

Study Protocol

Study Questionnaire

The parents were asked to respond to a structured questionnaire before the children's oral examinations. The questionnaire was comprised of items on socioeconomic status, oral hygiene and dietary habits and frequency of dental visits. The socioeconomic status of a child was evaluated based on parental education level (uncompleted elementary school, completed elementary school, high school diploma, university degree). The section on oral hygiene habits included frequency of tooth brushing (once weekly, once daily, twice daily, more than twice daily), use of fluoride toothpaste and fluoride-containing mouth wash (always, sometimes, rarely, never), and use of dental floss (always, sometimes, rarely, never). The section on dietary habits included orderly consumption of meals (breakfast, lunch, dinner), frequency of consumption of sweet snacks (none, two per day, more than two per day) and sweet drinks (none, two per day, more than two per day), frequency of consumption of sugar-free drinks (none, two per day, more than two per day), frequency of hypoglycemic episodes and frequency of nighttime eating and drinking.

Oral Examination Protocol

All clinical assessments were performed by two examiners (Pediatric Dentists) who were unaware of the child's group assignment. The subjects were seated in a reclining chair during the evaluations. Clinical examinations were conducted under artificial lighting with the aid of a dental mirror and explorer.

Caries Experience

Decayed, missing or filled teeth (DMFT/ dmft) according to the WHO guidelines.

Plaque Index (PI) and Gingival Index (GI)

The PI was measured on the buccal and lingual surfaces of the maxillary first permanent molar or the right primary second molar, primary or permanent left central incisor, and the right first bicuspid or primary molar. It was also measured on the mandibular left first permanent molar or second primary molar, the right central primary or permanent incisor, and the right first bicuspid or first primary molar (Table 1) [3,13,14]. The GI was also measured in a similar manner (Table 2) [2,13,14].

Scores	Plaque findings
0	No plaque in the gingival area
1	A film of plaque adhering to the free gingival margin and an adjacent area of the tooth.
2	Moderate accumulation of soft deposits within the gingival pocket and on the gingival margin and/or adjacent tooth surface that can be seen by the naked eye
	Abundance of soft matter within the gingival pocket and/or on the gingival margin and an adjacent tooth surface.

Table 1: Scoring of the Plaque Index.

Scores	Gingival Findings
0	Normal gingiva
1	Mild inflammation, slight change in color, slight edema, no bleeding on palpation
2	Moderate inflammation, redness, edema and glazing, bleeding on probing
3	Severe inflammation, marked redness and edema, ulceration, tendency to spontaneous bleeding.

Table 2: Scoring of the Gingival Index.

Collection of Saliva Samples and Microbiological Procedures

Non-stimulated whole saliva was collected using the spitting method as previously described [13,15,16]. The subjects were instructed not to eat or drink for at least 1 hour before sample collection. They were asked to collect saliva in their mouth and to spit it into a measuring cup over a period of 2 minutes. The saliva samples were analyzed for pH and buffering capacity extra-orally immediately after collection of saliva by means of pH paper [17] and test pads [18][19], respectively (GC Corp, Tokyo, Japan) according to the manufacturer's instructions. The saliva was collected in a graduated cup and kept at 4°C until analysis. Some children did not provide saliva samples either because they were unable to do so or because they refused to cooperate.

Unstimulated Salivary Flow (USF)

The USF rate was determined after 2 min by dividing the volume of collected saliva by 2. The salivary flow rate was calculated in mL/min.

Saliva Analysis

MS Counts

The MS counts were estimated by placing 0.2 mL of each saliva sample in mitis salivarius bacitracin agar medium, and the plates were incubated micro-aerophilically at 37°C for 24 hr. The microbiological counts were expressed as the number of colony forming units per milliliter (CFU/mL) of saliva. All counts were performed by the same researcher who was unaware of the donor's group assignment. The counts were classified as low (no greater than 10^3 CFU/mL), medium (10^4-10^5 CFU/mL), or high (at least 10^5 CFU/mL).

Electrolyte Concentrations

The saliva samples were centrifuged (2800 rpm, 10 min, 20°C), and the supernatants were analyzed in a Cobas 8000 ISE auto analyzer (Roche Ltd., Bohemia, NY). The concentrations of K, Na, and Cl were then measured.

Statistical Analysis

The mean number of surfaces with caries, the mean PI and GI values and the salivary parameters were compared between children with T1DM and non-diabetic children by means of Student's t test. Student's t test was also used to assess differences among the groups that had different levels of metabolic control. Maternal and paternal education, previous visits to the dentist, oral hygiene and dietary habits as well as SM counts were compared using the chi-square test. A linear regression analysis was performed to investigate the interaction between the different caries indicators as well as metabolic control on the caries history. The statistical analysis was performed using SPSS 15.0 software (SPSS Inc, Chicago, Ill., USA).

Results

Demographics, oral and hygiene habits, and dental, gingival and salivary characteristics of the study population are presented in Table 3. Both groups were homogeneous for the distribution of gender, with males comprising 45.8% of the T1DM group (n=24) and 46.7% of the control group (n=30). The socioeconomic status was similar for the two groups according to study design. The T1DM children were older than the non-diabetic children (mean age 8.2 ± 2.4 yr and 6.4 ±2.7 yr, respectively). The mean age at

diabetes diagnosis was 5.4 ± 2.5 yr, and the mean diabetes duration was 2.8 ± 2.5 yr. Parents of 21 children with T1D (88%) reported at least one nocturnal hypoglycemic episode per week that required the consumption of sweet drinks.

	Non-diabetic group (n=30)	T1DM Group (n=24)	p-value (Non-diabetic Group vs. T1DM Group)
Clinical characteristics			
Gender: M/F	14/16	13/11	1
Age, mean ± SD (range)	6.4 ± 2.7 (1.4-11)	8.2 ± 2.4 (1.4-11.4)	
Age at diagnosis of diabetes	IR	5.4 ± 2.5 (0.9 - 9.7)	
Duration of diabetes: mean ± SD (range)	IR	2.8 ± 2.5 (0.25-8.8)	
Hba1c (%), mean ± SD (range)	IR	8.0 ± 1.3 (6.6-12)	
Insulin pump	IR	14	
Multiple daily injections	IR	10	
Hypoglycemic episodes: Reported hypoglycemic episodes requiring sweet drink consumption, n (%)	IR		
Never		5 (21)	
Once weekly		8 (33)	
Twice weekly		9 (38)	
>3 episodes/week		2 (8)	
Reported nocturnal hypoglycemic episodes requiring sweet drink consumption, n (%)			
Never		3 (12)	
Once weekly		16 (67)	
Twice weekly		4 (17)	
>3 episodes /week		1 (4)	
Oral hygiene habits			
Frequency of tooth brushing, n (%)			0.8
Once weekly	1 (3)	2 (8)	
Once daily	10 (33)	9 (37)	
Twice daily	18 (60)	12 (50)	
More than twice daily	1 (3)	1 (4)	
Using fluoridated toothpastes, n (%)			0.43
Don't know	1 (3.3)	1 (4.2)	
Always	22(73.3)	20 (83.3)	
Sometimes	2 (6.7)	0 (0)	
Rare	0 (0)	1 (4.2)	
Never	2 (8.3)	5 (16.7)	
Parent helps tooth brushing, n (%)			0.3
Always	9 (30)	3 (12.5)	
Sometimes	8 (26.7)	5 (20.8)	

Rare	3 (10)	2 (8.3)	
Never	10 (33.3)	14(58.3)	
Dietary habits			
Regular meals, n (%)			0.2
Always	27 (90)	19 (79.2)	
Sometimes	2 (6.7)	5 (20.8)	
Never	1 (3.3)	0 (0)	
Consumption of sweet snacks, n **(%)**			0.3
Never	1 (4.2)	1 (3.3)	
Once weekly	6 (25)	8 (26.7)	
Up to 2 snacks per day	17 (70.8)	17 (56.7)	
More than 2 snacks per day	0 (0)	4 (13.3)	
Frequency of dental visits			0.5
Twice yearly	6 (25)	4 (13.3)	
Once yearly	7 (29.2)	12 (40)	
No regular visits	7 (29.2)	7 (23.3)	
Never	4 (16.7)	7 (23.3)	
Oral examination			
Plaque index	0.11 ± 0.26	0.25 ± 0.41	0.4
Gingival index	0.093 ± 0.26	0.28 ± 0.66	0.3
DMFT	1.37 ± 2.48	2.72 ± 3.3	0.2
dmft	1.207 ± 2.17	2.40 ± 2.9	0.2
Parameters of saliva			
MS count (CFU/ml), n (%)	n=15	n=19	
Low ($\leq 10^3$)	12 (80)	8 (42)	
Medium (10^4-10^5) and high ($\geq 10^5$)	3 (20)	11 (58)	**0.04**
Electrolytes in saliva (mg/dl)			
Na	20.1	21.1	**0.04**
Cl	22.1	20.6	0.61
K	19.4	18.6	0.18
Rate of secretion (ml/min)	1	0.97	0.56

T1DM = Type 1 Diabetes Mellitus; DMFT = Decayed (D), Missing (M) or Filled (F) Permanent Teeth; dmft = Decayed (D), Missing (M) or Filled (F) Primary Teeth; MS = Mutants Streptococci, IR = irrelevant.

Table 3: Comparison of demographics, lifestyle habits, oral hygiene practices and dental status of young children with and without type 1 diabetes mellitus.

Oral Hygiene Habits

The oral hygiene habits of the children with T1DM and the controls were similar as were those of the T1DM children with HbA1c levels below or above 7.5% (58mmol/mol). Most of the study participants (83.3% of the T1DM children and 73.3% of the non-diabetic children) reported using fluoridated toothpastes. The frequency of tooth brushing was similar between the groups, with the majority of the study participants brushing their teeth at least once daily. The frequency of supervised tooth brushing by parents was also similar between the groups ($p>0.05$), although the nondiabetic children had more supervision (30%) than the T1DM children (12.5%). Most (79.2%) of the T1DM children reported that they had never used dental floss, compared to 96.7% of the non-diabetic children ($p=0.09$).

The two study groups were similar with regard to the frequency of dental visits.

Dietary Habits

No differences of dietary habits were demonstrated between the T1DM children and the controls or between the T1DM children with HbA1c values below or above 7.5% (58mmol/mol). Most (70.8%) of the T1DM children and 56.7% of the non-diabetic children reported eating one or two sweets per day. Consumption of sweet drinks was significantly more frequent among the non-diabetic children compared to the T1DM children (76.7% and 34.8%, respectively, $p < 0.05$). The mean number of hypoglycemic episodes with sweet drink consumption per week was 2.33 (SD=0.91). Specifically, 33.3% of the children had one hypoglycemic episode per week, 37.5% had two episodes per week and 8.3% had 3-4 episodes per week. Most (75%) of the T1DM children reported drinking sweetened drinks (58.3% juice, 12.5% chocolate milk, and 4.2% milk) while having hypoglycemic episode, and 20.8% reported eating complex carbohydrates.

Oral Health Scoring

The results of the selected clinical variables that were evaluated in both groups are shown in Table 3. The PI and GI values were higher in the T1DM group, but they did not reach a level of significance (p=0.4 and p=0.3, respectively). The mean PI value was 0.4 for the T1DM group and 0.2 for the control group. The mean GI value was 0.5 for the T1DM group and 0.2 for the control group, respectively. The mean dmft and DMFT values were higher in the T1DM group, but did not reach statistical significance (p=0.09): they were 2.7 and 2.4, respectively, for the T1DM children and 1.4 and 1.2, respectively, for the control children. There were no significant differences between the children with T1DM who had a HbA1c level below or above 7.5% (58mmol/mol).

Salivary Parameters

Saliva samples were collected from 19 T1DM children and from 15 non-diabetic children. Some children did not provide saliva samples either because they were too young to follow directions or they were not cooperative. Significant differences (p=0.03) were observed in the number of children in each group in the medium and high salivary MS count categories. Medium counts (10^4-10^5 CFU mL saliva) and high counts (at least 10^5CFU/mL saliva) of salivary MS were significantly more frequent in the T1DM group ($p < 0.05$). There were no differences in the number of children in each group with a low salivary MS count ($\leq 10^3$ CFU/mL).

Salivary pH, Buffering Capacity and Flow Rate

There were no significant differences in salivary pH, buffering capacity or flow rate between the two study groups ($p>0.05$). The mean pH score was 6.95 ± 0.39 for the T1DM group and 6.794 ± 0.44 for the control group. The mean unstimulated salivary flow rate was 0.97 mL/min and 1 mL/min for the T1DM and control groups, respectively.

Sialo Chemistry

Differences in sodium (Na), chloride (Cl) and potassium (K) concentrations were observed between the groups. Salivary Na concentration in the T1DM group (mean = 21.1 mg⁄ dL) was significantly higher than the concentration in the control group (mean = 20.1 mg⁄dL) ($p = 0.036$). Salivary Cl and K concentrations were also higher in the T1DM group (mean = 22.2 mg⁄ dL and mean = 19.5 mg⁄ dL, respectively) compared to the control group (mean = 20.7, and mean = 18.6 mg⁄ dL, respectively), although these differences were not significant.

Oral Health Parameters and Diabetes Control

Oral health parameters were compared between children with HbA1c below 7.5% (58mmol/mol) (n=11) vs. children with HbA1c equal or above 7.5% (58mmol/mol) (n=13) and no differences were observed for any of them.

Discussion

The findings of the present study demonstrated that high MS CFU values were more prevalent among children with T1DM compared to non-diabetic matched controls. MS are pathognomonic for early childhood caries, and a high MS CFU level is correlated with a high risk for development of dental caries [20]. In addition, the prevalence of caries in both primary and permanent teeth among children with T1DM was higher than that of the non-diabetic children, consistent with previous reports [21,22]. Several studies have estimated the distribution of salivary MS counts in children with T1DM compared to healthy controls. Twetman et al. concluded that there were no differences in the MS counts in saliva between children with T1DM compared to healthy children aged 4 to 19 years [23]. In contrast, Swanljung et al. reported higher counts of salivary MS in 12-18 yr olds with T1DM compared to healthy controls [24]. El-Tekaya et al. found that the MS count was the only variable that showed a statistically significant effect on caries in the children with T1DM [10]. The present findings indicate that salivary MS counts may be a useful tool for the identification of T1DM children at risk for developing caries. No significant differences were found between the T1DM and control groups with regard to different behaviors related to oral health, such as frequency of tooth brushing, tooth brushing supervised by parents, use of fluoridated toothpaste, visits to the dentist and snacking habits. Only the consumption of sweet drinks was significantly more frequent among the non-diabetic children than among the T1DM children. Dental care among children with chronic diseases is often perceived as having low priority. Parents are often confronted with other essential aspects of their children's health, and that can be a critical factor in determining the level of dental care they receive. There were no differences in

PI and GI findings between the two groups of children. Lalla et al. demonstrated that periodontal destruction is increased in T1DM children and adolescents and that it starts at a very young age [11], while other studies did not show any high prevalence of PI and GI among diabetic children [25]. Not finding any group difference in PI and GI values is not surprising considering the very young age of the children who participated in the current study as well as their relatively good diabetes control. Examination of the salivary biochemistry with regard to K, Cl and Na revealed that the salivary Na levels were significantly higher among the T1DM children compared to the controls. The Cl and K concentrations were also higher, but not significantly. These results may suggest that there is alteration in the metabolism of the duct and/or acinar cells of salivary glands of children with T1DM, however, more studies with a large sample size would be necessary to arrive at any firm conclusions. There were no group differences in the salivary parameters of flow rate, pH and buffering capacity. Glycemic control appeared not to have any influence on various parameters of oral health according to our study results. This is in agreement with Edblade et al. [26] who examined the caries history of young adults who had T1DM since childhood and with El-Tekeya et al. [10] who found no significant differences in caries history and MS counts in T1MD children in relation to their metabolic control. On the other hand, several authors reported that there was an influence of suboptimal metabolic control on oral health: Siudikiene et al. [27] and Karjalainen et al. [28] found that well-to-moderately controlled T1DM children had fewer decayed surfaces than poorly controlled subjects. Carneiro et al. demonstrated a decrease in salivary flow, an increase in bleeding gums and more dental cavities in the permanent teeth of patients with poor metabolic control [29], but their patients were older than ours (including adolescents) and there was a very high frequency of poor diabetes control [HbA1c above 10% (86mmol/mol)]. This conflicting evidence for associations between diabetes control and oral health parameters might be attributed to variations in the age of the children, the diabetes duration and the different levels of glycemic control among the study participants. The relationship between dental caries and dietary factors is a question of particular interest for patients with T1DM. The nutritional recommendations for children with T1DM are to minimize the consumption of simple carbohydrates in order to optimize glycemic control. Nevertheless, hypoglycemic episodes are frequently seen in patients with T1DM at all hours of the day and night, leading to consumption of simple carbohydrates. Total as well as relative hyperglycemia are potential risk factors for caries and periodontal disease. In spite of the relation between oral pathologies and the level of metabolic control having been well investigated, it is still poorly understood. There are numerous investigations on the oral health status of patients with T1DM, but there is no consensus and the results are controversial. There is also a paucity of studies on oral health among young children with T1DM. Knowledge about the oral health status of children with T1DM is vital for the understanding of the many risk factors involved and for establishing appropriate preventive and therapeutic strategies against oral pathologies. Our study results emphasize the importance of dental care as an integral part of the routine management of pediatric diabetes. The need for oral health assessment early after diabetes diagnosis is essential for preventing oral complications in the future. Our study has several limitations, one of which is the relatively small sample size and another is the small number of saliva samples that had been collected. Caries is multifactorial disease, and its development and progression depend on many risk factors. The strength of this work is that we evaluated multiple potential risk factors, including behavioral and micro bacteriological ones. We believe that this study is the first to investigate such a large number of parameters that may influence oral health status within a single cohort. In conclusion, our findings show that even though children with T1DM could be expected to bear a potential high caries risk due to the diabetes-associated biological and behavioral alterations, we observed no significant differences in caries history and periodontal disease between them and non-diabetic controls. On the other hand, the higher SM counts that we detected among young children with relatively short diabetes duration indicate a clear tendency toward high risk for developing oral pathologies in the future. Children with optimal diabetes control were no different from those with suboptimal control with regard to caries history, SM counts, PI and GI values, salivary flow, pH levels and buffer capacity. T1DM children could, however, be expected to bear potential compromised oral conditions, making early identification of children at high risk vital for the prevention of oral complications in the future. These findings emphasize the importance of conducting longitudinal studies to further clarify the relationship between T1DM and oral health of young children with T1DM.

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