Article published online: 2025-03-07

Original Article

Estimation of Salivary Creatine Kinase Level and Periodontal Health Status among Type II Diabetic and Nondiabetic Patients with Chronic Periodontitis

Ansam Mahdi Khaleel[1] Tabarak Sabah Abbas[1] Shatha Hameed Ali[1] Mustafa Basim Ali[1]

[1] Department of Oral Diagnosis, College of Dentistry, University of Kufa, Najaf, Iraq

Address for correspondence Ansam Mahdi Khaleel, MSc, Department of Oral Diagnosis, College of Dentistry, Kufa University, Najaf, Iraq (e-mail: ansamm.salman@uokufa.edu.iq).

Eur J Gen Dent

Abstract

Objectives This study was conducted to determine the periodontal health status and the level of creatine kinase (CK) of the study and control groups and to correlate the level of this enzyme with clinical periodontal parameters in the study and control groups.

Materials and Methods This study included 80 male participants aged 35 to 55 years, divided into four groups: poorly controlled type 2 diabetes mellitus with chronic periodontitis (G1), well-controlled type 2 diabetes mellitus with chronic periodontitis (G2), chronic periodontitis without diabetes (G3), and periodontally healthy controls (G4). Clinical periodontal parameters (plaque index, gingival index, periodontal pocket depth [PPD], and clinical attachment loss) and salivary CK levels (measured using enzyme-linked immunosorbent assay) were compared between groups.

Results All clinical periodontal parameters and CK levels were highest in poorly controlled type 2 diabetes mellitus with chronic periodontitis patients, and the enzyme level revealed highly significant differences between all pairs of the study and control groups. There were nonsignificant weak correlations of CK with all clinical parameters in all groups except a significant moderate positive correlation with PPD in the nondiabetic with chronic periodontitis group.

Conclusion It was concluded that poor glycemic control negatively impacts periodontal health status. CK is considered a good biochemical marker of periodontal tissue destruction and is useful in the diagnosis, monitoring, and management of periodontal diseases.

Keywords
- chronic periodontitis
- clinical periodontal parameters
- creatine kinase
- saliva
- type 2 diabetes mellitus

Introduction

Chronic periodontitis (CP) is chronic inflammatory disease, initiated by the accumulation of a pathogenic dental plaque biofilm above and below the gingival.[1,2] Key periodontal pathogens, such as *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Aggregatibacter actinomycetemcomitans*, produce potent virulence factors that directly damage periodontal tissues and modulate the host immune response, leading to the breakdown of collagen, bone resorption, and the formation of periodontal pockets. It represents a consequence of local infections in the oral cavity resulting in

DOI https://doi.org/10.1055/s-0045-1802324.
ISSN 2320-4753.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

irreversible destruction of the tooth-supporting apparatus such as alveolar bone, cementum, and the periodontal ligament. The clinical presentation of CP varies, with disease severity characterized by probing pocket depths (PDs), clinical attachment loss (CAL), and radiographic bone loss,[3] often leading to tooth mobility and eventual tooth loss if left untreated. Genetic susceptibility, along with environmental factors such as smoking and systemic diseases, significantly influences the progression and severity of CP. The extent and severity of the disease are modified by host response, genetics, and lifestyle factors such as smoking, obesity, age, race, hormonal changes, and diabetes.[4,5]

Diabetes mellitus (DM) is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin action, insulin secretion, or both.[6,7] Diabetes is a condition primarily defined by the level of hyperglycemia giving rise to risk of micro-vascular damage, nephropathy, retinopathy, and neuropathy. It is associated with reduced life expectancy, significant morbidity due to specific diabetes-related microvascular complications, increased risk of macrovascular complications, stroke and peripheral vascular disease, and diminished quality of life.[8] A close relationship between DM and PD has been well recognized in several clinical and epidemiological studies.[9–11] DM is believed to promote periodontitis through an exaggerated inflammatory response to the periodontal microflora.[12] It has been shown that poorly controlled DM has a greater incidence of severe PD compared with those patients who are well controlled or have no DM, which has been more prevalent in persons with type 2 DM (T2DM).[13]

Saliva, a complex biological fluid with diverse functions, is essential for maintaining oral health.[14–16] It consists of water, electrolytes, proteins (including immunoglobulins, enzymes such as amylase and lysozyme, and growth factors), and various antimicrobial compounds.[17] Saliva plays crucial roles in lubrication, buffering, and the clearance of microorganisms and food debris from the oral cavity. It also contributes to maintaining oral pH and provides a protective barrier against infections.[18] Increasingly, saliva is being recognized as a rich source of biomarkers for detecting and monitoring various health conditions.[16,45] Its noninvasive collection method and the presence of proteins, nucleic acids, and other molecules reflecting both local oral and systemic processes make it a promising diagnostic fluid.[19]

Creatine kinase (CK), also known as creatine phosphokinase or phosphocreatine kinase, is 82 kDa enzyme that is found mainly in tissue with high energy demands, especially brain, skeletal muscle, and myocardium. The CK isoenzyme MM-CK is predominantly found in skeletal muscle, and its presence in other bodily fluids, such as saliva and gingival crevicular fluid (GCF), typically indicates cellular damage and tissue injury.[20] The increased levels of CK were associated with muscle disruption, cell damage, and necrosis. It was also used to detect periodontal diseases and determine the success of periodontal treatment.[21] Creatinine phosphokinase catalyzes the conversion of creatine and consumes adenosine triphosphate to create phosphocreatine and adenosine diphosphate. Creatine phosphokinase is stored in specific granules and secretory vesicles of the neutrophils and is mainly released during their migration to the site of infection. It is also present in bacteria within dental plaque. Intracellular enzyme (CK) is increasingly released from the damaged cells of periodontal tissues into the GCF. The enzymatic action changes reflect metabolic changes in the periodontium in inflammation.[22] Because there is no information about CK levels in the saliva of type II diabetic patients with CP, and it is important in the assessment of periodontal tissue destruction, for these reasons, this study was conducted.

Materials and Methods

Study Design

A cross-sectional approach was employed. The subjects consisted of 80 males with an age range of 35 to 55 years and body mass index (BMI) between 18.50 and 24.99 kg/m^2. Sample collection occurred from November 2022 to February 2023. Ethical approval for this study, which involved human participants, was granted by the local ethical committee (reference number 4871) of Kufa University/Najaf - IRAQ. The study adhered to the principles of the Helsinki Declaration of 1975, as revised in 2013.[23] The subjects recruited for the study were patients attending the Specialized Center for Endocrinology and Diabetes in Najaf and patients from the Department of Periodontics at a teaching hospital, College of Dentistry, University of Kufa. All the individuals were informed about the purposes of the investigation and consented to its protocol. The subjects were divided into:

Group 1 (G1): consists of 20 males with CP and T2DM, poorly controlled, and the glycated hemoglobin (HbA1c) was >9%.

Group 2 (G2): consists of 20 males with CP and T2DM, well controlled, and HbA1c was <7%.

Group 3 (G3): consists of 20 males with CP and without a history of any systemic diseases.

Group 4 (G4): consists of 20 males without a history of any systemic diseases and with healthy periodontium; this was defined by gingival index (GI) scores <0.5[24] and without periodontal pockets or CAL. This group represents baseline data for the level of salivary CK.

Inclusion criteria include T2DM patients (≥5 years) on oral hypoglycemic medication, BMI ranges between 18.5 and 24.9 kg/m2,[25] all subjects presenting at least 20 teeth, and CP in patients defined as the presence of at least four sites with PPD ≥4 mm and CAL of 1 to 2 mm or greater; this was made according to the international classification system for PD.[26]

Exclusion criteria include T1 and T2 diabetic patients taking insulin therapy, presence of systemic diseases other than diabetes, presence of retinopathy, neuropathy, or diabetic foot, patients who have undergone periodontal treatment and a course of anti-inflammatory or antimicrobial therapy 3 months prior to the study, a history of smoking, and a history of alcohol abuse or dependence.

Sample Size Determination

The sample size was determined using a power analysis conducted with G*Power software (version 5.1). With an

alpha level of 0.05, a power of 0.80, and an expected moderate effect size ($f = 0.25$), the analysis indicated a minimum sample size of 16 participants per group. To account for potential dropouts and increase in statistical power, we recruited 20 participants per group, resulting in a total sample size of 80. A sample size of 20 per group might be sufficient to detect the difference with acceptable statistical power (typically set at 0.80 or higher).

Sample Preparation

An unstimulated saliva sample was taken from each patient. Following this, a complete examination of clinical periodontal parameters [plaque index (PLI), GI, periodontal PD [PPD], and CAL] was done. Saliva was centrifuged at 2,000 rpm. For 10 minutes, the resultant supernatant was aspirated, put into an Eppendorf tube, and kept frozen at –20°C until analyzed. The salivary CK level was determined by enzyme-linked immunosorbent assay (ELISA; Human CK-MB ELISA kit) in the Al-Mustafa Laboratory in Karbala.

Hypotheses: this study was conducted based on the premise that poorly controlled type II diabetes negatively influences periodontal health and elevates salivary CK levels. Specifically, we hypothesized that:

- Patients with poorly controlled T2DM and CP will exhibit poorer periodontal health status (higher PLI, GI, probing PD, and CAL) compared to well-controlled T2DM patients and nondiabetic individuals with CP.
- Salivary CK levels will be significantly higher in patients with poorly controlled T2DM and CP compared to well-controlled T2DM patients, nondiabetic CP patients, and periodontally healthy controls.

Statistical Analysis

Statistical analysis was done using mean, standard deviation, ANOVA (analysis of variance) test, *t*-test, and Pearson correlation coefficient (*r*). The level of significance (S) was accepted at *p*-value ≤ 0.05, highly significant (HS) at *p*-value ≤ 0.01, and nonsignificant (NS) at *p*-value > 0.05.

Results

Clinical Periodontal Parameter Analysis

The highest mean values of the clinical periodontal parameters were recorded in G1, followed by G2, then G3 and G4 in terms of PLI, GI, PPD, and CAL. Inter-study group comparisons regarding all clinical periodontal parameters revealed highly significant differences between G1 versus G2 and G3, as well as between G2 and G3 (►**Table 1** and ►**Fig. 1**).

Biochemical Parameter Analysis

The biochemical analysis (►**Table 2** and ►**Fig. 2**) of the salivary CK revealed that the highest concentration was in G1 (8.154 U/L), followed by G2 (5.229 U/L), then G3 (3.083 U/L) and finally the G4 (1.609 U/L). Furthermore, highly significant differences in the mean values of the salivary CK concentration were revealed among the study and control groups. The results of the comparisons for all pairs of the study and control groups in ►**Table 2** and ►**Fig. 2** about

Table 1 Mean values of the clinical periodontal parameters and the intergroup comparisons between all pairs of the study groups

Parameters	G1 (mean ± SD)	G2 (mean ± SD)	G3 (mean ± SD)	G1 vs. G2 (*t*-test)	*p*-Value	G1 vs. G3 (*t*-test)	*p*-Value	G2 vs. G3 (*t*-test)	*p*-Value
PLI	0.281 ± 2.767	0.229 ± 1.972	0.271 ± 1.497	10.426	0.000 HS	16.227	0.000 HS	5.931	0.000 HS
GI	0.331 ± 2.473	0.197 ± 1.938	0.361 ± 1.565	6.391	0.001 HS	8.054	0.000 HS	4.097	0.000 HS
PPD (mm)	0.717 ± 6.966	0.454 ± 5.491	0.324 ± 4.949	8.098	0.002 HS	11.688	0.000 HS	3.549	0.000 HS
CAL (mm)	0.416 ± 2.914	0.241 ± 2.151	0.261 ± 1.809	6.446	0.001 HS	11.364	0.000 HS	4.019	0.000 HS

Abbreviation: CAL, clinical attachment loss; GI, gingival index; HS, highly significant; PLI, plaque index; PPD, periodontal pocket depth; SD, standard deviation.
Note: $p < 0.05$; significant difference.

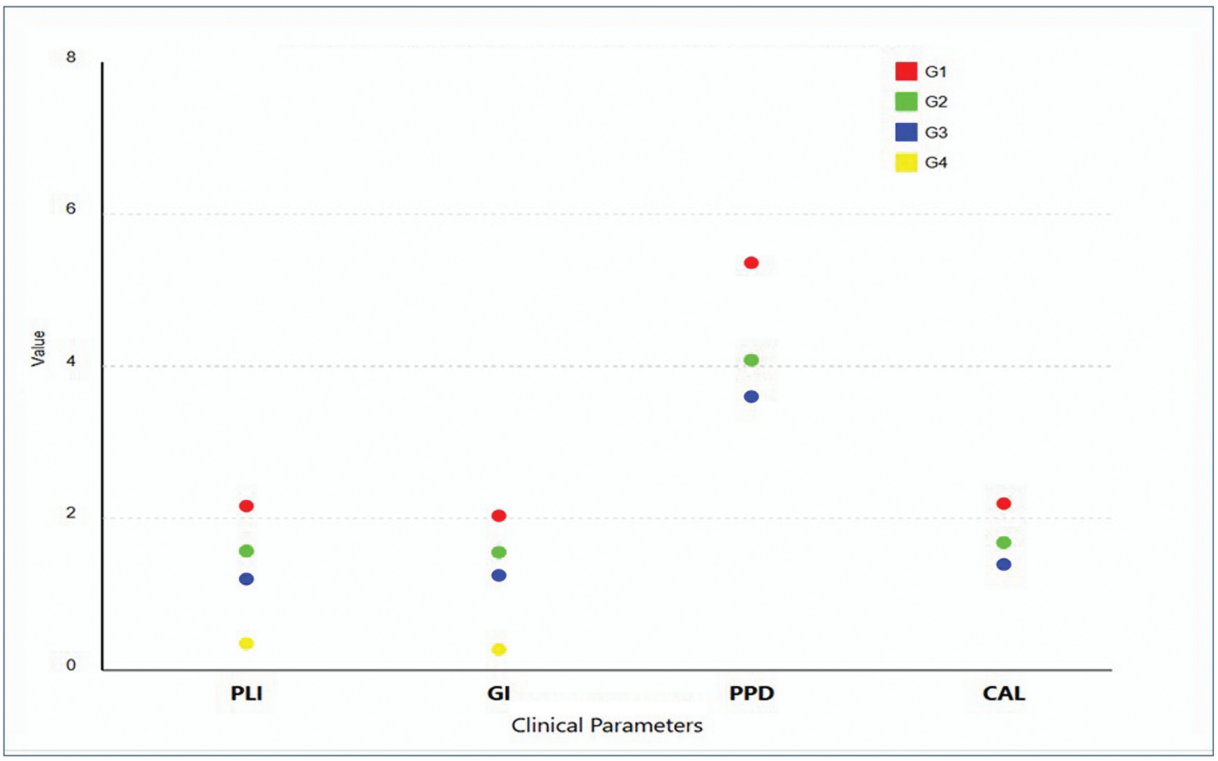

Fig. 1 Clinical periodontal parameters across study groups.

Table 2 Mean values of salivary creatine kinase (U/L) and the significance of difference among the study and control groups

Parameter	G1 (mean ± SD)	G2 (mean ± SD)	G3 (mean ± SD)	G4 (mean ± SD)	F-test	*p*-Value
Creatine kinase pg/mL	8.154 ± 2.049	5.229 ± 1.965	3.083 ± 1.518	1.609 ± 0.943	5.791	0.001 HS

Abbreviation: HS, highly significant; SD, standard deviation.
Note: $p < 0.05$; significant difference.

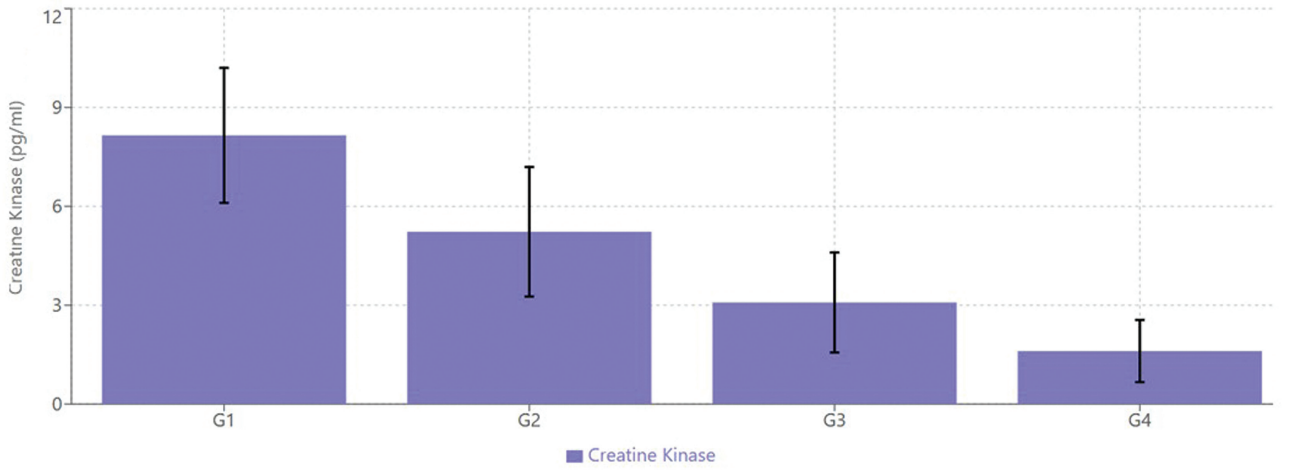

Fig. 2 Salivary creatine kinase (U/L) in difference among the study and control groups.

biochemical parameter levels revealed highly significant differences between the control group and all of the study groups, between G1 and G2, as well as between G2 and G3, and finally, between G1 and G3.

Correlations of Salivary Creatin Kinase with Clinical Periodontal Parameters

As seen in ►**Table 3** and ►**Fig. 3**, CK enzyme generally demonstrated nonsignificant weak correlations with all

Table 3 Correlations between the levels of salivary creatin kinase (IU/L) with the clinical parameters at each study and control groups

Parameter	G1 (R)	*p*-Value	G2 (R)	*p*-Value	G3 (R)	*p*-Value	G4 (R)	*p*-Value
PLI	−0.109	0.647 NS	0.328	0.159 NS	−0.047	0.844 NS	−0.134	0.573 NS
GI	0.006	0.980 NS	0.294	0.208 NS	0.198	0.404 NS	−0.367	0.111 NS
PPD	0.249	0.289 NS	0.063	0.793 NS	0.463	0.040 S	X	X
CAL	0.037	0.876 NS	−0.232	0.325 NS	0.360	0.119 NS	X	X

Abbreviation: CAL, clinical attachment loss; GI, gingival index; NS, not significant; PLI, plaque index; PPD, periodontal pocket depth; R, correlation coefficient; S, significant; X, not applicable.
Note: $p > 0.05$; no significant difference.

clinical parameters at all groups except a significant moderate positive correlation with probing PD in G3.

Discussion

The results demonstrate that patients with poorly controlled T2DM and CP exhibited significantly higher mean values for all periodontal parameters (PLI, GI, probing PD, and CAL) compared to the other groups. This aligns with previous research indicating a strong association between poorly controlled diabetes and increased periodontal disease severity.[27,28] The hyperglycemic state in poorly controlled T2DM contributes to several detrimental effects on periodontal health. Decreased salivary volume and buffering capacity, coupled with alterations in the oral microbiota, lead to increased plaque accumulation.[29] Furthermore, the detrimental effects of advanced glycation end-products (AGEs) and their interaction with the receptor for AGEs within the periodontium impair wound healing, increase vascular permeability, and contribute to periodontal tissue destruction.[30] Diabetes also dysregulates inflammatory and immune responses, leading to an accumulation of pro-inflammatory cytokines in gingival tissues and further tissue breakdown.[31] Impaired neutrophil function and hyperactivity of monocytes and macrophages contribute to the increased prevalence and severity of periodontal pockets observed in diabetic patients.[32] Poor glycemic control, associated with elevated AGEs,[33] significantly increases susceptibility to infection and periodontal tissue damage, resulting in greater attachment loss—a characteristic finding in diabetic patients who are twice as likely to experience this compared to nondiabetic individuals.[34]

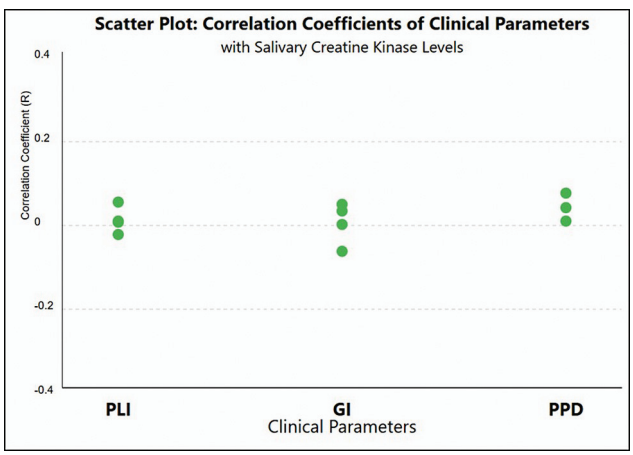

Fig. 3 Correlation between clinical parameters and salivary creatine kinase.

This study also reveals significantly higher salivary CK levels in the poorly controlled T2DM with CP group compared to all other groups ($p \leq 0.01$). CK, an intracellular enzyme, is released into the saliva and GCF during periodontal tissue destruction and inflammation. Its increased activity reflects metabolic changes and the degree of cellular damage within the periodontium.[12,35] The release of CK is likely mediated by several mechanisms, including necrosis, apoptosis, and membrane disruption caused by the inflammatory cascade involving cytokines and reactive oxygen species.[36] CK in saliva is likely derived primarily from GCF, which is in direct contact with the inflamed periodontal tissues. The contribution of different cell types, such as neutrophils, fibroblasts, and epithelial cells, to CK release warrants further investigation.[37] While this study showed only a weak, nonsignificant correlation between salivary CK and periodontal parameters, except for a moderate positive correlation with probing PD in the nondiabetic CP group, the significant difference in CK levels between groups suggests that it may serve as a useful adjunct biomarker.[38] However, further research is needed to establish its sensitivity and specificity compared to other established periodontal biomarkers (e.g., interleukin [IL]-1β, IL-6, tumor necrosis factor-α, matrix metalloproteinases). The ease of salivary CK measurement via ELISA is an advantage, but factors such as sample collection and storage protocols need to be standardized to minimize variability.

The clinical implications of these findings are significant. Salivary CK could potentially serve as a valuable noninvasive marker for assessing periodontal tissue destruction, particularly in T2DM patients.[39] Future research should focus on longitudinal studies to monitor CK levels during disease progression and treatment response in larger, more diverse populations, including female participants. Investigating the combined use of salivary CK with other biomarkers might enhance diagnostic accuracy. Furthermore, research should examine the potential of CK levels to predict response to various therapeutic interventions. In summary, while further research is needed to fully elucidate the clinical utility of salivary CK, our findings provide preliminary evidence supporting its potential role as a marker for periodontal damage in individuals with T2DM.

Conclusion

The current outcomes may provide evidence of an association between CP and DM. Patients with CP and poorly controlled T2DM had significantly higher activity levels of the salivary CK enzyme than other groups. Subsequently, the CK enzyme can be utilized as a marker to determine the amount of destruction of periodontal tissues.

Limitations

This study's limitations include its single-center design and the exclusive inclusion of male participants. The latter was due to concerns about the confounding influence of hormonal fluctuations on salivary CK levels and periodontal parameters in females, limiting generalizability to women. Furthermore, although a power analysis was conducted, a larger sample size could have increased statistical power, potentially revealing more subtle relationships. BMI was collected but not analyzed in the study. Future multicenter studies with larger, more diverse participant groups are needed to validate these findings and explore gender-specific differences.

Funding
None.

Conflicts of Interest
None declared.

Acknowledgements
The assistance received in preparing this manuscript is most gratefully acknowledged. We appreciate the assistance and resources provided by the Department of Oral Diagnosis at the Al-Kufa College of Dentistry.

References

1 Hassan RS, Hanoon ZA, Ibrahim SM, Alhusseini NB. Assessment of periodontal health status and treatment needs among dental students of Al-Kufa University by using the community periodontal index for treatment needs: a cross-sectional study. Dentistry 2024;12(02):752
2 Jepsen S, Blanco J, Buchalla W, et al. Prevention and control of dental caries and periodontal diseases at individual and population level: consensus report of group 3 of joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. J Clin Periodontol 2017;44(Suppl 18):S85–S93
3 Furukawa MV, Oliveira MF, da Silva RA, et al. Salivary proteomic analysis in patients with type 2 diabetes mellitus and periodontitis. Int J Mol Sci 2012;13(04):4642–4654
4 Carrillo-de-Albornoz A, Figuero E, Herrera D, Bascones-Martínez A. Gingival changes during pregnancy: II. Influence of hormonal variations on the subgingival biofilm. J Clin Periodontol 2010;37 (03):230–240
5 Pretzl B, El Sayed N, Cosgarea R, et al. IL-1-polymorphism and severity of periodontal disease. Acta Odontol Scand 2012;70(01): 1–6
6 Shahbaz M, Kazmi F, Majeed HA, Manzar S, Qureshi FA, Rashid S. Oral manifestations: a reliable indicator for undiagnosed diabetes mellitus patients. Eur J Dent 2023;17(03):784–789
7 Mohammed MJ, Al-Mizraqchi AS, Ibrahim SM. Oral findings, salivary copper, magnesium, and leptin in type II diabetic patients in relation to oral *Candida* species. Int J Microbiol 2024;2024:8177437
8 Ibrahim SM, Ibrahim Leka'a M. Biochemical analysis and periodontal health status in type 1 and type 2 diabetes (comparative study). J Bagh College Dent 2012;24(special issue 1):80–84
9 Preshaw PM, Foster N, Taylor JJ. Cross-susceptibility between periodontal disease and type 2 diabetes mellitus: an immunobiological perspective. Periodontol 2000 2007;45(01):138–157
10 Zheng M, Wang C, Ali A, Shih YA, Xie Q, Guo C. Prevalence of periodontitis in people clinically diagnosed with diabetes mellitus: a meta-analysis of epidemiologic studies. Acta Diabetol 2021; 58(10):1307–1327
11 Hassan RS, Salman SA. Evaluation of salivary melatonin and periodontal parameters in type II diabetic patients with chronic periodontitis: a comparative study. Indian J Public Health Res Dev 2019;10(10):2740
12 Palwankar P, Jain S, Pandey R, Mahesh S. IgA levels among type 2 diabetic and non-diabetic patients with periodontitis: a prospective clinical study. Eur J Dent 2023;17(03):823–827
13 Abdul-wahab GA, Ahmed MA. Assessment of some salivary enzymes levels in type 2 diabetic patients with chronic periodontitis clinical and biochemical study. J Bagh College Dent 2015;25 (01):138–143
14 Ibrahim S, Hussein AS. Role of hexidine, zak and biofresh mouth wash in commemoration deletion and oral health status (comparative study). Int J Pharm Res 2019;11(01):390–394
15 Ibrahim SM, Al-Mizraqchi AS, Haider J. Metronidazole potentiation by panax ginseng and Symphytum officinale: a new strategy for P. gingivalis infection control. Antibiotics (Basel) 2023;12(08): 1288
16 Li J, Song H, Zhang L, et al. Interaction of diesel exhaust particulate matter with mucins in simulated saliva fluids: bioaccessibility of heavy metals and potential health risks. J Hazard Mater 2024; 480:135811
17 Khalaf SJ, Hamad MS, Sarhat ER. Salivary biomarkers in periodontal diseases: a review. Tikrit Journal for Dental Sciences 2023;11 (01):105–108
18 Basilicata M, Pieri M, Marrone G, et al. Saliva as biomarker for oral and chronic degenerative non-communicable diseases. Metabolites 2023;13(08):889
19 Ljupka A, Sanja N. The power of saliva in diagnostic oral desease. MEDIS – International – J Med Sci Res 2023;2:13–14
20 Zhang L, Henson BS, Camargo PM, Wong DT. The clinical value of salivary biomarkers for periodontal disease. Periodontol 2000 2009;51(01):25–37
21 Gul S, Phil M. Cross sectional analysis of biomarkers in chronic periodontitis patients. JPDA 2019;28(01):23
22 Ferrara E, Converti I, Scarola R, et al. Mechanism behind the upregulation of proteins associated with the NLRP3 inflammasome in periodontitis and their role in the immune response in diabetes—a systematic review. Appl Sci (Basel) 2023;13(14): 8278
23 World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA 2013;310(20):2191–2194
24 Löe H. The gingival index, the plaque index and the retention index systems. J Periodontol 1967;38(06):610–616
25 Who ECWHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363(9403):157–163
26 Lang N, Bartold PM, Cullinan M, et al. Consensus report: aggressive periodontitis. Ann Periodontol 1999;4(01):53
27 Daily ZA, Mohammed AN. Periodontal health status and assessment of osteocalcin levels in saliva of diabetic patients and systemically healthy persons (comparative study). J Baghdad Coll Dent 2017;29(01):89–95

28 Khalel AM, Ali MB, Sadiq MA, Ibrahim SM, Ali SH. DMFT and PUFA indices in first permanent molars of Iraqi children in Najaf City. Dentistry 3000 2024;12(02):743
29 Zhao M, Xie Y, Gao W, Li C, Ye Q, Li Y. Diabetes mellitus promotes susceptibility to periodontitis-novel insight into the molecular mechanisms. Front Endocrinol (Lausanne) 2023;14:1192625–1192625
30 Ateeq H, Zia A, Husain Q, Khan MS, Ahmad M. Effect of inflammation on bones in diabetic patients with periodontitis via RANKL/OPG system-a review. J Diabetes Metab Disord 2022;21(01):1003–1009
31 Cassiano BA, Silveira ALPA, Kim YJ, et al. Role of circulating microparticles and cytokines in periodontitis associated with diabetes. Front Med (Lausanne) 2024;11:1394300
32 Pasarín L, Martu M-A, Ciurcanu OE, et al. Influence of diabetes mellitus and smoking on pro- and anti-inflammatory cytokine profiles in gingival crevicular fluid. Diagnostics (Basel) 2023;13(19):3051
33 Mohammed MJ, Al-Mizraqchi AS, Ibrahim SM. Salivary biomarkers and oral candida spp. in type II diabetic patients: a comparative analysis. J Med Pharm Chem Res 2025;7(07):1379–1397
34 Ibrahim SM, Abdul-Zahra Al-Hmedat SJ, Alsunboli MH. Histological study to evaluate the effect of local application of myrtus communis oil on alveolar bone healing in rats. Open Dent J 2024; 18:e18742106299510
35 Ibrahim SM, Al-Mizraqchi AS. Comparison of the antibacterial activity of panax ginseng and symphytum officinale with metronidazole against P. gingivalis: an MIC and MBC analysis. Open Dent J 2024;18:e18742106299402
36 Schuermans S, Kestens C, Marques PE. Systemic mechanisms of necrotic cell debris clearance. Cell Death Dis 2024;15(08):557
37 Rad AB, Saghafi S, Hashemi E, et al. Comparison of albumin, total protein, globulin and enzyme activity Creatine Phospho Kinase (CPK) in the Gingival Crevicular Fluid of patients with chronic periodontitis before and after treatment. Int J Multidiscip Curr Res 2018;6:1091–1096
38 Jevrić-Causević A, Malenica M, Dujić T Creatine kinase activity in patients with diabetes mellitus type I and type II. Bosn J Basic Med Sci 2006;6(03):5–9
39 Sangappa SB, Babu HM, Savadi RC, Krishnamurthy PT, Ravi Kiran AVVV. Salivary interleukin-6 as a non-invasive biomarker for chronic periodontitis and tooth loss in type 2 diabetes. Indian J Dent Res 2024;35(01):28–33

