

## Dental caries and periodontal status in children with type 1 diabetes mellitus

Intensywność próchnicy zębów oraz stan przyzębia u dzieci chorujących na cukrzycę typu 1

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### Abstract

**Introduction:** Type 1 diabetes mellitus (T1DM) is a chronic metabolic disease that strongly affects the health of individuals. Some studies have suggested that it affects oral health, thus indicating a higher-than-average predisposition of patients with diabetes to caries and periodontal diseases.

**Aim of the study:** We aimed at investigating the association between caries, periodontal diseases, and diabetes among children using dental indices.

**Material and methods:** The study included 50 children (aged 10–18 years) who had type 1 diabetes for at least years. The participants were divided into well controlled (WC), ( $HbA_{1c} < 7.5\%$ ) and poorly controlled (PC) ( $HbA_{1c} \geq 7.5\%$ ) groups (25 diabetic children each). The control group (GC) included non-diabetic children. The following clinical parameters were measured: DMFT index, plaque index (PI), approximal plaque index (API), gingival index (GI), and modified sulcus bleeding index (mSBI).

**Results:** The WC group had the lowest average value – 3.44 of the DMFT index with values of 5.80 and 3.88 in the PC and GC groups, respectively. A statistically significant difference was found in the DMFT value between PC and WC groups ( $p = 0.04$ ). No statistically significant differences in the values of other indices were found between the groups.

**Conclusions:** Children with poorly controlled type 1 diabetes were characterised by a significantly higher intensity of caries. In contrast, no statistically significant differences were observed in the periodontal status between the study groups.

### Key words:

dental caries, gingivitis, dental plaque, diabetes mellitus type 1.

### Streszczenie

**Wprowadzenie:** Cukrzyca typu 1 (T1DM) jest chorobą metaboliczną, silnie wpływającą na stan zdrowia całego organizmu. W jamie ustnej cukrzyca manifestuje się w postaci kserostomii, *gingivitis* i *periodontitis*, ropni przyzębnych, zmian zapalnych błony śluzowej oraz próchnicy.

**Cel pracy:** Ocena intensywności próchnicy oraz stanu przyzębia u dzieci chorych na cukrzycę typu 1.

**Materiał i metody:** Badanie przeprowadzono w trzech grupach dzieci (10–18 lat): z cukrzycą wyrównaną (WC,  $HbA_{1c} < 7,5\%$ ), z cukrzycą niewyrównaną (PC,  $HbA_{1c} \geq 7,5\%$ ) oraz w grupie kontrolnej (GC). Przy użyciu wskaźników analizowano następujące parametry: próchnicy (DMFT), higieny jamy ustnej (PI, API) oraz stanu przyzębia (GI, mSBI).

**Wyniki:** W grupie WC stwierdzono najniższe wartości wskaźnika DMFT –3,44, w grupie PC wartość ta wyniosła 5,80, a w grupie kontrolnej 3,88. Wartość istotną statystycznie odnotowano między grupami PC i WC ( $p = 0,04$ ). Wartości pozostałych ocenianych wskaźników nie różniły się istotnie statystycznie.

**Wnioski:** Dzieci z niewyrównaną cukrzycą typu 1 charakteryzują się istotnie większą intensywnością występowania próchnicy. Stan przyzębia dzieci z cukrzycą typu 1 nie odbiega natomiast od stanu przyzębia dzieci zdrowych.

### Słowa kluczowe:

cukrzyca typu 1, próchnica zębów, zapalenie dziąseł, płytką nazębna.

## Introduction

Type 1 diabetes mellitus (T1DM) is a chronic metabolic disease caused by lack of insulin secretion. Type 1 diabetes is most common in childhood. It is a chronic disorder with permanent annual increase [1, 2]. Effective metabolic control of diabetes is crucial in preventing or delaying the occurrence of future complications related to the disease [3].

Dental caries is a localised disorder that cause destruction hard tissues of the teeth. The damage is triggered by acids produced during processes such as bacterial fermentation of carbohydrates in food. The carious process is most strongly influenced by cariogenic bacterial flora, the bacterial substrate (carbohydrates), and host sensitivity. Although T1DM has a significant impact on oral health, its association with caries has not yet been fully elucidated [4]. Whereas some studies have reported that factors such as an increased concentration of glucose in saliva or reduced secretion of saliva predispose an individual to the initiation and progress of tooth decay [5], other studies have reported that people with type 1 diabetes have a reduced incidence of caries because of a low carbohydrate diet and reduced consumption of sucrose - the most cariogenic sugar [6].

Periodontal disease is a group of disorders that affects the tissue structures supporting the teeth (gingiva, periodontal ligament, cementum, and alveolar bone) [7]. The dominant form of periodontal disease among children and adults is gingivitis. Extensive research on its pathogenesis has demonstrated that bacteria alone are insufficient to cause gingivitis, and other factors in the host play a central role in the development of the disease. For example, it has been shown that systemic diseases such as diabetes change the host environment and increase a patient's susceptibility to gingivitis because of changes in the inflammatory response to microorganisms [8]. Furthermore, several clinical studies have confirmed that the presence of diabetes in childhood can be considered as a risk factor for the development of periodontal diseases [9].

## Aim of the study

The aim of this study was to assess, using dental indices, the intensity of dental caries and periodontal status in children with type 1 diabetes mellitus.

## Material and methods

### Characteristics of the study groups

The study group consisted of 50 randomly selected children aged 10–18 years, who had type 1 diabetes for at least five years. All of the children were patients of the regional diabetic clinic at the Upper John Paul II Silesian Children's Health Centre University Hospital in Katowice, Poland.

Participants from the study group were divided into two research groups (25 children each) according to their level of diabetes control. The allocation of diabetic children to the groups was based on the criterion of qualification, which was the level of glycated haemoglobin (HBA<sub>1c</sub>). According to the recommendations of the American Diabetes Association (ADA) and the International Society for Paediatric and Adolescent Diabetes (ISPAD 2014), the threshold value of HBA<sub>1c</sub> was set at 7.5% [10]. The Well Controlled ([WC], HBA<sub>1c</sub> ≤ 7.5%) group included children with compensated diabetes. The mean age of the subjects in the WC group was 14.40 ± 2.0 years. The group consisted of 10 girls and 15 boys. In this group, 23 children were using a personal insulin pump (continuous subcutaneous insulin infusion – CSII) and two children were using insulin pens (multiple daily insulin injection – MDII). The average level of glycated haemoglobin was 6.70 ± 0.40% (Table I). The Poorly Controlled ([PC], HBA<sub>1c</sub> > 7.5%) group consisted of children with decompensated diabetes. The mean age of the subjects in the PC group was 14.92 ± 1.87 years. The group consisted of 14 girls and 11 boys. In this group, 18 diabetic children were using a personal insulin pump (CSII) and seven were using insulin pens (MDII). The average glycated haemoglobin level in this group was 8.23 ± 0.64% (Table I).

**Table I.** Characteristic of the study groups of children – gender and age distribution, and level of HBA<sub>1c</sub>

Group	PC group (n = 25)	WC group (n = 25)	GC group (n = 25)	p value
Women	14/25 (56%)	10/25 (40%)	13/25 (52%)	0.5
Men	11/25 (44%)	15/25 (60%)	12/25 (48%)	0.5
Median (IQR)				
Age	15 (14–16)	14 (13–16)	15 (14–15)	0.41
HBA <sub>1c</sub> %	8.1 (7.8–8.3)	6.8 (6.4–7.0)	–	< 0.01

PC – poorly controlled; WC – well controlled; GC – control group

The control group (GC) consisted of 25 randomly selected children with no systemic diseases, who were treated at the NZOZ Pachońscy Dental Clinic in Tarnowskie Góry. The average age was  $14.52 \pm 1.29$  years. The group consisted of 13 girls and 12 boys.

The study groups were homogeneous in terms of gender and age ( $\chi^2$  Pearson test:  $p = 0.50$ ,  $p = 0.41$ ) (Table I).

### Exclusion criteria from the research

Children and/or legal guardians or parents not consenting to participate in the study; participants not willing to cooperate in the study, additionally burdened with other diseases: thyroid diseases, celiac disease, or arterial hypertension.

For the control group, the exclusion criteria were diabetes and any systemic disorders and lack of consent to participate in the study.

The tests were performed anonymously, and each child was given a code number. The parents or legal guardians of all participants in the study provided consent for their participation in the study. The research project was approved by the Bioethical Commission of the Silesian Medical University in Katowice (No. KNW/0022/KB1/26/I/14 of 22/04/2014).

### Clinical measurements

Oral health evaluation was conducted by a single physician. The following clinical parameters were measured: caries index: Decayed/Missing/Filled/Teeth index (DMFT), oral hygiene indexes: plaque index (PI) and approximal plaque index (API), gingival indices used to assess periodontal status: gingival index (GI) and modified sulcus bleeding index (mSBI). The DMFT index was evaluated for permanent teeth in consideration of the age of the subjects. Oral examination was conducted in artificial light with a dental mirror and periodontal probe (Hu Friedy probe).

### Oral hygiene indexes

#### 1. Plaque Index (PI)

One of the main factors causing dental caries is biofilm of dental plaque. The PI was used for the assessment of the thickness of the bacterial plaque in the area of the tooth's neck on four tooth surfaces (vestibular, lingual, mesial, and distal). The evaluation criteria were as follows: 0 – no plaque; 1 – thin layer of plaque adhering to the gingival margin and tooth neck found by a probe but invisible to the unaided eye; 2 – moderate plaque accumulation on the edge of the gum and/or on the tooth surface and in the gingival pocket visible with the unaided eye; and 3 – thick accumulation of plaques in the pocket and/or the edge of the gum and tooth surface. Values obtained from all tooth surfaces were summed and divided by four [7].

#### 2. Approximal Plaque Index (API)

The API assesses the presence or absence of plaque in the interdental spaces. The evaluation comprised half of the teeth from the lingual side and half from the vestibular side. The index value was calculated by dividing the sum of interdental spaces containing plaques by the sum of all evaluated inter-

dental spaces. The result was multiplied by 100. The evaluation criteria were as follows: 70–100% – bad oral hygiene; 40–70% – good oral hygiene; 25–39% – good hygiene; < 25% – optimal hygiene AN API value below 35% was considered indicative of effective oral hygiene [11].

### Gingival indices

#### 1. Gingival Index (GI)

The GI can be calculated for a group of teeth or people. The gingiva was scored within each of the three or four surfaces surrounding each tooth. The scoring criteria were based on the following qualitative parameters: 0 – healthy gum coloured pale pink; 1 – mild inflammation, characterised by slight changes in gum colour and mild changes in tissue structure without bleeding during probing; 2 – moderate inflammation, characterised by redness, swelling, gloss, hypertrophy, and bleeding under pressure or probing; 3 – heavy inflammation, described by severe redness, swelling of the gums, ulceration, and a tendency for spontaneous bleeding. The sum of scores was divided by three or four to derive the gingival index value for that tooth [11].

#### 2. Modified Sulcus Bleeding Index (mSBI)

Assessment of mSBI was based on the occurrence or absence of bleeding during examination of the gingival sulcus in the vicinity of tangential surfaces. The index value was calculated by dividing the sum of bleeding gingival units by the sum of all examined gingival units. The result was multiplied by 100 to derive the index value. The mSBI values were interpreted as follows: 50–100% – severe and generalised periodontitis; 20–49% – moderate gingivitis that requires intensive treatment; 10–19% – mild gingivitis that requires treatment; and < 10% – clinically healthy periodontium [11].

### Statistical analysis

All statistical analyses were performed using the STATISTICA 13 program package (StatSoft), SciPy module, and statsmodels Python module. All charts were prepared using matplotlib Python modules (pyplot and seaborn). Continuous variables between the two groups were compared using the Kruskal-Wallis and Mann-Whitney tests because the analysed variables were not normally distributed.

The post hoc tests after the Kruskal-Wallis test, the Dunn test was used. The nominal variables were compared between groups using the Pearson chi-squared test.  $P$  values < 0.05 were considered statistically significant.

## Results

The DMFT index was used to determine the level of dental caries among the participants of the study. The highest DMFT value (14) was observed in the PC group. In the WC and GC groups, the highest DMFT values were 11 and 9, respectively. The lowest value in all studied children was 0. Statistical analysis revealed a significant difference between the DMFT values in the PC and WC groups (post-hoc test  $p = 0.04$ ) (Fig. 1).

The WC group had the lowest average DMFT index value (3.44), whereas in the PC and GC groups, the average DMFT values were 5.80 and 3.88, respectively.

Analysis of the individual components of the DMFT index showed that the highest average value of decay (1.88) was obtained in the PC group, whereas in the WC and GC groups it was 1.04 and 1.12, respectively. Although none of the subjects had had a tooth removed because of caries, some had

fillings in their teeth. The highest average value of the DMFT filling component (3.9) was observed in the PC group. In the GC and WC groups, the average filling values were 2.80 and 2.40, respectively (Table II).

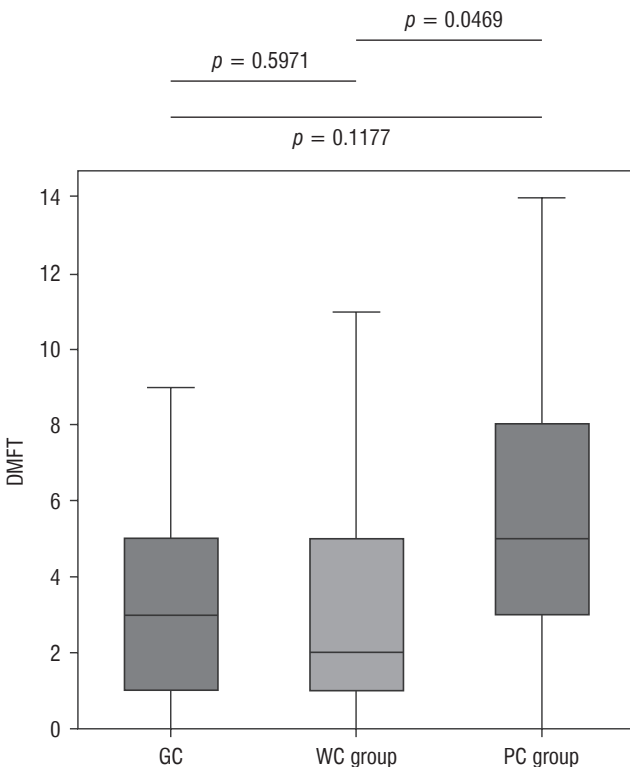
Evaluation of oral hygiene using the PI and API dental indices showed no significant differences between the analysed groups ( $p = 0.33, p = 0.10$ ). Nevertheless, the highest average value of the PI index (1.72) was observed in the PC group. In the WC and GC groups, the average PI values were 1.41 and 1.33, respectively. The average API values in the GC, PC, and WC groups were 58.77%, 58.06%, and 52.79%, respectively, with the GC group having the highest value (Table III). An average API (%) above 50% indicates that the patient's oral hygiene is average and requires improvement. Therefore, the obtained oral hygiene index values indicate an unsatisfactory hygiene condition in the examined individuals.

Analysis of gingival inflammation using the GI and SBI gingival indexes did not show any statistically significant differences between the examined groups ( $p = 0.74, p = 0.42$ ). The PC and WC groups had an average GI index value of 1.02, which indicates the presence of moderate gingivitis. In the GC group, the average GI value (0.92) corresponds to mild inflammation. In the WC, PC, and GC groups the mSBI (%) values were 15.67%, 22.22%, and 16.36%, respectively (Table III). In the PC group, the mSBI value corresponds to moderate gingivitis, whereas in the WC and GC groups the values correspond to mild inflammation. The observed values indicate the requirement for dentist intervention and oral hygiene improvement.

### Discussion

Contradictory results on the influence of type 1 diabetes on intensity of dental caries can be found in the literature.

In this study, we observed statistically significant differences in the level of caries (measured by the DMFT index) between the diabetic groups of the study (PC and WC). Importantly, in the children with poor diabetes metabolic control (PC), the DMFT index values were significantly higher than those observed in



PC – poorly controlled; WC – well controlled; GC – control group

**Figure 1.** DMFT values in study groups of children

**Table II.** Mean and standard deviation of DMFT index in study groups of children

DMFT Index	Descriptive statistics	PC group (n = 25)	WC group (n = 25)	GC group (n = 25)	p value
DMFT	Mean ±SD	5.80 ±3.75	3.44 ±3.37	3.88 ±3.35	0.18
D – decay	Mean ±SD	1.88 ±2.11	1.04 ±2.03	1.12 ±1.64	0.10
M – missing	Mean ±SD	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	–
F – filling	Mean ±SD	3.92 ±3.57	2.40 ±2.92	2.80 ±3.30	0.19

PC – poorly controlled; WC – well controlled; GC – control group

**Table III.** Mean, standard deviation (SD), and *p* value of PI, API, GI, and mSBI indexes in the study groups of children

DMFT Index	Descriptive statistics	PC group (n = 25)	WC group (n = 25)	GC group (n = 25)	<i>p</i> value
PI	Mean ±SD	1.72 ±0.88	1.41 ±0.43	1.33 ±0.62	0.34
	Minimum	0.50	1.0	0.25	
	Maximum	3.66	2.50	2.66	
API (%)	Mean ±SD	58.06 ±18.90	52.79 ±12.14	58.77 ±14.18	0.11
	Minimum	17.85	30.35	17.85	
	Maximum	98.20	87.00	89.20	
GI	Mean ±SD	1.02 ±0.79	1.02 ±0.54	0.92 ±0.52	0.75
	Minimum	0.00	0.00	0.16	
	Maximum	3.33	1.83	2.16	
mSBI [%]	Mean ±SD	22.22 ±16.66	15.67 ±14.98	16.36 ±16.96	0.42
	Minimum	0.00	0.00	0.00	
	Maximum	47.00	50.00	53.57	

PC – poorly controlled; WC – well controlled; GC – control group

the well-controlled children (WC). In contrast to our findings, a study conducted by Kamran *et al.* on a group of 100 children (aged 9–14 years) with type 1 diabetes showed no differences in the level of caries between the study and control groups [12].

Akpata *et al.*, including 53 children aged 12–15 years with type 1 diabetes in their study, also divided the research group to two study groups according to the diabetes control level (well controlled T1DM children – HBA<sub>1c</sub> < 8% and insufficiently controlled T1DM children – HBA<sub>1c</sub> > 8%). Although the researchers of the study reported a statistically significant difference in the DMFT values between the diabetic group and the control group, they did not find a correlation between the level of diabetes control and the intensity of caries [13]. Kuźmiuk *et al.* revealed that children with type 1 diabetes had a lower intensity of caries in their permanent dentition in comparison with non-diabetic children [11].

We did not observe significant differences in the values of individual components of the DMFT index between the study and control groups. However, the study by Arheiam *et al.* (conducted on a group of 70 children with type 1 diabetes) reported significantly higher average values of the decayed and missing components of the DMFT index in the diabetic group compared with healthy children [14].

Rafatjou *et al.*, in their study, reported that the differences in the occurrence of caries between a group of 80 diabetic individuals aged 5–18 years and a group of healthy individuals was not significant [15].

It is a well-known fact that in diabetes, the progression of caries depends on the level of metabolic control, poor hygiene, and high level of *Lactobacillus acidophilus* in saliva [5]. One of the easiest ways to prevent caries is by maintaining proper oral hygiene.

In the present study, the level of oral hygiene was evaluated using the PI and API indexes. We did not observe significant differences in oral hygiene in the study among research groups. Also, the study did not show the effect of metabolic control of diabetes on the values of indexes. Nevertheless, the obtained results reflect the average oral hygiene, testifying to the need to implement intense educational activities to widely improve oral hygiene. Similar results were obtained by Kuźmiuk *et al.*, who evaluated the API. The mean value in the diabetic group was 51.47% and in the control group 54.83% [11]. In our study the mean values of API were: in the PC group 58.06%, in the WC group 52.79%, and 58.77% in the control group. Rosas *et al.*, in their studies, did not obtain any significant differences in the PI index between the diabetic group and the control group [16] – similar results were obtained by Rafatjou *et al.* [15]. Contrasting results to those described above were obtained by Ismail *et al.* and da Cunha Coelho *et al.* The PI index values in their studies were significantly higher in the diabetic group in comparison to the control group [17, 18].

The periodontal status was evaluated using GI and mSBI indexes. Although diabetes is a well-known risk factor for the occurrence of periodontal diseases [19–21], we did not observe



significant differences in the periodontal health condition between the WC, PC, and GC groups. Similar results regarding the GI index were obtained by Duque *et al.* [7] and Ismail *et al.* [17]. Rafatjou *et al.* obtained significantly higher GI index values in children with T1DM compared to those in non-diabetic children [15]. A study by Siudikiene *et al.* revealed more frequent occurrence of gingivitis among young people with diabetes compared to a control group [22]. Whereas Kuźmiuk *et al.* showed a difference in mSBI index values in favour of children with T1DM. Significantly higher index values were noted in the group of non-diabetic children [11].

A limitation of this study may be the small sample size of the patients, which results in a small margin of error. Furthermore, the methodology of the study was based on the recommendations of the American Diabetes Association (ADA) and the International Society for Paediatric and Adolescent Diabetes (ISPAD

2014). Hence the threshold value of HBA<sub>1c</sub> was set at 7.5%. Nowadays the new recommendations (2018) for the threshold value of HBA<sub>1c</sub> are below 7%, and in Poland below 6.5%, which may have an influence on the results.

Young patients with type 1 diabetes belong to a risk group for developing dental caries. Therefore, these patients should receive enhanced dental care that includes frequent oral inspections and clinical prophylaxis.

## Conclusions

Children with poorly controlled type 1 diabetes were characterised by a higher intensity of caries. In contrast, no statistically significant differences were observed in the periodontal status between the study groups.

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