DENTAL MEDICINE

Clinical studies on the effect of type 1 diabetes on oral health in children and adolescents aged 6-17 years. A literature review

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Abstract

Background and aims. Type 1 diabetes mellitus is a chronic metabolic disease of autoimmune origin with early manifestations, which appear predominantly in childhood. Its incidence has increased in most European countries mainly due to refined diets and increased consumption of sweets. Diabetes is known as a predisposing factor for the development of oral diseases; therefore, prevention at an early age is essential. Genetic factors and environmental factors contribute to the risk of disease, indicating a multifactorial etiology. Along with chronic periodontitis and other oral manifestations, such as increased incidence of tooth decay, aphthous ulcers, salivary qualitative and quantitative changes represent an important segment of diabetes complications. It has been observed that people with diabetes are more prone to oral changes compared to healthy people.
In recent years, many studies have been published in the literature that have examined the relationship between type 1 diabetes and oral health. The purpose of this review is to investigate oral health indices in children with type 1 diabetes and how diabetes influences these indices.

Methods. An electronic search of the following databases was conducted to identify the literature assessing the effect of type 1 diabetes on oral health in children and adolescents aged 6-17 years: MEDLINE, Europe PMC, Google Scholar and PubMed. In total, 121 studies were identified. After removing duplicates, a total of 90 articles were included in this systematic review.

Results. This study describes the relationship between oral health in children with type 1 diabetes mellitus and presents the relationship between diabetes mellitus and the incidence of dental caries, periodontal diseases, microbial infections, as well as the influence of diabetes on orthodontic treatment and the measures that are required during the management of treatment in these patients.

Conclusions. The analysis of scientific evidence supports the fact that diabetes has a negative effect on oral health, and changes in the oral cavity will influence glycemic control, with the onset of multiple systemic complications. The association between diabetes and oral health is sometimes ignored and for this reason, instead of the early diagnosis and treatment of certain oral conditions, it leads to late diagnosis, resulting in tooth loss and sometimes even severe complications. Monitoring diabetic and dental patients can reduce diabetes-related complications.

Keywords: diabetes mellitus type I, oral health, dento-maxillary anomaly, dental caries, dental management

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Introduction

Diabetes mellitus (DM) is a chronic disease widespread in children, type 1 being the most common. Type 1 DM is mainly caused by an autoimmune destruction of insulin-producing beta cells in the pancreas [1,2]. Patients develop life-threatening hyperglycemia as a result of insulin deficiency, clinically manifested by a triad of disease-related symptoms: weight loss, polyuria, and polydipsia. The oral health of children with DM can be compromised by the quantity and quality of saliva, the appearance of dental caries and periodontal diseases and the triggering of oral microbial infections. Specific dental conditions should not be neglected when treating a patient with DM [3]. The most common manifestations in the oral cavity are dental caries, inhibition of salivary secretion, diseases of the oral mucosa, such as glossodynia, lichen planus, candidiasis, xerostomia, recurrent aphthous stomatitis, dry mouth syndrome and most importantly, gingivitis and periodontitis [4-8]. Periodontal disease, on the other hand, is a chronic gum disease usually caused by poor oral hygiene that leads to inflammation of the periodontium and eventually to the destruction of the periodontal ligament, and subsequent bone loss. Several studies have shown that the two conditions are interconnected so that periodontal disease is considered a complication of diabetes due to the predisposition to infections and slow healing observed in chronic uncontrolled diabetes [4-7,9]. There are conflicting studies on the oral health status of diabetic children compared to healthy individuals. Also, many studies have reported that T1DM affects tooth eruption. Many studies have reported that diabetes can cause accelerated tooth eruption, while other studies contradict these claims [10-12].

Purpose

The aim of this study is to analyze the effect of T1DM on the oral health of children aged 6–12 years and to evaluate the implications of diabetes mellitus on the management of orthodontic treatment.

Methods

An electronic search of the following databases was conducted to identify the literature assessing the effect of type 1 diabetes on oral health in children and adolescents aged 6-17 years: MEDLINE, Europe PMC, Google Scholar and PubMed. A total of 90 articles published between 2014 and December 2024 were analyzed .We used different keywords combinations such as “type 1 diabetes”, “oral health”, “dental structure”, “periodontal disease”, “tooth eruption”, “oral hygiene”, “orthodontic treatment”. Other articles were identified by exploring the reference list of significant works. The data relevant to the subject of the study were gathered from all the reviewed words written in English and quantified in tables on various parameters: saliva, carious lesions, periodontal diseases, dento-maxillary anomalies and orthodontic treatment in children and adolescents.

Inclusion criteria

• Studies involving children aged 6-17 years diagnosed with T1DM.

• The investigations focused on the impact of diabetes on children’s oral health

Exclusion criteria

• Studies that are not related to the effect of diabetes on oral health in children.

• Studies involving adult populations only.

The studies were grouped as follows:

1. Studies on” Diabetes Mellitus in Children and Adolescents.
2. Studies on “Dental caries in children and adolescents with T1DM “.
3. Studies on “Periodontal diseases in children and adolescents with T1DM“.
4. Studies on “The effect of T1DM on the dento-craniofacial complex in children and adolescents”.
5. Studies on “Orthodontic Treatment Considerations in Children and Adolescents with T1DM”.
6. Studies on “Oral health in children and adolescents with T1DM“.
7. Studies on “Influence of T1DM on saliva composition in children and adolescents”.

The studies were grouped in table I according to the topic addressed as follows:

Table I. Grouping of articles according to the theme of the study.

No. Crt.	Theme of the study	Number of published articles	
		Before 2014	2014 – March 2024
1.	Studies on “Diabetes Mellitus in Children and Adolescents”	5	5
2.	Studies on “Dental caries in children and adolescents with T1DM”	7	5
3.	Studies on “Periodontal diseases in children and adolescents with T1DM”	15	3
4.	Studies on “The effect of T1DM on the dento-craniofacial complex in children and adolescents”	6	3
5.	Studies on “Orthodontic Treatment Considerations in Children and Adolescents with T1DM”	3	-
6.	Studies on “Oral health in children and adolescents with T1DM”	18	14
7.	Studies on “Influence of T1DM on saliva composition in children and adolescents”	3	3
Total		57	33
		90	

Results

The largest number of articles related to the chosen topic are those related to the state of oral health in children and adolescents (28), followed by those related to dental caries (22), as can be seen in figure 1.

Oral events

There are no specific oral manifestations of DM, although affected individuals may be more prone to infections and have more severe periodontal disease. A broad spectrum of oral symptoms has been reported in the literature. [16,17] DM can give rise to immunological and salivary dysfunctions that will increase the risk of common oral diseases such as tooth decay, gingivitis and periodontal disease, lesions of the oral mucosa such as candidiasis and lichen planus, burning sensation, geographic tongue and cracked tongue as well as changes in the healing process of the lesions [7–9]. Table II summarizes the main oral manifestations of T1DM, their etiology and associated risks.

Salivary gland dysfunctions

The composition of saliva in children with T1DM may show certain differences from non-diabetic children, as a result of changes in the proteins and enzymes present in the saliva of children with T1DM. Recent studies show multiple changes in saliva composition in T1DM patients, but the results are controversial [18].

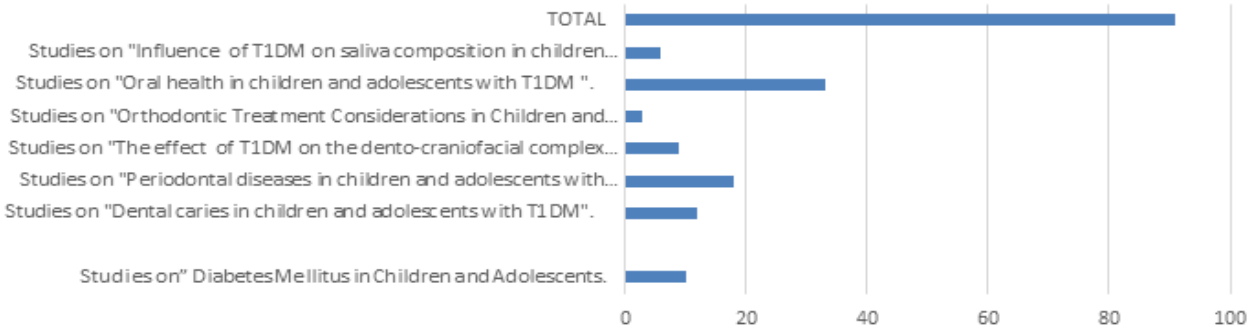

Figure 1. Grouping of articles according to the theme of the study.

Table II. Oral manifestations of T1DM, their etiology and associated risks.

Manifestation	Etiology	Risks
Salivary dysfunction	Polyuria Hyperglycemia	Caries Periodontal diseases Candida infections
Dental caries	Hyperglycemia Xerostomia	Parcel and root caries Delayed tooth eruptions
Oral infections	Xerostomia	Angular cheilitis
Periodontal disease	High levels of pro-inflammatory mediators Hyperglycemia	Pseudomembranous candidiasis Poor blood sugar control High risk of periodontal disease
Wound healing	Changes in the cell matrix	Delayed wound healing
Sensorineural disorders	Not specified	Taste disorders Compromised oral hygiene
Trigeminal neuropathy	Progressive dystrophy in the trigeminal nerve	Pain and discomfort

Table III. Manifestations of salivary gland dysfunctions, etiology and associated risks.

Manifestation	Etiology	Risks
Xerostomia	Hyperglycemia and Peripheral neuropathy Hyposalivation	Dry mouth Irritation of the oral lining, leading to inflammation and pain
Sialosis	Hyperglycemia and Chronic infections in the oral cavity	Decreased saliva secretion Dry mouth Difficulty chewing/swallowing
Sialadenosis	Enlargements of the salivary glands that are not inflammatory in nature	Reduced saliva secretion and with altered composition, fever.

Table III presents the main manifestations of salivary gland dysfunction in patients with T1DM, their etiology and associated risks.

The most common condition reported in the literature was ***xerostomia*** as a result of dehydration due to hyperglycemia and peripheral autonomic neuropathy [16,19,20]. Most patients with T1DM have reported the occurrence of xerostomia, but the exact reason for the occurrence is not completely known [21]. Symptoms of dry mouth may reflect increased glucose levels that lead to a more viscous consistency of saliva [21,22]. In T1DM, thirst, dehydration, oral sensory dysfunction, alteration of salivary composition, and reduced salivary flow can cause xerostomia [17].

Xerostomia can also result from dehydration of the patient associated with the phenomenon of osmotic diuresis, which develops due to inadequate glycemic control [22-26]. In addition, certain drugs used in antidiabetic therapy may have side effects, contributing to hyposalivation-induced xerostomia. Studies have shown that reduced saliva production is linked to metformin, an antidiabetic drug commonly prescribed in DM [28,29].

It can cause ***sialosis,*** which is manifested by an enlargement of the glands as a result of the enlargement of acinar cells [30]. In the literature, studies have shown that as HbA1c values increase, there is a tendency towards a decrease in salivary flow [31]. As a consequence of xerostomia, irritation of the oral mucosa can occur, leading to inflammation and pain. In addition, chronic complications of DM, such as endothelial dysfunction, microvascular complication, and neuropathy, can affect microcirculation and damage the flow and composition of saliva [32].

Diabetic patients often have enlargements of the salivary glands that are not inflammatory in nature ***(sialadenosis)*** accompanied by reduced saliva secretion and with a modified composition. Gland enlargement is linked to lipid droplets in acinar and ductal cells, resulting in increased gland volume and wider canals but with smaller acini [17].

Alteration of the dental structure

Children diagnosed with T1DM show notable changes in tooth structure, highlighting the complicated relationship between systemic health and dental development. The chronic hyperglycemia prevalent in diabetes can influence the processes of formation and mineralization during tooth development, affecting the formation of enamel and dentin. Changes in the maturation and mineral content of dental tissues, including enamel hypoplasia or hypomineralization, have been reported, resulting in qualitative and quantitative deficiencies in tooth structure. Such changes in tooth structure not only predispose teeth to an increased risk of tooth decay and coronary fractures, but they can also cause problems and challenges in planning dental treatment and maintaining oral health [33,34].

The main manifestations of alteration of the dental structure are presented in table IV.

A variety of studies have been conducted, and the results about the relationship between DM and tooth decay are ambiguous. Patients with DM show increased levels of ***Streptococcus mutans (S. mutans)*** **and** ***Lactobacillus*** [35] in combination with poor metabolic control [36]. However, there are studies that could not establish an association between ***Lactobacillus*** levels and DM [37–39], or even reported a negative association between them [40,41]. Some studies have shown that inadequate metabolic control is a significant factor in the development of tooth decay in children with DM. Studies have compared the level of S. mutans and the prevalence of tooth decay in children with poor metabolic control based on hemoglobin values in the blood [42]. The results of other studies have shown that there is a higher risk of cervical, interproximal, and root caries. This can be attributed to higher glucose levels in saliva and cervical fluid in patients with DM [43]. Poor metabolic control, reduced salivary flow, and altered saliva composition may increase the incidence of tooth decay, especially in patients with poor oral hygiene and a high intake of fermentable carbohydrates.

Dental caries

The association between diabetes and tooth decay is complex. No specific connection was identified, and the data are conflicting in most studies. There is no evidence that T1DM increases the risk of tooth decay [44]. Dentists should be aware that salivary dysfunction can reduce salivary production which, in combination with a high saliva glucose content, can increase the incidence of cavities [21,45].

Table IV. Manifestations of dental structure alteration, etiology and associated risks.

Manifestation	Etiology	Risks
Changes in the maturation and mineral content of dental tissues	Increased levels of Streptococcus mutans (S.mutans) *and* Lactobacillus	
Cervical, interproximal and radicular caries	Hyperglycemia High-carbohydrate diet	Increased risk of tooth decay and coronary fractures
Increasing the incidence of dental caries	Reduced salivary flow and impaired saliva composition	Poor metabolic control

Research has shown that in the presence of an oral health prevention standard with good diabetes control, patients with T1DM do not have a higher risk of developing cavities compared to the general population [21]. Diabetic patients might have more tooth decay due to poor oral hygiene or a higher number of meals per day [44]. Also, the buffering capacity of saliva is diminished, leading to a higher risk of developing tooth decay [32]. The interaction of systemic factors with inadequate oral hygiene practices and eating habits increases vulnerability to dental caries. Meticulous preventive oral care is required, including regular dental check-ups, dietary modifications, optimal blood glucose control, and local fluoridation [29,35,46-48].

Tooth eruption

Diabetic patients show altered pituitary gland activity, with changes in tooth eruption [49]. However, a recent study showed that there is no significant influence of diabetes on tooth eruption [12]. If diabetes is diagnosed before the age of 7, changes in the age of permutation of temporary teeth may be observed, as well as the early eruption of permanent teeth. In addition, a common finding is enamel hypoplasia, but it is not clear whether this complication is due to diabetes or the medication administered. Some studies have not found a correlation between diabetes and dento-maxillary abnormalities [12,49,].

Alteration of the sequence of tooth eruption can have several disadvantages, including the appearance of dento-alveolar incongruence with crowding, dental malpositions, difficulty in maintaining good oral hygiene, with the appearance of gingivitis and periodontitis, which will require orthodontic treatment [10]. The activity of osteoclasts, root formation, hormonal changes can influence tooth eruption, but the main cause of the change in the tooth eruption process is still unclear [12]. Adler et al. found that in patients with T1DM, younger than 11.5 years had an accelerated eruption, while children older than 11.5 years had a delayed tooth eruption [11]. Another study by Orbak et al. found that tooth eruption was faster in diabetic patients aged 5 to 10 years [10]. This finding is consistent with the result obtained by Alamoudi et al. who reported that patients with diabetes had teething acceleration compared to healthy individuals during the mixed dentition period (5–10 years) [49,50]. In contrast, the eruption of permanent teeth was delayed in diabetic patients aged 11 to 14 years [10]. There is one study that reported that there are no significant changes between healthy and diabetic people in terms of accelerating the tooth eruption process in patients over 10 years of age [12]. Lal et al. argue that there is no significant difference in tooth eruption between diabetic patients and healthy individuals with early mixed dentition [12].

Oral infections and other diseases of the oral mucosa

Patients with T1DM may have a number of oral mucosal disorders, but their frequency is low. ***Lichen planus*** may occur as a consequence of sulfonylurea therapy, while ***candida infection*** occasionally manifests as pseudomembranous candidiasis or median rhomboid glossitis [3]. Lichen planus may impair phagocytic function due to inadequate insulin therapy [3,21,32]. There have been a number of reports of geographic language (erythema migrans), but the vast majority of people with this disorder do not have T1DM [44].

The development of oral infections, such as herpes stomatitis, candidiasis or other fungal diseases, are commonly seen in patients with uncontrolled DM. Such infections are difficult to treat and pose a challenge to the dentist due to decreased immunity [51], which can alter insulin resistance and glucose control, affecting healing [52].

Canker sores

Children diagnosed with T1DM face an increased risk of developing canker sores, also known as oral candidiasis, highlighting the interaction between diabetes and diseases of the oral mucosa. This fungal infection, caused mainly by Candida species, especially Candida albicans, manifests itself as white lesions on the oral mucosa, tongue or palate, often accompanied by discomfort or pain. The predisposition to canker sores can be a consequence of several factors, especially the altered immune response inherent to diabetes, especially fluctuations in glucose levels that create an environment conducive to the excessive growth of candida. Chronic hyperglycemia compromises the immune system's ability to fight fungal infections, facilitating the proliferation of Candida species in the oral cavity. In addition, the use of medications such as antibiotics or corticosteroids, along with changes in salivary composition and reduced salivary flow, further exacerbate susceptibility to canker sores [29,53-55].

Table V shows the main diseases of the oral mucosa, their etiology and associated risks.

Periodontal disease

Periodontal disease is the sixth type of complication associated with T1DM after retinopathy, nephropathy, neuropathy, peripheral diseases, and cardiovascular disease [18,56]. The relationship between T1DM and periodontal health is considered the main oral problem observed by dental professionals.

T1DM can lead to decreased bone mineral density, osteopenia, osteoporosis [57], and an increased prevalence and severity of periodontal disease. The existence of a two-way relationship has been demonstrated. Not only does diabetes affect periodontal structures, but periodontal disease can also affect diabetes. Studies have demonstrated the effect of periodontal status on blood glucose levels due to the increased insulin resistance of tissues in reaction to mediators of systemic inflammation, leading to reduced glucose uptake from cells.

Table V. Oral infections and other diseases of the oral mucosa: etiology and associated risks.

Manifestation	Etiology	Risks
Oral lichen	Sulfonylurea therapy	Painful ulcers, erythema and gingival desquamation
Pseudomembranous candidiasis	Chronic hyperglycemia Fluctuations in glucose levels Use of antibiotics or corticosteroids	Canker sores – white or creamy lesions on the oral mucosa, tongue or palate, often accompanied by discomfort or pain
Gingivostomatitis	Viral or bacterial infections Poor oral hygiene	• Swollen, bloody gums • Swollen lymph nodes • Excess saliva • General malaise
Median rhomboid glossitis	It is very rare in children	Depapillated tongue
Geographical language (erythema migrans)	People with lichen planus	The appearance of lesions and swellings on the skin and inside the oral cavity

Table VI. Periodontal disease, etiology and associated risks.

Manifestation	Etiology	Risks
Chronic gingivitis	Persistent hyperglycemia	Increased plaque buildup, gum inflammation, bleeding and pain to the touch.
Severe periodontal disease	Poorly controlled Type 1 DZ Persistent hyperglycemia with increased serum C-reactive protein, cytokine levels, and interleukin	Worsening of periodontal disease with destruction of periodontal tissues, including gums and alveolar bone. Periodontal pockets

Poorly controlled T1DM is associated with severe periodontitis compared to those without diabetes [58,59]. Studies by Orbak et al. reported a higher risk of chronic gingivitis in children with DM that increased with age [10,46]. Rafatjou et al. reported increases in gingival indices related to the duration of diabetes [60]. Other studies have concluded that the depth of periodontal pockets was greater in children diagnosed with diabetes early, while the bleeding index was higher in newly diagnosed children [61]. Research from Brazil showed a correlation between periodontal disease and the patient's gender. Periodontal index was increased in girls with diabetes, but there was no difference in gingival index between boys and girls. Regarding the depth of the periodontal pocket, no notable difference was observed between boys and girls, while it was greater at the level of the palatal surfaces in girls [62]. In conclusion, children with diabetes are three times more likely to develop periodontitis [63], usually in adolescence, or even earlier [64], and there appears to be an association with poor metabolic and periodontal control. Popławska-Kita et al. reported that 15% of healthy people and 57.9% of DM patients developed periodontitis [65,66]. The possible advantage of periodontal therapy for metabolic control is not yet confirmed, and further studies are needed [63,67]. It is well described that poorly controlled diabetes can increase the incidence of gingival inflammation and alveolar bone loss [1,68]. The pathophysiology of this mechanism is similar to the microvascular and macrovascular pathophysiological complications of DM [21,31]. Evidence for the effect of periodontal disease on glycemic control is weak. However, compared to people with healthy periodontal tissues, people with periodontal disease and type 1 or type 2 DM have a higher risk of developing DM-related complications [57] (Table VI).

Some studies have shown that periodontal disease begins to occur when the child reaches puberty, while Lalla et al. in their study concluded that periodontal disease can also manifest itself from an early age (6–11 years) [10,67,69,70].

Recent studies have reported that T1DM is associated with prolonged expression of mRNA for TNF-alpha, tumor necrosis factor alpha (TNF-alpha) that are associated with osteoclast recruitment and activity during orthodontic treatment [71], which can lead to more persistent inflammation and tissue damage [72]. However, the cellular and molecular mechanisms associated with diabetic condition that may influence orthodontic movement are not known [73]. The application of fixed orthodontic appliances may produce significant bacteremia if significant oral bleeding and/or exposure to potentially contaminated tissue is anticipated, and this would usually require antibiotic prophylaxis in at-risk patients. Simple control of fixed orthodontic appliances does not require antibiotic prophylaxis [74,75].

Periodontal reactions to orthodontic forces have been studied by Holtgrave and Donath. They discovered delayed bone regeneration, a weakening of the periodontal ligament and microangiopathy in the gingival area [73].

The authors concluded that specific diabetic changes in the periodontal are more pronounced following orthodontic tooth movement. During orthodontic treatment, the orthodontist must monitor the periodontal condition of patients with diabetes and keep control of inflammation. As with all orthodontic patients, maintaining strict oral hygiene is very important [76-79].

Dental eruption abnormalities

Abnormalities of tooth eruption have been observed in children diagnosed with T1DM, as a result of the systemic impact of this condition on oral health. Studies indicate a potential association between T1DM and changes in the normal sequence and timing of tooth eruption, characterized by delays or disturbances in the appearance of primary and permanent dentition. The complicated interaction of systemic factors, such as chronic hyperglycemia and disorders in the endocrine environment, can contribute to these irregularities in dental development. Increased blood glucose levels could influence the function of odontogenic cells, preventing their activity and coordination during tooth formation and eruption. Moreover, the inflammatory environment associated with diabetes can affect the oral microenvironment that is essential for tooth eruption, which can lead to aberrant dental patterns. These tooth eruption abnormalities can manifest as delayed eruption, premature or ectopic eruption, or even changes in tooth number or volume [11,12,80] (Table VII).

Orthodontic treatment considerations

• In order for orthodontic treatment to be successful in a patient with T1DM, it is important to have a good medical check-up [81-84].

• In patients with well-controlled diabetes, all orthodontic procedures can be performed without special precautions, especially if there are no complications from it. Both movable and fixed appliances can be used. When using fixed braces, it is important to emphasize good oral hygiene, given the susceptibility to caries and periodontal disease [76,85,86].

• Delayed skeletal maturation and decreased cephalometric linear and angular parameters are common in patients with juvenile diabetes mellitus and should be considered during orthodontic treatment planning [76,86-88].

• Hypoglycemic reactions occur more often in young patients undergoing orthodontic treatment. If a patient is scheduled for a long treatment session, i.e. more than 1 hour and a half, the patient should be advised to take their usual meal and take their medications as usual. Before starting the dental procedure, the dental team must check that the patient has met these recommendations. In this way, a hypoglycemic reaction at the office can be easily avoided [76,83,84,86-88].

• Periodontal reactions to orthodontic forces were studied by Holtgrave and Donath who found delayed bone regeneration, a weakening of the dento-periodontal ligament and micro-angiopathies in the gingival area. The specific changes of diabetes in the periodontal are more pronounced following the orthodontic movement of the teeth [74].

• In adolescents, it is important to obtain a complete periodontal examination of the oral cavity before starting orthodontic treatment, including probing, plaque and gingival score, and to assess the need for periodontal treatment. Periodontal condition must be improved before starting any orthodontic treatment [87]. During orthodontic treatment, the orthodontist must monitor periodontal condition, maintain control of inflammation, and aim to maintain strict oral hygiene [75,89].

• Since at present there is no upper age limit for orthodontic treatment, the doctor will have both T1DM and type 2 patients. Type 2 patients can be considered more stable than type 1 patients, who can be assumed to be "frail": Strict adherence to the medical regimen is of the utmost importance to maintain control of blood glucose levels. Deviations from the proper diet and insulin injection schedule will result in distinct changes in serum glucose levels [75,87].

Table VII. Orthodontic treatment.

Manifestation	Etiology	Risks
Delayed eruption	Chronic hyperglycemia	Dento-alveolar incongruence with spacing of dental malpositions Open occlusion Psychosocial problems related to aesthetics
Premature rash	Disorders in the endocrine environment	Dento-alveolar incongruence with crowding dental malpositions
Ectopic rash	Local inflammation	Lack of space with ectopic eruption of the tooth Speech impairment Aesthetic consequences
Number changes	Chronic hyperglycemia	Mastication disorders Speech difficulties (the pronunciation of words is impaired) Periodontal disease;
Volume changes	Vascular and neurogenic disorders	Speech difficulties Aesthetic consequences

Discussion

To avoid diabetes-related oral health problems, children with T1DM should practice good oral hygiene, which includes regular brushing, flossing, and dental checkups. In addition, controlling blood sugar levels through proper diabetes management is essential in preventing or lessening the severity of dental problems. Regular visits to the dentist allow for early detection and treatment of any dental problems that may arise. The oral hygiene instructions are as follows [90]:

- Children should brush their teeth 2-3 times a day with fluoride toothpaste (children 2-6 years: 1,000 ppmF, children >6 years: 1,450 ppmF).
- Regarding the effect of DM on the development of dental caries, the results of clinical trials are controversial. For diabetic children with a high incidence of tooth decay, it was confirmed that some of the overall risk factors for tooth decay are more prevalent in a diabetic population compared to a non-diabetic control group. Quantitative and qualitative changes in the saliva of children with DM have been confirmed. In the case of patients at high risk of dental caries, fluoridation should be done in the dental office 3-4 times a year. It is also recommended to use fluoridated mouthwashes and special fluoride toothpaste 5,000 ppmF daily (children > 15 years).
- The development of oral infections, such as herpes stomatitis, candidiasis or other fungal diseases, are commonly seen in patients with uncontrolled DM. Also, a series of articles confirm the presence of xerostomia, especially that induced by hyposalivation .In patients at risk or with periodontal disease, the dentist should give special oral hygiene instructions and may prescribe oral antiseptic solutions as part of treatment.
- Delayed skeletal maturation and decreased cephalometric linear and angular parameters are common in patients with juvenile diabetes mellitus and should be taken into account during orthodontic treatment planning, as outlined in several articles. In addition, tooth eruption (early eruption of permanent teeth) is also affected.
- The diet that children with DM should be followed. Dentists should encourage parents and children to avoid frequent consumption of cariogenic foods [90].

Very good oral hygiene measures must be in place to reduce the risk of oral infections in patients with T1DM [86]. The Atlas of the International Diabetes Federation recommends regular, at least once a year check-ups of T1DM patients with the dentist and their awareness of the symptoms of gum disease, such as inflammation and bleeding gums [90]. It is also advisable to educate patients about the implications of T1DM on oral health and gum disease, especially if diabetes is poorly controlled [56]. If blood glucose levels are poorly controlled, infectious diseases are more common and insulin sensitivity is reduced [31,32,58].

Dentists have an important role in the preventive aspects of DM. They can detect and diagnose periodontal disease in diabetic patients and assess the general population at risk of developing diabetes[18,21].

In addition to these aspects described by many articles, there is also the possibility of changing the taste of diabetics. Taste is a complex symptom and may be related to dietary changes and changes in salivary flow associated with disease management [56]. One in three patients with T1DM may have hypogeusia. Consequently, it can affect 80% of patients with T1DM and 50% of individuals with uncontrolled and controlled type 2 DM [80]. Altered taste can affect salty, sweet, and sour flavors. In the literature, there is no relationship between the severity of the taste disorder and HbA1c levels [80]. Other disorders reported in diabetic patients are dry mouth syndrome and dysphagia [11,18].

Conclusions

The literature analyzed in this review shows that there is a bidirectional relationship between diabetes mellitus and endo-oral conditions, and the interception and periodic evaluation of the patient are essential factors that must be known by all dentists, regardless of the specialty. Most of the articles studied confirm higher levels of dental microbial plaque and increased incidence of chronic gingivitis in children with DM, and a few articles also reported an increased risk of developing periodontitis. Also, very few articles evaluate the implications of diabetes mellitus on the management of orthodontic treatment. In conclusion the dentist must evaluate the oral signs of diabetes, and oral hygiene practices are a first step in the management of these patients. The interdisciplinary approach of these patients is important in maintaining oral and general health by reducing local complications.

References

1. Dileepan K, Feldt MM. Type 2 diabetes mellitus in children and adolescents. Pediatr Rev. 2013;34:541-548.
2. Dabelea D. The accelerating epidemic of childhood diabetes. Lancet. 2009;373:1999-2000.
3. Davidopoulou S, Bitzeni-Nigdeli A, Archaki C, Arhakis A. Oral Health Implications and Dental Management of Diabetic Children. Int J Clin Pediatr Dent. 2022;15:631-635.
4. Lamster IB, Lalla E, Borgnakke WS, Taylor GW. The relationship between oral health and diabetes mellitus. J Am Dent Assoc. 2008;139 Suppl:19S-24S.
5. Ship JA. Diabetes and oral health: an overview. J Am Dent Assoc. 2003;134 Spec No:4S-10S.
6. Kudiyirickal MG, Pappachan JM. Diabetes mellitus and oral health. Endocrine. 2015;49:27-34.
7. Albert DA, Ward A, Allweiss P, Graves DT, Knowler WC, Kunzel C, et al. Diabetes and oral disease: implications for health professionals. Ann N Y Acad Sci. 2012;1255:1-15.

8. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2012;35 Suppl 1:S64-71.
9. Löe H. Periodontal disease. The sixth complication of diabetes mellitus. Diabetes Care. 1993;16:329-334.
10. Orbak R, Simsek S, Orbak Z, Kavrut F, Colak M. The influence of type-1 diabetes mellitus on dentition and oral health in children and adolescents. Yonsei Med J. 2008;49:357-365.
11. Adler P, Wegner H, Bohatka L. Influence of age and duration of diabetes on dental development in diabetic children. J Dent Res. 1973;52:535-537.
12. Lal S, Cheng B, Kaplan S, Softness B, Greenberg E, Goland RS, et al. Accelerated tooth eruption in children with diabetes mellitus. Pediatrics. 2008;121:e1139-e1143.
13. Mayer-Davis EJ, Lawrence JM, Dabelea D, Divers J, Isom S, Dolan L, et al. Incidence Trends of Type 1 and Type 2 Diabetes among Youths, 2002-2012. N Engl J Med. 2017;376:1419-1429.
14. Tuomilehto J, Ogle GD, Lund-Blix NA, Stene LC. Update on Worldwide Trends in Occurrence of Childhood Type 1 Diabetes in 2020. Pediatr Endocrinol Rev. 2020;17(Suppl 1):198-209.
15. Norris JM, Johnson RK, Stene LC. Type 1 diabetes-early life origins and changing epidemiology. Lancet Diabetes Endocrinol. 2020;8:226-238.
16. Manfredi M, McCullough MJ, Vescovi P, Al-Kaarawi ZM, Porter SR. Update on diabetes mellitus and related oral diseases. Oral Dis. 2004;10:187-200.
17. Priya BM, ShivaKumar V, Anitha V, Shanmugam M. Diabetes & dental diseases. CHC Med J. 2012; 1:188–191.
18. Fouani M, Basset CA, Jurjus AR, Leone LG, Tomasello G, Leone A. Salivary gland proteins alterations in the diabetic milieu. J Mol Histol. 2021;52:893-904.
19. Lewis D, Fiske J, Dougall A. Access to special care dentistry, part 7. Special care dentistry services: seamless care for people in their middle years--part 1. Br Dent J. 2008;205:305-317.
20. Scully C. Medical Problems in Dentistry E-Book. 7th ed. Elsevier Health Sciences; 2015:30
21. Mohamed K, Yates J, Roberts A. Diabetes mellitus: considerations for the dental practitioner. Dent Update. 2014;41:144-146, 149-150, 153-154.
22. Kurnatowska A, Bieniek E. Oral Lesions in Patients with Insulin−Dependent Diabetes Mellitus. Dent. Med. Probl. 2004; 41:113–118.
23. Lewusz K i wsp. Patient with diabetes in the dental office. review of the literature. Magazyn Stomatologiczny 2016;3:74-78.
24. Węgrzyn M, Wrobel A, Roemer-Slimak R, Mastalerz-Migas A. Xerostomia in geriatric patients. Problems and therapeutic options - literature review. Medycyny Rodzinnej Forum 2018;12:197–203. Available from: https://journals.viamedica.pl/forum_medycyny_rodzinnej/article/download/61605/46761.
25. Gandara BK, Morton TH. Non-periodontal oral manifestations of diabetes mellitus: a framework for medical care providers Diabetes Spectrum. 2011;24:199-205.
26. Carda C, Carranza M, Arriaga A, Díaz A, Peydró A, Gomez de Ferraris ME. Structural differences between alcoholic and diabetic parotid sialosis. Med Oral Patol Oral Cir Bucal. 2005;10:309-314.
27. Cabon J, Pejas J, Zawilska A, Trzcionka A. Diabetes in the context of dental treatment in an interdisciplinary approach. J Educ Health Sport [Internet]. 2023;13:38-45.
28. Mandel L, Khelemsky R. Asymptomatic bilateral facial swelling. J Am Dent Assoc. 2012;143:1205-1208.
29. Leite RS, Marlow NM, Fernandes JK, Hermayer K. Oral health and type 2 diabetes. Am J Med Sci. 2013;345:271-273.
30. Al-Maskari AY, Al-Maskari MY, Al-Sudairy S. Oral Manifestations and Complications of Diabetes Mellitus: A review. Sultan Qaboos Univ Med J. 2011;11:179-186.
31. Yamunadevi A, Basandi PS, Madhushankari GS, Donoghue M, Manjunath A, Selvamani M, et al. Morphological alterations in the dentition of type I diabetes mellitus patients. J Pharm Bioallied Sci. 2014;6(Suppl 1):S122-126.
32. Syed S, Yassin SM, Almalki AY, Ali SAA, Alqarni AMM, Moadi YM, et al. Structural Changes in Primary Teeth of Diabetic Children: Composition and Ultrastructure Analysis. Children (Basel). 2022;9:317.
33. Ferizi L, Dragidella F, Spahiu L, Begzati A, Kotori V. The Influence of Type 1 Diabetes Mellitus on Dental Caries and Salivary Composition. Int J Dent. 2018;2018:5780916.
34. Al- Khayoun JD, Diab BS. Dental caries, Mutans Streptococci, Lactobacilli and salivary status of type1 diabetic mellitus patients aged 18-22 years in relation to Glycated Haemoglobin. J Bagh Coll Dent. 2013;25:153-158.
35. López del Valle LM, Ocasio-López C. Comparing the oral health status of diabetic and non-diabetic children from Puerto Rico: a case-control pilot study. P R Health Sci J. 2011;30:123-127.
36. Siudikiene J, Machiulskiene V, Nyvad B, Tenovuo J, Nedzelskiene I. Dental caries and salivary status in children with type 1 diabetes mellitus, related to the metabolic control of the disease. Eur J Oral Sci. 2006;114:8-14.
37. El-Tekeya M, El Tantawi M, Fetouh H, Mowafy E, Abo Khedr N. Caries risk indicators in children with type 1 diabetes mellitus in relation to metabolic control. Pediatr Dent. 2012;34:510-516.
38. Groele L, Szajewska H, Szypowska A. Effects of Lactobacillus rhamnosus GG and Bifidobacterium lactis Bb12 on beta-cell function in children with newly diagnosed type 1 diabetes: protocol of a randomised controlled trial. BMJ Open. 2017;7:e017178.
39. Siudikiene J, Maciulskiene V, Nedzelskiene I. Dietary and oral hygiene habits in children with type I diabetes mellitus related to dental caries. Stomatologija. 2005;7:58-62.
40. Moreira AR, Passos IA, Sampaio FC, Soares MS, Oliveira RJ. Flow rate, pH and calcium concentration of saliva of children and adolescents with type 1 diabetes mellitus. Braz J Med Biol Res. 2009;42:707-711.
41. Naing C, Mak JW. Salivary glucose in monitoring glycaemia

in patients with type 1 diabetes mellitus: a systematic review. J Diabetes Metab Disord. 2017;16:2.

42. Lamster IB, Lalla E, Borgnakke WS, Taylor GW. The relationship between oral health and diabetes mellitus. J Am Dent Assoc. 2008;139 Suppl:19S-24S.
43. Wilson MH, Fitzpatrick JJ, McArdle NS, Stassen LF. Diabetes mellitus and its relevance to the practice of dentistry. J Ir Dent Assoc. 2010;56:128-133.
44. Novotna M, Podzimek S, Broukal Z, Lencova E, Duskova J. Periodontal Diseases and Dental Caries in Children with Type 1 Diabetes Mellitus. Mediators Inflamm. 2015;2015:379626.
45. Ferizi L, Bimbashi V, Kelmendi J. Association between metabolic control and oral health in children with type 1 diabetes mellitus. BMC Oral Health. 2022;22:502.
46. Wang Y, Xing L, Yu H, Zhao L. Prevalence of dental caries in children and adolescents with type 1 diabetes: a systematic review and meta-analysis. BMC Oral Health. 2019;19:213.
47. Ionescu O, Sonnet E, Roudaut N, Prédine-Hug F, Kerlan V. Signes buccaux de la pathologie endocrinienne [Oral manifestations of endocrine dysfunction]. Ann Endocrinol (Paris). 2004;65:459-465.
48. Alamoudi RA, Elhalabi M, Chogle S, et al. Oral health status of type 1 diabetes patients in the United Arab Emirates [abstract]. IADR 2013. Poster session (Reference ID 3858).
49. Pasquel FJ, Lansang MC, Dhatariya K, Umpierrez GE. Management of diabetes and hyperglycaemia in the hospital. Lancet Diabetes Endocrinol. 2021;9:174-188.
50. Nirmala SV, Saikrishna D. Dental care and treatment of children with diabetes - an overview. J Pediatric Neonatal Care.2016;4: 00134.
51. Babatzia A, Papaioannou W, Stavropoulou A, Pandis N, Kanaka-Gantenbein C, Papagiannoulis L, et al. Clinical and microbial oral health status in children and adolescents with type 1 diabetes mellitus. Int Dent J. 2020;70:136-144.
52. Bartholomew GA, Rodu B, Bell DS. Oral candidiasis in patients with diabetes mellitus: a thorough analysis. Diabetes Care. 1987;10:607-612.
53. Piccolo G, De Rose EL, Bassi M, Napoli F, Minuto N, Maghnie M, et al. Infectious diseases associated with pediatric type 1 diabetes mellitus: A narrative review. Front Endocrinol (Lausanne). 2022;13:966344.
54. Preshaw PM, Alba AL, Herrera D, Jepsen S, Konstantinidis A, Makrilakis K, et al. Periodontitis and diabetes: a two-way relationship. Diabetologia. 2012;55:21-31.
55. Chapple IL, Genco R; working group 2 of the joint EFP/AAP workshop. Diabetes and periodontal diseases: consensus report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. J Periodontol. 2013;84:S106-112.
56. International Diabetes Federation. OralHealth_EN2.indd/ Guideline on oral health for people with diabetes. 2009. Available from: https://idf.org/media/uploads/2023/05/attachments-52.pdf
57. Pontes Andersen CC, Flyvbjerg A, Buschard K, Holmstrup P. Relationship between periodontitis and diabetes: lessons from rodent studies. J Periodontol. 2007;78:1264-1275.
58. Rafatjou R, Razavi Z, Tayebi S, Khalili M, Farhadian M. Dental Health Status and Hygiene in Children and Adolescents with Type 1 Diabetes Mellitus. J Res Health Sci. 2016;16:122-126.
59. Aral CA, Nalbantoğlu Ö, Nur BG, Altunsoy M, Aral K. Metabolic control and periodontal treatment decreases elevated oxidative stress in the early phases of type 1 diabetes onset. Arch Oral Biol. 2017;82:115-120.
60. Takahashi K, Nishimura F, Kurihara M, Iwamoto Y, Takashiba S, Miyata T, et al. Subgingival microflora and antibody responses against periodontal bacteria of young Japanese patients with type 1 diabetes mellitus. J Int Acad Periodontol. 2001;3:104-111.
61. Preshaw PM, Alba AL, Herrera D, Jepsen S, Konstantinidis A, Makrilakis K, et al. Periodontitis and diabetes: a two-way relationship. Diabetologia. 2012;55:21-31.
62. Lalla E, Cheng B, Lal S, Kaplan S, Softness B, Greenberg E, et al. Diabetes mellitus promotes periodontal destruction in children. J Clin Periodontol. 2007;34:294-298.
63. Popławska-Kita A, Siewko K, Szpak P, Król B, Telejko B, Klimiuk PA, et al. Association between type 1 diabetes and periodontal health. Adv Med Sci. 2014;59:126-131.
64. Xavier AC, Silva IN, Costa Fde O, Corrêa DS. Condição periodontal de crianças e adolescentes com diabetes melito tipo 1 [Periodontal status in children and adolescents with type 1 diabetes mellitus]. Arq Bras Endocrinol Metabol. 2009;53:348-354.
65. Llambés F, Silvestre FJ, Hernández-Mijares A, Guiha R, Caffesse R. The effect of periodontal treatment on metabolic control of type 1 diabetes mellitus. Clin Oral Investig. 2008;12:337-343.
66. Campus G, Salem A, Uzzau S, Baldoni E, Tonolo G. Diabetes and periodontal disease: a case-control study. J Periodontol. 2005;76:418-425.
67. Taylor GW, Borgnakke W. Periodontal disease: associations with diabetes, glycemic control and complications. Oral Dis. 2008;14:191–203.
68. Erdoğan O, Esen E, Ustün Y. Bony palatal necrosis in a diabetic patient secondary to palatal rotational flap. J Diabetes Complications. 2005;19:364-367.
69. Lalla E, Cheng B, Lal S, Tucker S, Greenberg E, Goland R, et al. Periodontal changes in children and adolescents with diabetes: a case-control study. Diabetes Care. 2006;29:295-299.
70. Australian Research Centre for Population Oral Health. The relationship between diabetes and oral health among Australian adults. Aust Dent J. 2008;53:93-96.
71. Kansal G, Goyal D. Prosthodontic Management Of Patients With Diabetes Mellitus. J Adv Med Dent Scie Res 2013;1:38-44.
72. Holtgrave EA, Donath K. Die Reaktion des Parodonts auf kieferorthopädische Kräfte bei diabetischer Stoffwechsellage [Periodontal reactions to orthodontic forces in the diabetic metabolic state]. Fortschr Kieferorthop. 1989;50:326-337.
73. Burden D, Mullally B, Sandler J. Orthodontic treatment of patients with medical disorders. Eur J Orthod. 2001;23:363-372.

74. Swati S. Implants in diabetic patient. Int J Oral Implantol Clin Res 2013;4:30-35.
75. Bascones-Martinez A, Matesanz-Perez P, Escribano-Bermejo M, González-Moles MÁ, Bascones-Ilundain J, Meurman JH. Periodontal disease and diabetes-Review of the Literature. Med Oral Patol Oral Cir Bucal. 2011;16:e722-729.
76. Sanjeeta N. Oral changes in diabetes- a review. J DentMed Sci 2014; 13:36-39.
77. Bensch L, Braem M, Van Acker K, Willems G. Orthodontic treatment considerations in patients with diabetes mellitus. Am J Orthod Dentofacial Orthop. 2003;123:74-78.
78. Abbassy MA, Watari I, Bakry AS, Ono T, Abbassy MA, Watari I, et al. The Effect of Type 1 Diabetes Mellitus on the Dento-Craniofacial Complex. Type 1 Diabetes. 2013; Available from: https://www.intechopen.com/chapters/40880
79. Green A. Epidemiology of type 1 (insulin-dependent) diabetes mellitus: public health implications in the Middle East. Acta Paediatr Suppl. 1999;88:8-10.
80. Kaul K, Tarr JM, Ahmad SI, Kohner EM, Chibber R. Introduction to diabetes mellitus. Adv Exp Med Biol. 2012;771:1-11.
81. Alamo SM, Soriano YJ and Perez MG.; Dental consideration for the patient with diabetes. J Clin Exp Dent 2011;3: E25-E30.
82. Priya MB, Kumar VS, Anitha V and Shanmugam M.; Diabetes and dental diseases. CHC Med J 2012; 1:188-191
83. Leite RS, Marlow NM, Fernandes JK, Hermayer K. Oral health and type 2 diabetes. Am J Med Sci. 2013;345:271-273.
84. Vernillo AT. Dental considerations for the treatment of patients with diabetes mellitus. J Am Dent Assoc. 2003;134:24S-33S.
85. Sastrowijoto SH, van der Velden U, van Steenbergen TJ, Hillemans P, Hart AA, de Graaff J, et al. Improved metabolic control, clinical periodontal status and subgingival microbiology in insulin-dependent diabetes mellitus. A prospective study. J Clin Periodontol. 1990;17:233-242.
86. Saadoun AP. Diabetes and periodontal disease: a review and update. J West Soc Periodontol Periodontal Abstr. 1980;28:116-139.
87. McKenna SJ. Dental management of patients with diabetes. Dent Clin North Am. 2006;50:591-606, vii.
88. Gupta S, et al. Oral Health Consideration and Its Management In Diabetic Patient. Int J Recent Sci 2015;6:6347-6350.
89. American Academy of Pediatric Dentistry. Antibiotic prophylaxis for dental patients at risk for infection. Pediatric Dentistry; 2024:538-544.
90. Duncan BB, Magliano DJ, Boyko EJ. IDF diabetes atlas 11th edition 2025: global prevalence and projections for 2050. Nephrol Dial Transplant. 2025:gfaf177.