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Programvezető: Dr. Varga Gábor, egyetemi tanár

Témavezetők: Dr. Végh Dániel, egyetemi adjunktus

Dr. Kempler Péter, egyetemi tanár

INVESTIGATION OF ORAL HYGIENE BEHAVIOUR AND SELF-REPORTED ORAL HEALTH STATUS IN DIFFERENT POPULATIONS USING QUESTIONNAIRE-BASED METHODS

PhD thesis

Klaudia Lipták

Semmelweis University Doctoral School

Dental Research Division





Supervisors: Péter Kempler, MD, Ph.D., D.Sc
Dániel Végh, DMD, Ph.D.

Official reviewers: Kinga Körmöczi, DMD, Ph.D.
Kis János Tibor, MD, Ph.D.

Head of the Complex Examination Committee: István Gera, DMD, Ph.D., C.Sc

Members of the Complex Examination Committee:
Beáta Kerémi, DMD, Ph.D.
Balázs Sándor, DMD, Ph.D.

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List of Abbreviations

AAP – American Academy of Periodontology

ADA – American Diabetes Association

AGEs – Advanced Glycation End-products

CGM – Continuous Glucose Monitoring

COHQoL – Child Oral Health Quality of Life

COVID-19 – Coronavirus Disease 2019

DM – Diabetes Mellitus

DZ – Dizygotic Twins

EFP – European Federation of Periodontology

GOHAI – General Oral Health Assessment Index

HbA1c – Glycated Hemoglobin A1c

HTR – Hungarian Twin Registry

IDF – International Diabetes Federation

KSH – Központi Statsiztikai Hivatal

MZ – Monozygotic Twins

OHIP – Oral Health Impact Profile

PwDM – People/Patients with Diabetes Mellitus

RNA – Ribonucleic Acid

T1DM – Type 1 Diabetes Mellitus

T2DM – Type 2 Diabetes Mellitus

WHO – World Health Organization

1. Introduction

1.1. Oral health behaviour and self-reported oral health status in population-based research

Oral health is influenced by a combination of biological, behavioural, environmental, and socioeconomic factors. Daily oral hygiene practices, dietary habits, tobacco use, and patterns of dental attendance may contribute to differences in oral health between individuals and populations. Consequently, population-based oral health research increasingly considers behavioural characteristics and self-reported outcomes alongside clinical indicators [1].

Self-reported measures provide information on aspects of oral health that cannot always be captured through clinical examination alone, including oral hygiene practices, dental attendance, subjective symptoms, and individual perceptions of oral health. Questionnaire-based methods are therefore particularly useful in epidemiological research, where standardized information needs to be collected from larger populations in an efficient and reproducible manner [2, 3].

The validity of self-reported information depends on the parameter being assessed. Previous studies have demonstrated good agreement between self-reported and clinically determined numbers of remaining teeth and the presence of removable prostheses, whereas self-reported measures of dental caries and periodontal disease tend to be less reliable [2, 3]. Thus, questionnaire-based assessment should not be considered a substitute for clinical examination, but rather a complementary approach for investigating oral health behaviour and self-perceived oral health at the population level.

Standardized questionnaires further improve the comparability of data across study populations. The World Health Organization (WHO) has developed standardized oral health survey methods to support population-level surveillance and internationally comparable data collection [4]. Such instruments provide a common methodological framework for investigating oral health-related knowledge, behaviours, dental attendance, and self-reported oral health status across populations with different characteristics.

In the present dissertation, this standardized questionnaire-based approach provides the common methodological framework for investigating oral health behaviour and self-reported oral health status in two distinct population settings.

1.2. Assessment of oral health behaviour using standardized questionnaires

Standardized questionnaires are widely used in oral health research to assess behavioural patterns, knowledge, and attitudes related to oral health. Among these, instruments developed by the World Health Organization (WHO) are considered particularly valuable, as they provide a structured and internationally comparable framework for data collection. These tools have been applied in numerous studies to evaluate key aspects of oral health behaviour, including hygiene practices, access to dental care, and awareness of disease-related risks [5, 6]. In addition, several other validated instruments are commonly used in oral health research, particularly to assess oral health-related quality of life and patient-reported outcomes. Examples include the Oral Health Impact Profile (OHIP) [7], the General Oral Health Assessment Index (GOHAI) [8], and the Child Oral Health Quality of Life (COHQoL) questionnaire family [9], all of which are designed to evaluate the impact of oral conditions on quality of life and patient perception (Figure 1).



Figure 1. Role of standardized digital oral health questionnaires in large-scale population-based data collection and evidence-based oral healthcare improvement.

Typically, such questionnaires cover multiple domains of oral health behaviour. These include daily hygiene routines (such as toothbrushing frequency and the use of interdental

cleaning aids), levels of oral health knowledge, patterns of dental service utilization, and self-reported indicators of oral health status, including symptoms like gingival bleeding, tooth sensitivity, or xerostomia [4].

The use of standardized instruments allows for consistent data collection across different populations and supports the identification of behavioural risk factors. This is particularly relevant in the context of chronic conditions, such as DM, where oral health behaviour may significantly influence disease outcomes and the effectiveness of preventive strategies.

1.3. The importance of twin studies in oral health research

The study of twins has attracted considerable scientific interest because it offers a unique opportunity to investigate the relative contributions of genetic, epigenetic and environmental factors to human phenotypic and behavioral characteristics [10]. Monozygotic (MZ) twins develop when one zygote divides during the early stages of embryonic development, giving rise to two separate embryos. In contrast, dizygotic (DZ) twins result from the independent fertilization of two different ova. Consequently, MZ twins share almost the entirety of their genetic material, whereas DZ twins have approximately 50% genetic similarity on average [11-13] (Figure 2). Consequently, phenotypic differences observed between MZ co-twins are thought to reflect predominantly environmental and epigenetic influences [14].

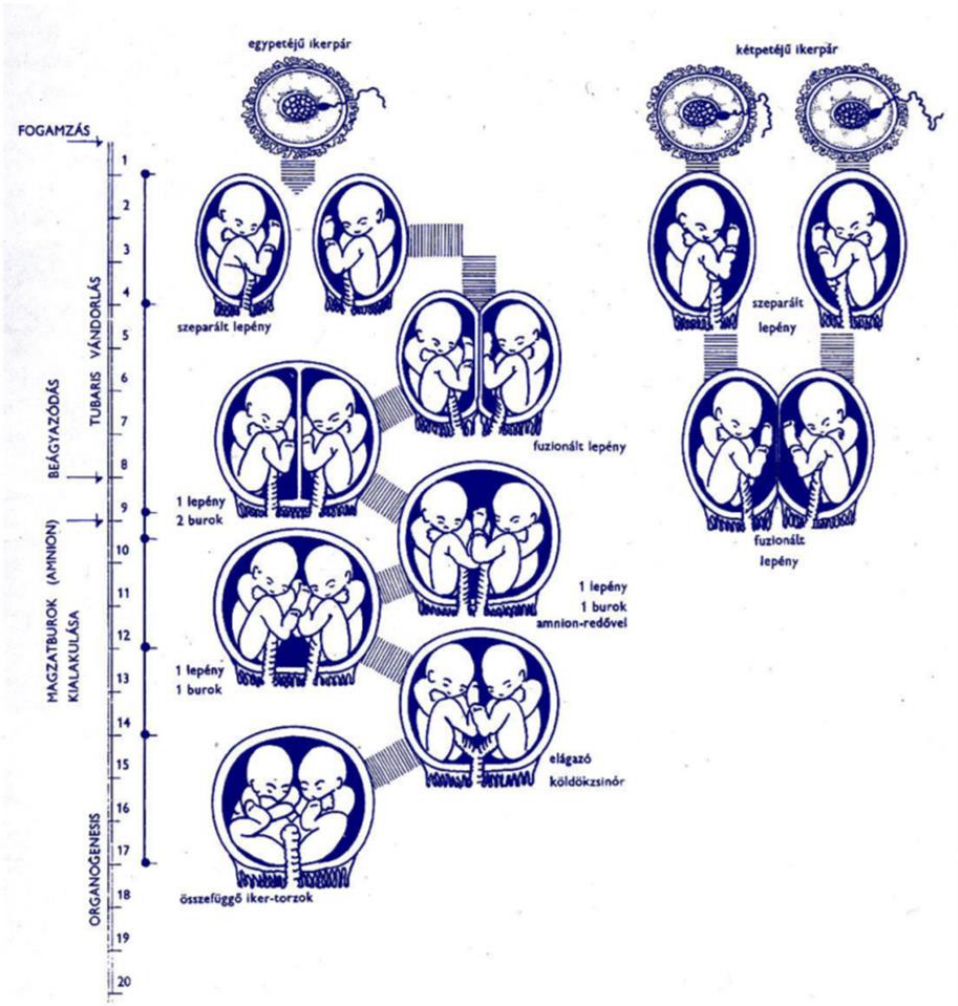


Figure 2. Schematic representation of the formation of monozygotic and dizygotic twins [15].

By comparing MZ and DZ twin pairs, the classical twin study design enables the estimation of the relative contributions of genetic influences, environmental factors shared between individuals, and individual-specific environmental effects to the variability of different traits and disease outcomes [16].

Twin-based investigations represent an effective approach for analysing factors associated with dentofacial development and oral health-related characteristics. Such studies may contribute to a better understanding of how environmental influences, lifestyle-related factors and behavioural habits affect oral health outcomes despite similar genetic backgrounds [14].

According to epidemiological estimates, approximately 91.7 million twins live worldwide, including around 28 million MZ, or identical, twins [17].

Previous studies provide limited information regarding potential differences in oral hygiene behaviour and oral disease-associated risk factors between MZ and DZ twins. Therefore, a pilot questionnaire-based investigation was conducted among Hungarian twin pairs using the simplified structured oral health survey recommended by the World Health Organization (WHO Annex 7) [4].

The present study aimed to investigate potential differences in oral health-related knowledge and self-reported oral hygiene behaviour between MZ and DZ twins living in Budapest and the surrounding regions of Hungary. Data collection was performed using a questionnaire based on the simplified structured oral health survey recommended by the World Health Organization (WHO). The study was conducted under the assumption that no significant differences exist between the oral hygiene habits of MZ and DZ twins.

1.4. Diabetes mellitus and oral health

1.4.1. Epidemiology of diabetes mellitus

According to the 11th edition of the IDF Diabetes Atlas, an estimated 589 million adults aged 20–79 years were living with diabetes mellitus (DM) worldwide in 2024, corresponding to approximately one in every nine adults. The global burden of DM is projected to increase further, reaching 853 million cases by 2050 [18]. In Hungary, DM affects approximately 10% of the population, including more than one-third of individuals over 65 years of age [19]. According to data published by the Hungarian Central Statistical Office (KSH) in 2019, more than 1.1 million adults and approximately 5,000 children are living with diabetes in Hungary. The prevalence of diabetes increases markedly with age and affects nearly one-third of individuals over the age of 75. Over the past two decades, the number of people living with diabetes has risen substantially [19]. Obesity and physical inactivity are among the most important factors contributing to the development and progression of the disease; in Hungary, nearly 60% of the population is overweight or obese, which significantly contributes to the high prevalence of diabetes.

Epidemiological data indicate that approximately 10% of patients presenting for dental care are affected by diabetes mellitus. Consequently, a fundamental understanding of diabetes mellitus is essential not only for physicians but also for dental professionals, highlighting the importance of incorporating annual dental screening examinations into the routine care of patients with diabetes mellitus (PwDM).

1.4.2. Systemic complications of diabetes mellitus

Numerous studies have demonstrated that poorly controlled DM may lead to several oral complications. Persistent hyperglycaemia contributes to the development of systemic complications, particularly microvascular damage, which may result in neuropathic alterations and endothelial dysfunction [20].

Microvascular complications are among the earliest and most characteristic consequences of DM. Neuropathy associated with DM, one of the most common complications, affects both the peripheral and autonomic nervous systems, leading to altered sensory perception, pain, dysfunction, and impaired nerve conduction. Similarly, nephropathy and retinopathy related to DM result from progressive damage to small blood vessels, ultimately contributing to organ dysfunction and reduced quality of life [21-23].

Macrovascular complications, on the other hand, are primarily associated with accelerated atherosclerosis. Patients with DM (PwDM) have a significantly increased risk of cardiovascular diseases, including coronary artery disease, as well as cerebrovascular events such as strokewith incidence rates approximately 1.5 to 2 times higher than in populations without DM. Moreover, recovery and functional outcomes following cerebrovascular events are generally less favorable among affected patients [24]. These conditions represent the leading causes of morbidity and mortality in PwDMs [20]. Importantly, vascular alterations in DM are systemic in nature, affecting not only major vessels but also smaller vascular structures, which may manifest in various tissues, including the oral and maxillofacial region [25, 26].

1.4.3. Oral manifestations and complications of diabetes mellitus

Current clinical guidelines recommend that individuals with diabetes mellitus attend dental examinations at least annually. These visits should include a comprehensive periodontal evaluation, professional plaque and calculus removal, and reinforcement of appropriate oral hygiene practices [27, 28].

Substantial evidence indicates that the complications of poorly controlled DM may also manifest in the oral cavity. A wide range of oral manifestations associated with DM may occur in both adults and children, including xerostomia (dry mouth), dental caries, periodontal diseases (gingivitis and periodontitis), oral candidiasis, burning mouth syndrome, taste disturbances, rhinocerebral zygomycosis (mucormycosis), aspergillosis, oral lichen planus, geographic and fissured tongue, delayed wound healing, increased

susceptibility to infections, salivary gland dysfunction, altered taste perception and other neurosensory disorders, disturbances in tooth eruption, as well as benign parotid gland enlargement [29].

Xerostomia may affect up to 46% of patients with type 2 diabetes mellitus (T2DM) and is associated with reduced salivary flow and elevated salivary glucose levels. These alterations may contribute to dental caries development, difficulties during food intake, and impaired tolerance of removable dental prostheses [30].

Adequate glycaemic control before dental treatment is of particular importance, as hyperglycaemia may impair the healing process and contribute to a higher susceptibility to infections following surgical procedures [31, 32]. This is especially relevant in oral surgical and implantological procedures, where a well-controlled metabolic status may significantly improve treatment outcomes. Chronic hyperglycaemia has been associated with an increased risk of periodontitis and peri-implantitis and may also negatively influence implant survival, particularly in patients with poor metabolic control. Previous studies demonstrated that HbA1c levels above 8% represent a considerable risk factor regarding the success of oral surgical interventions; therefore, optimization of glycaemic control prior to treatment is recommended in such cases [33, 34]. In addition, over the past two decades, the prevalence of T2DM among patients with oral malignancies has more than doubled, further supporting the association between metabolic disorders and malignant processes [35, 36].

Diabetic neuropathy has also been implicated in the pathogenesis of burning mouth syndrome, most likely due to the long-term effects of hyperglycaemia on peripheral neural structures [37].

When evaluating the effects of diabetes mellitus on oral health, children with type 1 diabetes generally demonstrate better oral hygiene than the average Hungarian population, likely reflecting increased health awareness and closer adherence to healthcare recommendations. Nevertheless, inadequate glycaemic control is associated with a higher risk of dental caries and an increased prevalence of orthodontic abnormalities [38, 39].

Local anaesthesia plays a fundamental role in dental treatment. Based on our experimental studies, the two most commonly used local anaesthetic agents in Hungarian dental practice, articaine and lidocaine, demonstrated similar effects on the central nervous

system in DM animal models. Both agents inhibited stimulus-evoked noradrenaline release while simultaneously increasing resting neurotransmitter release, without showing significant differences in their effects on nerve conduction function [40].

1.4.3.1. Periodontal disease and diabetes: a bidirectional relationship

More than three decades ago, Harald Löe described periodontitis as the sixth complication of DM [41, 42]. Periodontal diseases, particularly gingivitis and periodontitis, are inflammatory conditions affecting the soft and hard tissues surrounding the teeth. Gingivitis affects approximately 90% of the global population [43]. Patients with DM (PwDM) exhibit an increased susceptibility to periodontal diseases, with a two- to three-fold higher prevalence compared with individuals without DM [41]. In addition, periodontal inflammation may negatively affect glycaemic control, establishing a bidirectional relationship between periodontitis and hyperglycaemia [41, 44, 45]. Persistent hyperglycaemia facilitates the accumulation of advanced glycation end-products (AGEs), which stimulate local production of pro-inflammatory cytokines within gingival tissues. Other pathogenic mechanisms, including oxidative stress, altered circular RNA expression, and neutrophil hyperactivity, have also been implicated in DM-associated periodontal destruction [46-48]. These processes may increase the risk of periodontal tissue breakdown and eventual tooth loss [49, 50].

1.4.3.2.Oral manifestations of diabetes-related neuropathy

Diabetic neuropathy is one of the most common and severe chronic complications of DM, affecting up to 50% of patients with long-standing disease [51]. It represents a spectrum of peripheral nerve disorders caused by sustained hyperglycemia, metabolic alterations, and microvascular dysfunction. Neuropathy may be symptomatic or subclinical, with both sensory and autonomic fibers involved [20, 44]. While its systemic consequences, including distal symmetric polyneuropathy and autonomic cardiovascular neuropathy, are well documented, the potential manifestations in the stomatognathic system are less frequently recognized [44].

Clinical observations suggest that neuropathy may alter oral sensation, taste perception, and pain thresholds, which can influence both functional and psychosocial aspects of oral health [41, 52]. Patients may present with burning mouth syndrome, dysesthesia, or hypoesthesia, conditions that complicate everyday oral functions and may delay the

detection of oral pathology [21, 53]. Impaired salivary gland function associated with autonomic neuropathy may also contribute to xerostomia, which in turn increases the risk of dental caries, periodontal breakdown, and prosthesis intolerance [54].

Early recognition of sensory alterations and patient education on their possible oral consequences can facilitate timely interventions and improve quality of life. For this reason, integration of dental care into comprehensive DM management is strongly recommended, with special attention to neuropathic complications [25, 55, 56].

1.5. Interdisciplinary care in patients with diabetes mellitus

Dental screening and oral healthcare should constitute an integral component of comprehensive DM management (Figure 3). Despite the well-established association between DM and oral health, the oral cavity is still frequently overlooked during DM care. The Diabetes Dental Working Group of Semmelweis University recommends that routine DM management should include referral for regular dental examinations [51, 57].

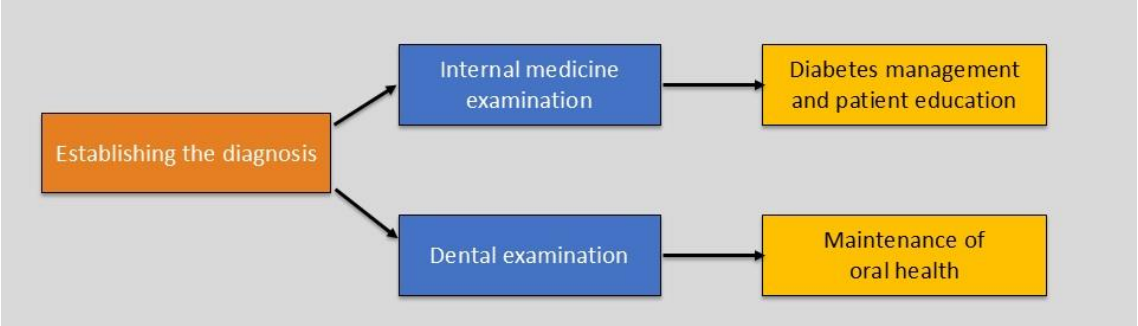


Figure 3. The care pathway of patients living with diabetes mellitus, in which dental screening contributes to health preservation as an integral part of comprehensive diabetes management [58].

The Figure 4 presents the activities of the Diabetes Dental Working Group of Semmelweis University and highlights how an integrated multidisciplinary approach may contribute to the early recognition, prevention and management of oral complications associated with DM. The figure also emphasizes the close relationship between DM and oral health and underlines the importance of interdisciplinary cooperation in improving patient outcomes and optimizing healthcare delivery [58].

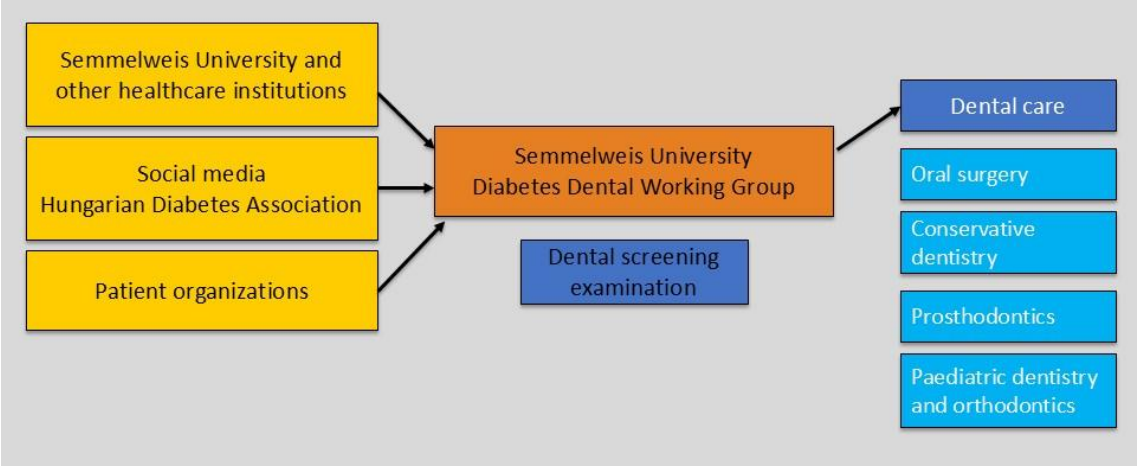


Figure 4. Operational structure of the Diabetes Dental Working Group of Semmelweis University [58]

The organization of the screening examinations conducted by the Working Group is coordinated by dr. Klaudia Lipták (mentor: dr. Dániel Végh) in the case of adults, and by dr. Laura Lipták (mentor: dr. Dorottya Bányai) in the case of paediatric patients.

Free dental screening examinations are coordinated by the Semmelweis University Diabetes Dental Working Group. Participation is possible only upon prior appointment, which is scheduled through an electronic registration system. The clinic aims to provide specialized dental screening and follow-up care for individuals living with both type 1 and type 2 diabetes mellitus, thereby supporting the early detection and prevention of diabetes-related oral complications. This initiative, known as the “Budapest pilot”, is considered unique even in an international context, as it operates within a university setting. Its long-term objective is to establish annual dental examinations as an integral part of routine diabetes care, not only at Semmelweis University but throughout Hungary [58].

The screening programme consists of several components, including structured questionnaires, clinical examinations, radiological assessments, and laboratory measurements, enabling the collection of comprehensive and reliable data. In addition to oral health evaluation, diabetes-related metabolic parameters are also recorded during the screening process. Blood glucose, ketone, and HbA1c levels are measured using the Dcont® NOVUM blood glucose meter, the KETO Cont® ketone meter, and the SmartTester HbA1c rapid test, respectively. The SmartTester device provides a rapid quantitative assessment of HbA1c levels using a finger-prick blood sample. This

comprehensive evaluation protocol facilitates an integrated assessment of patients' overall health status, supports the identification of associations between oral and systemic conditions, and enables the timely initiation of appropriate preventive and therapeutic interventions [58].

In Hungary, the financing of dental treatment fees and dental appliances, including prosthodontic restorations fabricated by dental laboratories and orthodontic appliances, is regulated by the National Health Insurance Fund of Hungary (NEAK). Under this system, tooth-preserving treatments, such as professional dental cleaning, restorative procedures, and root canal treatment, are provided free of charge for eligible patients [58]. In contrast, individuals between 18 and 62 years of age are generally required to cover both the professional treatment fee and the laboratory costs associated with prosthodontic and orthodontic treatment. Patients under the age of 18, those with a valid certificate of student status, and individuals over 62 years of age are exempt from treatment fees and are responsible only for the laboratory costs. From a dental healthcare perspective, this reimbursement system is considered relatively generous by European standards [58].

2. Objectives

The present thesis is based on two original research studies and a complementary clinical observation. The first study investigated oral health behaviour and self-reported oral health status among monozygotic and dizygotic twins using a standardized WHO questionnaire. The second study evaluated oral health behaviour and self-reported oral health status in adults with diabetes mellitus and matched controls using the same methodology. In addition, the thesis includes a clinical observation related to diabetic neuropathy, illustrating oral manifestations associated with one of the major chronic complications of diabetes mellitus. The relationship between the individual components of the thesis is summarized in Figure 5.

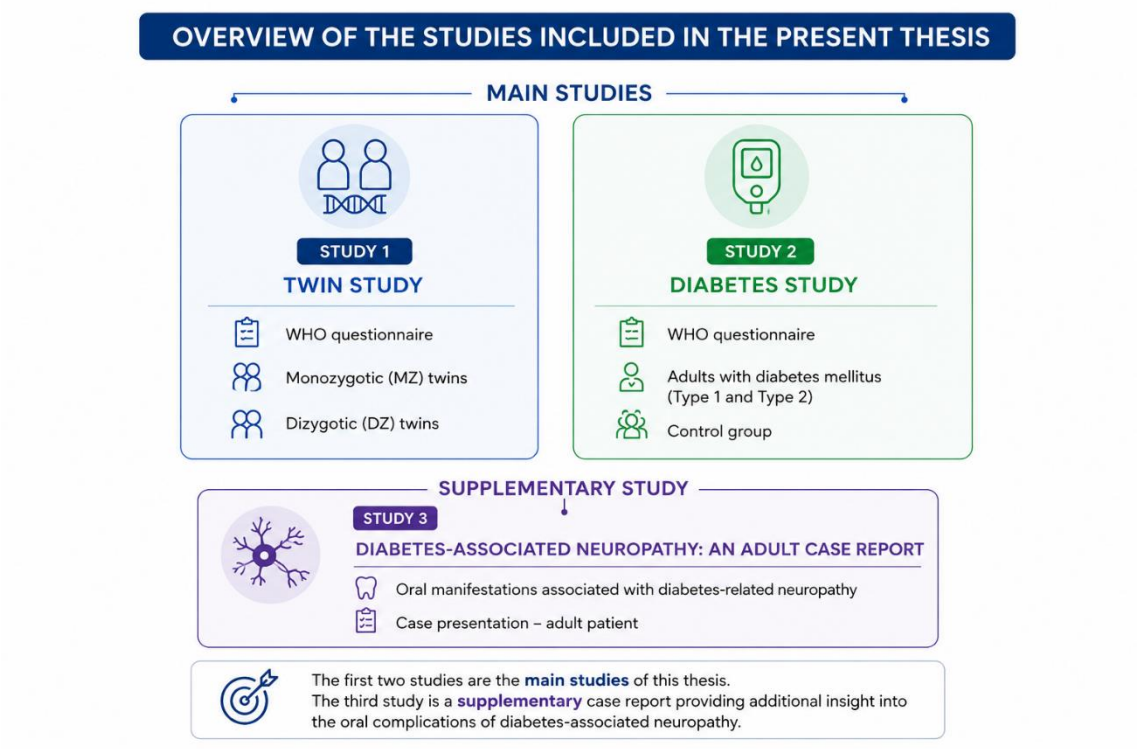


Figure 5. Overview of the studies included in the present thesis.

2.1. Objectives of the twin-study

The aim of this pilot study was to assess oral health knowledge, oral hygiene practices, and oral health-related behaviours among Hungarian MZ and DZ twins using the World Health Organization (WHO) Oral Health Questionnaire for Adults (Annex 7). The study further sought to determine whether differences exist between MZ and DZ twins with respect to self-reported oral health status, preventive oral health behaviours, patterns of dental attendance, and daily oral hygiene practices [6].

By comparing MZ and DZ twins, the study aimed to provide preliminary insights into the potential contribution of genetic and environmental factors to oral health-related behaviours and habits. The null hypothesis was that no significant differences exist between MZ and DZ twins regarding their oral health behaviours and oral hygiene practices [6].

2.2. Objectives of the diabetes-study

The aim of this pilot study was to assess oral health knowledge, oral hygiene practices, and oral health-related behaviours among Hungarian individuals with DM and controls without DM using a modified version of the World Health Organization (WHO) Oral Health Questionnaire for Adults (Annex 7). Furthermore, the study sought to compare self-reported oral health status, dental attendance patterns, oral hygiene habits, and oral health literacy between the two groups [59].

In addition, the study aimed to investigate potential differences between patients with type 1 diabetes mellitus (T1DM) and T2DM, with particular attention to oral hygiene behaviours, dentition status, prosthesis use, and self-perceived oral health. Logistic regression analyses were also performed to explore associations between oral hygiene practices, dietary habits, DM status, and the number of remaining natural teeth [59].

The ultimate objective of the study was to provide preliminary evidence on oral health behaviours and literacy among Hungarian PwDM and to support the development of preventive strategies and interdisciplinary approaches integrating oral health into routine DM care [59].

In accordance with the study objectives, two null hypotheses can be defined. The first assumes that there are no statistically significant differences between individuals with diabetes mellitus and non-diabetic controls regarding oral hygiene behaviours, dental attendance, oral health-related knowledge, and self-reported oral health status. The second assumes that there are no statistically significant differences in these parameters between individuals with type 1 and type 2 diabetes mellitus.

3. Methods

3.1. Ethical approvals

The study protocols were approved by the appropriate institutional research ethics committees of Semmelweis University and were conducted in accordance with the principles of the Declaration of Helsinki. All participants, or their parents/legal guardians in the case of minors, provided informed consent as required. Data collection, storage, and processing were performed in compliance with the General Data Protection Regulation (GDPR). All data were anonymised prior to analysis, personal identifiers were removed, and unique study codes were assigned to ensure confidentiality and data protection [6, 59].

3.2. Study populations and data collection

3.2.1. Twin-study

During the COVID–19 (Coronavirus Disease 2019) pandemic, data were collected through telemedicine-based solutions and online questionnaire methods. The use of digital platforms enabled remote participation and minimized the need for face-to-face contact and travel among participants. Furthermore, the widespread implementation of online data collection strategies during the pandemic provided practical and effective support for conducting the survey [60] [6].

The study population consisted of 58 Hungarian twins (38 females and 20 males) recruited from the Hungarian Twin Registry (HTR) [61]. Participation in the questionnaire-based survey was voluntary. Data collection was carried out between October and December 2022 using an online questionnaire administered via the Google Forms platform and accessible through computers, tablets and mobile devices. The questionnaire was completed in Hungarian [6].

The questionnaire consisted of 23 items, including several core questions regarded as essential for the assessment of oral health at a population level. The survey protocol was based on Annex 7 of the WHO Oral Health Questionnaire [4]. The questionnaire was completed online. To enable pairwise comparison while preserving anonymity, each twin pair used a self-generated identifier consisting of three letters and three numbers (e.g. ABC123). The same identifier was applied by both co-twins throughout the survey

process. This coding system ensured anonymous data handling and allowed comparison between twin pairs without revealing their MZ or DZ status prior to data analysis [6].
Incomplete questionnaires, duplicate entries submitted from identical email addresses, and responses from non-twin participants were excluded from the analysis. Furthermore, questionnaires were omitted if the corresponding co-twin did not complete the survey. Zygosity was determined using a standardized seven-item self-reported questionnaire with an estimated accuracy of approximately 99%. This method has been widely used in the Danish Twin Registry for several decades [62, 63] [6].

3.2.2. Diabetes-study

Our study included 99 participants with DM (33 with type 1 and 66 with type 2 DM (T2DM)) and 102 control subjects aged 18 years or older. In total, 103 responses were obtained from PwDMs; 4 were excluded due to incomplete data, while all responses from the control group (n = 102) were retained [59].
The survey was conducted between October 1, 2022, and January 31, 2024, using an online questionnaire platform (Google Forms; Google LLC, Mountain View, CA, USA), accessible via computers, tablets, and mobile devices and subsequently processed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). The questionnaire was administered in Hungarian. Only participants with a prior clinical diagnosis of DM were included, and no additional verification procedures were performed. Questionnaires were distributed both in person at diabetology outpatient clinics and online through DM-related communities [59].
No a priori sample size calculation was carried out. Data quality was ensured by excluding incomplete entries and screening for potential duplicate submissions based on identical IP addresses or email identifiers. Participants generated a unique identifier consisting of three letters and three numbers to enable data matching; no duplicate responses were identified [59].
The questionnaire consisted of 24 items and included questions considered essential for national oral health surveillance (Table 1 in Results). The study protocol was developed based on Annex 7 of the World Health Organization (WHO) oral health survey methodology [4]. The questionnaire was designed to ensure complete participant

anonymity, and no personally identifiable information was collected during data acquisition [59].

The collected data included demographic, medical, lifestyle, and oral health–related variables. Recorded parameters comprised sex, age, place of residence, educational level, type and therapy of DM, use of continuous glucose monitoring (CGM) systems, and the latest HbA1c value. HbA1c reflects the average blood glucose level over the previous three months and is routinely monitored during diabetology follow-up visits [59].

Oral health–related variables included the number of teeth, use of removable dentures, oral discomfort, self-reported oral health status, oral hygiene habits, toothpaste preference, oral care products used, frequency of dental visits, smoking status, alcohol consumption, dietary habits, and dental anxiety [59].

Statistical analyses included comparisons between the DM and control groups, followed by subgroup analyses of participants with T1DM and T2DM [59].

3.2.3. Clinical context of neuropathy-related observations

As part of the dissertation, the potential oral manifestations of diabetes-related neuropathy were illustrated through the presentation of a previously published clinical case involving a 46-year-old male patient with poorly controlled type 2 diabetes mellitus. Clinical, radiographic, and neuropathy-related findings were reviewed descriptively. Dental examination included assessment of oral health status and panoramic radiographic evaluation (Figure 6) [64].



Figure 6. Baseline panoramic radiograph showing the patient's initial oral condition [64].

The Figure 7 illustrates the severity of long-term complications associated with diabetes mellitus. Image 1 shows a severe soft-tissue infection that progressed to osteomyelitis. A characteristic neuropathic ulcer is visible in Image 3; due to impaired pain perception, such lesions are often recognized only at an advanced stage. Images 2 and 4 depict the post-amputation condition, highlighting the potentially devastating consequences of diabetes mellitus and diabetic neuropathy. Sensory neuropathy was assessed using a Neurometer device by measuring current perception thresholds (CPTs) in all four extremities, while autonomic function was evaluated using standard cardiovascular reflex tests. The observations were interpreted in the context of the relevant literature to explore possible associations between diabetic neuropathy and oral health conditions [64].



Figure 7. Clinical manifestations of diabetic neuropathy and diabetic foot syndrome [64].

3.3. Statistical analyses

3.3.1. Statistical analysis of the twin-study

All collected data were recorded and organized using Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Statistical evaluation was performed primarily using descriptive statistical methods to characterize the study population and questionnaire responses. Differences between groups were analysed using Fisher's exact test. A p-value below 0.05 was considered statistically significant [6].

3.3.2. Statistical analysis of the diabetes-study

Statistical analyses were performed using R software (version 4.3.3; R Foundation for Statistical Computing, Vienna, Austria), a widely used open-source environment for data analysis and visualization. Descriptive tables were generated using the table1 package (v1.4.3), while graphical outputs were created with ggplot2 (v3.5.0) [65-67]. For regression analyses, results were summarized using *gtsummary* (v1.7.2) and visualized with *sjPlot* (v2.8.16) [68, 69] [59].

Regression models were applied to examine the relationship between oral hygiene behaviours, DM status, and dental outcomes, as well as the association between number of teeth and HbA1c levels. Due to the relatively small sample size, only key variables and the most relevant confounders were included. The main comparisons focused on individuals with and without DM, as well as differences between T1DM and T2DM. Additional analyses considered dietary habits, including fruit and rapidly absorbable carbohydrate consumption. Age, sex, and oral hygiene behaviours, such as toothbrushing and flossing frequency, were treated as potential confounders [59].

When the number of teeth was used as the outcome variable, ordinal logistic regression assumptions were not met; therefore, pairwise logistic regression models with a logit link were applied across tooth categories, using the highest category as the reference. The association with HbA1c levels was assessed using linear regression. All models were adjusted for age and sex. Two-way interaction terms were tested but were not statistically significant at the 5% level and were therefore omitted from the final models [59].

4. Results

4.1. Oral health behaviour and self-reported oral status in monozygotic and dizygotic twins

A total of 58 Hungarian twin participants, including 38 females and 20 males, were enrolled in the study. The cohort consisted of 15 MZ and 14 DZ twin pairs, corresponding to 51.7% and 48.3% of the study population, respectively. The mean age of the participants was 35.2 ± 16.6 years. Most individuals resided in Budapest or Pest County (82.8%), whereas 17.2% lived in rural areas [6].

Overall, no statistically significant differences were identified between MZ and DZ twins regarding oral health knowledge, oral hygiene habits or the other evaluated parameters (Table 1). Similar responses regarding the use of oral hygiene devices were observed in 27.0% of MZ twins and 21.0% of DZ twins [6].

Manual toothbrushes represented the most commonly used oral hygiene aids, with approximately two-thirds (67.0%) of participants preferring manual toothbrushes over electric toothbrushes. Only 12.1% reported regular use of both types. Nearly all participants used a toothbrush as part of their daily oral hygiene routine, including almost all MZ twins and 93.0% of DZ twins. In addition, 51.7% of participants reported using dental floss, 44.8% used mouthwash and 36.2% used toothpicks (Figure 8) [6].

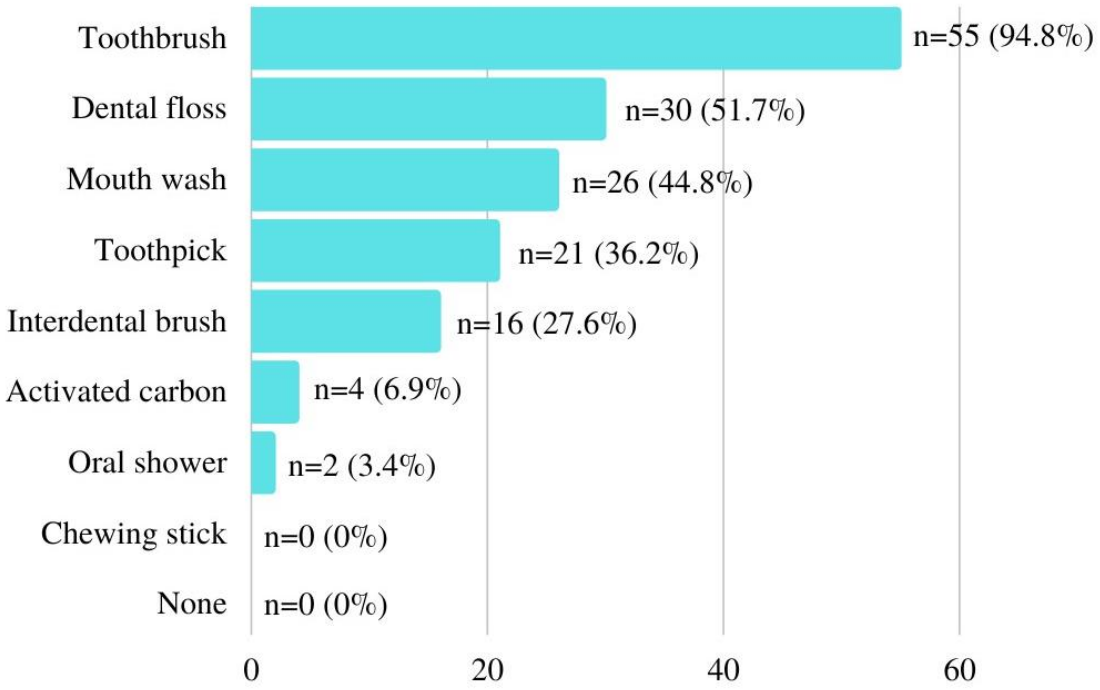


Figure 8. Use of oral hygiene device use by monozygotic and dizygotic twins [6].

The relative distribution of oral hygiene aids was comparable between MZ and DZ twins. Toothbrushes were the most frequently used oral hygiene devices in both groups (MZ: 73.0%; DZ: 64.0%), followed by dental floss (MZ: 53.0%; DZ: 50.0%). Similar responses regarding the regular use of dental floss were observed in 60.0% of MZ twins and 57.0% of DZ twins. Corresponding values for interdental brush use were 80.0% and 79.0%, respectively. Other oral hygiene aids, including mouthwash, toothpicks, activated charcoal and chewing sticks, were used by 63.3% of MZ twins and 64.3% of DZ twins (Figure 8). The Figure 9 shows there was not statistically significant differences were detected between MZ and DZ twins regarding the use of primary and supplementary oral hygiene devices (p = 0.355) (Table 1) [6].

Table 1. Responses of monozygotic and dizygotic twins to the WHO-recommended simplified oral health questionnaire [6].

Question	**Response**			
	Monozygotic twins No. (%)		Dizygotic twins No. (%)	
Number of participating twin pairs	15		14	
During the past 12 months, did have any discomfort in your teeth or mouht ?	9	(60%)	12	(86%)

Do you wear removable dentures?	8	(53%)	10	(71%)
Would you describe the state of your teeth and gums as very good or excellent				
• Teeth	6	(40%)	6	(43%)
• Gums (gingiva)	6	(40%)	7	(50%)
How often do you clean your teeth?	12	(80%)	10	(71%)
Do you use the following to oral hygeine aids to clean your teeth?				
• Tooth brush	11	(73%)	9	(64%)
• Toothpaste	15	(100%)	14	(100%)
• Fluoride containing toothpaste	9	(60%)	8	(57%)
Have you ever received oral care education/counseling?	10	(67%)	9	(64%)
How long is it since you last saw a dentist?	4	(27%)	9	(64%)
What was the reason of your last visit to the dentist?	7	(47%)	7	(50%)
• Routine checkup	6	(43%)	3	(25%)
• Tretament follow-up	5	(37%)	8	(64%)
Because of the state of your teeth or mouth, how often have you experienced any of the following problems during the past 12 months?				
• Difficulty in biting food	9	(60%)	10	(71%)
• Difficulty chewing food	8	(53%)	11	(79%)
• Difficulty with speech/trouble pronouncing words	13	(87%)	14	(100%)
• Dry mouth	11	(73%)	11	(79%)
• Felt embarrassed due to appearance of teeth	10	(67%)	12	(86%)
• Felt tense because of problems with teeth or mouth	10	(67%)	13	(93%)
• Have avoided smiling because of teeth	9	(60%)	13	(93%)
• Had sleep that is often interrupted	9	(60%)	11	(79%)
• Have taken days off work	13	(87%)	13	(93%)
• Difficulty doing usual activities	13	(87%)	14	(100%)
• Felt less tolerant of spouse or people who are close to you	11	(0%)	13	(93%)
• Have reduced participation in social activities	10	(67%)	13	(93%)
• Other	6	(40%)	8	(57%)
Are you taking sugary foods?	7	(47%)	7	(47%)
How often do you use any of the following tobacco products?				
• Cigarettes	12	(80%)	10	(71%)
• Cigars	14	(93%)	12	(86%)
• Pipe	14	(93%)	12	(86%)
• Chewing tobacco	15	(100%)	13	(93%)

• Snuff	15	(100%)	13	(93%)
During the past 30 days, on the days have you taken alcohol?	8	(53%)	10	(71%)
Are you afraid of dental treatment?	11	(73%)	11	(79%)

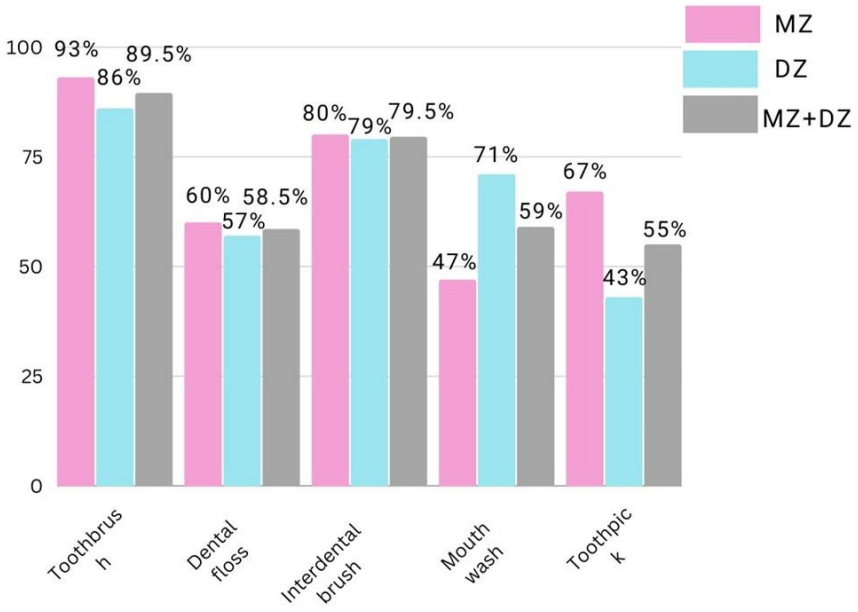


Figure 9. Percentage distribution of oral hygiene device use among monozygotic (MZ) and dizygotic (DZ) twins, including cumulative data (MZ+DZ) [6].

Most participants reported brushing their teeth at least twice daily, and concordant responses regarding toothbrushing frequency were observed in 80.0% of MZ twins and 71.0% of DZ twins. Approximately 70.0% of participants reported having previously received oral hygiene instruction or oral health education. Similar responses regarding oral health education were provided by 67.0% of MZ twins and 64.0% of DZ twins.

When participants were asked about fluoride-containing toothpaste, 58.6% of MZ twins confirmed regular use, whereas 20.7% were uncertain whether their toothpaste contained fluoride [6].

Almost half of the participants (48.3%) had attended a dental appointment within the previous six months (MZ: 27.0%; DZ: 64.0%; $P > .05$), while only a small minority (3.4%) reported not visiting a dentist for five years or longer. The most common reasons for the last dental visit were routine dental examination or preventive treatment (MZ: 43.3%; DZ: 25.0%) and follow-up treatment (MZ: 36.7%; DZ: 64.3%) (Table 1) [6].

Most participants (87.9%) retained at least 20 natural teeth, whereas only 1.7% were edentulous. Approximately half of MZ twins and nearly three-quarters (71.0%) of DZ

twins reported not wearing dentures. Removable prosthodontic appliances were present in 8.5% of participants, while fixed prosthodontic restorations were reported in 17.2% of cases [6].

Based on subjective self-assessment, approximately 40.0% of both MZ and DZ twins considered the condition of their teeth and gingiva to be good or excellent, whereas 10.3% rated their oral health as poor or very poor. Most participants indicated that oral health problems did not substantially interfere with their routine daily activities (Table 1). Nevertheless, more than half of the participants reported difficulties related to biting and chewing food [6].

Additional commonly reported complaints included speech difficulties, xerostomia, embarrassment related to dental appearance, emotional distress associated with oral problems and sleep disturbances caused by dental conditions (Table 1) [6].

Regarding dietary habits, approximately half of both MZ and DZ twins reported regular consumption of sugary foods and beverages, most commonly sugar-sweetened tea, sweet pastries and jams [6].

In the final section of the questionnaire, adverse lifestyle-related habits were also evaluated. Approximately half of all respondents reported alcohol consumption within the previous 30 days (MZ: 53.0%; DZ: 71.0%). Most participants reported no tobacco use; however, cigarette smoking and the use of other tobacco products were observed in a subset of both MZ and DZ twins [6].

In summary, no statistically significant differences were identified between MZ and DZ twins regarding the evaluated oral hygiene habits, oral health-related behaviours or subjective oral health parameters, despite the presence of minor variations between the groups (Table 1) [6].

4.2. Oral health behaviour and self-reported oral status in adults with diabetes mellitus

A total of 99 patients with DM (24 men, 75 women) and 102 controls (28 men, 74 women) were included. The mean age was higher in the DM group (53.5 vs. 47.8 years). Approximately one-third of patients had T1DM, while the majority had T2DM. Most participants had a college or university degree. Regarding DM management, oral antidiabetic medication or insulin therapy was most common, and 21.2% of patients used

continuous glucose monitoring (CGM). The mean HbA1c level was 6.75% (median: 6.8%) [59].

Self-reported oral health was less favourable among individuals with DM, who more frequently rated their teeth and gums as poor. One-third of participants with DM had visited a dentist within the previous six months, slightly fewer than in the control group. The most common reasons for dental visits were treatment, follow-up care, and routine check-ups. The prevalence and type of dental prostheses were similar between groups, with fixed prostheses being the most common. Complete edentulism was typically managed with removable dentures. More than half of the participants reported no fear of dental procedures (Table 2a) [59].

Within the DM group, twice as many participants had T2DM compared to T1DM, and the T2DM group was older. Median HbA1c values were similar between groups (T1DM: 6.7%; T2DM: 6.8%). CGM use was markedly more frequent among patients with T1DM (60.6%), while its use was minimal in T2DM. A higher proportion of T1DM patients had no dentures (78.8%), suggesting better preservation of dentition. In contrast, individuals with T2DM more frequently rated their oral health as average. No significant differences were observed between DM types regarding dental attendance or fear of dental procedures (Table 2b) [59].

Table 2. Demographic characteristics and oral health-related variables in adults with diabetes mellitus and healthy controls [59]

	Table 1a			Table 1b		
	Control (N=102)	DM (N=99)	Overall (N=201)	T1DM (N=33)	T2DM (N=66)	Overall (N=99)
Sex						
Female	74 (72.5%)	75 (75.8%)	149 (74.1%)	25 (75.8%)	50 (75.8%)	75 (75.8%)
Male	28 (27.5%)	23 (23.2%)	51 (25.4%)	8 (24.2%)	15 (22.7%)	23 (23.2%)
Missing data	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Age [years]						
Mean (SD)	47.8 (17.2)	53.5 (18.1)	50.6 (17.8)	38.8 (16.3)	60.8 (14.1)	53.5 (18.1)
Median (IQR)	47.5 (35.3)	54.0 (26.0)	51.0 (31.0)	38.0 (24.0)	66.0 (18.8)	54.0 (26.0)
Min, Max	21.0, 80.0	18.0, 81.0	18.0, 81.0	18.0, 69.0	20.0, 81.0	18.0, 81.0
Residence						
City	90 (88.2%)	76 (76.8%)	166 (82.6%)	26 (78.8%)	50 (75.8%)	76 (76.8%)
Countryside	9 (8.8%)	14 (14.1%)	23 (11.4%)	4 (12.1%)	10 (15.2%)	14 (14.1%)
Suburb	3 (2.9%)	9 (9.1%)	12 (6.0%)	3 (9.1%)	6 (9.1%)	9 (9.1%)
Education						
Less than primary school	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Primary school completed	4 (3.9%)	5 (5.1%)	9 (4.5%)	4 (12.1%)	1 (1.5%)	5 (5.1%)
Secondary/High school completed	31 (30.4%)	38 (38.4%)	69 (34.3%)	9 (27.3%)	29 (43.9%)	38 (38.4%)
Vocational school completed	16 (15.7%)	15 (15.2%)	31 (15.4%)	4 (12.1%)	11 (16.7%)	15 (15.2%)
College/university completed	48 (47.1%)	39 (39.4%)	87 (43.3%)	15 (45.5%)	24 (36.4%)	39 (39.4%)
Postgraduate degree	3 (2.9%)	1 (1.0%)	4 (2.0%)	0 (0%)	1 (1.5%)	1 (1.0%)
Diabetes mellitus						
T1DM	0 (0%)	33 (33.3%)	33 (16.4%)	33 (100%)	0 (0%)	33 (33.3%)
T2DM	0 (0%)	66 (66.7%)	66 (32.8%)	0 (0%)	66 (100%)	66 (66.7%)
Missing data	102 (100%)	0 (0%)	102 (50.7%)			
HbA1c level [%]						
Mean (SD)	NA	6.75 (1.14)	6.75 (1.14)	6.64 (0.734)	6.80 (1.29)	6.75 (1.14)
Median (IQR)	NA	6.80 (1.13)	6.80 (1.13)	6.70 (1.10)	6.80 (1.20)	6.80 (1.13)
Min, Max	NA	4.80, 14.0	4.80, 14.0	5.10, 8.00	4.80, 14.0	4.80, 14.0
Missing data	102 (100%)	0 (0%)	102 (50.7%)			
Therapy						
Both	0 (0%)	11 (11.1%)	11 (5.5%)	2 (6.1%)	9 (13.6%)	11 (11.1%)
Insulin	0 (0%)	37 (37.4%)	37 (18.4%)	28 (84.8%)	9 (13.6%)	37 (37.4%)
Nothing	0 (0%)	2 (2.0%)	2 (1.0%)	0 (0%)	2 (3.0%)	2 (2.0%)
Tablet	0 (0%)	46 (46.5%)	46 (22.9%)	3 (9.1%)	43 (65.2%)	46 (46.5%)
Missing data	102 (100%)	3 (3.0%)	105 (52.2%)	0 (0%)	3 (4.5%)	3 (3.0%)
Sensor						
No	0 (0%)	78 (78.8%)	78 (38.8%)	13 (39.4%)	65 (98.5%)	78 (78.8%)
Yes	0 (0%)	21 (21.2%)	21 (10.4%)	20 (60.6%)	1 (1.5%)	21 (21.2%)
Missing data	102 (100%)	0 (0%)	102 (50.7%)			
Complaint						
Yes	10 (9.8%)	18 (18.2%)	28 (13.9%)	22 (66.7%)	28 (42.4%)	50 (50.5%)
No	19 (18.6%)	23 (23.2%)	42 (20.9%)	11 (33.3%)	33 (50.0%)	44 (44.4%)
Don't know	72 (70.6%)	54 (54.5%)	126 (62.7%)	0 (0%)	5 (7.6%)	5 (5.1%)
Removable						
Lower and upper complete dentures	1 (1.0%)	5 (5.1%)	6 (3.0%)	0 (0%)	5 (7.6%)	5 (5.1%)
Lower and upper complete dentures, Fixed dentures	0 (0%)	1 (1.0%)	1 (0.5%)			
Lower complete dentures	3 (2.9%)	0 (0%)	3 (1.5%)	0 (0%)	0 (0%)	0 (0%)
Lower complete dentures, Fixed dentures	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Upper complete dentures	2 (2.0%)	5 (5.1%)	7 (3.5%)	2 (6.1%)	3 (4.5%)	5 (5.1%)
Upper complete dentures, Fixed dentures	1 (1.0%)	3 (3.0%)	4 (2.0%)	0 (0%)	3 (4.5%)	3 (3.0%)
I don't wear any dentures	57 (55.9%)	52 (52.5%)	109 (54.2%)	26 (78.8%)	26 (39.4%)	52 (52.5%)
Partial dentures	6 (5.9%)	12 (12.1%)	18 (9.0%)	3 (9.1%)	9 (13.6%)	12 (12.1%)
Fixed dentures	32 (31.4%)	20 (20.2%)	52 (25.9%)	2 (6.1%)	18 (27.3%)	20 (20.2%)
Condition teeth						
Average	29 (28.4%)	28 (28.3%)	57 (28.4%)	6 (18.2%)	22 (33.3%)	28 (28.3%)
Good	36 (35.3%)	24 (24.2%)	60 (29.9%)	11 (33.3%)	13 (19.7%)	24 (24.2%)
Excellent	6 (5.9%)	3 (3.0%)	9 (4.5%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Very good	15 (14.7%)	9 (9.1%)	24 (11.9%)	3 (9.1%)	6 (9.1%)	9 (9.1%)
Very poor	3 (2.9%)	12 (12.1%)	15 (7.5%)	5 (15.2%)	7 (10.6%)	12 (12.1%)
Don't know	1 (1.0%)	4 (4.0%)	5 (2.5%)	1 (3.0%)	3 (4.5%)	4 (4.0%)
Poor	12 (11.8%)	19 (19.2%)	31 (15.4%)	5 (15.2%)	14 (21.2%)	19 (19.2%)
Condition gum						
Average	23 (22.5%)	30 (30.3%)	53 (26.4%)	5 (15.2%)	25 (37.9%)	30 (30.3%)
Good	35 (34.3%)	23 (23.2%)	58 (28.9%)	10 (30.3%)	13 (19.7%)	23 (23.2%)
Excellent	15 (14.7%)	4 (4.0%)	19 (9.5%)	2 (6.1%)	2 (3.0%)	4 (4.0%)
Very good	10 (9.8%)	10 (10.1%)	20 (10.0%)	5 (15.2%)	5 (7.6%)	10 (10.1%)
Very poor	4 (3.9%)	11 (11.1%)	15 (7.5%)	5 (15.2%)	6 (9.1%)	11 (11.1%)
Don't know	1 (1.0%)	4 (4.0%)	5 (2.5%)	1 (3.0%)	3 (4.5%)	4 (4.0%)
Poor	14 (13.7%)	17 (17.2%)	31 (15.4%)	5 (15.2%)	12 (18.2%)	17 (17.2%)
Last visit						
2 years or more but less than 5 years	9 (8.8%)	15 (15.2%)	24 (11.9%)	5 (15.2%)	10 (15.2%)	15 (15.2%)
5 years or more	5 (4.9%)	10 (10.1%)	15 (7.5%)	2 (6.1%)	8 (12.1%)	10 (10.1%)
6-12 months	32 (31.4%)	21 (21.2%)	53 (26.4%)	9 (27.3%)	12 (18.2%)	21 (21.2%)
Less than 6 months	41 (40.2%)	35 (35.4%)	76 (37.8%)	9 (27.3%)	26 (39.4%)	35 (35.4%)
More than 1 year but less than 2 years	15 (14.7%)	18 (18.2%)	33 (16.4%)	8 (24.2%)	10 (15.2%)	18 (18.2%)
Last visit reason						
Pain or trouble with teeth, gums or mouth	21 (20.6%)	28 (28.3%)	49 (24.4%)	10 (30.3%)	18 (27.3%)	28 (28.3%)
Treatment/ follow-up treatment	40 (39.2%)	32 (32.3%)	72 (35.8%)	8 (24.2%)	24 (36.4%)	32 (32.3%)
Consultation/advise	7 (6.9%)	10 (10.1%)	17 (8.5%)	3 (9.1%)	7 (10.6%)	10 (10.1%)
Don't know/don't remember	0 (0%)	3 (3.0%)	3 (1.5%)	1 (3.0%)	2 (3.0%)	3 (3.0%)
Routine check-up/treatment	34 (33.3%)	26 (26.3%)	60 (29.9%)	11 (33.3%)	15 (22.7%)	26 (26.3%)
Fear dentist						
Yes	42 (41.2%)	44 (44.4%)	86 (42.8%)	17 (51.5%)	27 (40.9%)	44 (44.4%)
No	60 (58.8%)	55 (55.6%)	115 (57.2%)	16 (48.5%)	39 (59.1%)	55 (55.6%)

By DM (only DM patients)

Overall, 69.2% of participants reported brushing their teeth at least twice daily, while 30.8% brushed once or less. Dental floss was the most commonly used interdental cleaning aid. Among PwDMs, 50.5% used only a toothbrush and 17.2% also used floss, compared to 29.4% floss use in controls. Awareness of fluoride was lower among participants with DM, with 19.2% unsure whether their toothpaste contained fluoride, whereas 80.4% of controls reported actively choosing fluoride-containing products (Table 3a) [59].

When comparing DM types, 71.2% of T2DM patients reported brushing at least twice daily, compared to 45.5% of T1DM patients. The use of oral hygiene products and fluoride toothpaste was otherwise similar between the groups (Table 3b) [59].

Despite relatively frequent toothbrushing, individuals with DM had fewer natural teeth than controls (Figure 10). However, the proportion of participants with at least 20 teeth did not differ significantly (54.5% vs. 70.6%) (Table 3c) [59].

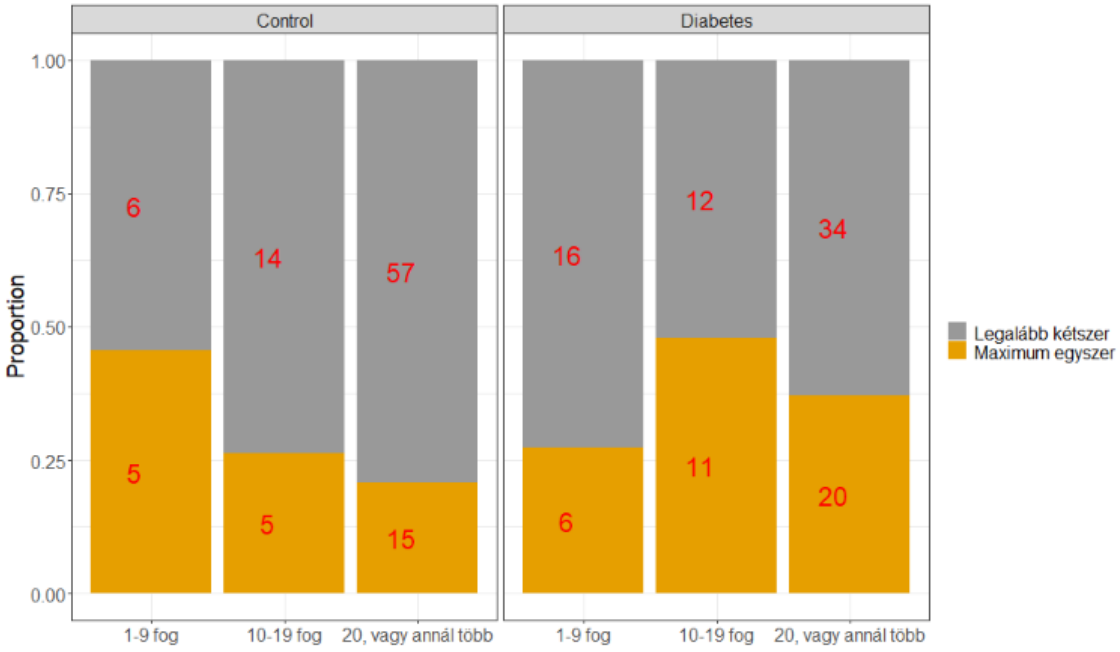


Figure 10. Distribution of toothbrushing frequency and natural tooth count among participants with diabetes mellitus and healthy controls.

No significant association was found between HbA1c levels and the number of teeth after adjusting for age and sex, and neither variable significantly influenced HbA1c variation (Table 3d). The relationship between HbA1c and prosthesis use was not evaluated [59].

Table 3. Distribution of oral hygiene practices and habits in adults with diabetes mellitus and controls [59]

	Table 3a			Table 3b		
	Control (N=102)	DM (N=99)	Overall (N=201)	T1DM (N=33)	T2DM (N=66)	Overall (N=99)
Frequency teeth clean						
2-3 times a week	2 (2.0%)	3 (3.0%)	5 (2.5%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Once a month	0 (0%)	3 (3.0%)	3 (1.5%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Once a week	1 (1.0%)	3 (3.0%)	4 (2.0%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Twice or more a day	77 (75.5%)	62 (62.6%)	139 (69.2%)	15 (45.5%)	47 (71.2%)	62 (62.6%)
Once a day	22 (21.6%)	27 (27.3%)	49 (24.4%)	12 (36.4%)	15 (22.7%)	27 (27.3%)
Never	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Frequency teeth clean						
At least twice a day	77 (75.5%)	62 (62.6%)	139 (69.2%)	15 (45.5%)	47 (71.2%)	62 (62.6%)
Maximum once a day	25 (24.5%)	37 (37.4%)	62 (30.8%)	18 (54.5%)	19 (28.8%)	37 (37.4%)
Tools						
Other	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush	31 (30.4%)	50 (50.5%)	81 (40.3%)	17 (51.5%)	33 (50.0%)	50 (50.5%)
Toothbrush, Charcoal	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Toothbrush, Other	10 (9.8%)	5 (5.1%)	15 (7.5%)	1 (3.0%)	4 (6.1%)	5 (5.1%)
Toothbrush, Wooden toothpicks	6 (5.9%)	6 (6.1%)	12 (6.0%)	3 (9.1%)	3 (4.5%)	6 (6.1%)
Toothbrush, Wooden toothpicks, Charcoal	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Toothbrush, Wooden toothpicks, Other	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Toothbrush, Wooden toothpicks, Dentalfloss	7 (6.9%)	2 (2.0%)	9 (4.5%)	1 (3.0%)	1 (1.5%)	2 (2.0%)
Toothbrush, Wooden toothpicks, Dentalfloss, Other	1 (1.0%)	2 (2.0%)	3 (1.5%)	0 (0%)	2 (3.0%)	2 (2.0%)
Toothbrush, Wooden toothpicks, Plastic toothpicks	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush, Wooden toothpicks, Plastic toothpicks, Other	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush, Wooden toothpicks, Plastic toothpicks, Dentalfloss, Charcoal	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush, Wooden toothpicks, Chewstick/miswak	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush, Dentalfloss	30 (29.4%)	17 (17.2%)	47 (23.4%)	6 (18.2%)	11 (16.7%)	17 (17.2%)
Toothbrush, Dentalfloss, Charcoal	2 (2.0%)	0 (0%)	2 (1.0%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush, Dentalfloss, Other	9 (8.8%)	3 (3.0%)	12 (6.0%)	0 (0%)	3 (4.5%)	3 (3.0%)
Toothbrush, Plastic toothpicks	0 (0%)	2 (2.0%)	2 (1.0%)	0 (0%)	2 (3.0%)	2 (2.0%)
Toothbrush, Plastic toothpicks, Dentalfloss	2 (2.0%)	4 (4.0%)	6 (3.0%)	2 (6.1%)	2 (3.0%)	4 (4.0%)
Toothbrush, Plastic toothpicks, Dentalfloss, Charcoal	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush, Chewstick/miswak	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Dentalfloss	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Missing data	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush						
Toothbrush	101 (99.0%)	98 (99.0%)	199 (99.0%)	33 (100%)	65 (98.5%)	98 (99.0%)
None	1 (1.0%)	1 (1.0%)	2 (1.0%)	0 (0%)	1 (1.5%)	1 (1.0%)
Dentalfloss						
Dentalfloss	52 (51.0%)	21 (21.2%)	73 (36.3%)	0 (0%)	21 (31.8%)	21 (21.2%)
None	50 (49.0%)	78 (78.8%)	128 (63.7%)	33 (100%)	45 (68.2%)	78 (78.8%)
Other						
Yes	22 (21.6%)	20 (20.2%)	42 (20.9%)	0 (0%)	20 (30.3%)	20 (20.2%)
None	80 (78.4%)	79 (79.8%)	159 (79.1%)	33 (100%)	46 (69.7%)	79 (79.8%)
Toothpaste						
Yes	102 (100%)	96 (97.0%)	198 (98.5%)	33 (100%)	63 (95.5%)	96 (97.0%)
No	0 (0%)	3 (3.0%)	3 (1.5%)	0 (0%)	3 (4.5%)	3 (3.0%)
Fluoride						
Yes	82 (80.4%)	66 (66.7%)	148 (73.6%)	23 (69.7%)	43 (65.2%)	66 (66.7%)
No	11 (10.8%)	14 (14.1%)	25 (12.4%)	5 (15.2%)	9 (13.6%)	14 (14.1%)
Don't know	9 (8.8%)	19 (19.2%)	28 (13.9%)	5 (15.2%)	14 (21.2%)	19 (19.2%)

	By diabetes (only diabetic patients)		
Table 3c	**At least twice a day (N=139)**	**Maximum once a day (N=62)**	**Overall (N=201)**
Teeth			
1-9 teeth	22 (15.8%)	11 (17.7%)	33 (16.4%)
10-19 teeth	26 (18.7%)	16 (25.8%)	42 (20.9%)
20 teeth or more	91 (65.5%)	35 (56.5%)	126 (62.7%)

Table 3d	**1-9 teeth (N=22)**	**10-19 teeth (N=23)**	**20 teeth or more (N=54)**	**Overall (N=99)**
HbA1c level [%]				
Mean (SD)	6.81 (0.950)	7.06 (1.72)	6.59 (0.858)	6.75 (1.14)
Median (IQR)	6.90 (1.05)	6.80 (1.44)	6.59 (1.18)	6.80 (1.13)
Min, Max	4.80, 9.10	5.40, 14.0	4.80, 8.10	4.80, 14.0

Logistic regression analysis was used to assess the impact of dietary habits and interdental cleaning on dental status. Higher fruit consumption was associated with increased odds of having fewer teeth (OR ≈ 3.8 for 1–9 vs. 10–19 teeth), independent of age, sex, and oral hygiene behaviours (Table 4a–c). Similar trends were observed when comparing

lower and higher tooth categories. Although some associations did not reach statistical significance, the observed tendencies suggest potential clinical relevance (Table 3) [59].

Table 4. Impact of dietary habits and interdental cleaning on dental status across different tooth count categories based on logistic regression analysis [59]

	Table 4/a			Table 4/b			Table 4/c		
Characteristic	**OR***	**95% CI****	**p-value**	**OR***	**95% CI****	**p-value**	**OR***	**95% CI****	**p-value**
Frequency teeth clean			0.74			0.31			0.19
At least twice a day	—	—		—	—		—	—	
Maximum once a day	0.82	0.25, 2.63		1.81	0.58, 5.80		1.88	0.73, 4.93	
Sex			0.59			0.16			0.89
Female	—	—		—	—		—	—	
Male	0.69	0.17, 2.61		0.40	0.10, 1.43		01.07	0.38, 2.96	
Age [years]	01.02	0.98, 1.06	0.39	1.10	1.06, 1.15	**<0.001**	01.09	1.06, 1.13	**<0.001**
Dentalfloss			0.52			**0.050**			0.48
Dentalfloss	—	—		—	—		—	—	
None	1.47	0.45, 4.97		2.94	1.00, 9.44		1.39	0.56, 3.55	
Fruits eating			**0.020**			**0.023**			0.41
Less	—	—		—	—		—	—	
More	3.81	1.23, 13.4		3.82	1.19, 14.2		0.68	0.27, 1.69	
Eating too much			0.25			0.84			0.36
No	—	—		—	—		—	—	
Yes	1.86	0.65, 5.49		1.11	0.40, 3.12		0.67	0.28, 1.57	
Group			0.31			0.27			0.88
Control	—	—		—	—		—	—	
Diabetes mellitus	1.72	0.60, 5.09		1.77	0.64, 5.06		0.94	0.39, 2.20	

** OR = Odds Ratio*
*** CI = Confidence Interval*

Figure 11 presents the predicted probability of having 1–9 natural teeth according to age, flossing habits, and fruit consumption. Although several associations were not statistically significant, the observed trends may still indicate clinically relevant patterns and should be interpreted in light of the pilot design and limited sample size [59].

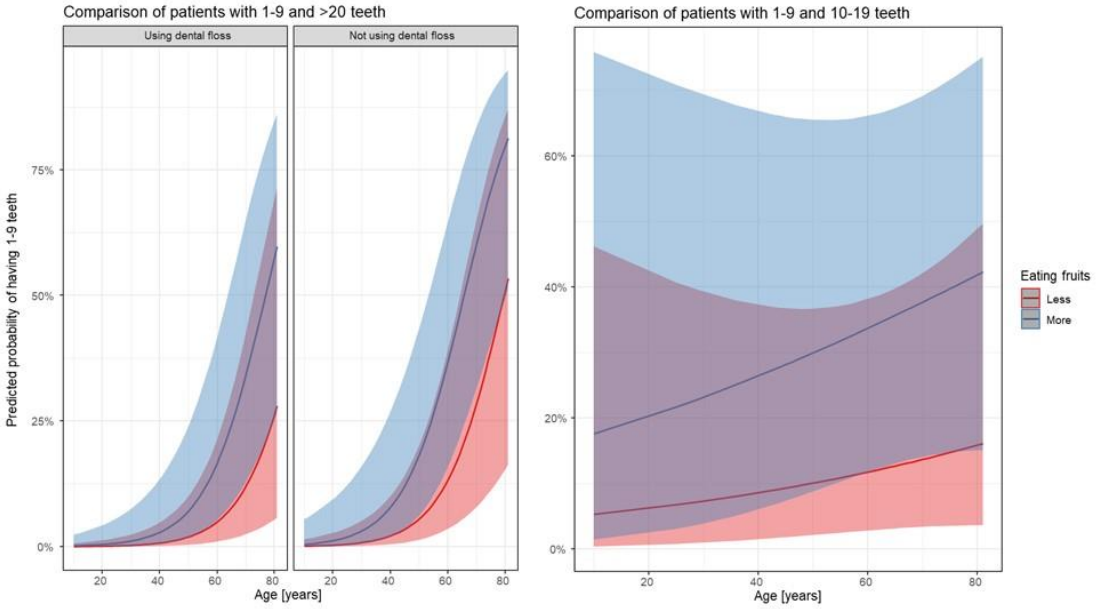


Figure 11. Model-based prediction of tooth retention in relation to age, interdental cleaning, and fruit consumption [59]

4.3. Clinical observations related to diabetes-associated neuropathy

Clinical To illustrate the potential oral manifestations of diabetes-related neuropathy, a previously documented clinical case is presented, supported by relevant findings from the literature. Although this case was not included in the quantitative analyses, it provides important contextual information regarding the oral consequences of systemic diabetic complications and contributes to the interpretation of the radiographic and clinical findings [64].

The patient exhibited signs of sensory dysfunction, including altered pain perception and reduced oral sensitivity. Such alterations may contribute to delayed symptom recognition, impaired oral hygiene, and the progression of oral diseases [64].

Sensory neuropathy was objectively assessed using a Neurometer diagnostic device by determining current perception thresholds in all four extremities. Elevated threshold values, indicative of hypoesthesia, were detected in the large and small myelinated fibres of the left upper limb, as well as in all examined sensory fibre types of the right upper limb and both lower extremities. The most severe degree of sensory nerve impairment was observed in the lower limbs (Table 5) [64].

Table 5. Current perception threshold (CPT) values measured in the patient using the Neurometer device [64].

Assessment of sensory function using the Neurometer						
Current Perception Thresholds (CPTs) (mA)						
Median nerve				Peroneal nerve		
Left	Reference range	Right		Left	Reference range	Right
6,5	1,2-3,98	6	2000 Hz	9,99	1,79-5,23	9,99
2,8	0,22-1,89	2,58	250 Hz	9,99	0,44-2,08	9,99
0,6	0,16-1,01	1,65	5 Hz	9,99	0,18-1,70	9,99

This case highlights that diabetes-related neuropathy may affect not only peripheral nerve function but also oral sensory perception and oral health. Therefore, early recognition and appropriate management of neuropathic sensory disturbances may play an important role in preventing oral complications and improving patients' quality of life [64].

5. Discussion

5.1. Oral health behaviour in monozygotic and dizygotic twins (twin-study)

To the best of our knowledge, this study is the first to compare oral hygiene habits and oral health-related behaviour between MZ and DZ twins in a Hungarian population. Overall, no statistically significant differences were identified between the two groups regarding the evaluated oral hygiene parameters, thereby supporting our null hypothesis. Participants included in the questionnaire-based survey were recruited from the Hungarian Twin Registry (HTR) and predominantly resided in Budapest and its surrounding urban or suburban regions. In line with previous reports, residential background did not appear to substantially influence oral hygiene practices or patterns of dental attendance [70-72]. A considerable proportion of the study population had completed secondary or higher education, which may reflect the predominantly urban origin of the cohort [6].

The present findings demonstrated no significant differences between MZ and DZ twins regarding the use of oral hygiene devices. Toothpaste and toothbrushes were routinely used by nearly all participants, with manual toothbrushes representing the most frequently applied oral hygiene tools. More than half of the participants reported regular use of dental floss. Previous studies demonstrated that flossing may contribute to the reduction of interproximal plaque accumulation and may decrease the risk of periodontal diseases and approximal caries formation [73-75] [6].

Although electric toothbrushes have been shown to provide superior plaque control and gingival health outcomes in both short- and long-term evaluations [76], manual toothbrushes remained the preferred option in the present cohort. Previous twin studies have suggested a considerable genetic contribution to caries susceptibility [77]. Although caries prevalence was not directly evaluated in the present questionnaire survey, only approximately half of the participants reported using fluoride-containing toothpaste, despite the well-established preventive effect of fluoride against dental caries. In addition, dental attendance patterns were not entirely favourable, as only approximately half of the participants had attended a dental examination within the previous six months. These findings may indicate the need for further oral health education and preventive programmes emphasizing the importance of regular dental visits [6].

Regarding oral function and oral health-related quality of life, most participants did not report major difficulties associated with speech, mastication or xerostomia [78]. Furthermore, almost half of the study population reported regular fruit consumption, while only a minority preferred diets rich in sugary foods. This observation may be clinically relevant, as frequent sugar consumption is considered a major risk factor for dental caries development [79, 80] [6].

Despite the widely recognized harmful effects of tobacco products on general and oral health [81], cigarette smoking and the use of other tobacco products were reported in both MZ and DZ twins. These findings may reflect insufficient public awareness or limited effectiveness of preventive educational programmes targeting tobacco use [6].

Another important observation was that a substantial proportion of participants expressed fear or anxiety related to dental treatment. This finding highlights the importance of improving patient comfort during dental care and further emphasizes the need for educational programmes aimed at reducing dental anxiety and increasing awareness regarding modern, minimally painful dental treatment options [6].

Certain limitations of the present pilot study should also be acknowledged. The study relied primarily on self-reported questionnaire data, including subjective assessment of oral health and general well-being. Furthermore, the limited number of participants may reduce the extent to which these findings can be generalized to a broader population. Consequently, larger-scale studies involving broader twin populations are required to confirm or refute the observations reported in the present investigation [6].

In conclusion, the present study provides novel data regarding oral hygiene habits, oral health-related behaviour and subjective oral health characteristics among MZ and DZ twins in Hungary. Within the examined twin population, variability in attention to oral care and preventive behaviour was observed; however, the overall level of oral health awareness and oral hygiene practices appeared to be comparable between MZ and DZ twins. Further studies involving larger cohorts are warranted to validate these findings [6].

5.2. Oral health behaviour and oral health status in adults with diabetes mellitus (Diabetes-study)

The present findings are consistent with previous reports demonstrating increased tooth loss among PwDM [49]. At the same time, the relatively low frequency of interdental cleaning observed in the Hungarian cohort may reflect regional differences in oral hygiene behaviour [82]. The study further demonstrated significant differences in oral hygiene habits, self-reported dental status and oral health-related outcomes between individuals with and without DM, emphasizing the importance of oral health education as part of comprehensive DM care [59].

Although the frequency of toothbrushing was comparable between DM and control participants, individuals with DM tended to retain fewer natural teeth. This observation is in agreement with previous studies reporting an increased risk of tooth loss associated with chronic periodontal inflammation in PwDM [83, 84]. The bidirectional relationship between dysglycaemia and oral health is well established, as persistent hyperglycaemia negatively affects periodontal tissues, while chronic oral inflammation may further impair metabolic control [34, 45] [59].

Current recommendations of the American Diabetes Association (ADA) and the International Diabetes Federation (IDF) emphasize maintaining HbA1c levels below 7–8% to reduce DM-related complications [85]. In parallel, professional dental organizations, including the American Academy of Periodontology (AAP) and the European Federation of Periodontology (EFP), recommend regular dental examinations and glycaemic monitoring in PwDM to minimize oral complications such as impaired wound healing, peri-implant disease and increased susceptibility to infections [33] [59].

Differences between DM types were also observed. Patients with T1DM more frequently used continuous glucose monitoring systems and generally reported more favourable oral health conditions than patients with T2DM. In contrast, T2DM patients more commonly described their dental and gingival condition as average, which may partly reflect the cumulative effects of ageing and longer disease duration [86] [59].

Interdental cleaning habits were less favourable among PwDM, as dental floss use was reported less frequently compared to controls. Regression analyses additionally suggested that increased sugary food consumption and inadequate interdental cleaning were associated with a higher risk of severe tooth loss, independent of DM status [5]. These

findings further support the importance of integrating preventive dental care and oral health education into DM management programs [59].

Certain limitations should also be acknowledged. The study was largely based on questionnaire responses provided by the participants themselves, which may be subject to recall bias and subjective interpretation. Therefore, future investigations should incorporate objective clinical oral examinations and periodontal assessments to validate the present findings [59].

Overall, the present study highlights the importance of multidisciplinary DM care and emphasizes the need for closer cooperation between diabetologists and dental professionals in order to improve oral health outcomes in PwDM [59].

5.3. Clinical relevance of diabetes-associated neuropathy in dental practice

Although the microvascular and macrovascular complications of DM are well established, oral complications still receive comparatively limited attention in routine DM care [87] [64].

The relationship between DM and oral disease is multifactorial. Hyperglycaemia, chronic low-grade inflammation, altered immune responses, and shared risk factors, including hypertension, hyperlipidaemia, smoking, obesity, alcohol consumption, advanced age, and socioeconomic factors, may all contribute to the coexistence of DM, neuropathy, and periodontal disease [25] [87] [64].

Hyposalivation may also play an important role, potentially developing as a consequence of diabetic autonomic neuropathy affecting salivary gland innervation. Reduced salivary secretion impairs protective oral mechanisms and may promote the development of caries and periodontal disease [25]. Previous studies have reported increased frequencies of xerostomia and hyposalivation in patients with diabetic neuropathy [88] [87] [64].

The presented clinical case further supports the potential contribution of neuropathy to oral disease progression. Despite extensive carious destruction and severe periodontal involvement, the patient reported minimal symptoms, suggesting possible DM-associated sensory impairment affecting the orofacial region. Such findings may correspond to the "negative" manifestations of diabetic polyneuropathy, characterised by reduced physiological sensation [87] [64].

Although causal conclusions cannot be drawn from a single case, previous studies have also demonstrated associations between periodontal disease severity, diabetic neuropathy, and diabetic foot syndrome [55, 56]. These observations underline the importance of regular dental screening and preventive oral care in patients with DM, as neuropathy-related sensory dysfunction may delay recognition of oral pathology and treatment-seeking behaviour [87] [64].

5.4. Strengths and limitations

5.4.1. Strengths and limitations in the twin-study

As a pilot study, the present investigation has several strengths despite its exploratory nature. To the best of our knowledge, this is the first study conducted in Hungary comparing oral health knowledge, oral hygiene practices, and oral health-related behaviours between MZ and DZ twins. Participants were recruited from the Hungarian Twin Registry, providing access to a well-characterized twin cohort. Furthermore, data collection was based on the World Health Organization (WHO) simplified oral health questionnaire (Annex 7), allowing the assessment of a broad range of oral health-related behaviours using a standardized methodology. An additional strength of the study is the inclusion of both MZ and DZ twin pairs, enabling the investigation of potential similarities and differences between groups with differing degrees of genetic relatedness. Several limitations should also be considered when interpreting the findings. Owing to the pilot nature of the study, the primary objective was not to draw definitive conclusions but rather to provide preliminary insights and generate hypotheses for future research. The limited number of participants may have decreased the statistical power of the analysis and made it more difficult to identify subtle differences between the groups. Furthermore, all data were obtained from participants' self-reported questionnaire responses without clinical oral examinations, which may have introduced bias related to participants' recollection and individual perceptions. Although zygosity was determined using a standardized questionnaire with high reported accuracy, genetic confirmation was not available. Furthermore, the cross-sectional design precludes causal inference. Most participants were recruited from Budapest and its surrounding urban areas, which may limit the generalizability of the findings to the wider Hungarian population. Finally, information on potentially relevant confounding factors, such as detailed socioeconomic status, dietary habits, and access to dental care, was limited.

Despite these limitations, the study provides valuable preliminary data regarding oral health-related behaviours among MZ and DZ twins and may serve as a foundation for future investigations involving larger cohorts, objective clinical assessments, and longitudinal follow-up.

5.4.2. Strenghts and limitations in the diabetes-study

As a pilot study, the present investigation has several important strengths despite its exploratory nature. The study included both individuals with DM and a control group without DM, allowing direct comparisons of oral health-related knowledge, behaviours, and self-reported oral health outcomes. In addition, patients with T1DM and T2DM were evaluated separately, providing further insight into potential differences between these populations. Data collection was based on a modified version of the World Health Organization (WHO) Oral Health Questionnaire for Adults (ANNEX 7), ensuring the use of a standardized and internationally recognized framework for oral health surveillance. Furthermore, the analysis combined descriptive and regression-based statistical approaches, enabling the assessment of potential associations between oral hygiene practices, dietary habits, DM status, and dental outcomes while accounting for relevant demographic variables [59].

The findings should be interpreted in light of several methodological limitations. Owing to the pilot nature of the study, the primary objective was not to draw definitive conclusions but rather to provide preliminary insights and generate hypotheses for future research. The limited number of participants may have reduced the statistical power of the analysis and made it more difficult to identify weaker associations. The study relied primarily on self-reported questionnaire data, which may not fully reflect actual clinical oral health status and are inherently susceptible to recall bias and subjective interpretation. Furthermore, the cross-sectional nature of the study does not allow conclusions to be drawn regarding causal relationships. Participants were recruited through diabetology outpatient clinics and DM-related online communities, which may have introduced selection bias and may limit the generalizability of the findings to the broader DM population. Although regression analyses were adjusted for key demographic and behavioural variables, residual confounding by unmeasured factors cannot be excluded. Finally, objective clinical oral examinations and periodontal assessments were not

performed; therefore, future studies should combine questionnaire-based data with clinical evaluations to provide a more comprehensive assessment of oral health outcomes in PwDM [59].

Despite these limitations, the study provides valuable preliminary data on oral health literacy, oral hygiene behaviours, and self-reported oral health status among Hungarian PwDM and may serve as a foundation for future multicentre longitudinal investigations involving larger cohorts and objective clinical assessments [59].

6. Conclusions

6.1. Conclusion of the twin-study

The present pilot study provides novel data on oral health knowledge, oral hygiene practices, and oral health-related behaviours among MZ and DZ twins in Hungary. No statistically significant differences were identified between the two groups across the evaluated oral health parameters, suggesting a broadly similar level of oral health awareness and oral hygiene behaviour among MZ and DZ twins within the investigated cohort.

Although individual variability in oral care habits was observed, the overall patterns of oral hygiene practices and self-reported oral health characteristics were comparable between the two twin groups. Given the exploratory nature of this pilot study and the relatively limited sample size, the findings should be interpreted with appropriate caution. Nevertheless, the results provide a useful foundation for future research and contribute to the currently limited evidence regarding oral health behaviours in twin populations.

Further investigations involving larger and more diverse twin cohorts are warranted to confirm these observations and to better understand the potential influence of genetic and environmental factors on oral health-related behaviours.

6.2. *Conclusion of the diabetes-study*

The present study identified notable differences in self-reported oral health status and oral health-related behaviours between PwDM and controls without DM. PwDM, particularly those with T2DM, generally reported less favourable oral health outcomes, more frequent use of dental prostheses, and a lower number of remaining natural teeth despite broadly similar toothbrushing habits. These findings further support the close relationship between DM and oral health and highlight the importance of integrating oral health promotion into routine DM care [59, 89].

The results emphasize the need for targeted preventive strategies, including comprehensive oral hygiene education, regular dental examinations, and closer collaboration between diabetologists and dental professionals. Annual dental check-ups should be encouraged for all PwDM, while more frequent follow-up may be justified in individuals affected by periodontal disease or other oral complications [59].

The experience of the Semmelweis University Diabetes Dental Working Group further underlines the value of early referral pathways and interdisciplinary care in improving patient management and facilitating the prevention, early recognition, and treatment of DM-related oral complications. From a public health perspective, increasing oral health awareness among individuals with DM may contribute not only to improved oral health outcomes but also to more effective long-term disease management [59].

Given the pilot nature of the study, further investigations involving larger cohorts and longitudinal follow-up are warranted to confirm these findings, clarify the underlying mechanisms linking DM and oral health, and support the development of evidence-based preventive and therapeutic strategies [59].

6.3. Conclusions regarding diabetes-associated neuropathy

This case report highlights the potential association between diabetic neuropathy and severe oral manifestations in patients with poorly controlled diabetes mellitus. The extensive dental and periodontal destruction observed in the absence of significant symptoms suggests that diabetes-related oral hypaesthesia may contribute to delayed recognition of oral diseases and postponed dental care. Although causality cannot be established from a single case, the findings underline the importance of regular dental screening, proper oral hygiene, and close collaboration between diabetologists and dental professionals. Early detection and management of oral conditions may improve both oral health and overall diabetes care.

7. Summary

Oral health is influenced by genetic, environmental, behavioural, and systemic factors. The aim of the present dissertation was to investigate oral hygiene behaviour, oral health-related knowledge, and self-reported oral health status in different populations using standardized questionnaire-based methods, with particular emphasis on twins and individuals living with DM.

The twin study included 58 Hungarian MZ and DZ twins. Using the WHO Oral Health Questionnaire for Adults, oral hygiene practices, oral health-related knowledge, and self-perceived oral health status were assessed. No statistically significant differences were identified either between MZ and DZ twins or between co-twins within individual twin pairs regarding oral hygiene habits, dental attendance patterns, oral health-related knowledge, or self-reported oral health status.

The second part of the dissertation included 99 individuals with DM and 102 controls. Participants with DM generally reported poorer oral health and lower awareness of fluoride-containing toothpaste and tended to have fewer natural teeth than controls. Comparisons between T1DM and T2DM revealed differences in age distribution, CGM use, and certain oral hygiene behaviours. However, no significant association was found between HbA1c levels and the number of remaining natural teeth after adjustment for age and sex.

The dissertation also highlights the potential oral manifestations of diabetes-related neuropathy. Clinical observations and literature data suggest that neuropathy may affect oral sensation, pain perception, and quality of life, emphasizing the importance of recognizing oral symptoms as part of comprehensive DM care.

Overall, the findings underline the importance of oral health promotion, preventive dental care, and interdisciplinary collaboration in chronic disease management. Standardized questionnaires proved useful for assessing oral health behaviour and self-reported oral health status and may support the development of targeted preventive strategies and improved patient care.

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9. Bibliography of the candidate's publications

1.1.Publications related to the thesis

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1.2.Publications not related to the thesis

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Scientific Research Report

Oral Health Knowledge and Habits of Hungarian Monozygotic and Dizygotic Twins: A Pilot Study

Klaudia Liptak [a], *Laura Liptak* [b], *Noemi Katinka Rozsa* [b], *Peter Hermann* [a], *Adam Domonkos Tarnoki* [c], *David Laszlo Tarnoki* [c], *Daniel Vegh* [a*]

[a] *Department of Prosthodontics, Semmelweis University, Budapest, Hungary*
[b] *Department of Paediatric Dentistry and Orthodontics, Semmelweis University, Budapest, Hungary*
[c] *Medical Imaging Centre, Semmelweis University, Budapest, Hungary*

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ABSTRACT

Objective: The aim of this research was to collate and analyse the data on the oral health knowledge and the related habits of a Hungarian cohort of monozygotic (MZ) and dizygotic (DZ) twins using the newly developed World Health Organisation Oral Health Questionnaire for Adults (Annex 7).

Method: A total of 15 sets of MZ twins and 14 sets of DZ twins (58 individuals) aged between 18 and 71 years were enrolled in the study. Each participant had to fill out a web-based questionnaire which comprised 23 questions (Google Forms). The data were collated and the oral health/hygiene habits of MZ and DZ twins were compared.

Results: No significant differences were detected between MZ and DZ twins with regards to their daily tooth-cleaning habits or the tooth-cleaning products used by the 2 groups. For instance, when asked how often they clean their teeth, 80% of MZ twins and 71% of DZ twins responded similarly. Further, both groups provided similar responses when questioned about the use of fluoride toothpaste, frequency of dental visits, and dental counselling received as well as a number of other parameters such as snacking of sweets and fear of visiting dentists.

Conclusions: Our pilot analysis of the questionnaire responses from MZ and DZ twins in Hungary did not indicate any significant differences in their oral care habits in general. Further studies with a large cohort are required to confirm or refute our findings.

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Introduction

The study of human twins has always been fascinating. The interest in the subject has been further enhanced by the phenotypic and behavioural differences between monozygotic (MZ) and dizygotic (DZ) twins.[1] Genetic and environmental factors are related to the behavioural and other phenotypic attributes of MZ and DZ twin pairs. Since MZ twins share almost identical genomes, any variation between them must stem from environmental influences alone.[2,3] Hence, twin studies in general offer valuable insights on the environmental factors affecting their behaviour.

As there are no studies, to our knowledge, on whether there are differences between oral hygiene and risk factors for oral disease between MZ and DZ twins, a pilot study was performed amongst such pairs in Hungary. For this purpose, we used the World Health Organisation (WHO)–recommended simplified structured questionnaire survey (Annex 7).[4]

The data collection was performed using telemedicine technology during the COVID-19 pandemic period. This approach eliminated the need for in-person visits and travel by the interviewees, as well as their travel cost.[5] In addition, the efficient and effective data collection tools and methodology popularised during the COVID-19 pandemic were of great utility for our survey.[6]

This study, therefore, was aimed at eliciting differential features, if any, between oral health knowledge and self-reported oral hygiene habits of a small cohort of MZ and DZ twins in Budapest, Hungary, and its suburbs. The

* *Corresponding author*. Daniel Vegh assistant professor – Department of Prosthodontics, Semmelweis University, Hungary, 1088, Budapest, Szentkiralyi utca 47.
E-mail address: vegh.daniel@semmelweis.hu (D. Vegh).

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questionnaire included items on oral health knowledge and self-reported daily oral hygiene habits as per the WHO recommended simplified structured questionnaire.[4] The null hypothesis for the study was that there is no significant difference between the oral care habits of MZ and DZ twins in Hungary.

Methods

Participants

A total of 58 twin Hungarian participants (38 women and 20 men), randomly selected from the Hungarian Twin Registry (HTR) database, were used for the online survey. Participation in the questionnaire survey was voluntary.

The questionnaire survey was performed over a 3-month period from October to December 2022. The instrument used for the survey was the Google Survey interphase available on either a computer, tablet, or a mobile phone device, whilst the language of the questionnaire was Hungarian.

Exclusion criteria included an incomplete questionnaire and more than one sample from the same person through an identical email address. Non-twins, if any, were excluded from the study. In addition, we excluded the questionnaire of those whose co-twin did not fill out the questionnaire. The zygosity of twin pairs was determined by a standardised 7-question self-reported questionnaire that yields nearly 99% accuracy. This questionnaire has been the basis of zygosity assessment in the Danish Twin Registry for over half a century.[7,8]

The study was carried out as per the Declaration of Helsinki and approved by the Semmelweis University Ethical Board (ethical clearance number: SE RKEB 2023).

Questionnaire

The questionnaire comprised a total of 23 questions including fundamental questions that are considered to be of basic importance for evaluating national oral health.[4]

Online survey

The study protocol was based on the Annex 7 of the WHO survey form.[4] When filling out the questionnaire, the twin pairs used the same identifier, a combination of 3 letters and 3 numbers (eg, ABC123), which the twin pairs proposed. This identifier helped us in the comparison of twin pairs and also to maintain the anonymity of the twin pairs related to their MZ or DZ nature until the code was broken.

Data collection and outcome measures

We collected the data online. All data were stored using Google Surveys and Microsoft Excel.

Statistical analysis and visualisation

The data were analysed using an Excel spreadsheet, which was also used to store the data. The significant differences between the 2 groups were tested using Fisher exact test (P). Differences below the 5.0% limit ($P < .05$) were considered significant.

Results

In total, 15 sets of MZ twins (51.7%) and 14 sets of DZ twins (48.3%), a total of 58 individuals, with an average age of 35.2 ± 16.6 years took part in the survey. Most participants resided in Pest County of Budapest (82.8%) and 1.7% in the peri-urban and 17.2% in the rural areas.

In general, the findings showed that there were no significant differences between MZ and DZ twins in their overall general oral health knowledge and the other parameters evaluated. The MZ twins responded similarly to the question of using various teeth-cleaning tools in 27.0% of cases, whilst the DZ twins did so in 21.0% of cases. Two-thirds (67.0%) of participants used manual toothbrushes rather than electric toothbrushes to clean their teeth, and only 12.1% used both types of brushes.

When asked whether they use a fluoride-containing toothpaste, 58.6% of MZ twins replied in the affirmative, whilst 20.7% were ambivalent. Thus, almost one-fifth (20.7%) of the total group were unaware of whether the toothpaste they used contained fluoride.

Overall, 70.0% of both MZ and DZ twins had received oral care advice/education; 67.0% of MZ twins and 64.0% of DZ twins provided similar answers related to oral care education/counselling.

We noted that 80.0% of the identical twin participants and 71.0% of the DZ twins gave the same answer as to how often they brush their teeth. Further, 72.4% of the participants brush their teeth twice or more a day, 27.6% less often. As for the appliance they use for their routine oral hygiene, a vast majority (94.8%) primarily used toothbrushes. Furthermore, 51.7% used dental floss, 44.8% used mouthwash, and 36.2% used toothpicks (Figure 1). Almost 100.0% of MZ twins and 93.0% of DZ twins used a toothbrush.

The relative use of the oral hygiene aids between MZ and DZ twins was also similar and indicted that the toothbrush is the most frequently used cleaning tool (MZ: 73.0%, DZ: 64.0%) followed by flossing (MZ: 53.0%, DZ: 50.0%). In total, 60.0% of MZ and 57.0% of DZ twins gave the same answer on the regular use of dental floss, whilst rates were 80.0% of MZ and 79.0% of DZ twins for the interdental brush; 63.3% of MZ twins and 64.3% of DZ twins use other oral care devices (mouthwash, toothpick, activated carbon, chewing sticks) (Figure 1).

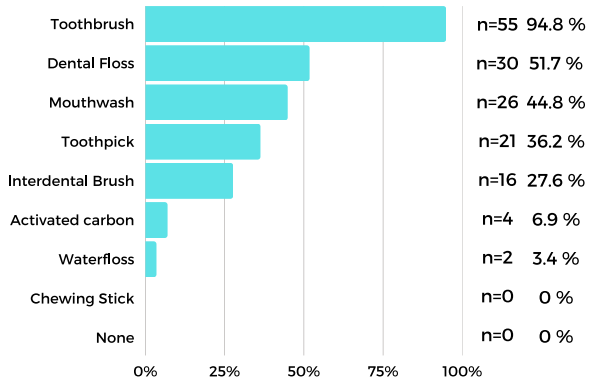


Fig. 1 – Use of dental cleaning tools by monozygotic and dizygotic twins (cumulative data).

Table 1 – The response of the monozygotic and dizygotic twin pairs to the World Health Organisation (WHO) recommended simplified structured questionnaire survey.

Question	Response			
	Monozygotic twins, No. (%)		Dizygotic twins, No. (%)	
No. of participating twin pairs	15		14	
During the past 12 months, did have any discomfort in your teeth or mouth ?	9	(60%)	12	(86%)
Do you wear removable dentures?	8	(53%)	10	(71%)
Would you describe the state of your teeth and gums as very good or excellent?				
• Teeth	6	(40%)	6	(43%)
• Gums (gingiva)	6	(40%)	7	(50%)
How often do you clean your teeth?	12	(80%)	10	(71%)
Do you use the following to oral hygiene aids to clean your teeth?				
• Toothbrush	11	(73%)	9	(64%)
• Toothpaste	15	(100%)	14	(100%)
• Fluoride-containing toothpaste	9	(60%)	8	(57%)
Have you ever received oral care education/counselling?	10	(67%)	9	(64%)
How long has it been since you last saw a dentist?	4	(27%)	9	(64%)
What was the reason for your last visit to the dentist?	7	(47%)	7	(50%)
• Routine checkup	6	(43%)	3	(25%)
• Treatment follow-up	5	(37%)	8	(64%)
Because of the state of your teeth or mouth, how often have you experienced any of the following problems during the past 12 months?				
• Difficulty in biting food	9	(60%)	10	(71%)
• Difficulty chewing food	8	(53%)	11	(79%)
• Difficulty with speech/trouble pronouncing words	13	(87%)	14	(100%)
• Dry mouth	11	(73%)	11	(79%)
• Felt embarrassed due to appearance of teeth	10	(67%)	12	(86%)
• Felt tense because of problems with teeth or mouth	10	(67%)	13	(93%)
• Have avoided smiling because of teeth	9	(60%)	13	(93%)
• Had sleep that is often interrupted	9	(60%)	11	(79%)
• Have taken days off work	13	(87%)	13	(93%)
• Had difficulty doing usual activities	13	(87%)	14	(100%)
• Felt less tolerant of spouse or people who are close to you	11	(0%)	13	(93%)
• Have had reduced participation in social activities	10	(67%)	13	(93%)
• Other	6	(40%)	8	(57%)
Do you prefer sugary foods?	7	(47%)	7	(47%)
How often do you use any of the following tobacco products?				
• Cigarettes	12	(80%)	10	(71%)
• Cigars	14	(93%)	12	(86%)
• Pipe	14	(93%)	12	(86%)
• Chewing tobacco	15	(100%)	13	(93%)
• Snuff	15	(100%)	13	(93%)
During the past 30 days, have you consumed alcohol?	8	(53%)	10	(71%)
Are you afraid of dental treatment?	11	(73%)	11	(79%)

There was no significant difference between MZ and DZ twins ($P = .355$) with regards to the ratio of the use of the main oral care and other toothbrushing utensils (Table 1). Other responses to the questionnaire are as follows. Almost one-half of all the participants (48.3%) had been to the dentist less than 6 months ago (MZ: 27.0%, DZ: 64.0%; $P > .05$), and only a small minority (3.4%) had been 5 years or more. The major reasons for the last visit were routine checkup/treatment (MZ: 43.3%; DZ: 25.0%) and treatment/follow-up (MZ: 36.7%; DZ: 64.3%) (Table 1).

Most of the participants (87.9%) had 20 or more natural teeth and only 1.7% had none. Overall, one-half of MZ twins and almost three-quarters (71.0%) of DZ twins did wore dentures. Relatively few participants had removable dentures (8.5%), whilst 17.2% wore fixed prosthodontics.

Based on the subjective assessment the minority of both DZ and MZ twins (40.0%) considered the condition of their teeth and gums as good or excellent; 10.3% rated the condition of their teeth and gums as poor or very poor. For both the MZ and DZ twins, the health of the teeth and mouth was not a major concern when conducting routine daily activities (Table 1). However, over one-half of both MZ and DZ twins complained of difficulty in biting and chewing food.

Other notable grievance in the whole cohort with over one half of both MZ and DZ twins complaining were difficulty with speech, dry mouth, feeling embarrassed about their dentition feeling tense and waking up because of their dental issues, taken time off due to dental issues (Table 1). As regards eating habits, approximately one-half of MZ and DZ twins preferred sugary foods, mostly drinks with sugar-sweetened tea and sweet pies and jams as their go-to sugary treats.

We attempted to identify the respondents' adverse social habits in the final section of the questionnaire. When questioned on alcohol intake, one-half of all respondents had

consumed alcohol in the last 30 days (MZ: 53%; DZ: 71%), and most participants never used tobacco products. Further, a majority of both MZ and DZ twins smoked cigarettes (MZ: 80%; DZ: 71%) and other tobacco products.

In summary, there were no significant differences in the responses to any of the oral hygiene attributes questioned between members of MZ and DZ twins for any of the questions, though there were minor variations (Table 1).

Discussion

As far as we are aware, this is the first study comparing the oral care/hygiene and related habits of MZ and DZ twins. Taken together, the data imply that there were no behavioural changes in the oral hygiene habits between these 2 cohorts, thus confirming our null hypothesis.

The participants for the web-based questionnaire survey were randomly selected from the HTR database, and they resided in the capital Budapest in Hungary and its catchment area. Their urban or suburban residence status does not appear to have influenced the visits to the dentist and oral hygiene habits, as reported in other previous studies.[9–11] In general, approximately one-half of the participants were well educated, graduated from college/university, or had a high school diploma. This may be a reflection of our cohort that was mainly derived from the urban/suburban areas of Hungary and not from underdeveloped rural regions of the country.

In evaluating the data, we found no significant difference between MZ and DZ twins in the frequency of using dental care tools. Almost 100.0% of the twins regularly use toothpaste, and a majority use a manual toothbrush to clean their teeth. More than half of the participants supplement this with dental floss, the regular use of which can reduce interproximal plaque[12,13] and reduce periodontal diseases and interproximal caries.[14] Although electric toothbrushes are more effective in reducing plaque and gingivitis in both the short and long term,[15] our cohorts predominantly used manual toothbrushes.

A significant genetic role in the development of caries amongst twins has been demonstrated in a previous study by Bretz et al.[16] Although we could not ascertain the caries status form the survey, only about one-half of the participants used fluoride-containing toothpaste, which effectively prevents tooth decay. The response to the frequency of dental visits was not that satisfactory, as almost one-half of the participants visited a dentist within the preceding 6 months. These imply that the participants require further education on prevention of oral diseases through regular visits to the dentist.

In terms of the functionality of their dentition, most of the participants did not experience difficulty speaking or chewing, and they didn't experience dry mouth,[17] and almost one-half of the participants consumed fruit on a daily basis. Furthermore, only a minority of MZ twins prefer sugary diets, and this implies that they will be less prone to caries as excessive sugary snacks lead to caries.[18,19]

Although the harmful health effects of tobacco products are well known,[20] a majority of both MZ and DZ twins smoked cigarettes and other tobacco products. This implies that tobacco prevention education in the country is inadequate. We also noted that a majority of the cohort feared dental treatment, which emphasises the importance of addressing dental anxiety as well as ensuring patient comfort during dental visits and the need for further public education programmes of contemporary dentistry, which is virtually painless.

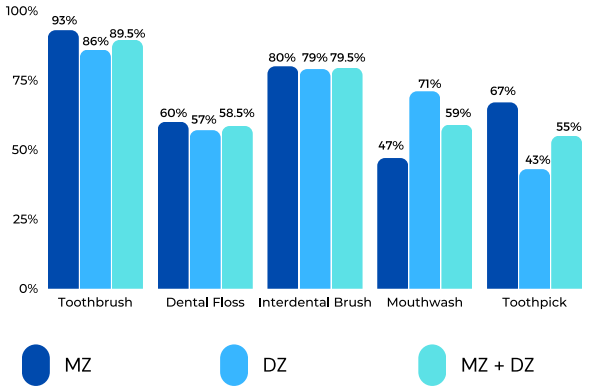


Fig. 2 – Percentage difference in oral hygiene/care devises used by monozygotic and dizygotic twin pairs.

One limitation of this pilot study is the subjective assessments by participants of their oral health and general well-being. Further, the small number of participants is also a limitation, and additional larger studies of MZ and DZ twins need to be conducted to verify or refute our pilot findings. Nevertheless, our data should serve as a basis for future workers in this field.

In conclusion, our study provides important insights into the oral health, hygiene, and related habits of MZ and DZ twins in Hungary. Within the twin population, there appears to be twins who pay more attention to oral care and others who pay less attention. Given the limited sample size and the relatively short questionnaire, our findings suggest that both these groups have a similar degree of oral health habits and awareness. Further research with a larger twin cohort is warranted to confirm or refute our findings (Figure 2).

Conflict of interest

None disclosed.

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Author contributions

Klaudia Liptak and Laura Liptak: writing–original draft, resources and investigation, project administration, writing

and editing. Péter Hermann and Noemi Katinka Rozsa: supervision. Daniel Vegh: supervision and conceptualisation. Ádám Domonkos Tárnoki and Dávid László Tárnoki: resources. Klaudia Liptak and Laura Liptak contributed equally to this work.

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Oral health practices and literacy in Hungarian diabetes patients: insights from a pilot-study using a WHO-adapted questionnaire

Klaudia Lipták[1†], Laura Lipták[2†], Kata Sára Haba[1], Dorottya Bányai[2], Dániel S. Veres[3], Noémi Katinka Rózsa[2], Péter Hermann[1] and Dániel Végh[1*]

Abstract

Introduction This study aimed to compare the self-reported oral health status, knowledge, and habits of individuals living with diabetes mellitus and healthy controls. To achieve this, the modified version of the World Health Organization's Oral Health Questionnaire for Adults (ANNEX 7; Google Forms) was employed for data collection.

Methods The study included 99 diabetes patients (33 with type 1 and 66 with type 2 diabetes mellitus) and 102 non-diabetic controls. Logistic regression models, adjusted for demographic factors, were applied to examine associations between oral hygiene practices, dietary habits, and the number of natural teeth.

Results Individuals with diabetes exhibited a greater frequency of oral pathological conditions. Despite 74% of people with diabetes mellitus (PwDM) brushing their teeth twice daily, they had fewer natural teeth compared to the control group (20 or more teeth: DM: 54.5%, controls: 70.6%). In our study, there is no evidence that number of teeth is dependent on HbA1c levels, and we found that neither age nor gender influenced the change in HbA1c levels. Lower interdental cleaning habits and frequent fruit consumption were identified as significant risk factors for severe tooth loss.

Conclusion and clinical relevance This study highlights significant oral health disparities in diabetes patients, particularly those with T2DM, who reported poorer oral health, more frequent denture use, and fewer natural teeth. These findings underscore the need for integrating oral health education, preventive care, and interdisciplinary collaboration into diabetes management to improve overall health outcomes.

Keywords Diabetes, Oral health, Health education, Public health, Interdisciplinary care, Advocacy

[†]Klaudia Lipták and Laura Lipták contributed equally to this work.

*Correspondence:
Dániel Végh
vegh.daniel@semmelweis.hu
[1]Department of Prosthodontics, Semmelweis University, Szentkirályi u. 47, Budapest 1088, Hungary
[2]Department of Paediatric Dentistry and Orthodontics, Semmelweis University, Szentkirályi u. 47, Budapest 1088, Hungary
[3]Department of Biophysics and Radiation Biology, Semmelweis University, Tűzoltó u. 37-47, Budapest 1094, Hungary

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Introduction

Diabetes mellitus (DM) is a metabolic disorder characterized by elevated blood glucose levels due to a lack of insulin secretion, function, or both. It is estimated that 537 million people had DM in 2021, a number that is projected to rise steadily to 643 million by 2030, and 783 million by 2045 according to the International Diabetes Federation (IDF) Diabetes Atlas [1]. The same statistics are also true for Hungary, where the most recent statistics show that DM affects one in six Hungarians and more than one third of people over 65 years [2].

Despite the growing recognition of diabetes-related oral health issues, they remain underrepresented in diabetes care. To better understand the oral health behaviors and literacy of Hungarian diabetes patients, we conducted a survey using a WHO-adapted questionnaire. This questionnaire has been previously used in international research to assess key aspects of oral hygiene habits, access to dental care, and awareness of diabetes-related oral health risks [3, 4]. The questionnaire covers several key domains: oral hygiene practices (toothbrushing frequency, flossing), oral health awareness (knowledge of diabetes-related oral health risks), dental care behaviors (regularity of dental visits, barriers to dental care), and self-perceived oral health status (gum bleeding, tooth sensitivity, dry mouth). By analyzing these aspects, our study aims to identify potential gaps in oral health education and preventive care among Hungarian diabetes patients.

Although not commonly discussed in DM care, even slightly elevated blood glucose levels can have detrimental affects on oral health, manifesting in a wide range of oral diseases and conditions [5]. More than two decades ago, periodontitis was identified as the sixth complication of DM by Harald Löe, the Director of the National Institute of Dental Research [6]. Despite this, the concept need more attention in the medical community until recently. This becomes even more important when it is recognized that periodontal disease negatively affects blood glucose levels so that periodontitis and hyperglycemia are mutually and bi-directionally related and adversely affect each other [7, 8]. In current DM management, the oral cavity is often overlooked, despite the fact that professional societies such as the Semmelweis University Diabetes Dental Research Group recommend that routine DM screening should include a referral to a dental examination [6, 9]. The two most common forms of periodontal disease are gingivitis and periodontitis, infections caused by inflammation of the soft tissues around the tooth. Gingivitis affects up to 90% of the world population [10]. It has been found that people with DM have an increased susceptibility to periodontal disease, with a risk two to three times higher than that of people without DM. In addition, research has shown a chronic and reciprocal relationship between DM and periodontal disease [11].

Chávez et al. (2001) noted that xerostomia is prevalent in up to 46% of patients with type 2 diabetes mellitus (T2DM). This condition is directly associated with reduced salivary flow and increased glucose levels in saliva, contributing to dental caries, difficulties in nutritional intake, and prosthetic use [12]. DM neuropathy often plays a role in the development of burning mouth syndrome, a painful condition that affects many DM patients, probably as a complication of long-term hyperglycemia and its impact on nerve health [13]. Patients with DM (PwDM), especially those with poorly controlled blood sugar levels, face an increased risk of implant failure and delayed healing due to heightened inflammatory responses and reduced blood circulation. In addition, a weakened immune response makes them more susceptible to infections, further complicating the healing process [14]. Furthermore, PwDM is more prone to oral infections such as candidiasis, and there is emerging evidence that DM is associated with an increased risk of oral cancers [15]. Persistent hyperglycemia and hyperinsulinemia are known to trigger abnormal cellular proliferation [16, 17].

Severe periodontal disease is the sixth most prevalent disease in the world (11.2%) [18, 19]. Given the relevant correlation between periodontal disease and DM, as well as the positive effects of maintaining good oral health to mitigate the risk of periodontal disease, it is imperative to prioritize encouraging individuals with DM to adopt proper oral hygiene practices. This includes offering regular risk assessments and dental referrals as an integral component of routine DM care [3, 20]. The implementation of this review is of paramount importance, as proficient knowledge and literacy on oral health are positively correlated with favorable oral health practices. These practices include a heightened frequency of toothbrushing, regular dental appointments, and the maintenance of good periodontal health [21, 22].

We extended an earlier study, the "Budapest Pilot Study", in Hungary. This pilot study contributes to the global understanding by offering insights into the oral health practices and knowledge of Hungarian diabetes patients and controls. This aim of this study was to collect data on the oral health knowledge and practices of PwDM. Despite growing evidence linking DM and oral health, limited studies focus on the bidirectional relationship in specific populations, such as Hungarian patients, who may exhibit unique oral hygiene practices and risk profiles. This study aims to address this gap by providing region-specific data. Our primary goal was to gain insight into the oral health habits and education levels among PwDM.

Methods

This study is classified as a pilot study as it represents an initial exploration of oral health behaviors and awareness among Hungarian diabetes patients using a WHO-adapted questionnaire. The primary objective was to assess feasibility, refine research methodology, and identify key trends that could inform future large-scale studies.

Our study involved 99 participants (33 with type 1 diabetes mellitus (T1DM) and 66 with T2DM) (Diabetes Descriptive plots) and 102 controls; 18 years of age or over. A total of 103 responses were collected in the diabetes group, of which 4 were excluded due to incomplete data. In the control group, 102 responses were received, with no exclusions. The survey was open to responses from October 1, 2022 to January 31, 2024 and could be accessed through a Google Survey (Google LLC, Mountain View, CA, USA) form on a variety of devices, including computers, tablets, or mobile phones. The presence of DM was our priority. The study included clinically confirmed diabetes patients, with no additional measurements conducted to determine their diabetes status. The questionnaires were distributed both in-person at diabetology outpatient clinics, where patients completed them during their visits, and online within diabetes communities. The study did not involve a predefined sample size calculation. Participation in the survey was voluntary, and certain criteria were applied to ensure data integrity, such asthe exclusion of incomplete questionnaires and multiple submissions from the same IP or email address to avoid duplicate responses, adhering to General Data Protection Regulation (GDPR) regulations for data protection. Participants created a unique identifier consisting of three letters and three numbers (e.g., ABC123) when filling out the questionnaire. This identifier facilitated data comparison. In cases where responses originated from the same IP address or email, they were reviewed for identical answers. If completely identical responses had been identified, they would have been excluded; however, no such cases were found. The survey language was Hungarian, and the questionnaire was translated accordingly to ensure clarity for all participants. Data were obtained from online sources and subsequently stored using Google Surveys (Google LLC, Mountain View, CA, USA) and Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). In the study, we first compared the control group and the DM group, and then compared the responses of people with T1DM and T2DM.

Online questionnaire

The questionnaire comprised a total of 24 inquiries and included questions essential for a national oral health surveillance (Table 1). The study protocol was based on ANNEX 7 of the World Health Organisation (WHO) survey [23]. The questionnaire was designed to ensure complete participant anonymity, as no personally identifiable information was collected. These structured questionnaires contain fundamental questions essential for national oral health surveillance. The collected data included the following variables: sex, age, place of residence, type of diabetes, number of teeth, presence of oral discomfort, use of removable dentures, oral hygiene habits, self-reported oral health status, types of oral care products used, toothpaste preference, frequency of dental visits, dietary and alcohol consumption habits, smoking status, level of primary education, potential fear of dental treatment, the type of medication used for diabetes management, and whether the participant uses a continuous glucose monitoring (CGM) sensor, therapy of diabetes mellitus (tablets or insulin), level of the last HbA1c. HbA1c represents the average blood glucose level over the past three months and is regularly monitored during diabetology outpatient visits. In this study, participants self-reported their most recent HbA1c value through a specific question in the questionnaire.

Statistical analysis and visualisation

Statistical analyses were performed using R software, an open-source programming language and software environment widely used for statistical computing, data analysis, and visualization (v4.3.3, R Foundation for Statistical Computing, Vienna, Austria). We used the `Table 1` (v1.4.3) package to simplify the creation of descriptive statistical tables (Data Science, Munich, Germany), and `ggplot2` (v3.5.0) to create complex and customizable visualizations (RStudio, Boston, USA) [24–26]. To interpret regression analyses, we employed the `gtsummary` (v1.7.2) package to summarize statistical models in clear tables (RStudio, Boston, USA), and `sjPlot` (v2.8.16) to visualize model results and relationships between variables (Statistical Software, Berlin, Germany) [27, 28]. Regression models were used to assess the effect of teeth cleaning frequency and DM (PwDM versus non-DM patients) on number of teeth and the effect of number of teeth and diabetes on HbA1c level. Due to the limited sample size, only the key variables of interest and the most relevant potential confounders were included as predictors. The primary focus was on comparing diabetes and non-diabetes patients, as well as examining the type of diabetes (T1DM vs. T2DM). Additionally, eating habits (fruit and rapidly absorbable carbohydrate consumption) were analyzed. Age, sex, and oral hygiene behaviors (frequency of tooth cleaning and flossing) were considered potential confounders in the analysis.

In cases where the number of teeth was the outcome variable, as the assumptions of ordinal logistic regression did not fit, simple logistic regression models (with logit

Table 1 Dental status and compliance

	Table 1a			Table 1b		
	Control (*N* = 102)	**DM (*N* = 99)**	**Overall (*N* = 201)**	**T1DM (*N* = 33)**	**T2DM (*N* = 66)**	**Overall (*N* = 99)**
Sex						
Female	74 (72.5%)	75 (75.8%)	149 (74.1%)	25 (75.8%)	50 (75.8%)	75 (75.8%)
Male	28 (27.5%)	23 (23.2%)	51 (25.4%)	8 (24.2%)	15 (22.7%)	23 (23.2%)
Missing data	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Age [years]						
Mean (SD)	47.8 (17.2)	53.5 (18.1)	50.6 (17.8)	38.8 (16.3)	60.8 (14.1)	53.5 (18.1)
Median (IQR)	47.5 (35.3)	54.0 (26.0)	51.0 (31.0)	38.0 (24.0)	66.0 (18.8)	54.0 (26.0)
Min, Max	21.0, 80.0	10.0, 81.0	10.0, 81.0	10.0, 69.0	20.0, 81.0	10.0, 81.0
Residence						
City	90 (88.2%)	76 (76.8%)	166 (82.6%)	26 (78.8%)	50 (75.8%)	76 (76.8%)
Countryside	9 (8.8%)	14 (14.1%)	23 (11.4%)	4 (12.1%)	10 (15.2%)	14 (14.1%)
Suburb	3 (2.9%)	9 (9.1%)	12 (6.0%)	3 (9.1%)	6 (9.1%)	9 (9.1%)
Education						
Less than primary school	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Primary school completed	4 (3.9%)	5 (5.1%)	9 (4.5%)	4 (12.1%)	1 (1.5%)	5 (5.1%)
Secondary/High school completed	31 (30.4%)	38 (38.4%)	69 (34.3%)	9 (27.3%)	29 (43.9%)	38 (38.4%)
Vocational school completed	16 (15.7%)	15 (15.2%)	31 (15.4%)	4 (12.1%)	11 (16.7%)	15 (15.2%)
College/university completed	48 (47.1%)	39 (39.4%)	87 (43.3%)	15 (45.5%)	24 (36.4%)	39 (39.4%)
Postgraduate degree	3 (2.9%)	1 (1.0%)	4 (2.0%)	0 (0%)	1 (1.5%)	1 (1.0%)
Diabetes mellitus						
T1DM	0 (0%)	33 (33.3%)	33 (16.4%)	33 (100%)	0 (0%)	33 (33.3%)
T2DM	0 (0%)	66 (66.7%)	66 (32.8%)	0 (0%)	66 (100%)	66 (66.7%)
Missing data	102 (100%)	0 (0%)	102 (50.7%)			
HbA1c level [%]						
Mean (SD)	NA	6.75 (1.14)	6.75 (1.14)	6.64 (0.734)	6.80 (1.29)	6.75 (1.14)
Median (IQR)	NA	6.80 (1.13)	6.80 (1.13)	6.70 (1.10)	6.80 (1.20)	6.80 (1.13)
Min, Max	NA	4.80, 14.0	4.80, 14.0	5.10, 8.00	4.80, 14.0	4.80, 14.0
Missing data	102 (100%)	0 (0%)	102 (50.7%)			
Therapy						
Both	0 (0%)	11 (11.1%)	11 (5.5%)	2 (6.1%)	9 (13.6%)	11 (11.1%)
Insulin	0 (0%)	37 (37.4%)	37 (18.4%)	28 (84.8%)	9 (13.6%)	37 (37.4%)
Nothing	0 (0%)	2 (2.0%)	2 (1.0%)	0 (0%)	2 (3.0%)	2 (2.0%)
Tablet	0 (0%)	46 (46.5%)	46 (22.9%)	3 (9.1%)	43 (65.2%)	46 (46.5%)
Missing data	102 (100%)	3 (3.0%)	105 (52.2%)	0 (0%)	3 (4.5%)	3 (3.0%)
Sensor						
No	0 (0%)	78 (78.8%)	78 (38.8%)	13 (39.4%)	65 (98.5%)	78 (78.8%)
Yes	0 (0%)	21 (21.2%)	21 (10.4%)	20 (60.6%)	1 (1.5%)	21 (21.2%)
Missing data	102 (100%)	0 (0%)	102 (50.7%)			
Complaint						
Yes	10 (9.8%)	18 (18.2%)	28 (13.9%)	22 (66.7%)	28 (42.4%)	50 (50.5%)
No	19 (18.6%)	23 (23.2%)	42 (20.9%)	11 (33.3%)	33 (50.0%)	44 (44.4%)
Don't know	72 (70.6%)	54 (54.5%)	126 (62.7%)	0 (0%)	5 (7.6%)	5 (5.1%)
Removable						
Lower and upper complete dentures	1 (1.0%)	5 (5.1%)	6 (3.0%)	0 (0%)	5 (7.6%)	5 (5.1%)
Lower and upper complete dentures, Fixed dentures	0 (0%)	1 (1.0%)	1 (0.5%)			
Lower complete dentures	3 (2.9%)	0 (0%)	3 (1.5%)	0 (0%)	0 (0%)	0 (0%)
Lower complete dentures, Fixed dentures	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Upper complete dentures	2 (2.0%)	5 (5.1%)	7 (3.5%)	2 (6.1%)	3 (4.5%)	5 (5.1%)
Upper complete dentures, Fixed dentures	1 (1.0%)	3 (3.0%)	4 (2.0%)	0 (0%)	3 (4.5%)	3 (3.0%)
I don't wear any dentures	57 (55.9%)	52 (52.5%)	109 (54.2%)	26 (78.8%)	26 (39.4%)	52 (52.5%)
Partial dentures	6 (5.9%)	12 (12.1%)	18 (9.0%)	3 (9.1%)	9 (13.6%)	12 (12.1%)

Table 1 (continued)

	Table 1a			Table 1b		
	Control (*N* = 102)	**DM (*N* = 99)**	**Overall (*N* = 201)**	**T1DM (*N* = 33)**	**T2DM (*N* = 66)**	**Overall (*N* = 99)**
Fixed dentures	32 (31.4%)	20 (20.2%)	52 (25.9%)	2 (6.1%)	18 (27.3%)	20 (20.2%)
Condition teeth						
Average	29 (28.4%)	28 (28.3%)	57 (28.4%)	6 (18.2%)	22 (33.3%)	28 (28.3%)
Good	36 (35.3%)	24 (24.2%)	60 (29.9%)	11 (33.3%)	13 (19.7%)	24 (24.2%)
Excellent	6 (5.9%)	3 (3.0%)	9 (4.5%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Very good	15 (14.7%)	9 (9.1%)	24 (11.9%)	3 (9.1%)	6 (9.1%)	9 (9.1%)
Very poor	3 (2.9%)	12 (12.1%)	15 (7.5%)	5 (15.2%)	7 (10.6%)	12 (12.1%)
Don't know	1 (1.0%)	4 (4.0%)	5 (2.5%)	1 (3.0%)	3 (4.5%)	4 (4.0%)
Poor	12 (11.8%)	19 (19.2%)	31 (15.4%)	5 (15.2%)	14 (21.2%)	19 (19.2%)
Condition gum						
Average	23 (22.5%)	30 (30.3%)	53 (26.4%)	5 (15.2%)	25 (37.9%)	30 (30.3%)
Good	35 (34.3%)	23 (23.2%)	58 (28.9%)	10 (30.3%)	13 (19.7%)	23 (23.2%)
Excellent	15 (14.7%)	4 (4.0%)	19 (9.5%)	2 (6.1%)	2 (3.0%)	4 (4.0%)
Very good	10 (9.8%)	10 (10.1%)	20 (10.0%)	5 (15.2%)	5 (7.6%)	10 (10.1%)
Very poor	4 (3.9%)	11 (11.1%)	15 (7.5%)	5 (15.2%)	6 (9.1%)	11 (11.1%)
Don't know	1 (1.0%)	4 (4.0%)	5 (2.5%)	1 (3.0%)	3 (4.5%)	4 (4.0%)
Poor	14 (13.7%)	17 (17.2%)	31 (15.4%)	5 (15.2%)	12 (18.2%)	17 (17.2%)
Last visit						
2 years or more but less than 5 years	9 (8.8%)	15 (15.2%)	24 (11.9%)	5 (15.2%)	10 (15.2%)	15 (15.2%)
5 years or more	5 (4.9%)	10 (10.1%)	15 (7.5%)	2 (6.1%)	8 (12.1%)	10 (10.1%)
6–12 months	32 (31.4%)	21 (21.2%)	53 (26.4%)	9 (27.3%)	12 (18.2%)	21 (21.2%)
Less than 6 months	41 (40.2%)	35 (35.4%)	76 (37.8%)	9 (27.3%)	26 (39.4%)	35 (35.4%)
More than 1 year but less than 2 years	15 (14.7%)	18 (18.2%)	33 (16.4%)	8 (24.2%)	10 (15.2%)	18 (18.2%)
Last visit reason						
Pain or trouble with teeth, gums or mouth	21 (20.6%)	28 (28.3%)	49 (24.4%)	10 (30.3%)	18 (27.3%)	28 (28.3%)
Treatment/ follow-up treatment	40 (39.2%)	32 (32.3%)	72 (35.8%)	8 (24.2%)	24 (36.4%)	32 (32.3%)
Consultation/advise	7 (6.9%)	10 (10.1%)	17 (8.5%)	3 (9.1%)	7 (10.6%)	10 (10.1%)
Don't know/don't remember	0 (0%)	3 (3.0%)	3 (1.5%)	1 (3.0%)	2 (3.0%)	3 (3.0%)
Routine check-up/treatment	34 (33.3%)	26 (26.3%)	60 (29.9%)	11 (33.3%)	15 (22.7%)	26 (26.3%)
Fear dentist						
Yes	42 (41.2%)	44 (44.4%)	86 (42.8%)	17 (51.5%)	27 (40.9%)	44 (44.4%)
No	60 (58.8%)	55 (55.6%)	115 (57.2%)	16 (48.5%)	39 (59.1%)	55 (55.6%)
By DM (only DM patients)						

link) were used pairwise to the number of tooth categories, where the reference level was always the larger number of teeth. The effect on the HbA1c level was assessed using a linear regression model. The effects were adjusted for sex and age in both models. Two-level interactions were assessed but were found non-significant (at 5%) and not relevant and were therefore excluded from the final models reported.

Results

A total of 99 patients with DM, comprising 24 men and 75 women, and 28 men and 74 women in the control group, participated in this survey. The mean age was 53.5 years in the DM group and 47.8 years in the control group. Among PwDM, one-third had T1DM, while the majority had T2DM. Most participants had a college/university degree. Regarding diabetes management, most PwDM used oral medication or insulin therapy, and 21.2% used a sensor to control blood glucose levels. The standard deviation of HbA1c levels of DM participants was 6.75% and the median was 6.8%. Self-reported oral health varied between groups: PwDM were more likely to rate their teeth and gums as "bad" compared to controls. One-third of PwDM had seen a dentist in the past six months, slightly lower than in the control group. The most common reasons for the last visit were treatment/ follow-up treatment and routine check-ups. The proportions of patients with DM and controls wearing the same type of dentures were almost the same, and with fixed dentures being the most common, whereas in complete edentulism, participants wore lower and upper removable dentures. Over half of participants reported no fear of dental procedures (Table 1a).

Twice as many T2DM patients completed the questionnaire compared to T1DM patients, with a higher mean age in the T2DM group. The median HbA1c levels were nearly identical between the two types (T1DM: 6.7%; T2DM: 6.8%). Continuous Glucose Monitors (CGMs) were predominantly used by T1DM patients (60.6%), whereas their use was minimal among T2DM patients. A CGM is a device that continuously monitors glucose levels through a subcutaneous sensor. It is advantageous because it provides real-time glucose data, helps users detect trends, and offers alerts for high or low blood sugar levels, allowing better management of diabetes and reducing the need for frequent finger-prick tests. A higher proportion of T1DM patients wore no dentures (78.8%), suggesting that their dentition was better preserved. The subjective perception of T2DM patients was worse, with 33.3% of them considering the condition of their teeth and 37.9% the condition of their gums to be "average". There was no significant difference between the two groups in responses to the last dental visit or fear of dental procedures (Table 1b).

A total of 69.2% of the respondents (DM group, controls) brushed their teeth at least twice a day, while 30.8% brushed once or less. Dental floss was the most common interdental cleaning tool. Among PwDM, 50.5% used only a toothbrush, while 17.2% also flossed, compared to 29.4% in the control group. Regarding fluoride awareness, 19.2% of PwDM were unsure if their toothpaste contained fluoride, while 80.4% of the control group actively chose fluoride-containing toothpaste (Table 2a).

The responses show 71.2% of T2DM patients brushed their teeth at least twice daily, compared to 45.5% of T1DM patients. The use of oral care products and fluoride toothpaste was similar in both groups (Table 2b).

Despite more frequent brushing, PwDM had fewer teeth than the control group. However, the proportion of respondents with 20 or more teeth was not significantly lower in PwDM (54.5% vs. 70.6% in controls) (Table 2c).

Examining the association between HbA1c and the number of teeth, we found no evidence that HbA1c levels are dependent on number of teeth, considering gender and age, and we found that neither age nor gender explained (affected) the variation in HbA1c levels significantly (Table 2d). Although not statistically significant, the lower number of natural teeth in PwDM may indicate potential long-term complications, highlighting the importance of early dental interventions [29]. The relationship between HbA1c levels and dental prostheses was not analyzed, as prosthesis use reflects patient compliance rather than a determinant of diabetes.

To evaluate the impact of dental floss use and diet (fruit and rapidly absorbable carbohydrate consumption) on dental health, logistic regression models were applied, adjusting for age and sex. As ordinal logistic regression was unsuitable, pairwise logistic regression was used, with the reference always being the greater number of teeth. Results showed that individuals consuming more fruit had 3.8 times higher odds of having 1–9 teeth (vs. 10–19), independent of age, sex, tooth cleaning, flossing, and other carbohydrate intake (Table 3/a). For fruit consumption, the odds ratio of 3.81 was considered high. However, the effects of excessive consumption (eating too much) and group classification (diabetes vs. controls) were not statistically significant, though they may still hold clinical relevance. A similar association was observed when comparing 1–9 teeth to >20 teeth (Table 3/b). Fruit consumption proved to be high in effect, while excessive consumption (eating too much) was negligible. The impact of the group variable (diabetes vs. non-diabetes) was moderate—borderline in significance. Additionally, in this comparison, the odds were about 2.94 times higher among those who did floss and approximately 1.1 times greater for each year of growth (adjusted for DM, sex, or consumption of other rapidly absorbable carbohydrates). (Table 3/c). In this case, these effects (fruit consumption, eating too much, group) do not appear to be clinically relevant.

Figure 1 shows the predicted probability of having 1–9 teeth based on age, flossing habits, and fruit consumption. Although the effects were not statistically significant in this sample, the observed trends suggest potential clinical relevance. These findings align with previous research on the impact of diet and oral hygiene on dental health, especially in diabetes patients [30, 31]. The lack of significance may be due to the limited sample size and cross-sectional design, highlighting the need for larger studies.

Although some results were not statistically significant, this does not rule out a potential association. Given the pilot nature of this study, a larger sample size may be required to detect meaningful these effects.

Discussion

Our findings align with previous research indicating higher rates of tooth loss among diabetes patients globally [29]. However, the relatively lower interdental cleaning habits observed in the Hungarian cohort suggest regional disparities that warrant further investigation [32]. This pilot study provides insights into oral health behaviors and outcomes in DM patients compared to non-DM controls, highlighting significant differences in oral hygiene practices, self-reported dental conditions, and the impact of DM on oral health. A total of 99 DM patients and 102 controls participated, with DM patients exhibiting poorer oral health outcomes. Raising awareness about oral health can be a new tool for professionals in the prevention and management of DM. This finding

Table 2 Oral hygiene and habits

	Table 2a			Table 2b		
	Control (*N* = 102)	**DM (*N* = 99)**	**Overall (*N* = 201)**	**T1DM (*N* = 33)**	**T2DM (*N* = 66)**	**Overall (*N* = 99)**
Frequency teeth clean						
2–3 times a week	2 (2.0%)	3 (3.0%)	5 (2.5%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Once a month	0 (0%)	3 (3.0%)	3 (1.5%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Once a week	1 (1.0%)	3 (3.0%)	4 (2.0%)	2 (6.1%)	1 (1.5%)	3 (3.0%)
Twice or more a day	77 (75.5%)	62 (62.6%)	139 (69.2%)	15 (45.5%)	47 (71.2%)	62 (62.6%)
Once a day	22 (21.6%)	27 (27.3%)	49 (24.4%)	12 (36.4%)	15 (22.7%)	27 (27.3%)
Never	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Frequency teeth clean						
At least twice a day	77 (75.5%)	62 (62.6%)	139 (69.2%)	15 (45.5%)	47 (71.2%)	62 (62.6%)
Maximum once a day	25 (24.5%)	37 (37.4%)	62 (30.8%)	18 (54.5%)	19 (28.8%)	37 (37.4%)
Tools						
Other	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush	31 (30.4%)	50 (50.5%)	81 (40.3%)	17 (51.5%)	33 (50.0%)	50 (50.5%)
Toothbrush, Charcoal	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Toothbrush, Other	10 (9.8%)	5 (5.1%)	15 (7.5%)	1 (3.0%)	4 (6.1%)	5 (5.1%)
Toothbrush, Wooden toothpicks	6 (5.9%)	6 (6.1%)	12 (6.0%)	3 (9.1%)	3 (4.5%)	6 (6.1%)
Toothbrush, Wooden toothpicks, Charcoal	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Toothbrush, Wooden toothpicks, Other	0 (0%)	1 (1.0%)	1 (0.5%)	1 (3.0%)	0 (0%)	1 (1.0%)
Toothbrush, Wooden toothpicks, Dentalfloss	7 (6.9%)	2 (2.0%)	9 (4.5%)	1 (3.0%)	1 (1.5%)	2 (2.0%)
Toothbrush, Wooden toothpicks, Dentalfloss, Other	1 (1.0%)	2 (2.0%)	3 (1.5%)	0 (0%)	2 (3.0%)	2 (2.0%)
Toothbrush, Wooden toothpicks, Plastic toothpicks	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush, Wooden toothpicks, Plastic toothpicks, Other	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush, Wooden toothpicks, Plastic toothpicks, Dentalfloss, Charcoal	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush, Wooden toothpicks, Chewstick/miswak	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush, Dentalfloss	30 (29.4%)	17 (17.2%)	47 (23.4%)	6 (18.2%)	11 (16.7%)	17 (17.2%)
Toothbrush, Dentalfloss, Charcoal	2 (2.0%)	0 (0%)	2 (1.0%)	0 (0%)	0 (0%)	0 (0%)
Toothbrush, Dentalfloss, Other	9 (8.8%)	3 (3.0%)	12 (6.0%)	0 (0%)	3 (4.5%)	3 (3.0%)
Toothbrush, Plastic toothpicks	0 (0%)	2 (2.0%)	2 (1.0%)	0 (0%)	2 (3.0%)	2 (2.0%)
Toothbrush, Plastic toothpicks, Dentalfloss	2 (2.0%)	4 (4.0%)	6 (3.0%)	2 (6.1%)	2 (3.0%)	4 (4.0%)
Toothbrush, Plastic toothpicks, Dentalfloss, Charcoal	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush, Chewstick/miswak	1 (1.0%)	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)
Dentalfloss	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Missing data	0 (0%)	1 (1.0%)	1 (0.5%)	0 (0%)	1 (1.5%)	1 (1.0%)
Toothbrush						
Toothbrush	101 (99.0%)	98 (99.0%)	199 (99.0%)	33 (100%)	65 (98.5%)	98 (99.0%)
None	1 (1.0%)	1 (1.0%)	2 (1.0%)	0 (0%)	1 (1.5%)	1 (1.0%)
Dentalfloss						
Dentalfloss	52 (51.0%)	21 (21.2%)	73 (36.3%)	0 (0%)	21 (31.8%)	21 (21.2%)
None	50 (49.0%)	78 (78.8%)	128 (63.7%)	33 (100%)	45 (68.2%)	78 (78.8%)
Other						
Yes	22 (21.6%)	20 (20.2%)	42 (20.9%)	0 (0%)	20 (30.3%)	20 (20.2%)
None	80 (78.4%)	79 (79.8%)	159 (79.1%)	33 (100%)	46 (69.7%)	79 (79.8%)
Toothpaste						
Yes	102 (100%)	96 (97.0%)	198 (98.5%)	33 (100%)	63 (95.5%)	96 (97.0%)
No	0 (0%)	3 (3.0%)	3 (1.5%)	0 (0%)	3 (4.5%)	3 (3.0%)
Fluoride						
Yes	82 (80.4%)	66 (66.7%)	148 (73.6%)	23 (69.7%)	43 (65.2%)	66 (66.7%)
No	11 (10.8%)	14 (14.1%)	25 (12.4%)	5 (15.2%)	9 (13.6%)	14 (14.1%)
Don't know	9 (8.8%)	19 (19.2%)	28 (13.9%)	5 (15.2%)	14 (21.2%)	19 (19.2%)
	By diabetes (only diabetic patients)					

Table 2 (continued)

	Table 2a			Table 2b		
	Control (*N* = 102)	**DM (*N* = 99)**	**Overall (*N* = 201)**	**T1DM (*N* = 33)**	**T2DM (*N* = 66)**	**Overall (*N* = 99)**
Table 2c	**At least twice a day (N = 139)**	**Maximum once a day (N = 62)**	**Overall (N = 201)**			
Teeth						
1–9 teeth	22 (15.8%)	11 (17.7%)	33 (16.4%)			
10–19 teeth	26 (18.7%)	16 (25.8%)	42 (20.9%)			
20 teeth or more	91 (65.5%)	35 (56.5%)	126 (62.7%)			
Table 2d	**1–9 teeth (N = 22)**	**10–19 teeth (N = 23)**	**20 teeth or more (N = 54)**	**Overall (N = 99)**		
HbA1c level [%]						
Mean (SD)	6.81 (0.950)	7.06 (1.72)	6.59 (0.858)	6.75 (1.14)		
Median (IQR)	6.90 (1.05)	6.80 (1.44)	6.59 (1.18)	6.80 (1.13)		
Min, Max	4.80, 9.10	5.40, 14.0	4.80, 8.10	4.80, 14.0		

Table 3 Impact of diet and flossing on dental health across tooth categories

	Table 3/a			Table 3/b			Table 3/c		
Characteristic	**OR***	**95% CI****	**p-value**	**OR***	**95% CI****	**p-value**	**OR***	**95% CI****	**p-value**
Frequency teeth clean			0.74			0.31			0.19
At least twice a day	—	—		—	—		—	—	
Maximum once a day	0.82	0.25, 2.63		1.81	0.58, 5.80		1.88	0.73, 4.93	
Sex			0.59			0.16			0.89
Female	—	—		—	—		—	—	
Male	0.69	0.17, 2.61		0.40	0.10, 1.43		01.07	0.38, 2.96	
Age [years]	01.02	0.98, 1.06	0.39	1.10	1.06, 1.15	**< 0.001**	01.09	1.06, 1.13	**< 0.001**
Dentalfloss			0.52			**0.050**			0.48
Dentalfloss	—	—		—	—		—	—	
None	1.47	0.45, 4.97		2.94	1.00, 9.44		1.39	0.56, 3.55	
Fruits eating			**0.020**			**0.023**			0.41
Less	—	—		—	—		—	—	
More	3.81	1.23, 13.4		3.82	1.19, 14.2		0.68	0.27, 1.69	
Eating too much			0.25			0.84			0.36
No	—	—		—	—		—	—	
Yes	1.86	0.65, 5.49		1.11	0.40, 3.12		0.67	0.28, 1.57	
Group			0.31			0.27			0.88
Control	—	—		—	—		—	—	
Diabetes mellitus	1.72	0.60, 5.09		1.77	0.64, 5.06		0.94	0.39, 2.20	

* OR = Odds Ratio

** CI = Confidence Interval

emphasizes the need to include oral health education as an integral part of diabetes care programs.

Despite similar rates of brushing teeth twice a day (69.2% among PwD and controls), patients with DM had fewer teeth on average. Only 54.5% having 20 or more teeth compared to 70.6% of the control group. However, this relevant effect was found not significant in our statistical models. This finding aligns with existing literature, indicatings that individuals with DM are at higher risk of tooth loss due to the chronic inflammatory nature of periodontal disease commonly associated with DM [33, 34].

The reciprocal relation between DM (dysglycemia) and oral health indicates a detrimental cycle where one factor negatively influences the other. This interaction underscores the complexity of managing DM, where systemic inflammation, immune response, and oral microbial changes contribute to worsening oral health [11, 35]. Several diabetes associations, including the American Diabetes Association (ADA) and the International Diabetes Federation (IDF), recommend maintaining HbA1c levels below 7–8% to reduce the risk of complications [36]. In parallel, dental associations, such as the American Academy of Periodontology (AAP) and the European

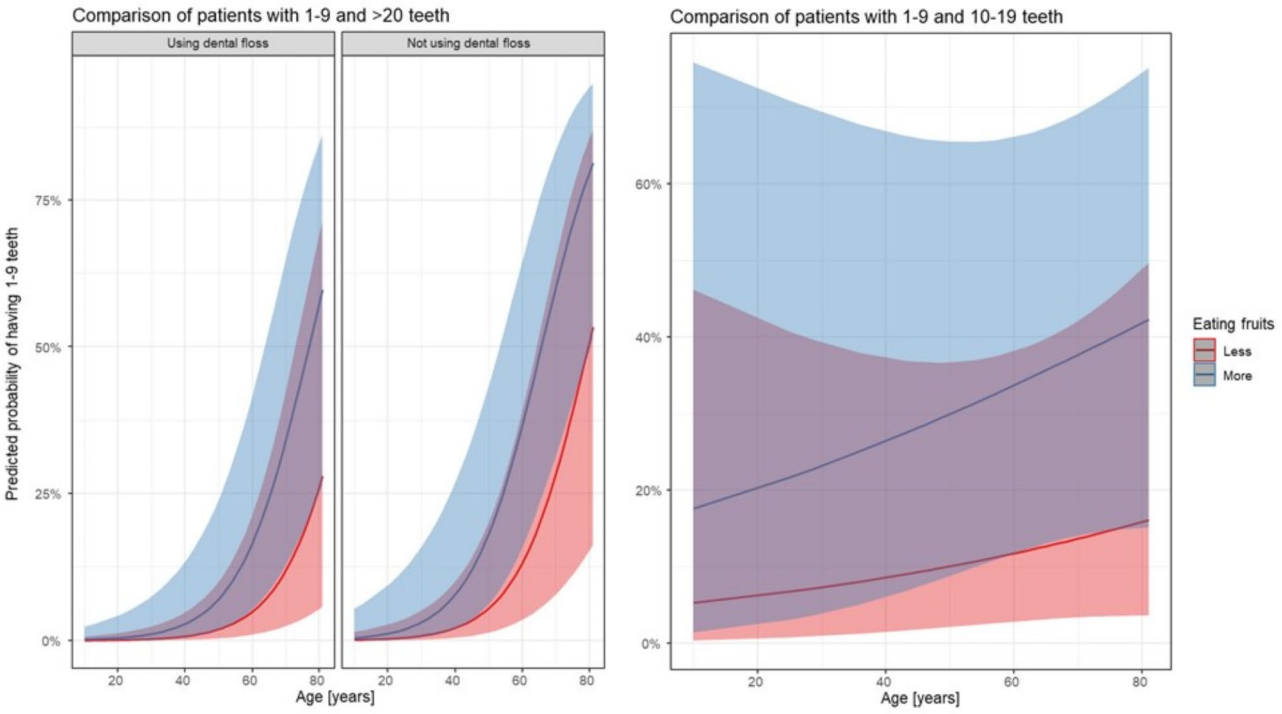


Fig. 1 Prediction plots: Predicted tooth retention by age, flossing, and fruit consumption

Federation of Periodontology (EFP), emphasize that individuals with diabetes should undergo regular dental check-ups (at least annually) and have their glycemic status monitored to minimize the risk of oral complications, including implant failure, impaired bone healing, delayed wound healing, and increased susceptibility to infections [37].

The relationship between DM type and oral health behaviours was particularly noteworthy. A higher proportion of patients with T1DM used advanced blood glucose monitoring technologies, such as sensors, and they generally reported better oral health compared to T2DM patients. T1DM patients were less likely to wear dentures, with 78.8% not using any form of dental prostheses, suggesting that their dental hygiene might be better. This is in contrast with T2DM patients, where self-reported dental and gum conditions were often rated as "average," indicating possible neglect of oral health or the cumulative effect of older age and prolonged duration of the disease [38].

Interdisciplinary cooperation is needed to provide the best care for our patients. Integrating dental care with diabetes management can address the interconnected risks and improve overall patient outcomes.

It is noteworthy that the study found no significant effect of number of teeth on HbA1c levels when controlling for age and gender, indicating that the severity of metabolic disease, characterized by higher HbA1c, is not affected by the number of teeth. However, the broader impact of DM on oral health is likely to involve complex interactions between systemic inflammation, immune response, and oral microbial changes [32].

Oral hygiene practices, such as the frequency of tooth brushing and dental flossing, differed between DM and non-DM individuals. Although 69.2% of participants brushed their teeth at least twice daily, this rate was slightly higher among T2DM patients (71.2%) compared to T1DM patients (45.5%). However, despite frequent brushing, the DM group tended to have fewer teeth compared to the control group. This may be attributed to the cumulative effects of DM on oral tissues, impaired wound healing, and susceptibility to infections, factors that significantly increase the risk of tooth loss [32]. The results underscore the importance of integrating specific oral health education and preventive care into DM management programs.

The use of dental floss and interdental cleaning aids was less common among DM participants; only 17.2% of DM patients reported flossing, compared to 29.4% in the control group. This discrepancy suggests that patients with DM may benefit from additional education on comprehensive oral hygiene practices, beyond regular brushing.

The use of logistic regression models highlighted the complex interplay between diet, oral hygiene, and dental outcomes, emphasizing that higher fruit consumption and inadequate flossing may lead to a significantly increased risk of severe tooth loss, independent of DM status. These findings underscore the universal need for

interdisciplinary care models that integrate oral health into diabetes management protocols [3].

A key limitation of this study is the reliance on self-reported data, which may not fully reflect clinical oral health status. Self-reported measures are subject to recall bias and individual perception differences, potentially affecting accuracy. Future research should integrate objective clinical assessments, such as dental examinations and periodontal evaluations, to validate these findings and provide a more comprehensive understanding of oral health outcomes in diabetes patients.

Overall, the study highlights the need for a multidisciplinary approach to DM care, emphasizing the integration of routine dental check-ups, improved education on oral hygiene, and close collaboration between diabetologists and dentists to address the oral health risks associated with diabetes.

Limitations

As a pilot study, this research has inherent limitations, including a small sample size and reliance on self-reported data, which may introduce biases. Additionally, the cross-sectional design prevents causal inferences. Despite these constraints, the findings offer valuable preliminary insights and highlight the need for larger, longitudinal studies. This pilot study provides a foundation for future, larger-scale research to validate these preliminary findings and explore causal relationships in greater depth.

Conclusion

The findings of this study highlight significant oral health disparities between DM and non-DM individuals. Patients with DM, particularly those with T2DM, report poorer oral health outcomes, more frequent denture use, and fewer natural teeth despite similar oral hygiene practices. These results emphasize the need for targeted oral health interventions, including comprehensive oral hygiene education, preventive care, and stronger integration between dental and diabetes care.

Annual dental check-ups are recommended for all DM patients, with biannual visits for those with periodontal disease. The "Budapest pilot" at the Semmelweis University Diabetes Dental Research Group further reinforces the importance of early referral and interdisciplinary cooperation to enhance patient outcomes. From a public health perspective, improving oral health awareness among DM patients is essential for prevention and long-term disease management. Future research will focus on conducting longitudinal studies to further explore the relationship between diabetes and oral health, as well as developing targeted preventive strategies.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-025-05820-x.

Supplementary Material 1

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Author contributions

All authors made substantial contributions to the present study. KL and LL participated in patient recruitment and performed the documentation. KL and LL were major contributors to the writing of the manuscript. DSV acquired and analyzed the data. DV and PH revised the manuscript before submission. All authors have read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed in the current study are available from the corresponding author upon reasonable request. These datasets include de-identified participant data and comply with ethical and privacy considerations.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethical Board of Semmelweis University (ethical clearance number BM/6562-4/2023). All participants provided their full written informed consent to participate in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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A neuropathia diabetica és a szájüregi betegségek közötti potenciális összefüggés bemutatása egy eset kapcsán

Lipták Klaudia dr.,[1] Lipták Laura dr.,[2] Hermann Péter dr.,[1] Végh Dániel dr.,[1] Balaton Gergely dr.,[2] Kempler Péter dr.,[3] Körei Anna dr.,[3] Rózsa Noémi Katinka dr.[2]

[1] Semmelweis Egyetem, Fogorvostudományi Kar, Fogpótlástani Klinika, Budapest
[2] Semmelweis Egyetem, Gyermekfogászati és Fogszabályozási Klinika, Budapest
[3] Semmelweis Egyetem, Belgyógyászati és Onkológiai Klinika, Budapest

Kulcsszavak

- **diabetes mellitus**
- **diabéteszes neuropathia**
- **fogászati implantátum**
- **szájhigiéné**

Összefoglalás

A diabéteszes polyneuropathia a cukorbetegség leggyakoribb krónikus szövődménye, mely jelentős morbiditással és mortalitással jár. Egyes – cukorbetegekben gyakori – szájüregi eltérések – az égő száj szindróma, az ízérzés károsodása, a fájdalomérzés csökkenése vagy a parodontitis – összefüggést mutatnak a diabéteszes polyneuropathia fennállásával.

A szerzők egy 46 éves férfi beteg esetét mutatják be, akinek cukorbetegségét 2019-ben igazolták. A beteg kedvezőtlen anyagcserehelyzete miatt már ekkor intenzív konzervatív inzulinkezelés (humán ICT) indult. A beteg rendszeres diabetológiai kontrollra, szűrővizsgálatokra nem járt; látókörünkbe ismételten 2020-ben fogászati problémák miatt került. A beteg súlyos szájüregi elváltozásai hátterében felmerült a diabéteszes szenzomotoros polyneuropathia következtében kialakult hypaesthesia kóroki szerepe is. Neuropathiavizsgálat során mind a négy végtagot érintő, súlyos hypaesthesisás típusú szenzoros neuropathia volt igazolható. A kardiovaszkuláris reflextesztek ortosztatikus hipotóniára utaltak szimpatikus autonóm neuropathia kórjeleként.

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A levelezésért felelős szerző: Dr. Lipták Klaudia
Semmelweis Egyetem, Fogorvostudományi Kar, Fogpótlástani Klinika
1088 Budapest, Szentkirályi u. 47.
E-mail: liptak.klaudia_margit@dent.semmelweis-univ.hu

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A felső állcsonton implantátumokon elhorgonyzott fémkerámia sínt és 3 tagú hidat, illetve 5 tagú fémkerámia sínt terveztünk. Az alsó állcsontra protetikai terv nem készült, folyamatos konzervatív kezelést végzünk. A szerzők esetismertetésükkel elsősorban a diabéteszes neuropathia és a szájüregi állapot közötti összefüggés lehetőségére, valamint a megfelelő szájhigiénére és a rendszeres és szoros fogászati kontrollra szeretnék felhívni a figyelmet. A diabéteszes neuropathia által okozott szájüregi hypaesthesia hozzájárulhat ahhoz, hogy a betegek későn keresnek megfelelő fogászati ellátást. A parodontitis által kiváltott proinflammatorikus citokinexpresszió, illetve a hiperglikémia és microangiopathia mint közös patogenetikai tényezők magyarázhatják az előrehaladott parodontitis és a diabéteszes neuropathia közötti összefüggést.

Key words
- **dental implant**
- **diabetes mellitus**
- **neuropathy**
- **oral health**

Presentation of the potential relationship between diabetic neuropathy and oral cavity conditions – a case report

Diabetic polyneuropathy is one of the most deleterious complication of diabetes mellitus with significant morbidity and mortality. Some oral symptoms frequently found in diabetic patients – such as the „burning mouth", gustatory dysfunction and periodontitis may be related to diabetic polyneuropathy.
The authors present the case of a 46-year-old male patient whose diabetes was confirmed in 2019. Due to poor metabolic control (HbA_{1c}), the patient was given human basal-bolus insulin therapy. The patient neither attended diabetology controls nor screenings for diabetic complications during the next 3 years. In 2022, the patient showed up again due to teeth loss. At the Department of Prosthodontics, high-level prothetisation was indicated. Based on the advanced oral cavity alterations in the young patient, the role of severe hypaesthesia as a consequence of diabetic polyneuropathy emerged. Neuropathy examinations indicated severe sensory hypaesthesia of all limbs. Cardiovascular reflex tests proved orthostatic hypotension as a sign of sympathetic autonomic neuropathy.
We designed a metal-ceramic splint and a 3-member bridge and a 5-member metal-ceramic splint anchored on implants on the upper jaw. No prosthetic plan was prepared for the lower jawbone, we planned a conservative restoration.
The authors would like to draw attention to the potential associations between diabetic polyneuropathy and oral cavity symptoms, oral hygiene and the importance of regular dental follow-up. Oral hypaesthesia caused by diabetic polyneuropathy can contribute to the fact that diabetic patients seek for dental help only in advanced stages of oral pathology. Besides, proinflammatory cytokine expression evoked by periodontal processes as well as hyperglycaemia and microangiopathy as common pathways might explain the relation between advanced periodontitis and diabetic polyneuropathy.

A diabéteszes neuropathia a cukorbetegség leggyakoribb mikrovaszkuláris szövődménye, magas morbiditással és mortalitással társul, valamint jelentősen rontja betegeink életminőségét.[1] Az 1-es és 2-es típusú cukorbetegségben szenvedő betegek akár 50%-ánál is kialakul élete során a diabéteszes neuropathia,[2,3] és az újonnan diagnosztizált diabéteszes betegek csaknem egytizede (8%) már szenved ebben a betegségben.[2] Klinikai formái széles skálát mutatnak, ezek közül a disztális, szimmetrikus polyneuropathia a legelterjedtebb. Számos szájüregi szövődmény, köztük az égő száj („burning mouth" vagy glossodynia) szindróma, a szájszárazság, valamint az ízérzés és szaglás károsodása (dysgeusia és olfactorius dysfunctio) a diabéteszes neuropathia kevésbé ismert megnyilvánulása, így ezeket gyakran figyelmen kívül hagyják. A parodontitis, a fogak elvesztése és a temporomandibuláris ízület diszfunkciója szintén gyakran jelen van.

Számos szakirodalmi adat bizonyítja a szájüregi elváltozások és a nem megfelelően kontrollált cukorbetegség közötti összefüggést, aminek nyomán a parodontitist 1993-ban a cukorbetegség hatodik szövődményének nyilvánította az Amerikai Nemzeti Fogászati Kutatóintézet igazgatója, *H. Löe.*[4] Ez az összefüggés és a rendszeres fogászati kontroll, illetve a szájüregi higiéné jelentősége cukorbetegek körében ugyanakkor egészen a közelmúltig nem kapott kellő figyelmet a klinikai gyakorlatban. Az összefüggés jelentőségét húzza alá, hogy a parodontális betegség is negatívan befolyásolja a szénhidrátanyagcsere-helyzetet,[5] így a parodontitis és a hiperglikémia kölcsönösen hátrányosan befolyásolják egymást.[6,7]

A cukorbetegség jelenlegi kezelésében a szájüreget gyakran figyelmen kívül hagyják, annak ellenére, hogy szakmai társaságok, például az American Diabetes Association (ADA) azt ajánlják, hogy a rendszeres cukorbeteggondozás részeként a fogorvosi vizsgálatra való beutalás is szerepeljen.[5,8] A szájüregi állapotok és betegségek azonban gyakran észrevétlenek maradnak, mivel nem feltétlenül okoznak fájdalmat, vérzést vagy egyéb tüneteket, vagy mert a beteg nem jelzi fogászati panaszait orvosának. A fogágybetegség két leggyakoribb formájának egyike az ínygyulladás, amely egy visszafordítható fertőzés, a fog körüli lágyrészek későbbi gyulladásával jár, amit otthoni szájhigiéniával kezeltek, néhány napon belül elmúlik. Az ínygyulladás a világ népességének akár 90%-át érinti.[9] Ezzel szemben a parodontitis egy multifaktoriális, krónikus bakteriális fertőzés következménye, amely érzékeny egyénekben a fogakat körülvevő lágy és kemény szövetek gyulladásához és leépüléséhez vezet, ami kezelés hiányában végül a fog/fogak mozgathatóvá válásához és teljes elvesztéséhez vezethet. A súlyos parodontális betegség a hatodik legelterjedtebb betegség a világon (11,2%).[10]

Cukorbetegekben a sztomatológiai elváltozások és a neuropathia összefüggését eddig kevéssé vizsgálták. Feltételezhető, hogy a diabéteszes neuropathia által okozott érzéscsökkenés következtében a beteg később észleli a fogak, illetve a szájüreg elváltozásait, így a neuropathia fogászati elváltozások korai felismerésének korlátja lehet.

Esetismertetésünkkel a sztomatológiai elváltozások és a nem megfelelően kontrollált diabétesz, valamint a diabéteszes polyneuropathia közötti összefüggésekre szeretnénk felhívni a figyelmet. Emellett hangsúlyozzuk a fogászati szűrővizsgálatok fontosságát a diabetológiai gondozás során.

ESETISMERTETÉS

Anamnézis

A 46 éves férfi beteg kórelőzményében hipertónia és 2-es típusú cukorbetegség szerepel. Cukorbetegsége 2019 óta volt ismert, jelentős mértékű hiperglikémia miatt metformin mellett már a kezdetektől intenzív konzervatív inzulinkezelésben részesült (humán ICT). Emellett hosszú évek óta jelentős obezitás is fennállt (BMI: 43,8 kg/m^2). A beteg rendszeres diabetológiai gondozásra nem járt, a cukorbetegség mikro- és makrovaszkuláris szövődményei irányában szükséges szűrővizsgálatok nem történtek. A beteg kezelését később napi egyszeri bázisinzulin-kezelésre módosították (Insulatard, 36 E/die), melyet – az obezitás és a magas kardiovaszkuláris kockázatot figyelembe véve – az évek során SGLT-2-gátló empagliflozinnal egészítettek ki. Fentiek a beteg elmondásán alapultak, dokumentáció nem állt rendelkezésre, az EESZT-ben semmilyen adat nem volt fellelhető. Hyperuricaemia vagy hyperlipidaemia kezelésére gyógyszeres kezelésben nem részesült. A beteg fiatal kora ellenére számos fogászati kezelésen esett már át.

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Fogászati vizsgálat

Az első találkozás – bár a betegnek voltak fogászati panaszai is – nem emiatt, hanem a frontfogak nem megfelelő esztétikai állapota miatt jött létre *(1. ábra)*. Sztomatológiai vizsgálat során előrehaladott carieses léziók, gyökércsúcs körüli gyulladások, foghiányok voltak megfigyelhetők. Emellett a szájhigiéné sem volt megfelelő. A késői jelentkezés oka – a gyermekkori rossz élmények alapján – a fogászati beavatkozásoktól való félelem volt. Ezért a beteg nehezen vette rá magát fogorvosi rendelő felkeresésére. Rendszeresen mosott fogat, ennek ellenére rossz állapotba került a fogazata. A kezelési sor a jelentősen destruált frontfogak kezelésével kezdődött. A szuvas léziók néhány fog esetében (11, 21, 22) elérték a pulpakamrát, így azok gyökérkezelése vált szükségessé. Fontos azt is kiemelni,



1. ábra. Kiindulási ortopantomogram-felvétel



2. ábra. A behelyezett implantátum a gyógyulási időt követően

hogy az elhanyagolt diabétesz mellett a fogászati kontrollokra sem járt éveken keresztül. A későbbiekben sztomatológiai szempontból együttműködése javult, így a fogászati beavatkozások is tervezhetővé váltak. Az érzelmi gátak folyamatos leomlása után egyre több beavatkozáshoz járult hozzá, a tömésektől egészen a fogászati implantátumok behelyezéséig *(2. ábra)*.

A beteg számára az előrehaladott fogszuvasodás, a letört fogkoronák fájdalmat, panaszokat csak hosszú idő után okoztak, az eltérések esztétikai szempontból jelentettek problémát – különösen a korábban már említett frontfogak területén.

A súlyos, fájdalmatlan orális eltérések felvetik annak lehetőségét, hogy – mivel a diabéteszes neuropathia által okozott érzéscsökkenés mindenfajta érzetre vonatkozik – a beteg a fájdalomérzet és hőérzet kiesése következtében nem vagy későn érezte a fogszuvasodással járó esetleges fájdalmakat. Ez magyarázhatja a kórfolyamatok késői észlelését, aminek következtében a megfelelő kezelésre is csak megkésve kerülhetett sor.

Neuropathiavizsgálat

A szenzoros neuropathia értékelése Neurometer diagnosztikus készülék segítségével történt, mellyel mind a négy végtagon áramérzet-küszöbértéket határoztunk meg. A vizsgálat során – a hypaesthesisának megfelelően – a bal felső végtag vastag és vékony mielinizált rostjain, valamint a jobb felső végtag és mindkét alsó végtag mindhárom szenzoros rostféleségén emelkedett áramérzet-küszöbértékek voltak kimutathatóak. Az alsó végtagokon a szenzoros rostok károsodása extrém súlyosnak bizonyult *(1. táblázat)*.

A kardiovaszkuláris autonóm funkciót a hagyományos kardiovaszkuláris reflextesztek segítségével értékeltük. A mélylégzés-teszt mutatott kóros eredményt, illetve 24 Hgmm-es ortosztatikus hipotónia (szisztolés vérnyomásesés) volt észlelhető.

A beteg számára a – testsúlytöbbletet is figyelembe véve – a humáninzulin-kezelés távol állt az ideálistól, az egyéb kardiovaszkuláris rizikófaktorok tekintetében is a gyógyszeres kezelés kiegészítése lett volna szükséges. A kezelés deeszkalációját terveztük – a testsúlycsökkenést és a kardiovaszkuláris rizikócsökkentést előmozdítandó – a metformin + empagliflozin terápia megtartása mellett az intenzív inzulinterápia GLP-1-RA + bázisinzulin-analóg fix kombinációjára történő átállításával. A beteg számára a klinikai felvétel és a diabetológiai gondozásba vétel lehetőségét felajánlottuk, azonban nem kívánt élni a lehetőséggel.

Fogászati kezelési terv

A klinikai vizsgálat, röntgenfelvételek és tanulmányi minták alapján elkészítettük a kezelési tervet. A felső állcsonton implantátumokon elhorgonyzott fémkerámia sínt (pillérek: 14, 15) és 3 tagú hidat (pillérek: 23, 25 hézagfog: 24), illetve 5 tagú fémkerámia sínt (pillérek: 13, 12, 11, 21, 22) terveztünk. Az alsó állcsontra protetikai terv nem készült, konzervatív helyreállítást terveztünk.

A fogászati kezelés menete

A kezelési terv ismertetése és elfogadása után professzionális szájhigiénés kezeléssel kezdtük a beavatkozást, mely a szub- és szupragingivális fogkő eltávolításából és a fogfelszínek polírozásából állt. A beteget a helyes szájápolási technikák elsajátítására motiváltuk, különös hangsúlyt fektetve a fogközök tisztítására. A protetikai helyreállítást konzerváló fogászati beavatkozások előzték meg, melyek során 11-es, 21-es, 22-es, 35-ös, 45-ös fogak gyökérkezelése történt meg. Az 14, 15, 23, 25 pozícióban implantátumok kerültek behelyezésre, amit 3 hónapos csontgyógyulás követett. Következő lépésként az 11-es, 21-es, 22-es fogak preparációja történt meg. A lenyomatvételt követően elkészültek a fogpótlások fémvázai, majd

1. táblázat. A beteg Neurometer készülékkel mért áramérzet-küszöbértékei

Áramérzet-küszöbértékek (CPTs) (mA)						
Nervus medianus				Nervus peroneus		
Bal	Normális tartomány	Jobb		Bal	Normális tartomány	Jobb
0,5	1,20–3,98	6,00	**2000 Hz**	9,99	1,79–5,23	9,99
2,8	0,22–1,89	2,58	**250 Hz**	9,99	0,44–2,08	9,99
0,6	0,16–1,01	1,65	**5 Hz**	9,99	0,18–1,70	9,99

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3. ábra. A kész fogpótlás ortopantomogram-felvételen a felső állcsonton

a végleges fogpótlások *(3. ábra)*, melyeket a természetes fogakra cementtel, az implantátumokra csavarokkal rögzítettünk.

MEGBESZÉLÉS

Bár a diabetes mellitus mikro- és makrovaszkuláris szövődményei széles körben ismertek, a fogászati szövődményekről a mai napig csak ritkán tesznek említést. Ugyanakkor a diabetes mellitus fennállása – különösen a kedvezőtlen szénhidrátanyagcsere-helyzet – növeli a szájüregi kórfolyamatok előfordulását.

Cukorbetegségben gyakoribbak és súlyosabbak a fogászati szövődmények, melyek a krónikus szövődmények közül elsősorban a neuropathiával mutatnak összefüggést. Talán a legtöbb bizonyíték a parodontitis (régebbi nevén parodontosis) és a diabétesz összefüggésével kapcsolatban áll rendelkezésre, hiszen *Harald Löe* professzor publikációja[4] nyomán ez a cukorbetegség leggyakrabban vizsgált fogászati szövődménye. Több keresztmetszeti[11,12] és prospektív vizsgálat,[13,14,15] illetve számos keresztmetszeti és prospektív tanulmány adatai alapján végzett metaanalízis[16] is igazolta, hogy a parodontitis szignifikánsan gyakoribb és súlyosabb cukorbetegekben. A mérföldkövet a pima indiánok körében végzett vizsgálatok jelentették az 1990-es években: a nem megfelelően kontrollált diabéteszes betegekben kétszeres prevalenciát észleltek az optimális glikémiás kontrollal rendelkező cukorbetegekhez képest.[12] Rossz anyagcserehelyzet esetén az alveoláris csontvesztés nagyobb mértékű volt és gyorsabb volt a betegség progressziója.[14] A glikémiás kontroll jelentőségét húzzák alá azok a vizsgálatok, melyekben nem találtak érdemi különbséget a szövődmény tekintetében a jól kontrollált diabéteszes betegek és az egészséges kontrollok között.[15]

De miért lehetnek gyakoribbak és súlyosabbak cukorbetegekben a parodontitis és az egyéb fogászati szövődmények? Egy hipotézis szerint a vér magasabb cukortartalma miatt a glükózkoncentráció a nyálban is magasabb értéket ér el, és ez direkt károsító hatású lehet. Másrészt, a diabétesz részben egy állandó proinflammatorikus állapottal, részben megváltozott immunstátusszal jár, így a betegek fogékonyabbak lehetnek a szájüregi patogének iránt, és az elhúzódó vagy nem elégséges sebgyógyulási folyamatok következtében gyakoribbá válik a parodontális megbetegség.

Fontos patogenetikai tényező lehet a hyposalivatio is. A csökkent nyálelválasztás miatt számos protektív és regenerációt segítő faktor (laktoferrin, immunglobulinok, nyálamiláz, EGF [epithelial growth factor – epiteliális növekedési faktor]) szekréciója károsodik. Emellett a diabétesz, illetve a diabéteszes neuropathia és a periodontitis számos közös rizikófaktorral rendelkezik, mint a hipertónia, a hyperlipidaemia, a dohányzás, a magasabb életkor, az obezitás, az alkoholfogyasztás és a D-vitamin-hiány, örökletes és szocioökonómiai tényezők.[6] A microangiopathia érintheti a periapikális szöveteket – ez szintén a diabéteszes neuropathiával közös patomechanikai tényező.

A fent említett hyposalivatio, a nyálelválasztás objektív mérőmódszerrel kimutatható csökkenése hátterében a nyálmirigyek beidegzésének károsodása állhat diabéteszes neuropathia részjelenségeként. A hyposalivatio elősegíti a caries, a parodontitis kialakulását.[6] A hyposalivatio összefügg az anyagcserehelyzettel: a pittsburghi diabéteszszövődmény-vizsgálatban az 1-es típusú diabéteszben szenvedők körében mind a perifériás, mind az autonóm neuropathiás betegekben gyakoribb volt a szájszárazság, akár a szubjektív xerostomiát, akár a hyposalivatiót tekintve.[16]

Az „égő száj" (burning mouth vagy glossodynia) egy állandó (hónapokon át minden nap jelentkező) égő, csipkedő, zsibbadó fájdalom, mely leggyakrabban a nyelv hegyét érinti. A pittsburghi szövődményvizsgálatban egyértelmű összefüggés adódott a perifériás neuropathia és a glossodynia között.[17] Az „égő száj" a fájdalmas diabéteszes neuropathia orofaciális manifesztációjának tűnik.[18]

Jól ismert cukorbetegekben a szenzomotoros polyneuropathia pozitív és negatív tünetegyüttese. A negatív tünetegyüttes a fiziológiás érzetek (tapintás, hőérzet, ízületi helyzetérzés stb.) csökkenését, sőt akár teljes kiesését jelenti, míg a pozitív tünetegyüttes fiziológiásan nem jelen lévő érzetek (zsibbadás, égő érzés, fájdalom, allodynia) megjelenését. Betegünk szubjektív panaszt nem említett, xerostomiát, trigenimális fájdalmat vagy glossodyniát rákérdezésre is negált: vagyis a diabéteszes szenzomotoros polyneuropathia – ez esetben orofaciális – pozitív tünetegyüttese nem volt jelen. Ugyanakkor a sztomatológiai szakvizsgálat során igen kiterjedt carieses folyamatok, parodontitis mutatkozott, ami a beteg számára kezdetben fogérzékenységet, fájdalmat egyáltalán nem vagy csak minimális mértékben okoztak. Ez felveti jelentős, az orofaciális területet érintő hypaesthesiás típusú szenzoros károsodás lehetőségét a diabéteszes polyneuropathia következtében, vagyis a beteg a fogak, az íny vagy az állcsont területét beidegző idegrostok károsodása következtében nem érezhette a cariest és a parodontitist egyébként általában kísérő fájdalmat. Ez megfelelhet a szenzoros neuropathia „negatív" tünetegyüttesének, a fogak elvesztése pedig – mint következményes szövődmény – a fájdalmatlan talpi fekéllyel vagy a silent infarktussal mutathat párhuzamot. Betegünk esetében a súlyos fokú parodontális betegség igen kifejezett mértékű hypaesthesiás típusú szenzoros idegkárosodással társult. Természetesen messzemenő ok-okozati összefüggés a diabéteszes neuropathia és a parodontitis között esetünk alapján nem vonható le, de a két kórkép kapcsolata mindenképpen további vizsgálatra érdemes. Egy nemrégiben megjelent vizsgálatban a parodontitis súlyossági mutatói összefüggést mutattak 2-es típusú diabéteszes betegekben a glikémiás kontrollal, a diabéteszes perifériás, szenzoros neuropathia súlyosságával és a diabéteszes láb szindróma fennállásával.[19] A fogágybetegség diabéteszes neuropathiával és talpi fekély fennállásával mutatott független összefüggését igazolta egy brazil felmérés is, amelyben a teljesen fogatlan, illetve a mérsékelt/súlyos parodontitisben szenvedő 2-es típusú cukorbetegek kétharmadában volt jelen talpi fekély; ez utóbbi és a parodontitis közötti összefüggés ez esetben is független volt minden egyéb kockázati tényezőtől.[20]

A fentiek alapján a cukorbetegek ellátása során javasolt kitérni a diabetológiai gondozás során az évenkénti fogászati szűrővizsgálatra és a szájápolás fontosságára. Betegünk esetében látható, hogy súlyos, fogvesztéshez vezető carieses, parodontális folyamatok tünetmentesen zajlanak le cukorbetegségben, és e folyamatok elhanyagolt anyagcserehelyzet fennállásakor már rövid diabétesztartam esetén kifejezett destrukciót okozhatnak. A diabéteszes neuropathia által okozott szájüregi hypaesthesia hozzájárulhat ahhoz, hogy a betegek későn keresnek megfelelő fogászati ellátást.

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Fogászati szűrővizsgálat fontossága a cukorbetegek ellátásában: a Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportjának szerepe

Lipták Laura,[1] Lipták Klaudia,[2] Hermann Péter,[2] Rózsa Noémi Katinka,[1] Somogyi Kata Sára,[2] Végh Ádám,[3] Bencze Bulcsú,[2] Kammerhofer Gábor,[4] Németh Zsolt,[4] Ujpál Márta,[4] Somogyi Anikó,[5] Dobó Nagy Csaba,[3] Somogyi Andrea,[2] Merkely Béla,[6] Moldován Anna,[1] Hegedüs Tamás,[2] Bányai Dorottya,[1] Kempler Péter,[7] Végh Dániel[2]

[1] Semmelweis Egyetem, Fogorvostudományi Kar, Gyermekfogászati és Fogszabályozási Klinika, Budapest
[2] Semmelweis Egyetem, Fogorvostudományi Kar, Fogpótlástani Klinika, Budapest
[3] Semmelweis Egyetem, Fogorvostudományi Kar, Orális Diagnosztikai Tanszék, Budapest
[4] Semmelweis Egyetem, Fogorvostudományi Kar, Arc-Állcsont-Szájsebészeti és Fogászati Klinika, Budapest
[5] Semmelweis Egyetem, Általános Orvostudományi Kar, Belgyógyászati és Hematológiai Klinika, Budapest
[6] Semmelweis Egyetem, Általános Orvostudományi Kar, Városmajori Szív- és Érgyógyászati Klinika, Budapest
[7] Semmelweis Egyetem, Általános Orvostudományi Kar, Belgyógyászati és Onkológiai Klinika, Budapest

Kulcsszavak

- **betegedukáció**
- **diabetes mellitus**
- **fogászati szűrővizsgálat**
- **multidiszciplináris megközelítés**
- **szájüregi szövődmények**

Összefoglalás

A diabetes mellitus világszerte egyre növekvő népegészségügyi problémát jelent, amely számos szövődménnyel járhat, beleértve az orális egészséget érintő elváltozásokat is. A diabétesszel élő betegek körében magasabb a parodontális betegségek, a fogszuvasodás és egyéb szájüregi problémák előfordulási aránya, amelyek jelentős hatással lehetnek az életminőségre és a vércukorszint szabályozására is.

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A levelezésért felelős szerző: Dr. Lipták Laura
Semmelweis Egyetem Gyermekfogászati és Fogszabályozási Klinika
1088 Budapest, Szentkirályi u. 47. V. em.
E-mail: liptak.laura.maria@semmelweis.hu

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A Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportja multidiszciplináris megközelítéssel dolgozik a cukorbetegek szájüregi egészségének javítása érdekében, integrálva a fogorvosi és diabetológiai ellátást. Nemzetközi példák is igazolják, hogy az interdiszciplináris betegellátás és a rendszeres fogászati ellenőrzés hozzájárulhat a diabéteszes szövődmények csökkentéséhez. A jelen tanulmány célja bemutatni a Semmelweis Egyetemen működő integrált betegút modellt, amely elősegítheti a diabétesszel élő betegek korai diagnózisát, kezelését és a hosszú távú egészségügyi kimenetelek javítását.

Key words
- **dental screening examination**
- **diabetes mellitus**
- **multidisciplinary approach**
- **patient education**
- **oral complications**

Diabetes and oral health: The role of the Semmelweis University Diabetes Dental Working Group

Diabetes mellitus is a growing global public health concern, associated with multiple complications, including significant oral health issues. Patients with diabetes mellitus are at a higher risk of developing periodontal diseases, dental caries, and other oral conditions, which can negatively impact their quality of life and glycemic control. The Semmelweis University Diabetes Dental Working Group developed a multidisciplinary approach to enhance the oral health of patients with diabetes by integrating dental and diabetological care. International studies confirm that interdisciplinary patient care and regular dental check-ups can reduce the incidence of diabetes-related complications. This study aims to present the integrated patient care model implemented at Semmelweis University, which facilitates early diagnosis, treatment, and improved long-term health outcomes for patients with diabetes.

Becslések alapján 2021-ben világszerte 537 millió ember élt cukorbetegséggel, ez a szám várhatóan folyamatosan emelkedik, és 2030-ra eléri a 643 milliót, míg 2045-re a 783 milliót az IDF Diabetes Atlas szerint.[1] A cukorbetegség a magyarok körülbelül 10%-át, azon belül is a 65 év felettiek több mint egyharmadát érinti.[2] Statisztikai adatok alapján a fogorvosi rendelőbe érkező betegek közül átlagosan minden tizedik cukorbeteg. Emiatt nemcsak az általános orvosok, hanem a fogorvosok számára is fontos a cukorbetegséggel kapcsolatos alapismeretek elsajátítása, illetve a fogorvosi szűrővizsgálat évenkénti beütemezése. Számos bizonyíték igazolja, hogy a rosszul kontrollált diabétesz szövődményei a szájüregben is megjelennek. A tartós hiperglikémia számos szervrendszerben komplikációk kialakulásához vezet, különösen a kisérkárosodás következtében, amely neuropátiás károsodást és endoteliális diszfunkciót eredményezhet.[3] A diabéteszhez kapcsolódó szájüregi elváltozások a felnőttek mellett a gyermekekben is megjelennek, ezek a következők: xerosztómia (szájszárazság), fogszuvasodás, ínybetegségek (parodontitisz és gingivitisz), orális kandidiázis, égő száj szindróma (burning mouth syndrome), ízérzékelési zavarok, rhinocerebrális zygomycosis (mucormycosis), aspergillosis, orális lichen planus, térképnyelv és repedezett nyelv, késleltetett sebgyógyulás, fertőzések fokozott előfordulása, nyálmirigy-diszfunkció, megváltozott ízérzékelés és egyéb neuroszenzoros zavarok, a fogak áttörésének károsodása, valamint jóindulatú parotisz-hipertrófia.[4] Több mint három évtizeddel ezelőtt *Harald Löe,* világhírű parodontológus a diabétesz hatodik szövődményeként azonosította a parodontitiszt, a fog támasztószöveteinek súlyos és irreverzibilis károsodását.[5] A parodontális betegségek két leggyakoribb formája a gingivitisz és a parodontitisz,

amelyek a fogat körülvevő kemény- és lágyszövetek gyulladásos folyamatai. A gingivitisz a világ népességének 90%-át érinti.[6] A cukorbetegek fokozott hajlamot mutatnak parodontális betegségek kialakulására, és körükben ezek előfordulási kockázata kétszer-háromszor magasabb, mint a cukorbetegséggel nem élő egyének esetében. Különösen fontos, hogy a parodontális betegség negatívan befolyásolja a vércukorszintet, így a parodontitisz és a hiperglikémia kölcsönösen és kétirányúan potencírozzák és súlyosbítják egymás hatásait.[5,7,8] A megemelkedett vércukorszint elősegíti az előrehaladott glikációs végtermékek (advanced glycation end-products – AGE) képződését, amelyek növelik a proinflammatorikus citokinek helyi termelődését a gingivális szövetekben. További kóroki mechanizmusokat is azonosítottak, ezek közé tartozik az oxidatív stressz, a cirkuláris RNS szintjének emelkedése és a neutrofil leukociták hiperaktivitása.[9,10,11,12] Ezek a mechanikai hatások a parodontális szövetekben növelik a parodontitisz és ennek esetleges következményeként előforduló fogvesztés kockázatát.[13,14]

A xerosztómia a 2-es típusú diabétesszel (T2DM) élő betegek akár 46%-ánál is előfordulhat, ami közvetlenül összefügg a csökkent nyáltermeléssel és a megemelkedett glükózszinttel a nyálban, hozzájárulva a fogszuvasodás kialakulásához, a táplálékfelvétellel kapcsolatos nehézségekhez, valamint a fogpótlások használatának problémáihoz.[15] A diabéteszes neuropátia gyakran szerepet játszik az égő száj szindróma kialakulásában, amely valószínűleg a tartós hiperglikémia idegrendszerre gyakorolt hatása miatt alakul ki.[16]

A diabéteszes betegek gondozását végző kollégák gyakran figyelmen kívül hagyják a szájüreget. A Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportja azt javasolja, hogy a rutin diabéteszszűrés foglalja magába a fogászati vizsgálatra történő beutalást is.[17,18] A cikk célja, hogy átfogó képet nyújtson a Semmelweis Egyetemen belül a cukorbetegek betegútjáról, különös tekintettel a diabetológusok és fogorvosok közötti szakmai együttműködésre. Bemutatja a Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportjának működését, valamint azt, hogy ez az integrált, multidiszciplináris megközelítés hogyan segíti elő a diabétesszel élő betegek szájüregi szövődményeinek hatékony felismerését, kezelését és megelőzését. A tanulmány rávilágít a diabétesz és az orális egészség közötti szoros kapcsolatra, hangsúlyozva az interdiszciplináris együttműködés fontosságát a betegek életminőségének javításában és az ellátás optimalizálásában.

A CUKORBETEGSÉG EPIDEMIOLÓGIAI HELYZETE MAGYARORSZÁGON

A Központi Statisztikai Hivatal (KSH) legfrissebb, 2019-es adatai alapján Magyarországon több mint 1,1 millió felnőtt és több mint 5 ezer gyermek él cukorbetegséggel. Az adatok azt mutatják, hogy a diabétesz előfordulása az életkor előrehaladtával jelentősen növekszik: 44 éves korig a nők körében gyakoribb, ezt követően a férfiak esetében magasabb a prevalencia, a 75 év feletti korcsoportban már minden harmadik ember cukorbeteg *(1. ábra)*.[19] Az elmúlt két évtizedben a felnőtt cukorbetegek száma háromszorosára nőtt *(2. ábra)*, ami rávilágít a betegség egyre növekvő társadalmi terheire.[19] A cukorbetegség kialakulásában és súlyosbodásában szerepet játszó tényezők között az elhízás és a mozgásszegény életmód is kiemelkedő jelentőségű. A magyar lakosság közel 60%-a túlsúlyos vagy elhízott, ez hozzájárul a diabétesz gyakori előfordulásához.[19]

FOGÁSZATI SZŰRŐVIZSGÁLATOK DIABÉTESSZEL ÉLŐ BETEGEK SZÁMÁRA A SEMMELWEIS EGYETEMEN

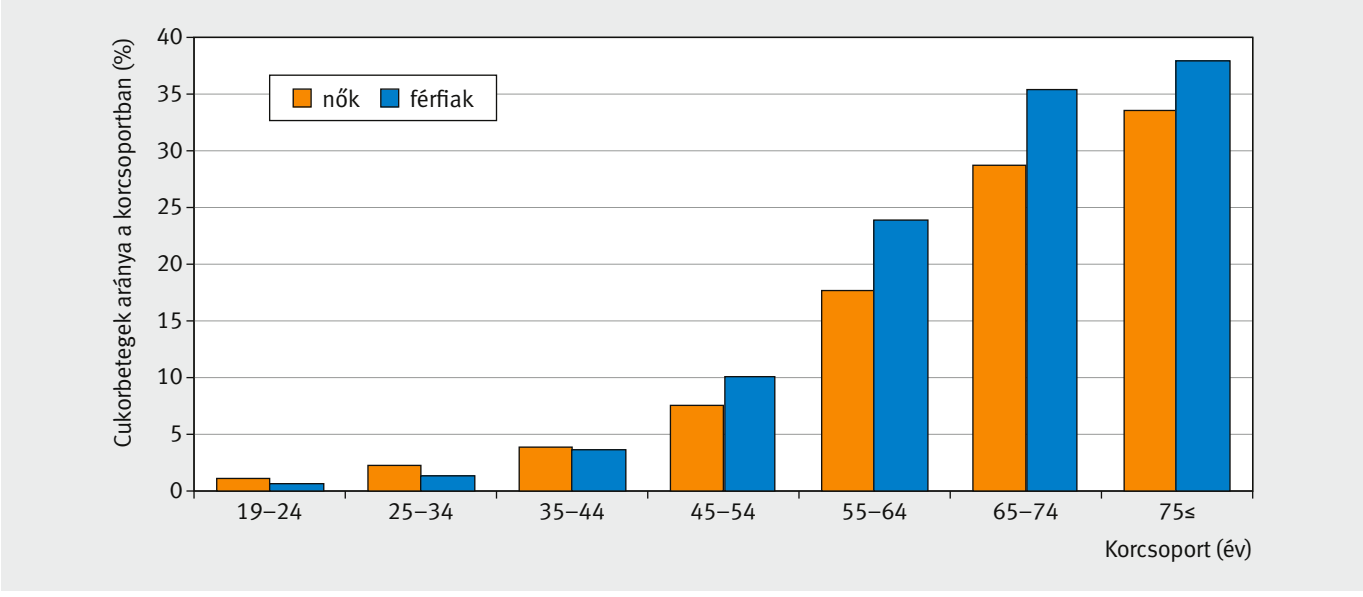
Az ingyenes fogászati szűrővizsgálatokat a Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportja szervezi. A részvétel kizárólag előzetes időpontfoglalással lehetséges, mely elektronikus formában a következő e-mail címen lehetséges: sediabdent@gmail.com. A rendelés helyszíne: Semmelweis Egyetem, 1088 Budapest, Szentkirályi utca 47.

A szakrendelés célja, hogy mind 1-es, mind 2-es típusú cukorbetegséggel élő betegek számára elérhetővé tegye a speciális fogászati szűrést és gondozást, elősegítve a szájüregi elváltozások korai felismerését és megelőzését. Ez a kezdeményezés („Budapest-pilot”) nemzetközi viszonylatban is egyedülállónak tekinthető, mivel

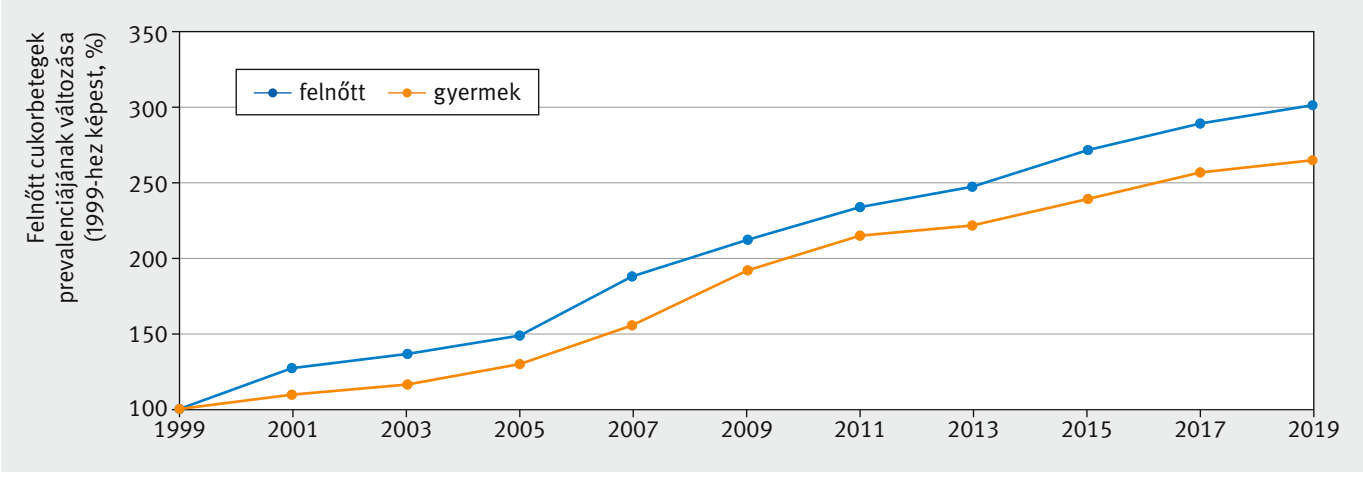
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egyetemi környezetben valósul meg. A szakrendelés célja, hogy a diabétesszel élő betegek éves fogászati ellenőrzése a klinikai gyakorlat részévé váljon, nemcsak a Semmelweis Egyetemen, hanem az ország egész területén.

A szűrővizsgálat több lépésből áll, ami során strukturált kérdőívek, klinikai vizsgálatok, radiológiai elemzések és laboratóriumi mérések segítségével nyerünk pontos adatokat. Az első lépésben a beteg – kiskorú cukorbeteg gyermek esetén a gondviselő – részletes anamnézist és egy standardizált kérdőívet tölt ki. A WHO ajánlása szerint az önértékelő kérdőív olyan strukturált kérdéseket tartalmaz, amelyek felmérik a szájhigiénés szokásokat,



1. ábra. A cukorbetegség előfordulása életkori és nemek szerinti megoszlásban Magyarországon, 2019 (a KSH adatai alapján)[19]



2. ábra. A felnőtt és gyermek cukorbetegek számának alakulása Magyarországon (1999–2019) a KSH adatai alapján[19]

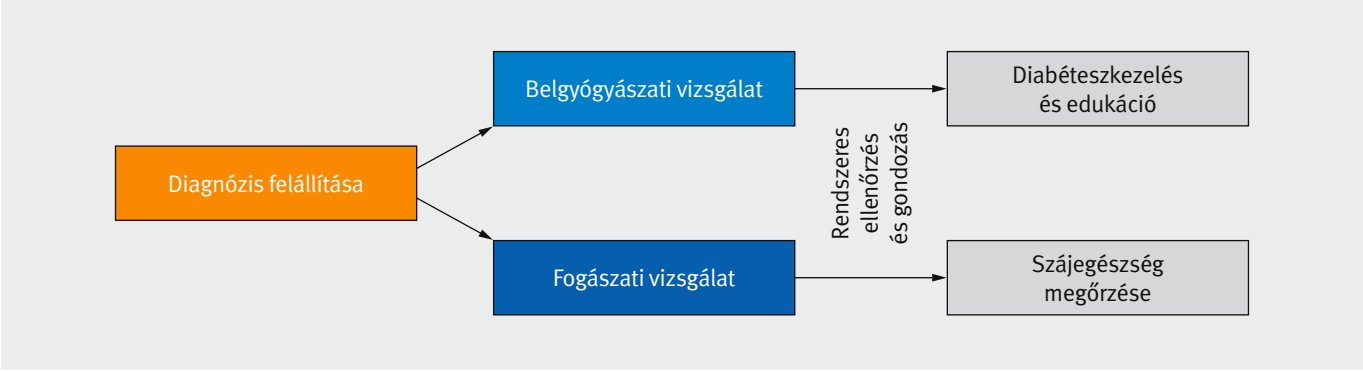
a fogászati panaszokat és az életmódbeli kockázati tényezőket. A kérdőíves adatgyűjtést (gyermekek és felnőttek esetén is) követően a klinikai fogászati vizsgálat során meghatározzuk a szuvas, hiányzó vagy tömött fogak számát (DMF-T index), a parodontális állapotot, valamint a fogászati és fogazati anomáliákat. Ezt követően a szűrés részeként röntgenfelvételeket készítünk, gyermekek esetén az ortopantomogram-felvétel mellett laterális cefalogramot is készítünk fogszabályozási vizsgálat céljából. A szűrővizsgálat során a cukorbetegséggel kapcsolatos metabolikus paramétereket is rögzítjük. Vércukorszintet, ketonszintet és HbA_{1c}-szintet mérünk, amihez Dcont® NOVUM vércukorszintmérőt, KETO Cont® ketonszintmérőt és SmartTester HbA_{1c}-gyorstesztet alkalmazunk. A SmartTester készülékkel a HbA_{1c}-érték gyors, kvantitatív meghatározására szolgál, melyhez ujjbegyes vérmintát használunk. A szűrővizsgálat ezen komplex értékelési rendszere biztosítja a betegek átfogó egészségi állapotának felmérését, lehetővé téve a fogászati és a szisztémás betegségek közötti összefüggések felismerését és a szükséges kezelések időben történő megkezdését.

Magyarországon a fogászati beavatkozások orvosi díjának, valamint a gyógyászati segédeszközök (fogtechnikusok által készített eszközök, fogszabályozó készülékek) díjának finanszírozása a Nemzeti Egészségbiztosítási Alapkezelő (NEAK) szabályozásának megfelelően történik. Ennek megfelelően a fogmegtartó kezelések (pl. fogkő eltávolítása, tömés, gyökértömés készítése) térítésmentesek a betegek számára, viszont a 18 és 62 év közötti személyek esetében a fogpótlások és a fogszabályozó kezelések után mind az orvosi díjat, mind a fogtechnikai laboratórium költségét (ebbe tartoznak a fogszabályozás során használatos eszközök) a páciensnek kell megfizetnie. 18 év alatti pácienseknek – illetve azoknak, akik érvényes iskolalátogatási igazolással rendelkeznek –, valamint 62 éves kor felett orvosi díjat nem, csak fogtechnikai költséget kell fizetni. Ez a támogatási rendszer európai szinten bőkezűnek számít fogászati szempontból.

A SEMMELWEIS EGYETEM DIABÉTESZES FOGÁSZATI MUNKACSOPORTJÁNAK TEVÉKENYSÉGE

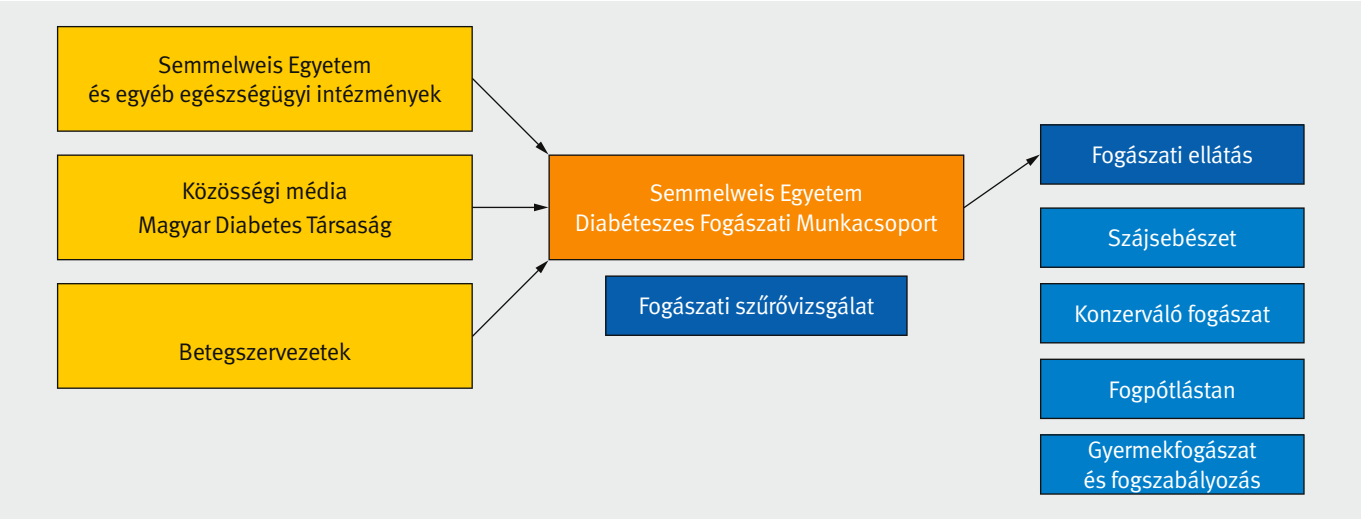
A teljes körű diabéteszgondozás egyik alapvető pillérét kell hogy képezze a fogászati szűrés és ellátás *(3. ábra)*. A 2015-ben alakult munkacsoportunk célja a cukorbetegek fogászati ellátásával kapcsolatos problémák mélyreható vizsgálata, valamint a tudományos eredmények felhasználásával a kezelési protokollok fejlesztése és ezen keresztül a betegek életminőségének javítása.

A *4. ábra* a Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportjának működését mutatja be, amely kiterjedt együttműködésben áll egészségügyi intézményekkel és betegszervezetekkel. A páciensek többsége a közösségi médián keresztül értesül az ingyenes fogászati szűrővizsgálatok lehetőségéről, amelyeket a munkacsoport szervez. A program szakmai hátterét a Magyar Diabetes Társaság és a Nemzetközi Diabétesz Társaság (IDF) támogatja, míg



3. ábra. A diabétesszel élő betegek ellátási folyamata, amelyben a fogászati szűrés a teljes körű diabéteszkezelés részeként hozzájárul az egészségmegőrzéshez

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4. ábra. A Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportjának működési rendje

A munkacsoport szűrővizsgálatainak szervezése a felnőttek esetén *dr. Lipták Klaudia* (mentor: *dr. Végh Dániel*), míg a gyermekek esetén *dr. Lipták Laura* (mentor: *dr. Bányai Dorottya*) vezetésével történik

a fogorvosi ellátás területén a Magyar Orvosi Kamara Fogorvosi Tagozata biztosítja a szakmai iránymutatást.

A DIABÉTESSZEL ÉLŐ BETEGEK FOGÁSZATI ELLÁTÁSÁNAK SPECIÁLIS SZEMPONTJAI

A Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportjának vizsgálatai rávilágítanak arra, hogy a tartós hiperglikémia jelentős kockázati tényező az orális egészség szempontjából, és közvetlen kapcsolatot mutat az emelkedett HbA_{1c}-szint, a gyulladásos citokinek aktivációja, valamint a sebgyógyulás lassulása között.

A fogászati beavatkozások előtt a vércukorszint stabilizálása kiemelten fontos, mivel a hiperglikémia kedvezőtlen hatással lehet a sebgyógyulásra és a fertőzések kockázatára.[20,21] Különösen igaz ez sebészeti és implantológiai beavatkozások esetén, ahol a kontrollált glikémiás állapot jelentősen javíthatja a kimenetelt. A krónikus hiperglikémia fokozza a parodontitisz és a periimplantitisz kialakulásának esélyét, valamint hozzájárulhat az implantátumok túlélési arányának csökkenéséhez, különösen rossz anyagcserekontroll esetén. Vizsgálataink kimutatták, hogy a HbA_{1c}-szint 8% feletti értéke jelentős kockázatot hordoz a fogászati sebészeti beavatkozások sikerességére, ezért ezekben az esetekben javasolt az anyagcserehelyzet optimalizálása a beavatkozás előtt.[22,23]

Az elmúlt két évtizedben a 2-es típusú cukorbetegség prevalenciája a szájüregi daganatos betegek körében több mint kétszeresére nőtt, ami tovább erősíti a metabolikus zavarok és a malignus folyamatok közötti összefüggéseket.[24,25] A cukorbetegség szájüregi egészségre gyakorolt hatásainak elemzése során azt is megállapítottuk, hogy az 1-es típusú cukorbetegségben érintett gyermekek szájhigiéniája általában jobb, mint a magyar populáció átlaga, ami valószínűleg a nagyfokú egészségtudatosságnak és odafigyelésnek köszönhető. Ugyanakkor a rossz glikémiás kontroll jelentősen növeli a fogszuvasodás előfordulását, valamint az ortodontiai eltérések esélyét. Emellett az 1-es típusú diabétesszel élő gyermekek körében kiemelkedően magas a cöliákia előfordulása, ami genetikai és szisztémás összefüggésekre is utalhat.[26,27,28]

A cukorbetegek fogászati ellátásának hatékonyságát tovább javíthatja a pontosabb diagnosztikai eljárások alkalmazása. A gyors HbA_{1c}-mérés (point-of-care teszt) lehetővé teheti a diabétesz korai felismerését fogászati praxisokban is, elősegítve ezzel a diabetológiai diagnózist.[22]

Kutatásaink igazolták a szisztémás és a szájüregi gyulladás közötti szoros kapcsolatot, ami rávilágít arra, hogy a parodontális terápiák nemcsak a szájüregi egészséget javítják, hanem hozzájárulhatnak a glikémiás kontroll optimalizálásához is. Bebizonyítottuk, hogy a parodontális kezelések után a HbA_{1c}-szint csökkenése figyelhető meg, különösen azon betegek esetében, akiknél a kiindulási HbA_{1c}-érték magasabb volt.[29]

Új diagnosztikai lehetőségként vizsgáltuk a gingivális szulkus vérmintáinak alkalmazását a HbA_{1c}-szint mérésére, amely a jövőben alternatívát jelenthet a hagyományos vérmintavétellel szemben. Ez a módszer csökkentheti az invazív beavatkozások szükségességét, valamint a fogorvosi szűrések során segítheti a diabétesz korai felismerését.[30]

Az eredmények alátámasztják, hogy az emelkedett glükózszint növeli a gyulladásos reakciók és az iszkémiás károsodások kockázatát, különösen sebészeti beavatkozások esetén. A megfelelő preoperatív előkészítés csökkentheti a gyógyszer indukálta állkapocs-nekrózis (MRONJ) és egyéb szájsebészeti komplikációk előfordulását, javítva ezzel a kezelések hatékonyságát és a betegek hosszú távú egészségi állapotát.[31]

Az érzéstelenítés rendkívül fontos a fogászati ellátás során. Saját experimentális vizsgálataink alapján megállapítható, hogy magyar fogorvosi rendelőkben leggyakoribb két hatóanyag, az articain és a lidocain hasonló hatásmechanizmussal rendelkezik a központi idegrendszerre cukorbeteg állatokkal végzett kísérletekben, mivel mindkettő gátolta az ingerületfüggő noradrenalin-felszabadulást és növelte a nyugalmi felszabadulást, miközben nem mutattak jelentős különbséget az idegvezetési funkciók befolyásolásában.[32]

A jelenlegi szakmai ajánlások szerint a diabétesszel élő betegek számára legalább évente javasolt fogászati ellenőrzés, amely magában foglalja a parodontális állapotfelmérést, a plakk- és fogkőeltávolítást, valamint a szájhigiénés szokások felülvizsgálatát.[33,34]

A diabétesszel élő betegek szájüregi szövődményeinek megelőzése szempontjából a betegedukáció kulcsfontosságú. A megfelelő szájhigiénés gyakorlatok tudatosítása csökkentheti a káros következmények előfordulását. A betegek számára hangsúlyozni kell a rendszeres fogmosás és a fogselyemhasználat fontosságát, valamint a cukros ételek és italok mértékletes fogyasztását.[35] A multidiszciplináris megközelítés elősegíti a betegellátás optimalizálását, így a fogászati és diabetológiai szakterületek közötti együttműködés hatékonyabbá tehető.

A jövőben érdemes lenne továbbfejleszteni az integrált betegellátási modelleket és új prevenciós stratégiákat kidolgozni a cukorbetegek szájüregi egészségének megőrzése érdekében. A digitális technológiák, például az AI-alapú diagnosztikai rendszerek vagy a telemedicina alkalmazása lehetőséget teremthet a páciensek még hatékonyabb követésére. További kutatások szükségesek annak megértésére, hogy a hiperglikémia hogyan befolyásolja a szájüregi mikrobiomot, továbbá milyen új terápiás megközelítések alkalmazhatók a cukorbetegek szájüregi egészségében. A Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportja megalapítása óta a szakmai együttműködés keretében több száz beteg ellátását valósította meg, és továbbra is vállalja ezt a feladatot. A Semmelweis Egyetem és a Fogorvostudományi Kar egyik legsikeresebb munkacsoportjaként több millió forint értékben elnyert pályázatokból mobil szűrővizsgálati pontokkal, illetve szék melletti diagnosztikai berendezésekkel bővítettük eszközparkunkat. A Semmelweis Egyetem kari kutatási pályázatán 4 elnyert ösztöndíjjal (*dr. Végh Dániel* 3 alkalom, *dr. Kammerhofer Gábor* 1 alkalom, *dr. Bányai Dorottya* 1 alkalom, összesen 2,5 millió forint), valamint Dr. Korányi András-ösztöndíjjal (*dr. Végh Ádám* 2 millió forint) rendelkezünk.

A munkacsoport alapítása óta 3 befejezett PhD-munka valósult meg, és jelenleg 7 PhD-munka van folyamatban.

A munkacsoport a betegvizsgálatok és kezelések mellett az elméleti háttér jelentősebb megértését is célozza tudományos érdeklődésével. A munkacsoport saját affiliációval rendelkezik a Semmelweis Egyetemen, tudományos cikkeink száma 20 feletti, amelyek nemzetközi és hazai publikációkban jelentek meg. A munkacsoportunk egyik kiemelt kutatási területe a diabéteszes neuropátia és a szájüregi betegségek közötti összefüggések vizsgálata, aminek jelentőségét az MDT által 2024-ben odaítélt az „Év Legjobb Magyar Nyelvű Közleménye” díj is elismerte. A díjazott, a Diabetologia Hungarica hasábjain megjelent kazuisztika („A neuropathia diabetica és a szájüregi betegségek közötti potenciális összefüggés bemutatása egy eset kapcsán”) rámutatott arra, hogy a neuropátiás betegek esetében fokozott kockázatot jelenthetnek bizonyos szájüregi elváltozások, így különös figyelmet kell

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fordítani ezen páciensek szájüregi státuszának rendszeres ellenőrzésére és célzott ellátására. Kutatásaink során arra törekszünk, hogy mélyebb betekintést nyerjünk a neuropátia patomechanizmusába, valamint annak hatásaira az orális egészségre, elősegítve ezzel a szájüregi kockázatok korai felismerését és megelőzését. Munkacsoportunk végzett először nemzetközi kérdőíves vizsgálatot az 1-es típusú cukorbetegek fogászati szokásairól, de a 77 Elektronika SmartTester fogászati környezetben történő HbA_{1c}-méréseiről is mi közöltünk a világon elsőként cikket.[36] A budapesti munkacsoport szerepet vállalt a diabétesszel élő betegek fogászati ellátásának fejlesztésében, és tapasztalataink hozzájárultak hasonló protokollok kialakításához több nemzetközi központban, köztük Grazban és Londonban. Emellett fontosnak tartjuk a madridi konszenzust (2017), amely egy nemzetközi szakmai ajánlás a diabétesszel élő betegek fogászati ellátásáról. A konszenzus kialakításában a munkacsoportunk vezetője, *dr. Végh Dániel* az IDF képviseletében vett részt. Az ajánlás nyílt hozzáférésű (open access), és mind a fogorvosok, mind a diabetológusok, valamint a betegek számára iránymutatást nyújt.

ÖSSZEGZÉS

A diabétesz és az orális egészség közötti kétirányú kapcsolat mára széles körben elfogadott, és egyre több tudományos bizonyíték támasztja alá, hogy a szájüregi állapot közvetlen hatással van a glikémiás kontrollra, valamint a diabétesz szövődményeinek kialakulására. A rosszul kontrollált vércukorszint elősegíti a gyulladásos folyamatokat, rontja a sebgyógyulást és növeli a parodontális betegségek, caries és egyéb szájüregi elváltozások előfordulását. Ugyanakkor megfelelő szájhigiéné és időben végzett parodontális kezelés kedvező irányban befolyásolhatja a metabolikus státuszt.

A Semmelweis Egyetem Diabéteszes Fogászati Munkacsoportja által kialakított interdiszciplináris betegútmodell példaértékű megközelítést kínál a cukorbetegek komplex gondozására. A rendszeres fogászati szűrések beépítése a diabetológiai ellátásba elősegíti a szájüregi szövődmények korai felismerését, megelőzését, és csökkenti a hosszú távú egészségügyi terheket. A munkacsoport működése és kutatási tevékenysége bizonyítja, hogy a multidiszciplináris együttműködés jelentős szerepet játszhat a betegek életminőségének javításában, valamint a nemzetközi ajánlások (pl. madridi konszenzus) gyakorlati alkalmazásában.

Eredményeink megerősítik, hogy a fogászati ellátás szerves részévé kell hogy váljon a diabétesz komplex gondozásának mind a klinikai gyakorlatban, mind az oktatás és a betegedukáció szintjén. A jövőben célzott prevenciós stratégiák, innovatív diagnosztikai módszerek és integrált betegutak kialakítása szükséges a szájüregi és szisztémás szövődmények hatékony megelőzése érdekében.

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