

Original Research Article

Oral lesions in diabetic patients, data from the published literature

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ABSTRACT

Objectives: The study is oriented around the collection of already published data on diabetes as a systemic endocrine pathology and the oral lesions that accompany it. Diabetes is known as a systemic pathology that has the primary effect on the appearance of hyperglycemia in the blood, which gives local effects through the systemic pathways of blood vessels in the oral mucosa.

Material and Methods: The electronic search was performed in PubMed with the keywords diabetes and oral lesions and oral mucosa, according to the predetermined stages. The time search interval is 10 years. Articles published in PubMed about diabetes and concomitant oral lesions. To find the right articles, the inclusion and non-inclusion criteria of the articles in further analysis were applied. The filters or the selected criteria are abstract and full text, English language, and publications within the time interval of about 10 years. The time interval of the research is 10 years. Articles published in PubMed about diabetes and oral lesions that can appear in the oral cavity as a result of this pathology. The period was chosen due to the fact that the evolution of ideas on the treatment of this systemic pathology and the control, possible or not, that the patient himself exercises over this endocrine pathology have been in significant exploration and evolution for decades, as presented in the already published literature.

Results: From a total of 46 articles, through the second phase of selecting articles of interest in accordance with the purpose of our study, eight articles are excluded in this direction of scientific research. The concrete correlation between oral lesions and diabetes has the highest value for cross-sectional studies with the tendency to find the prevalence of oral lesions, and in the non-concrete diabetes category, it appears in the values of 16% again in cross-sectional studies. It is worth drawing attention to the case-report type studies where it is distinguished that the concrete correlation of oral lesions with diabetes is expressed in 8% of cases, and the non-concrete correlation is expressed in 13% of cases.

Conclusion: There is a tendency to associate oral lesions caused by diabetes with their infectious nature, but without leaving aside the possibility of malignant or immune modifications, as caused by diabetes. Mucositis is an infection of the oral mucosa and, as such, is associated with all the signs of infection, which can also be caused by *Candida*; even in most cases, this fact is mentioned. Traumatic ulcers are associated with delayed healing, that is characteristic of diabetes as a systemic pathology. Hyperglycemia causes cellular changes in the buccal epithelial cells and in the cells of members of the oral flora, mainly in *Candida albicans*. Diabetes delays healing as it reduces the proliferation of fibroblasts; the number of glucosaminoglycans is also reduced, promoting the formation of granular tissue.

Keywords: *Candida*, Coronavirus disease-19, Diabetes, Mucositis, Oral lesions, Oral mucosa

INTRODUCTION

Chronic hyperglycemia is the primary characteristic of the endocrine disease diabetes, with a major impact on the health of the periodontal tissues. The three mechanisms of the appearance of this pathology that is based on the non-production of insulin, its weakened action due to the dysfunction of the corresponding receptors, or the combination of both of these mechanisms are by the action of the inability to introduce glucose or its passage from the blood to tissues that need it.^[1-3] These mechanisms bring excess glucose into the blood and its filtration through urine in the kidneys. During the appearance of diabetes as a metabolic pathology, it is also accompanied by alteration of lipids and

proteins, which in complexity as a systemic pathology is associated with retinopathy, nephropathy, neuropathy, and cardiovascular and cerebrovascular disease.^[2,4-9] Diabetes is also associated with increased vulnerability against infections, which also causes a delay in the wound healing process. It is these two elements that are also visible in the periodontal tissues and in the clinical appearance of accompanying periodontal pathologies.^[2,6,10-12] Although the classification of diabetes is known to be type 1 and type 2, these two types also have further subclassifications. Type 1 diabetes is also called insulin-dependent, as the individual is unable to produce insulin as a result of the destruction of insulin-producing beta cells in the pancreas.^[3,6,7,12-15] This patient is forced to be treated with injected doses of insulin.

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The frequency of this type of diabetes in values of 5–10% occurs more often in children and adults. The control of this type of diabetes is more difficult to control by the patients, presenting them with the most complete picture of diabetes as a systemic pathology with the main signs of polyphagia, polydipsia, and polyuria, accompanied by the increased tendency of the patients to susceptibility to infections.^[16-21]

Type 2 diabetes, or as it is also called, non-insulin-dependent diabetes, is caused by peripheral resistance to the action of insulin. This type of diabetes affects adults more often and is the diagnosis of almost 90–95% of diabetes cases.^[7,22-25] It is not the immune reaction with the destructive ability of insulin-producing cells in the pancreas, but the peripheral resistance to the produced insulin of the pancreas expressed in its receptors in the relevant even tissues.^[2,6,26-30] It is found more often in obese patients and can even be controlled in these patients through diet control or oral hypoglycemic agents. Most of the affected individuals are not aware of the presence of the disease until the systemic consequences appear clearly in the patient, which causes significant complications.^[31-34]

Type 2 diabetes has the same symptoms as type 1 diabetes, but is much lighter in severity. Secondary hyperglycemia is the most accurate term that describes diabetes caused by another systemic condition, for example, pregnancy.^[35-39] It is diabetes that appears in almost 2–5% of cases of pregnancy, but with the ability to resolve or disappear of the pathology at the end of pregnancy. It is just that the presence of diabetes during pregnancy serves as a signal for the affected patient for the increased possibility of actually being affected by type 2 diabetes in the following years of life. Secondary hyperglycemia would be the most suitable term also for cases when it is caused by destructive chemicals of the pancreas in cases of pancreatic tumors or in cases of the presence of other endocrine pathologies.^[7,12,35,36-40]

Among the tissues affected by chronic hyperglycemia are the periodontal tissues, which are initially affected by the delay in the healing process and by the increased possibility of periodontal tissues for infections. Seen from this point of view, all the constituent tissues of the tooth-supporting structures are affected by the pathology of diabetes.^[41-43]

MATERIAL AND METHODS

The study is oriented around the collection of already published data on the relationship between the occurrence of oral lesions as a result of diabetes and further on the nature of these lesions according to the prevalence of the occurrence and the concrete or non-concrete relation with the pathology of diabetes. This study was approved by the Institutional Ethics Committee of Albanian University (June 02, 2019), Tirana, Albania, according to national regulations. The electronic search was carried out in PubMed with the keywords according to the following steps:

- Stage 1: Application of keywords: diabetes and oral lesions and oral mucosa^[1-46]
- Stage 2: Applying inclusion and non-inclusion criteria to articles in further analysis.

The time search interval is 10 years. Articles published in PubMed about diabetes and lesions of this pathology in the oral mucosa.

The filters or the selected criteria are abstract and full text, English language, and publications within the time interval of about 10 years. Articles published in PubMed about diabetes and oral lesions that can appear in the oral cavity as a result of this pathology. The period was chosen due to the fact that the evolution of ideas on the treatment of this systemic pathology and the control, possible or not, that the patient himself exercises over this endocrine pathology have been in significant exploration and evolution for decades, as presented in the already published literature. From a total of 46 articles, through the second stage of selecting articles of interest in accordance with the purpose of our study, eight articles are excluded.^[6,7,23,33,35,38,43,44]

Based on the analysis of 46 articles extracted from the literature on the combination of the keywords diabetes, oral lesions, and oral mucosa, it was observed that eight articles were not included in the scope of our study.

Reasons for exclusion

1. Articles where other primary diseases are mentioned and diabetes is seen as a concomitant systemic pathology – two articles^[6,35]
2. Pathological conditions accompanying other systemic pathologies and diabetes are seen as a concomitant systemic pathology (one article)
3. Oral pathology unrelated to diabetes – one article^[23]
4. Herbal medical treatment and its effect – one article^[33]
5. Protocols of different diagnostic stages and diabetes are viewed as a concomitant systemic pathology – one article^[38]
6. Medical treatments: Diabetes is seen as a concomitant systemic pathology – two articles.^[43,44]

The inclusion or not of the articles in the further study was difficult since diabetes as a systemic pathology is characterized by co-association with other systemic pathologies. The most frequent association of diabetes with hypertension is the most common combination of systemic pathologies with vulnerability of different systems in the body. According to a study, this association reaches the value of 30%, with 19% in the female gender and 11% possibility in the male gender.^[47]

RESULTS

After analyzing the studies selected in this study, based on the selection criteria, data collection and processing are presented in the following tables. Table 1 and Figure 1 show the collected

data depending on the type of article published and the year it was published. The 10-year period of inclusion of the articles selected for this study has been divided not equally but by separating the years of the coronavirus disease-19 (COVID-19) pandemic to reflect the trend of scientific research on diabetes, regardless of the onset of the pandemic. This is because diabetes itself, depending on the degree of vulnerability of the population and the danger it causes to life, is in itself a pandemic.

In Table 2 and Figure 2, the articles are presented based on the type of case report, cross-sectional, or retrospective study of the *in vivo* category articles.

Figure 2 shows the data from Table 2 on the distribution of articles on oral lesions of diabetes and how they are analyzed by articles.

Table 3 shows data on the association between oral lesions and diabetes.

Figure 3 graphically shows the data in Table 3.

Table 4 shows specifically the type of oral lesions that are thought to be in the list of oral lesions caused, or at risk of being caused, by the existence of the systemic pathology of diabetes in the body of the affected individual [Figure 4].

Table 5 shows another shorter summary of the data from Table 4, showing the pathologies depending on their nature.

Figure 5 shows the data from Table 5 reflected.

Table 6 shows those articles that have derived approximate values of the prevalence of oral lesions caused by diabetes

again in the concrete diabetes and non-diabetic categories. Table 7 shows concrete results regarding the mechanism of how diabetes causes oral lesions.

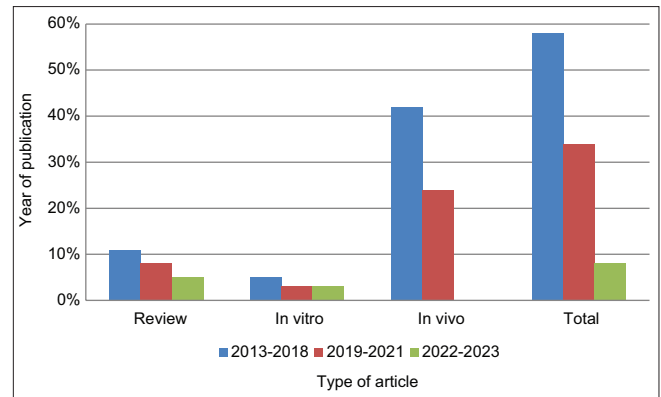


Figure 1: Data on the type of articles included in the study presented depending on the type of articles in the article.

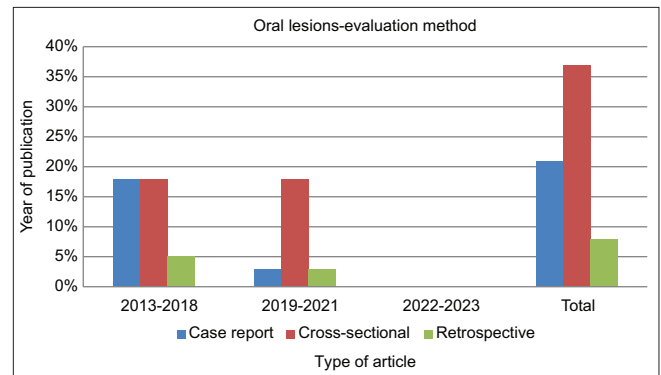


Figure 2: Graphic presentation of the data from Table 2 on the way of analyzing the oral lesions of diabetes according to the articles included in the study.

Table 1: Data on the type of articles included in the study are presented depending on the year of publication of the article.

Type of article	Year of publication			Total (%)
	2013–2018 (%)	2019–2021 (%)	2022–2023 (%)	
Review	4–11	3–8	2–5	9–24
<i>In vitro</i>	2–5	1–3	1–3	4–11
<i>In vivo</i>	16–42	9–24	0	25–66
Total	22–58	13–34	3–8	38–100

Table 2: Distribution of articles in the *in vivo* category based on the year of publication and the type of study conducted.

Year of publication	Type of study			Total (%)
	Case report (%)	Cross-sectional (%)	Retrospective (%)	
2013–2018	7–18	7–18	2–5	16–42
2019–2021	1–3	7–18	1–3	9–24
2022–2023	*	*	*	-
Total	8–21	14–37	3–8	25–66

*This row in the table is left to emphasize once again the lack of *in vivo* articles, regardless of the type of analysis or the type of article on oral lesions of diabetes, in the 2022–2023 batches

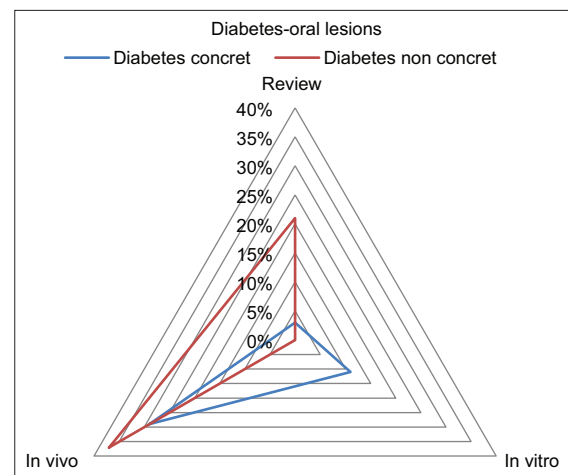


Figure 3: The percentage data of the number of articles by type of studies that show the concrete relationship of oral lesions with diabetes or not.

Table 3: The relationship between oral lesions and diabetes is presented in this table, depending on the type of study conducted in the articles included in the review.

Type of study	Link with diabetes		
	Diabetes concrete (%)	Diabetes non-concrete (%)	Total (%)
Review	1-3	8-21	9-24
<i>In vitro</i>	4-11	-	4-11
<i>In vivo</i>			
Case report	3-8	5-13	8-21
Cross sectional	8-21	6-16	14-37
Retrospective	0	3-8	3-8
Total	16-42	22-58	38-100

Table 4: Data on the type of oral lesion and the specific or non-specific correlation of existing diabetes in the affected patient.

Association with diabetes	Diabetes concrete (%)	Diabetes non-concrete (%)	Total (%)
Candidosis	3-8 ^[3,26,42]	3-8 ^[1,15,27]	6-16
Mucositis	3-8 ^[20,21,31]	4-11 ^[2,17,36,39]	7-19
Premalignant lesions	1-3 ^[30]	2-5 ^[4,8]	3-8
Traumatic ulcers	2-5 ^[5,45]	2-5 ^[11,22]	4-11
Glossitis	2-5 ^[9,13]	1-3 ^[16]	3-8
Trismus		1-3 ^[10]	1-3
Lichen		8-21 ^[12,14,18,19,24,25,34,46]	8-21
Actinic cheilitis	1-3 ^[29]		1-3
Esophagitis	1-3 ^[32]		1-3
Intestinal mucositis	1-3 ^[41]	1-3 ^[37]	2-5
Hyperpigmentation	1-3 ^[28]		1-3
Periodontitis	1-3 ^[40]		1-3
Total	16-42	22-58	38-100

Table 5: The data of Table 4 are presented in this table by classifying oral pathologies depending on their etiology.

Association with diabetes	Diabetes concrete (%)	Diabetes non-concrete (%)	Total (%)
Infections	28	21	49
Premalignant lesions	11	13	24
Autoimmune disease	3	24	27
Total	42	58	100

DISCUSSION

Table 1 shows that despite the years of the pandemic, diabetes is still a pathology that attracted attention due to the fact that

Table 6: The data on the declared prevalence of oral lesions in the oral cavity caused directly or indirectly by the presence of diabetes as a systemic disease in the patients included in the study.

Oral lesions	Prevalence		
	Diabetes concrete (%)	Diabetes non-concrete (%)	Average (%)
Traumatic ulcers	78.4 ^[5]	4.48 ^[5]	42
Actinic cheilitis	12.7 ^[5]		12.7
Lichen		5 ^[19]	5
Candidosis		15.8 ^[27]	15.8
Non-specific	45.5 ^[13]		

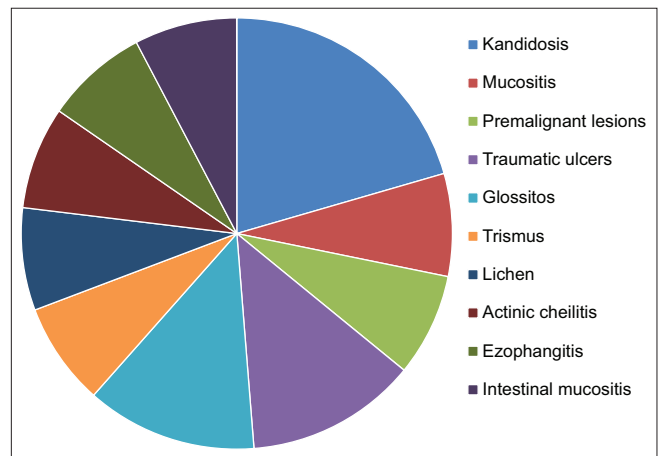


Figure 4: The data from Table 4 about the frequency of occurrence of different types of oral lesions.

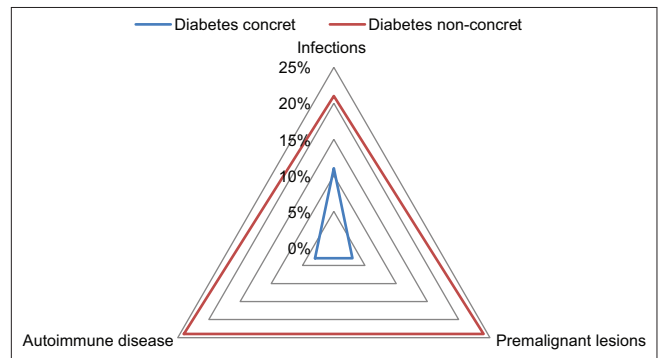


Figure 5: The concrete or non-concrete correlations of oral lesions with diabetes.

during the COVID-19 pandemic, the vulnerability of patients with systemic diseases was high, and among these pathologies was diabetes, which worsened the infection and progression of COVID-19. The value of 42% of the articles in *in vivo* studies on diabetic patients attracts attention, a value that was also reduced in the years 2019-2021 to almost half of this value to reach the

Table 7: Concrete data on the mechanism of how diabetes causes the appearance of oral lesions.

No.	References	Mechanism of action
1.	Negrini <i>et al.</i> , 2021 ^[3]	Hyperglycemia causes alterations of the oral microbiota and increases the level of periodontal pathogens. Diabetic patients exhibit an exaggerated inflammatory response, slow healing, and bone resorption.
2.	Scardina <i>et al.</i> , 2020 ^[20]	Videocapillaroscopy examination showed capillaries radiating around a non-vascularized area in the oral mucosa, giving a sunburst appearance.
3.	Saravani <i>et al.</i> , 2021 ^[21]	Diabetes causes cytopathological changes in cells and makes them react by creating pathological lesions. The nuclear area of affected cells is larger than that of normal cells, while the increase in hemoglobin A1C level increases the cytoplasmic area of buccal mucosal cells in patients with type 2 diabetes.
4.	Nouraei <i>et al.</i> , 2021 ^[26]	Due to the potential changes in the enzymes phospholipase, hemolysin, and esterase of <i>Candida albicans</i> enzymes with an effect on the pathogenesis and virulence of this fungus, it can be said that the gravity of extracellular enzymes plays a role in the severity of signs and symptoms of candidal infections in diabetic patients.
5.	Tanaka <i>et al.</i> , 2017 ^[30]	Diabetes and obesity both together cause esophageal carcinogenesis.
6.	Elshazly <i>et al.</i> , 2020 ^[31]	Diabetes is a pathology that compromises the immune system.
7.	Min <i>et al.</i> , 2022 ^[41]	Hyperglycemia caused by short-term doses of increased glucose lasting at least 2 weeks increases the level of IL-6 and TNF- α in the blood, leading to jejunal mucosal damage, hepatocyte steatosis, and disturbances in the balance of the intestinal microbiota.
8.	Divyadharshini <i>et al.</i> , 2021 ^[42]	Diabetes increases oral candidal colonization, turning the latter into the cause of diegeia mouth burning syndrome.
9.	Puspasari <i>et al.</i> , 2018 ^[45]	Traumatic ulcers caused by diabetes mellitus result from advanced end-product glycosylation, which delays healing. This process causes angiogenesis, vasculogenesis, and reduction of leukocytes, proliferation of fibroblasts, and the number of glycosaminoglycans falls, promoting the formation of granular tissue, deposition of collagen, and growth factors derived from thromboblats.

IL-6: Interleukin-6, TNF- α : Tumor necrosis factor-alpha

value of 0% in the years 2022–2023. From the data in Table 1, the trend of continuity at the same level of research on diabetes can be observed, despite the appearance of another pandemic, much more dangerous than the first. Articles of human studies, i.e., of the *in vivo* type, are the trend of scientific research regardless of the years of publication, occupying a weight of about 66%, while *in vitro* articles that are more experimental in rodents occupy a lower place, even after articles of the review type on diabetes, which are in the value of 24%.

From the data in Table 2, it is shown the high value of articles that are case reports in almost 21% of the articles, but that each of the articles can serve as a new field of research on diabetes, since each of the articles of the case report type speaks for an oral mucosal lesion related to the existence of diabetes in the affected patient, which requires more in-depth study in that area. The weight of cross-sectional type articles reaches 37%, while the weight of retrospective articles is 8%, data that show once again that for diabetes and specifically for oral lesions of diabetes, scientific research is still oriented around finding the prevalence and the incidence of the appearance of oral lesions caused and associated with diabetes.

In this Table 3, it is reflected in the point of view that the pathology of diabetes actually exists for the patient and the oral examination for pathological lesions is performed on this patient, or the oral lesion has appeared and the patient turns out to be diabetic. In the table, these two categories are presented as specific diabetes and non-specific diabetes.

From the data in Table 3, it is shown that drawing attention and the real connection between oral lesions and diabetes is expressed in 42% of the articles included in the study, while in a non-concrete way and considering diabetes as a risk factor or as a concomitant of pathologies other than systemic, it is in the value of 58% of the articles included in the study.

The concrete correlation between oral lesions and diabetes has a value of 21%,^[5,9,13,20,21,26,40,42] the highest for cross-sectional studies, with the tendency to also find prevalence of oral lesions, and in the diabetes category. “Not concrete” category appears in the values of 16% but still in cross-sectional type studies. Oral lesions direct connection with diabetes is expressed in 8% of cases^[28,29,32] and the non-specific connection is expressed in 13% of cases.^[18,34,36,39,46] While in terms of experimental studies in rodents about diabetes, the connection is in all studies of this type, accounting for 11% of the articles included in this category.^[30,31,41,45] In terms of review-type studies, this value is a deep indicator that there is a lack in analyzing the results of the articles that talk about this interplay between oral lesions and diabetes, which was proven in 42% of the articles included in our study. The value of 3% of articles of the review type, which indicates a concrete connection between diabetes and oral lesions, is distinguished compared to the value of 21% of the total number of articles included in the study. From the data in Table 4, it can be seen that the most frequent pathologies that diabetes causes and which are talked about more in articles on this topic are

lichen planus in almost 21% of cases, mucositis in almost 18% of cases, candidiasis in 16% of cases, and traumatic ulcers in 11% of cases. Mucositis is an infection of the oral mucosa and, as such, is associated with all the signs of infection, which can also be from *Candida*; even in most cases, this fact is mentioned. Hence, if you look at the data in Table 4 as such, then we can say that 34% is the highest frequency mentioned in articles about the appearance of *Candida*.

Traumatic ulcers are associated with delayed healing that is characteristic of diabetes as a systemic pathology. Another connection that can be made is the infection of the gastrointestinal system starting from esophagitis and continuing to intestinal mucositis, which is presented with 6% direct concrete connection with diabetes and 3% non-concrete connection. From the data in Table 5, it is clear that the main lesions appearing as a result of diabetes are infectious in nature; in almost 28% of the articles based on the connection with diabetes, and in 21% of the articles, diabetes is a risk factor. In total, this value goes to 49%. Hence, the correlation with diabetes is almost 1:1. In terms of premalignant lesions, these data are shown to be almost 1:1 related to diabetes, but far below the percentage of infection cases at 17% related to diabetes and 8% not related to diabetes. For the lesions of autoimmune diseases, there is a category of non-specific correlation with diabetes in the value of 24% and a category with correlation with diabetes in the value of 3%, almost 8 times less. From the data in Table 6, the high percentage of prevalence of traumatic ulcers in diabetic patients is observed in almost 42%, followed by candidiasis in 15.8%, followed by actinic cheilitis in 12.7%, and lichen in 5% of cases.

From the data of Table 7, such conclusions emerge as hyperglycemia causes alterations of the oral microbiota, part of which are potential changes in the enzymes phospholipase, hemolysin, and esterase of *Candida albicans*. Diabetes causes cytopathological changes in normal epithelial cells, bringing the nuclear area of the affected cells larger than that of normal cells and also increasing the cytoplasmic area of the cells of the buccal mucosa. Hyperglycemia induced by a short-term dose of increased glucose lasting for at least 2 weeks increases the level of interleukin-6 and tumor necrosis factor-alpha. As a consequence of glycosylation of advanced end products, it delays healing. This process causes angiogenesis, vasculogenesis, and reduction of leukocytes. Proliferation of fibroblasts and the number of glucosaminoglycans decrease, promoting the formation of granular tissue.

CONCLUSION

Studies about diabetes are oriented toward the *in vivo* assessment of the effects of diabetes in patients, with the highest number in the years before the pandemic. These data show that diabetes as a pathology has been exhausted with *in vitro* studies, and expectations for new experimental elements about

this pathology have been reduced. For diabetes and specifically for oral lesions of diabetes, scientific research is still oriented around finding the prevalence and incidence of occurrence of oral lesions caused and accompanying diabetes. There is a lack of articles about *in vivo* studies in diabetic patients about oral lesions. The concrete correlation between oral lesions and diabetes has the highest value for cross-sectional studies with the tendency to find the prevalence of oral lesions, and in the non-concrete diabetes category, it appears in the highest values still in cross-sectional studies. There is a tendency to associate oral lesions caused by diabetes with their infectious nature, but without leaving aside the possibility of malignant or immune modifications as caused by diabetes. Mucositis is an infection of the oral mucosa and, as such, is associated with all the signs of infection, which can also be from *Candida*; even in most cases, this fact is mentioned. Traumatic ulcers are associated with delayed healing that is characteristic of diabetes as a systemic pathology. Hyperglycemia causes cellular changes in the buccal epithelial cells and in the cells of members of the oral flora, mainly *C. albicans*. Diabetes delays healing as it reduces the proliferation of fibroblasts and the number of glucosaminoglycans, promoting the formation of granular tissue.

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Ethical approval: The research/study approved by the Institutional Ethics Committee at Albanian University, Tirana, Albania, according to national regulations, number nr.320/2, dated 02nd June 2019.

Declaration of patient consent: Patient's consent not required as there are no patients in this study.

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