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ORTHODONTIC APPROACH IN THERAPY OF PATIENTS WITH DIABETES MELLITUS

Vanja Ichkova[1], Emilija Grujoska Dimovska[1], Biljana Bogdanovska[1 2], Katerina Adamova[3]
[1]Clinic for Orthodontics, Faculty of dentistry, Ss. Cyril and Methodius University, in Skopje, R.North Macedonia
[2]Clinic for Orthodontics, University dental clinical center "St. Pantelejmon", Skopje, R.North Macedonia
[3]University clinic of Endocrinology, Diabetes and Metabolic Disorders, Faculty of Medicine, Ss Cyril and Methodius University, Skopje. R.North Macedonia

Abstract

We live in a modern society where a beautiful smile becomes commonplace, so orthodontic patients are not just children and teenagers but also adults. If we take into account that the age limit of patients is growing, the number of different types of diseases is growing at the same time.

Knowing that factors such as stress, overweight, and low physical activity are common causes for the development of diabetes mellitus, it is expected that diabetes would increase systemic diseases faced by dentists during orthodontic procedures.

Diabetes mellitus is one of the most common chronic diseases and is characterized by increased blood sugar concentration - hyperglycemia.

Patients with diabetes mellitus who need orthodontic treatment require special treatment and knowledge of the changes that this disease gives in the oral cavity, periodontal changes in the supporting apparatus of the tooth, the tendency to infection, and the orthodontic tooth movements. In this paper, we focus on the impact of diabetes on the oral changes, tooth movements, and considerations that every orthodontist needs to have in mind when treating these patients.

Keywords: orthodontic approach, orthodontic treatment, diabetes mellitus, orthodontic tooth movement

Introduction

Although orthodontic treatment is commonly indicated at a younger age, in the last decades with the development of orthodontic appliances there has been an increase in the adult population seeking orthodontic treatment. The increased age does not come only with a serious and internal motive for cooperation. There is a proportionate increase in the prevalence of systemic diseases also, such as diabetes mellitus (DM).

DM is a chronic metabolic disease characterized by higher blood sugar levels and occurs most often due to a lack of insulin secretion or resistance of cells to the action of insulin, or both [1-3].

It is the most common endocrine disorder in humans, with a peak incidence in the 5th decade in life referring to Type 2 DM-. The World Health Organization (WHO) has recently declared it to be pandemic, its prevalence has increased dramatically over the past few decades and it is expected to triple in the next decade. Also, the International Federation of Diabetes with its latest data reveals an alarming increase in the incidence of diabetes.

There were 7432 newly diagnosed and over 133,000 patients with diabetes in 2020 in Macedonia. As a country and as an area with 11.2% of patients diagnosed with diabetes, Macedonia belongs to the group of countries with a high prevalence of diabetes. This is a very alarming indicator of a dynamic progression of this health condition [3].

The effect of DM on dental structures and the outcome of dental procedures were well documented in the past years. In everyday dental practice, different situations with DM patients occur, many of them

not yet diagnosed. DM patients present themselves with oral changes and symptoms while asking for an orthodontic treatment. DM is often difficult to be controlled and managed. Chronic hyperglycemia leads to various changes in the body and certainly causes a series of changes in the whole craniofacial complex during growth and at a later age, especially the lower part of the face as an orthodontic target zone.

Therefore, there is a necessity for a study where an overview of orthodontics' concerning considerations in the treatment of DM patients will be conducted.

Types of Diabetes Mellitus

1) Type 1 diabetes: In this type of diabetes, the body does not produce insulin at all. Some people may refer to this type as insulin-dependent diabetes, juvenile diabetes, or early-onset diabetes [4].

This type occurs in young people before their 20s, most often in early adulthood or adolescence, and rarely after 40 years of age. Approximately 10% of all cases of diabetes are type 1. Patients with type 1 diabetes must receive insulin therapy for the rest of their lives.

2) Type 2 diabetes: This type of diabetes occurs in people whose body does not produce enough insulin for normal functioning or produces enough but the cells in the body do not detect it and do not respond to insulin (insulin resistance). Type 2 diabetes mellitus is also called "non-insulin-dependent DM (NIDDM)" [5].

The symptoms of type 2 diabetes in some people can be controlled by losing weight, consuming a healthy diet, moderate exercise, and controlling blood glucose levels. However, type 2 diabetes is typically a progressive disease, and if harmful habits are not corrected, the disease will progress and therapy has to be started – first in the form of tablets (to stimulate the secretion of the insulin, to improve the insulin resistance) and later subcutaneous insulin injection is used. People who are overweight have a higher risk of developing type 2 diabetes than those with normal weight. Older people are at a higher risk of developing type 2 diabetes.

3) Gestational diabetes: This type occurs for the first time in pregnant women, who have been non-diabetic prior to pregnancy. In some pregnant women, blood glucose levels may be high and their bodies may not be able to produce enough insulin to transport all the glucose into their cells, leading to a progressive increase in glucose levels [6].

Diagnosis of gestational diabetes is made during pregnancy by OGTT (oral glucose tolerance test) between 24 and 28 gestational weeks. Gestational diabetes can be controlled by eating a healthy diet with a low glycemic index and by practicing moderate physical activity. Ten to twenty percent of pregnant women will need to take insulin therapy. Women with gestational diabetes are at an increased risk of complications during pregnancy and at delivery. They are also at increased risk of type 2 diabetes in the future. The majority of patients with type 2 diabetes initially had gestational diabetes. Cells in the body become insulin resistant.

Oral and Dental Manifestations of Diabetes Mellitus

Since half of the diabetic patients are not yet diagnosed, an oral exam may sometimes provide the first opportunity for it. Mechanisms that most commonly lead to oral complications of diabetes include impaired neutrophil function, increased collagenase activity, decreased collagen synthesis, microangiopathy, and neuropathy [7].

Complications that occur in the oral cavity are proportional to the duration of hyperglycemia.

The oral manifestations and complications include dry mouth (xerostomia) and cracking of mucosa, ketone breath, tooth decay (including root caries), periapical lesions, gingivitis, periodontal disease, changes in the oral cavity flora - mainly oral candidiasis, burning mouth, altered taste, geographic tongue, coated and tongue with pronounced fissures, oral lichen planus (OLP), aphthous stomatitis, increased susceptibility to infections and difficulty in wound healing, as well as recurrent oral infections [1-7].

Herein, we briefly describe the impact of DM on oral manifestations and complications.

XEROSTOMIA

People with diabetes have changes in the composition of saliva. The secretion of saliva decreases (the so called hyposalivation) and hence, a feeling of dry mouth occurs and burning. Xerostomia can lead to many problems such as difficulty swallowing, chewing, and accumulation of dental plaque. It certainly impairs the quality of daily life in these patients [7,8].

DENTAL CARIES

Patients with diabetes are more likely to develop new and recurrent caries. Reduced cleaning and buffering capacity of the saliva, increase of carbohydrate in the saliva, and increased level of oral yeasts, *S. mutans streptococci* and *lactobacilli* can lead to an increase in the incidence of tooth decay. In addition, chronic hyperglycemia may cause irreversible pulpitis leading to pulp necrosis [1,8]. Some studies have shown that apical periodontitis and radiolucent periapical lesions are more common in diabetic compared to non-diabetic individuals [1,9].

PERIODONTAL DISEASE

Progression of gingivitis, periodontitis, and alveolar bone loss may also be associated with increased blood glucose levels. Periodontal disease has been reported with increased incidence and prevalence in patients with type 1 and 2 diabetes [1,2,8].

Diabetes does not cause periodontal disease directly but it alters the response of periodontal lesions to local irritants, hastening bone loss and retarding post-surgical healing of the periodontal lesion. Also, gingival fluid in diabetes has higher glucose levels which favor the growth of microflora. Diabetes compromises the condition of the periodontium through the following mechanisms: causes changes in the blood vessels of the gingival tissue, increases collagenase levels, compromises the immune response of the organism, impairs the normal production of cytokines and growth factors, decreases the synthesis and cross-linking of collagen, i.e., Advanced Glycosylation End Products (AGES). When treating the pathogens, leads to a decrease in inflammation. That, in turn, reduces insulin resistance, and glucose levels. Therefore, there is a two-way relationship between periodontal disease and diabetes [2,8,9).

With the progression of periodontal disease in elderly patients, there is increased mobility of the teeth, which leads to their loss. Therefore, treatment of periodontitis, in addition to lowering blood glucose levels, can prevent tooth loss [1].

ORAL INFECTIONS

Oral infections are more common in patients with diabetes, most commonly caused by bacteria and fungi, due to the changed pH. Decreased salivary flow rate and the absence of its antimicrobial effects can cause these infections [1,2]. Oral candidiasis is an opportunistic fungal infection, which is very frequently encountered. Predisposing factor for the development of oral candidiasis is, of course, xerostomia. Salivary dysfunction in these patients can contribute to the higher carriage of fungi. Candida-related lesions include denture stomatitis, angular cheilitis, and median rhomboid glossitis [2].

Candida infection is more prevalent in diabetic patients who smoke, wear dentures, have poor glycemic control, and use steroids and broad-spectrum antibiotics [1,2].

ORAL MUCOSA ALTERATIONS

The most common changes in the oral mucosa associated with diabetes are cladding and cleft palate, geographic tongue, recurrent aphthous stomatitis, and some premalignant lesions, including lichen planus [1,8,9]. Opinions are controversial about the susceptibility of these patients to changes in the oral cavity, but insufficient control of diabetes leads to immunological changes, microcirculatory changes with a decrease in blood supply, xerostomia, and changes in the flow and composition of saliva and smoking [1,2].

POOR ORAL WOUND HEALING

Delayed healing of soft and hard tissues in diabetic patients is a well-known complication during oral surgeries [2,8].

According to some studies, factors that prolong wound healing in these patients include delayed vascularization, decreased blood flow and hypoxia, local hyperglycemia, decreased innate immunity, decreased growth factor production, and psychological stress [1].

Impact of Diabetes Mellitus on the Development and Treatment of Malocclusions

The literature data show that diabetes can indeed affect orthodontic treatment, whether in the form of unexpected complications, an influence on skeletal and dental maturity, or variations in diagnostic reference points.

● **Tooth Eruption**

DM also seems to influence tooth eruption. A more recent study, on the other hand, reports accelerated tooth eruption at the age of 10–14 years in 240 type 1 DM patients in comparison with a healthy control group. [10]

● **The Effect on the Craniofacial Complex**

A study conducted in young individuals discovered that:

1. Type 1 DM reduces craniofacial growth, resulting in retardation of skeletal development [11].

2. Based on height, weight, lateral cephalometry, and radiography of the wrist, it was found that patients with diabetes had decreased skeletal maturation and linear and angular cephalometric measurements when compared with the control group [11].

These findings should be considered when conducting any treatment in the craniofacial region in Type 1 DM since a better understanding of how diabetes affects bone will improve our ability to protect bone health in diabetic patients. Furthermore, studies have shown that type 1 diabetes has a significant impact also on the process of bone remodeling, which is observed during treatments involving the use of mechanical forces within the masticatory system, e.g. in orthodontic treatment [12].

Several mechanisms explaining the revised model of bone remodeling in patients with diabetes have been identified. One of them is the reduction in bone formation due to decreased osteoblast activity or increased osteoblastic cell apoptosis [13]. Other mechanisms might be that the elevated glucose concentration present throughout the development of murine osteoblasts stimulates cellular proliferation while inhibiting calcium uptake. Glucose inhibition of calcium uptake suggested that bone could be structurally altered [13].

Related to the previously mentioned gum bone erosion, these patients often have misaligned teeth. So far, diabetes mellitus has not shown itself as a contraindication of orthodontic treatment.

An orthodontist has to take into considerations several factors before and during treatment, and hence, we will divide them into 3 time periods [14, 15, 16].

1. Considerations before deciding on orthodontic treatment
2. Considerations during the process of orthodontic intervention
3. Diabetic emergencies during orthodontic treatment

Table 1. Summary of orthodontic considerations in diabetic patients

Considerations before starting the orthodontic treatment	Medical anamnesis at the first appointment. Check for HbA1c value or verify the control of the disease by communication with the physician. With DMT2 check for the frequency of hypoglycemic reactions. Type 2 DM patients are usually more stable.
	Ensure good oral hygiene and dental health
	Tight control of diabetes
	Exclude periodontitis
	Monitor blood glucose before starting the orthodontic treatment
Considerations during the process of orthodontic treatment	-Apply light physiological forces -During treatment, regularly check the periodontal condition and take care of the inflammation. -Perfect oral hygiene and hygiene of the appliance -Regularly check the vitality of the teeth involved. -Antibiotic prophylaxis before: • orthodontic bed placement; • separator placement; • screw insertion -Antibiotic prophylaxis is not needed in: • simple adjustment of appliances; • simple replacement of appliances
Considerations to prevent or manage emergencies during the process (especially hypoglycemia)	Morning meal on the day of orthodontic treatment
	If symptoms of hypoglycemia occurred dextrose should be applied i.v. and; glucagon 1 mg i.m
Summary	-Patients with well-controlled diabetes are not a contraindication for orthodontic treatment -Avoid orthodontic treatment if DM is poorly controlled or not controlled at all.

For bone repositioning and bone growth to take its normal pace, diabetic patients must establish a very tight control of their glycemic levels on a daily basis.

Since bone repositioning is the main factor on which all the orthodontic movements are possible, regular glycemic status is the prerequisite for an orthodontist to agree to treat the patient.

Glycemic status must not exceed 8 mmol, 2 hours after the meal. In addition to this, Hba1c has to be monitored every three months by an endocrinologist.

The method of choice in monitoring the treatment of DM is the determination of the glycosylated hemoglobin concentration assay.

HbA1c is more commonly used [16].

- 4% to 6% - Normal
- <7% - Good diabetes control
- 7% to 8% - Moderate diabetes control
- >8% - Action suggested improving diabetes control

The glycemic status and Hba1c have to be stable and under proper monitoring before starting the orthodontic treatment.

The bone in patients with both types of diabetes seems to show increased adipogenesis. Orthodontic treatment should be avoided in patients with poorly controlled insulin-dependent DM as these patients are particularly susceptible to periodontal breakdown.

Officially there is neither an age limit for orthodontic treatment nor limitations for over-treatment based on the type of DM.

From the aspect of the oral cavity, good oral hygiene and periodontal health are the second foundation for a successful orthodontic intervention. Burden *et al.* have demonstrated that diabetic patients who undergo orthodontic treatment while their glucose is poorly controlled had a very high risk of periodontal breakdown [17].

Diabetes patients are considered to have a high risk of periodontal disease, and subsequently a poor bone modulation. Additionally, patients with T1DM are presented with decreased BMD while patients with T2DM with increased BMD.

This discrepancy is related to hyperglycemia, altered insulin levels, and increased obesity rates, and all of them have an impact on bone turnover markers [18].

Because of this and other factors, diabetic patients are prone to tooth loss. This should also be taken into consideration when making the orthodontic treatment plan.

Periodontitis was demonstrated to significantly relate to blood glucose levels and their fluctuations. Because it is very much present in diabetic patients, it is essential to exclude it before proceeding to orthodontic treatment. The presence of inflammation will also increase the risk of unpredictable teeth movement [19].

Good oral hygiene has been established as the most important factor in fighting against poor dental health among diabetic patients. That is why, it is one of the most important considerations before initiating active orthodontic treatment, either by removable or fixed appliances [20].

Considerations during the process of orthodontic intervention

There is no treatment preference concerning fixed or removable appliances. Given the diabetes-related low blood flow to teeth and dental tissue, orthodontists should take into consideration that diabetic patients' teeth are fragile and thus apply as light physiological forces as possible not to overload the already compromised teeth [17].

Many studies have investigated the tooth movements in diabetic orthodontic patients directly or indirectly [16, 19, 21, 22].

DM can adversely affect bone remodeling and tooth movement during the application of orthodontic forces.

However, further long-term, well-planned studies are needed before the exact mechanism and impact of DM on orthodontic treatment outcomes can be fully understood.

Diabetic patients' immune system is often compromised. Therefore, antibiotic prophylaxis is considered essential during certain orthodontic interventions.

Diabetic patients who will undergo orthodontic band placement, separator placement, or screw insertion are at a high risk of developing an oral infection, a matter that requires the use of prophylactic antibiotics before these procedures.

The mini-implant retention results from the mechanical interlocking of its metal structure in cortical and dense bone and is not based on the concept of osseointegration. One of the key success factors is bone

quality and/or density. The well-controlled glycemic status allows patients to undergo mini-screw placement but under antibiotic prophylaxis. Every orthodontist will carefully plan the insertion of the appliance and thus prepare the patient for its obligations and his body for the effects of the appliance. A simple adjustment or replacement of appliances, however, does not necessitate antibiotics [16, 20 21, 23].

Removable appliances are a popular tool for moving or retaining teeth in a certain position. They usually contain an acrylic base which is well known for its hydrophobic surface to which *C. Albicans* can bind. The reduction in immune function and low night saliva flow, as in diabetic patients, allows *C. Albicans* to proliferate and to cause infection. If exposed to a removable appliance, this special group of patients should be particularly motivated for high hygiene of these appliances.

Ghazal *et al.* [24] have studied different methods of removing *C. Albicans* from removable orthodontic appliances. Their study showed that brushing, denture cleaning tablets, chlorhexidine gluconate, and ultrasonic cleaning can remove *C. Albicans* from the surface of orthodontic acrylic. Although the authors found no significant difference between the test methods, they said that commercially available denture cleaning tablets proved to be the most effective method [24].

Unlike the removable, the investigations of Khanpayeh *et al*. showed that fixed appliances caused more colonization of *Candida*, especially *Candida* species that are not *Albicans*.

Patients using orthodontic therapy, particularly fixed appliances, should make special efforts and pay attention to maintain their oral hygiene and health [25].

Diabetic emergencies during orthodontic treatment

After deciding for starting a treatment, every therapist should be aware of and ready to deal with potential diabetic emergencies that are likely to occur during orthodontic treatment.

The most dangerous emergency is hypoglycemia. Hypoglycemia occurs when serum blood glucose level drops below 70 mg/dL (3.9 mmol/L), and severe hypoglycemia is when blood glucose level is under 50 mg/dL (2.8 mmol/L) [26]. When patients develop hypoglycemia, they go through two stages; first the neurogenic (or adrenergic) stage, and second the neuroglycopenic stage.

During the adrenergic stage, there is a considerable activation of sympathoadrenal systems leading to shivering, cold sweating, tremors, and tachycardia. If the diagnosis of this stage was missed, patients develop neuroglycopenic symptoms including dizziness, blurred vision, confusion, generalized weakness, and even coma and death.

Dentists, as well as the orthodontic team, should be well-trained to early identify and manage hypoglycemia [26, 27].

For ultimate control, they should always have to take this issue into consideration when dealing with a diabetic. Once early hypoglycemia symptoms are recognized, it is better for an oral glucose to be administered. If the patient was unconscious, first dextrose i.v. should be infused fast, and then glucagon 1 mg i.m. Another measure to avoid hypoglycemia is to recommend and ensure that the patient consumes a morning meal on the day at least 2 hours before the orthodontic procedure.

Conclusions

Diabetes mellitus type 1 is not so rare in the young population as it was once thought. Diabetes mellitus type 2 is getting very common in adult orthodontic patients. Because of the considerable negative effect on bone remodeling, it is not unlikely for this kind of person to ask for treatment at any age. There is a lack of studies evaluating the tooth movements in diabetic patients to be confirmed with certainty.

Everything above mentioned leads to the fact that diabetes is not a contraindication for orthodontic treatment;

However, uncontrolled diabetes, uncontrolled glycemia may have significant negative consequences on the outcomes of the procedures. Tight control of diabetes before conducting any procedure is a must;

During an orthodontic treatment, therapists should be careful not to overload the weakened teeth, to give prophylactic antibiotics when required, and to be aware of early signs of hypoglycemia;

Because of the difficulties in maintenance of oral hygiene in these patients, it seems that traditional braces using wires can cause complications. A good alternative might be the use of transparent Invisalign holders. Patients can remove them before the meal, clean the teeth and whole mouth and then place the holders over teeth for therapy to be continued;

Furthermore, we would like to implicate the recent use of supplements, like D3, to ease the movement of the teeth. D3 is welcomed in the regular therapy of diabetic patients.

Since the prevalence of DM is expected to triple in the next decade, orthodontists would face a larger number of DM patients in the future. We sincerely hope that this review paper gave the orthodontists a positive direction on the treatment of DM patients.

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