Dental health status in children with type 1 diabetes mellitus in Montenegro

Dentalno zdravlje kod dece sa dijabetesom melitusom tipa I u Crnoj Gori

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Abstract

Background/Aim. The number of children with diabetes is constantly increasing. The aim of this study was to evaluate oral health in children with type 1 diabetes mellitus (T1DM) compared to healthy children. **Methods.** The study included 177 patients aged 10–15 years, divided into two groups. The group T1DM included children with type I diabetes mellitus, and healthy children were in the control group. Dental health was assessed using the decayed, missing, filled teeth (DMFT) index. The Plaque Index (PI), according to Silness-Löe, and the Calculus Index (CI) by Green, were used to determine oral hygiene. Salivary status involved determining the amount of secreted stimulated saliva and buffer capacity of the same patient. **Results.** In terms of average values of the DMFT index of permanent teeth, there were no statistically significant differences between the groups. A significant difference ($p = 0.001$) was found in the PI value between the T1DM group (1.29 ± 0.56) and the control group (1.01 ± 0.50). Also, a significant difference was found in the CI value between the T1DM group (0.09 ± 0.23) and the control group (0.03 ± 0.14) ($p = 0.047$). The average amount of secreted stimulated saliva for diabetic children was significantly lower (0.99 ± 0.14 mL/min) compared to healthy children (1.06 ± 0.20 mL/min) ($p = 0.020$). **Conclusion.** Children with T1DM do not have more diseased teeth; however, they have more dental plaque, dental calculus, and lower salivation than the children in the control group. Also, our results point to the absence of preventive measures and programs in maintaining dental health in Montenegro.

Key words:
child; dental caries; dmf index; diabetes mellitus, type 1; oral health; oral hygiene; saliva.

Apstrakt

Uvod/Cilj. Broj dece sa dijabetes melitusom u stalnom je porastu. Cilj istraživanja je bio da se utvrdi stanje dentalnog zdravlja kod dece obolele od dijabetes melitusa tip I (T1DM) u odnosu na zdravu decu. **Metode**. Studijom je bilo obuhvaćeno 177 pacijenata uzrasta 10–15 godina, podeljenih u dve grupe. Grupu T1DM činila su deca obolela od T1DM. Zdrava deca činila su kontrolnu grupu. Stanje zdravlja zuba ocenjeno je pomoću indeksa karioznih, ekstrahovanih i plombiranih (KEP) zuba. Za utvrđivanje oralne higijene primenjivan je Plak indeks (PI) po Silness-Löe i Indeks zubnog kamenca po Green-u (CI). Salivarni status je podrazumevao određivanje količine izlučene stimulisane pljuvačke i puferski kapacitet istog pacijenta. **Rezultati.** Nije bilo statistički značajnih razlika između obolele i zdrave dece u prosečnim vrednostima indeksa KEP stalnih zuba. Uočena je značajna razlika u vrednostima PI između grupe T1DM ($1,29 \pm 0,56$) i kontrolne grupe ($1,01 \pm 0,50$), ($p = 0,001$), kao i značajna razlika u vrednostima CI između grupe T1DM ($0,09 \pm 0,23$) i kontrolne grupe ($0,03 \pm 0,14$), ($p = 0,047$). Prosečna količina izlučene stimulisane pljuvačke kod obolele dece bila je značajno niža i iznosila je $0,99 \pm 0,14$ mL/min, u odnosu na zdravu decu, kod koje bila $1,06 \pm 0,20$ mL/min ($p = 0,02$). **Zaključak.** Deca obolela od T1DM u Crnoj Gori nemaju više obolelih zuba, ali imaju više dentalnog plaka, zubnog kamenca i manji protok pljuvačke u odnosu na decu iz kontrolne grupe. Takođe, naši rezultati ukazuju na nepostojanje preventivnih mera i programa u očuvanju zdravlja zuba u Crnoj Gori.

Ključne reči:
deca; zub, karijes; dmf indeks; dijabetes melitus, tip 1; usta, zdravlje; usta, higijena; pljuvačka.

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Introduction

Diabetes mellitus (DM) is a metabolic disorder caused by an absolute or functional insulin deficiency. Type 1 DM (T1DM) is a common metabolic disease in childhood [1, 2]. The main characteristic of childhood diabetes is instability, variability, sudden changes in blood glucose levels from day to day, and changes that occur during growth and development.

The increase in the incidence of diabetes in childhood reaches a worrying stage; therefore, the 21st-century epidemic can be rightfully discussed. The occurrence of the incidence is greatest in the population up to 14 years of age, equally among ill boys and girls. The incidence of T1DM decreases going from North to South Europe and is highest in children aged 0–14 years in the Scandinavian countries. Compared to other former Yugoslavian countries, Montenegro has the highest incidence of T1DM in the 0–14 years age group, and it is 18.6 in 100,000 children [1, 2].

This disease has a significant influence on oral health, as shown by numerous studies [3–6]. The most common complications in oral health in DM are the changes in the tissues of the periodontium (periodontitis and gingivitis) salivary dysfunction, xerostomia, changes in salivary composition, oral mucosal diseases, taste dysfunction, oral lichen planus, skin hyperpigmentation, infection by *Candida albicans,* dental caries, odontogenic abscesses, and tooth loss. In 1993, periodontal diseases were identified as the sixth complication of diabetes, and four years later, it has been listed as one of the pathologic states diagnosed in these patients (Expert Commitment on the Diagnosis and Classification of Diabetes Mellitus) [7].

The relationship between DM and dental caries has not yet been clarified. Dental caries can be defined as an infectious and easily transmissible disease caused by a specific bacterial infection. Saliva, with its numerous exogenous and endogenous factors, is considered an important factor in the etiology of dental caries. Reduced salivary flow rate and consequently reduced salivary clearance can lead to dental caries development as well as various other disorders of the mucosal lining of the oral cavity. Reducing the flow rate modifies the buffer's salivary effect resulting in reduced resistance to dental plaque microorganisms and can present favorable conditions for dental caries development in these patients. On the other hand, restricted sugar intake can slow the development of dental caries in diabetics [4–6]. Plaque control and fluoride use are quite important in preventing dental caries and periodontal disease. Brushing teeth with fluoride paste at least twice a day is a professional recommendation. However, children do not usually follow these recommendations.

The aim of this study was to evaluate the dental health status in children with T1DM compared to healthy subjects in Montenegro.

Methods

The study was designed as a cross-sectional study and was carried out in the period from June 2014 to December 2015. The study was conducted in accordance with the Helsinki Declaration and principles of Good Clinical Practice. The study protocol was approved by the Ethics Committee of the Clinical Center of Montenegro in Podgorica (No. 03-5/23).

One dental team was qualified and calibrated for clinical measurements, regardless of experience. The reliability of inspection criteria was measured by a pretest performed on a group of 20 randomly selected schoolchildren (10 children with T1DM and 10 healthy children) aged 10–15 years. Inter-rater agreement was measured by the Cohen kappa index. Kappa values evaluated after the study for inter-rater agreement amounted to 0.94.

Subjects

The study was conducted on 177 children, including 87 children with T1DM (48 boys and 39 girls) aged 10–15 years, treated at the Institute of Child Diseases of the Clinical Center of Montenegro. All diabetic children were treated with insulin. Insulin was dosed according to individual patient needs (0.7–1.3 U/kg/24 h). These children constituted one group of the respondents [8, 9]. The parents of the affected children were fully acquainted with the research protocol. Only children whose parents have given their signed consent were included in the study.

Children with T1DM were examined in the dental offices of the Faculty of Medicine, study program Dentistry in Podgorica, after regular control examination of endocrinologists in the presence of parents. Data on the value of glycosylated hemoglobin (HbA1c) not older than six days were obtained from the patients' medical documentation. The exclusion criteria for this group with T1DM were the presence of other systemic disorders unrelated to the complications of DM.

The control group, aged 10–15 years, included 90 healthy children (47 boys and 43 girls) with the absence of active diseases and no history of drug therapy, selected from elementary schools in the municipality of Podgorica by random sample method. The school principal, school staff, and the parents were informed of the research protocol. The realization of the study started after receiving the written consent of the principal and parents' signatures. These children were examined in the school dental offices, in the presence of their parents, in a period that did not interfere with their regular teaching.

General exclusion criteria for all participants were the need for antibiotic prophylaxis and the children who refused to cooperate. The patients and their families lived in the same geographic area.

Questionnaire

The parental questionnaire consisted of two parts. Part 1 included questions on socioeconomic data (municipality, school, grade, gender, date of birth, parents' education and employment, parents' marital status, number of children at home, family income). The second part was focused on children, including questions on their oral hygiene habits (the frequency of tooth-brushing and the use of fluoride toothpaste). The questionnaire is given in Addendum.

Furthermore, the socioeconomic status estimate was implemented. Socioeconomic status was classified into low, moderate, or high, according to the household income, with nationally defined cutoffs according to Eurostat [10]. After examining, every child was trained to properly brush his/her teeth.

Dental examination

The dental caries status of permanent teeth was registered using the decayed, missing, filled teeth (DMFT) system according to the World Health Organization (WHO) standards [11]. Caries was diagnosed with an inspection with the use of standard dental diagnostic instruments. Clearly visible lesions with the cavity formed on the tooth surface were registered as dental caries, while changes in transparency or initial demineralization of the eyes with an intact surface and without cavitation were registered as healthy teeth. The oral hygiene was assessed using the Plaque Index (PI) according to Silness-Löe [12], which determines the absence or the presence, the quantity and distribution of dental plaque and other soft deposits on teeth, as well as the Calculus Index (CI) by Green, which determines the absence or the presence of dental calculus on the teeth [13].

Saliva collection

The children involved in the study were healthy and did not undergo antibiotic therapy for at least 15 days until saliva sampling or taking any other therapy (other than anti-diabetic for patients suffering from the disease) and were not in the process of tooth repairing during saliva sampling. Investigations were carried out on samples of total stimulated saliva taken at least two hours after the last meal (between 10 and 11 a.m.).

The Dentobuff Strip System (Orion Diagnostics, Espoo, Finland) was used to determine the amount of stimulated saliva and buffer capacity. Samples of saliva were collected by giving medical paraffin tablets to children, who chewed them to induce stimulation and spontaneously spit in a graduated plastic bowl for a period of 5 min. The measurement did not include the foam formed during shrinkage. After that, the readout value was divided by number five, and thus the amount of stimulated secretion of saliva in one minute (mL/min) is obtained. Then

one drop of saliva was applied to the test strip. After five minutes, the test strip changed color, and the buffer capacity of saliva was recorded. The results of the saliva buffer capacity of diabetic children were compared with those of the control group. The scoring, or the results of the buffer capacity of the saliva, was carried out as follows: 0 – blue color; the test strip is currently turned into this color; indicates a very high buffering capacity (pH > 6); 1 – blue color; the test strip changed colors within 5 min; indicates a high buffering capacity (pH = 6); 2 – green color; represents a mean buffer capacity (pH = 4.5–5.5); 3 – yellow color; represents a low buffering capacity (pH = 4, or less than 4). The blue color of the test strip, that is, the values 0 and 1, indicate a high buffering capacity [14].

Statistical analysis

Statistical data processing was done in SPSS v.11.5 for Windows (SPSS Inc., Chicago, IL, USA). Methods of descriptive and analytical statistics were used to describe the results. The descriptive statistical methods used were the mean value, standard deviation, and percentages. Student's t-test and χ^2-test were used to test statistical significance in the average values between two independent samples. P-values of less than 0.05 were considered statistically significant.

Results

Subjects characteristics

A total of 177 children (95 boys and 85 girls), aged 10–15 years, participated in this research. The average age of children suffering from DM was 12.7 ± 1.6 years, while the average age of children from the control group was 12.8 ± 1.6 years. The disease lasted for 4.44 ± 2.02 years from the moment of diagnosis. The mean hemoglobin A1c (HbA1c) value in the diabetics was $9.9 \pm 1.7\%$, reflecting an inadequate control of their diabetes. Of those, 75% had HbA1c higher than 8%.

All the examined children brushed their teeth with fluoridated toothpaste. Only 33.3% of patients with T1DM and 31.1% of respondents from the control group brushed their teeth twice a day or more frequently (χ^2-test, $p > 0.05$). Socioeconomic family statuses were similar for both groups (χ^2-test, $p > 0.05$). Oral hygiene habits and socioeconomic status of the study groups are shown in Table 1.

Table 1
Oral hygiene habits and socioeconomic status of the examined patients

Parameter	T1DM group (%)	Control group (%)	p (χ^2-test)
Daily brushing			
1 daily	66.7	68.9	n. s.
≥ 2 daily	33.3	31.1	
Using fluoridated toothpaste	100.0	100.0	
Socioeconomic status			
low	22.9	21.1	n. s.
medium/high	77.1	78.9	

Note: **All values are expressed in percentages of the examined patients.**
T1DM – a group of children with type I diabetes mellitus; Control group – a group of healthy children; n.s. – non-significant.

Dental examination

The percentage of children with all healthy teeth in the T1DM group was 4.6%, while the number of children with permanent teeth affected by the illness was 83 (95.4%). The percentage of children with diseased permanent teeth was slightly lower in the control group compared to the group of children with diabetes mellitus (92.2%), and the number of children with all healthy teeth was 7 (7.8%). Testing the results did not show statistically significant differences in the values of this index (Student's *t*-test, $p > 0.05$).

The average value of DMFT index was almost identical for both groups and it was 4.3. The average values of carious, extracted, and filled teeth were very similar in both groups ($p > 0.05$, Student's *t*-test).

The distribution of the DMFT index in the examined patients is shown in Table 2.

Oral hygiene

Children with DM had significantly higher average PI ($p = 0.001$, Student's *t*-test) and CI values ($p = 0.047$, Student's *t*-test) compared to healthy children. These values are shown in Table 4.

Saliva

The mean value of the stimulated salivary flow for the children with DM was significantly lower (0.99 ± 0.14 mL/min) compared to the children in the control group (1.06 ± 0.2 mL/min), ($p = 0.020$, Student's *t*-test). The average buffer capacity of the saliva value for diabetic children was somewhat higher than in the control group, but there was no statistically significant difference between groups ($p = 0.652$, Student's *t*-test) (Table 4).

In the group of patients with T1DM, the highest

Table 2

The values of DMFT components and DMFT index in the observed groups

Index	T1DM group* mean ± SD (range)	Control group* mean ± SD (range)	*p* (*t*-test)
D	1.66 ± 1.58 (0–6)	1.96 ± 1.47 (0–6)	0.190
M	0.20 ± 0.48 (0–2)	0.26 ± 0.49 (0–2	0.427
F	2.45 ± 1.59 (0–7)	2.11 ± 1.52 (0–8)	0.148
DMFT	4.30 ± 1.79 (0–8)	4.33 ± 1.99 (0–9)	0.866

DMFT – decayed (D), missing (M), filled (F) teeth (T); SD – standard deviation.
*For explanations see under Table 1.

The filled teeth dominated in the structure of DMFT in both groups. The percentage of carious and extracted teeth was slightly higher in the control group (Table 3). There were no significant differences found in the values of the DMFT components (χ^2-test, $p > 0.05$).

percentage (44.8%) of children examined had a high buffering capacity of saliva (grade 1), and only 5.7% of subjects had a low buffering capacity of saliva. The highest percentage (44.4%) of children in the control group had a high buffering capacity of the saliva. The

Table 3

Components of the DMFT index in the examined patients

Components of DMFT*	T1DM group* (%)	Control group* (%)	*p*-value
D	38.5	45.4	n. s.
M	4.8	5.9	n. s.
F	56.7	48.7	n. s.
Total	100.0	100.0	

Note: **All values are expressed in percentages of the examined patients.**
*For explanations see under Tables 1 and 2.

Table 4

The values of Plaque Index (PI), Calculus Index (CI), stimulated salivary flow and buffer capacity of the saliva in the examined patients

Parameter	T1DM group* mean ± SD (range)	Control group* mean ± SD (range)	*p* (*t*-test)
PI	1.29 ± 0.56 (0.12–2.63)	1.01 ± 0,50 (0.11–2.12)	0.001
CI	0.09 ± 0.23 (0.00–1.16)	0.03 ± 0,14 (0.00–1.16)	0.047
Salivary flow (mL/min)	0.99 ± 0.14 (0.70–1.60)	1.06 ± 0.20 (0.70–1.70)	0.020
Buffer capacity of saliva	1.35 ± 0.77 (0–3)	1.29 ± 0.85 (0–3)	0.652

*For explanations see under Table 1.
SD – standard deviation.

difference between the observed groups was not statistically significant (χ^2-test, $p > 0.05$). Values of the saliva buffering capacity are shown in Table 5.

Table 5

Buffer capacity of the saliva in the examined patients

Buffer capacity	T1DM group* n (%)	Control group* n (%)
0	11 (12.7)	15 (16.7)
1	39 (44.8)	40 (44.4)
2	32 (36.8)	28 (31.1)
3	5 (5.7)	7 (7.8)
Total	87 (100.0)	90 (100.0)

Note: **All values are expressed in number (percentage) of the examined patients.**
*For explanations see under Table 1.
Buffer capacity: 0 – very high (pH > 6); 1 – high (pH = 6); 2 – mean (pH = 4.5–5.5); 3 – low (pH = 4, or less than 4).

Discussion

This study examined the relationship between T1DM in schoolchildren and their oral health condition. We believe that this is the first study dedicated to this topic in Montenegro.

Dental caries is the ultimate result of a complex, dynamic multifactorial effect. Some factors may increase the risk of developing dental caries in diabetes, and others may reduce it. Reduced salivation, accelerated accumulation of dental plaque, and increased frequency of meals in diabetics are factors that could increase the risk of developing dental caries [4]. On the other hand, reduced consumption of fermentable carbohydrates and a well-balanced diet are factors that could slow the development of dental caries. Bearing these facts in mind, it is logical that numerous studies devoted to the impact of diabetes on the appearance of dental caries have shown contradictory results. Findings of individual studies indicate an increased prevalence of dental caries, especially in patients with poorly controlled disease [15–18], while others find no differences between people suffering from DM and the healthy population [3, 19–23]. Studies conducted in Portugal [19], Brazil [21], Egypt [22], and Iran [23] did not find the correlation between these two diseases. In contrast to their results, a higher incidence of dental caries in children with DM has been determined by studies carried out in Kuwait [24], Bosnia [25], and India [16, 17].

The results of this study indicate a high percentage of children with diseased permanent teeth in the control group (92.2%). Following the WHO criteria, the average value of the DMFT control group is considered high. These results point to the absence of preventive measures and programs in Montenegro; therefore, it is necessary to form a strategy for controlling dental caries.

In our study, the percentage of children in Montenegro with DM and with all healthy teeth was slightly lower than in the control group, which was expected. Namely, we established a significantly worse oral hygiene condition and significantly lower average

values of the stimulated salivary secreted in these children. The lower buffer capacity of saliva was observed in diseased children. The occurrence of salivary glycoside, the increase in its viscosity, the salivary gland dysfunction, and dry mouth in this disease favor a faster accumulation of dental plaque and the formation of calculus [19, 20, 23]. Accordingly, our respondents with DM had significantly more calculus deposits on their teeth compared to the subjects from the control group. The results of our research are generally in agreement with the results of studies conducted by Orbak et al. [25] in Turkey, Daković et al. [26] in Serbia [27], and López del Vall and Ocasio-López [28] in Puerto Rico. Hyposalivation was confirmed in patients with insulin-dependent diabetes [17, 29, 30]. Reduced saliva secretion reduces its bactericidal role; this creates a disposition for oral infection. Increased saliva density increases the concentration of enzymes; this enhances fermentation and leads to acidosis. Increased acidity in the mouth causes changes in the biofilm structure and makes it easier to colonize *streptococci* and *lactobacilli*, thereby increasing the risk of dental caries [31, 32]. In contrast, the results of our study did not find an association between the amount of salivation and dental caries prevalence. Similar observations were found earlier [20, 33]. Namely, the average value of the DMFT index of 4.3 was almost identical for both of the investigated groups. The explanation of this statement lies in the etiology of dental caries that arises as a result of the interaction of three primary factors: host (tooth), causative agent (microorganism), and environment (nutrition, substrate) in the function of time. Additionally, fluoride use, nutrition, social factors, habits, and patients' behavior are of great importance. Furthermore, the results of our research show that most children from both groups brush their teeth with fluoride paste at least once a day, and they had very similar oral hygiene habits. Similar findings have also been found by Lai et al. [33]. Moreover, the participants of our research were very similar according to socioeconomic status, which could explain the same values of the DMFT index.

After analyzing the individual components of DMFT, no significant differences were found between the comparing groups. The filled teeth dominated both of the observed groups, but the ratio of dental caries and tooth fillings was a bit better in the group of diabetics. A slightly better structure of DMFT in diabetic children in Montenegro can be explained by the relatively good cooperation between pediatricians and dentists.

Similar oral hygiene habits in both study groups indicate the necessity of implementing oral health education in children and their parents. Effective removal of dental plaque is quite significant for good oral health. It is, therefore, necessary to apply this knowledge to promoting oral health on the individual and social level [34, 35].

The relationship between DM and oral disease is not only at the level of clinical signs of illness but at the level of inflammatory mediators, especially those occurring in

autoimmune processes [3, 4, 27]. Regular dental appointments for guidance, dental plaque control, fluor prophylaxis, fissure sealing, a well-balanced diet, and glycemic control will certainly contribute to improving both oral and overall health [35].

In order to relate this variable to the patient's oral health, our study provides significant data on the oral health condition of children with T1DM in Montenegro even though there were some limiting factors, such as a small number of subjects and a small number of diabetics with good glycemic control. Moreover, the study points to the importance of additional salivary analysis in assessing the state of oral health.

Conclusion

The results of this research indicate that children with T1DM do not have more diseased teeth; however, they have more dental plaque, dental calculus, and a lower saliva rate than the children in the control group. The high average value of DMFT for both groups points to the absence of preventive measures and curative-oriented dental policy in Montenegro. It is crucial to propose a plan of preventive activities aimed at educating diseased children and at applying prophylactic measures at an individual level in dental offices.

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Addendum

Questionnaire

Number _____

Answer the questions by filling out the number of answers or enter the 'X' .

General data

Name and surname of the child

Day, month, year, and place of birth

Gender

School

Grade

Address

Municipality

Part 1

1. Paternal education

    a) No education

    b) Elementary school

    c) Secondary school

    d) College

    e) University

2. Maternal education

    a) No education

    b) Elementary school

    c) Secondary school

    d) College

    e) University

3. Paternal employment

    a) Employed

    b) Unemployed

4. Maternal employed

    a) Employed

    b) Unemployed

5. Family income in the last month

6. Number of siblings

7. Number of family members

8. Child living with

    a) Both parents

    b) Mother

    c) Father

    d) Custody

Part II

9. The child brushes the teeth

    a) Only in the morning

    b) Only in the evening

    c) In the morning and in the evening

    d) After each meal

    e) Not brushing every day

10. The child brushes his/her teeth with fluoride paste

    a) Yes

    b) No