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Clinical peri-implant outcomes, technical complications, and patient satisfaction with single *vs.* splinted crown supported implants in the anterior mandible region of diabetic individuals

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Abstract. – OBJECTIVE: To compare the clinical and radiographic peri-implant parameters around narrow diameter implants (NDI) supported single (NDISCs) and splinted crowns (NDISPs) in the anterior maxilla of non-diabetics and type 2 diabetes mellitus patients (T2DM).

MATERIALS AND METHODS: The clinical and radiographic parameters of NDISC and NDISP were assessed in the anterior mandibular jaw of T2DM and non-diabetic individuals. Plaque index (PI), bleeding on probing (BoP), probing depth (PD) and crestal bone levels were recorded. Technical complications and patient satisfaction were also assessed. ANOVA (one-way analysis of variance) was used to compare the inter-group means of clinical indices and radiographic bone loss while Shapiro-Wilk was used to compute the normal distribution of dependent variables. A *p*-value of less than 0.05 was considered significant.

RESULTS: Sixty-three patients (35 males and 28 females) were part of the study out of which 32 were non-diabetics and 31 were T2DM patients. A total of 188 implants (124 NDISCs and 64 NDISPs) having moderately roughened topography were used for the study. The mean glycated hemoglobin in the non-diabetic group was 4.3 while that in the T2DM group was 7.9 with an average diabetic history of 8.6 years. Peri-implant parameters, including PI, BoP, and PD, were comparable between the single crown and splinted crown groups. However, there was a statistically significant difference in PI, BoP, and PD when a comparison was made between the non-diabetes and T2DM groups ($p<0.05$). An overall 88% of the patients were satisfied with the esthetics of the crowns while 75% of the subjects were satisfied with the function of the crowns.

CONCLUSIONS: Narrow diameter implants of both types had satisfactory clinical and radiographic outcomes within non-diabetic and diabetic individuals. However, clinical and radiographic parameters were worse in type 2 diabetes mellitus patients when compared to non-diabetics.

Key Words:
Diabetes mellitus, Narrow diameter implants, Crestal bone levels, Single crowns, Splinted crowns, patient satisfaction.

Introduction

The increasing numbers of diabetic individuals are a cause of grave concern to the healthcare industry worldwide[1]. Type 2 diabetes mellitus (T2DM) is due to either defective insulin production or compromised insulin action or a combination of both. Chronic hyperglycemia leads to a vast variety of complications[2]. Increased blood sugar irreversibly injures the vascular endothelium and causes retinopathy, neuropathy, nephropathy, cardiovascular and various other pathological changes[3]. Similarly, the oral cavity undergoes skeletal and mucosal changes

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as a sequel of long-standing diabetes mellitus. Prolonged hyperglycemia may cause pathology of the vessels leading to the proliferation of osteoclasts and inhibition of osteoblast[4]. Additionally, high blood sugar may cause an exaggerated immune response raising the gingival, serum and salivary levels of interleukins and tumor necrosis factor-α, worsening inflammation of oral tissues[5]. This is the possible etiology behind the high incidence of periodontal and peri-implant inflammation, and tooth loss in diabetic individuals[6,7].

Previously, implant therapy was believed to be a contraindication in type 2 diabetes mellitus because of the associated microvascular complications. However, it has now been proven that dental implants can be placed in such patients with predictable results[8]. Although peri-implantitis characterized by bone loss and mucosal inflammation is markedly high in T2DM because of the accumulation of advanced glycation end-products, implants are a viable solution to the higher incidence of tooth loss in diabetes[9].

Implant-supported restorations are the widely acceptable long-term solution for tooth loss, provided the health of soft and hard tissues around the implants are maintained through stringent oral hygiene measures. A recent cost-effective improvisation to the regular diameter implants (RDI) is the narrow diameter implants (NDI) which can be effectively used where mesiodistal bone thickness is inadequate, particularly in the incisor region[10,11]. The frequently used implant-supported single crown restorations have the advantage of better hygiene control, convenient repair, and greater comfort to the patient[12]. However, the concept of narrow diameter implants supported splinted crowns (NDISP) and single crowns (NDISCs) in patients with diabetes remains uninvestigated. This study, therefore, aims to compare the peri-implant health of splinted and single crowns supported by NDIs in the anterior mandible of non-diabetics and patients suffering from T2DM. The peri-implant bone loss, probing depth, plaque index, technical complication, and patient satisfaction parameters were then compared between healthy individuals and T2DM.

Patients and Methods

Study Design and Ethical Adherence

A cross-sectional clinical study was conducted in accordance with the principles of the Declaration of Helsinki where the clinical peri-implant and prosthodontic parameters were assessed. All the participants were called to fill out the data form that elucidated the details pertaining to the purpose and methodology of the current study. They were also required to provide details of the duration of diabetes, family history of diabetes, and brushing habits. The participants then gave their informed consent to be a part of the research. The ethical committee of specialist dental practice and clinical research center (UDCRC-RB-036-21-), Riyadh, Saudi Arabia.

Inclusion and Exclusion criteria

Both healthy individuals (HbA1c <6) and diabetic patients (HbA1c >6) were included if they were 25 years or greater, had single and splinted crowns supported by NDIs in the anterior mandible region, and had a follow-up of a minimum of 10 years. Patients were excluded if they had undergone bone augmentation surgery, were chronic smokers, or had compromised periodontal health. Patients who did not have baseline radiographic data or were completely edentulous were not included in the study.

Screening of Implants and Prosthesis

All the implants with a diameter of 2.9 mm and lengths of either 10 or 12 mm were placed at the bone level and had moderately rough surfaces. Patients received either splinted or single crowns in the anterior mandible in keeping with the standard protocol. One hundred and twenty-five restorations were screw-retained, and 63 implants were cement-retained with the help of cast abutments. A detailed radiographic assessment was done using periapical radiographs. Age and gender of the patients, the number of implants, restoration type, periodontal conditions, length and location of the implant, implant survival, technical complication, follow-up period and peri-implant conditions were recorded by one trained examiner.

Patient Satisfaction

A questionnaire containing questions related to function and esthetics of restoration was filled by all participants. The participants were required to answer sections containing the Likert scale ranging from ‘extremely satisfied’ to ‘extremely dissatisfied.

Assessment of Technical Complications

A detailed examination was carried out to check for loosening or fracture of implant or abutment screw, chipping of crown and/or loss of retention.

Clinical Peri-Implant Parameters

Following the recording of baseline data, a trained examiner examined the dental implants and recorded all the clinical peri-implant readings. Inter examiner reliability measurement using kappa was 0.90. Plaque index (PI) and bleeding on probing (BOP) were recorded at six sites (mesiobuccal, distolingual, mid-lingual, distobuccal, mid-buccal, mesiolingual) as 1 if present or 0 if absent. A graded periodontal probe (UNC-15 Hu-Friedy, Chicago, IL, USA) was used to assess the probing depth to the nearest mm. The mesial and distal crestal bone was also measured to the nearest mm.

Radiographic Assessment

A trained examiner who was blinded to the study groups carried out the radiographic analysis. Digital periapical radiographs were recorded and evaluated on a computer display screen (Samsung SyncMaster digital TV monitor, Seoul, Korea) using an image analyzer (Scion Image Analyzer, Scion, Frederick, MD, USA). Peri-implant bone loss was calculated as the total vertical distance from the crest of the alveolar bone to the topmost supracrestal part of the dental implant[13].

Statistical Analysis

A specialized software (SPSS v 21, Armonk, NY, USA) was utilized to carry out the statistical analysis. A *p*-value of less than 0.05 was interpreted as significant. ANOVA (one-way analysis of variance) was used to compare the inter-group means of clinical indices and radiographic bone loss. Shapiro-Wilk was used to compute the normal distribution of dependent variables.

Results

Table I shows the basic demographics of the study participants and their diabetes history and brushing habits. A total of 63 participants were included in the study out of which 32 were non-diabetic while 31 subjects were suffering from T2DM. In the non-diabetic group, 19 were males and 13 were females whereas 16 males and 15 females were included in the T2DM group. The mean HbA1C in the non-diabetic group was 4.3 while that in the T2DM group was 7.9 with an average diabetic history of 8.6 years. Only 5 individuals in the non-diabetic group, while 18 T2DM participants had a family history of diabetes. Sixty-two percent of the participants in the non-diabetic group brushed their teeth once a day while the rest of the 38% were habitual of brushing twice a day. In the T2DM group, 84% of the individuals had a habit of brushing once a day and the remaining 16% brushed their teeth twice a day.

Table II demonstrates the characteristics of all the implants used in the study participants. A total of 188 (124 NDISCs and 64 NDISPs) platform-switched NDIs having moderately roughened topography were used in the study. Of the 124 NDISCs, 64 were placed in the non-diabetic individuals and 60 were placed in T2DM group whereas 32 NDISPs each were placed in both diabetic and non-diabetic study groups. All the implants used had a 2.9 mm diameter placed at bone level and loaded at approximately 3 months. Out of the 188 implants used, 136 were 10 mm, and 52 NDIs were 12 mm in length, whereas 125 were screw-retained and only 30 were cement-retained. In the non-diabetic group, NDISCs were in function for 14.5 years while NDISPs were in function for 13.2 years. In the T2DM group, NDISCs were in function at 11.8 years whereas NDISPs were functional at 12.9 years.

Table III depicts the soft and hard peri-implant tissue parameters around NDISCs and NDISPs within the non-diabetic and T2DM groups. PI and BoP in the non-diabetic group were measured as 25.4% and 12.3% and 28.3% and 15.6% around NDISCs and NDISPs, respectively. In the

Table I. Baseline demographics of the study participants.

	Non-diabetic	T2DM
Number of patients	32	31
Male/Female	19/13	16/15
Mean HbA1c (SD)	4.3 ± 0.8	7.9 ± 1.2
Mean duration of diabetes in years (SD)	NA	8.6 ± 3.5
Family history of diabetes (n)	5	18
Tooth brushing (%)		
Once daily	62	84
Twice daily	38	16

Table II. Implant-related description within the study groups.

Parameters	Non-diabetic		T2DM	
	NDISC	NDISP	NDISC	NDISP
Total number of implants	64	32	60	32
Depth of placement	BL	BL	BL	BL
Implant design	PS with moderately rough surfaces	PS with moderately rough surfaces	PS with moderately rough surfaces	PS with moderately rough surfaces
Implant length (10/12 mm) and diameter	44/20 and 2.9 mm	20/12 and 2.9 mm	51/9 and 2.9 mm	21/11 and 2.9 mm
Implant loading after placement (in months)	3.4 ± 0.5	3.5 ± 0.4	3.7 ± 0.4	3.2 ± 0.2
Type of restoration	55 SR/9 CR	12 SR/4 CR	49 SR/11 CR	9 SR/6 CR
Duration of implants in function (in years)	14.5 ± 2.4	13.2 ± 1.5	11.8 ± 1.2	12.9 ± 1.7

NDISC: narrow-diameter implant supporting single crowns, NDISP: narrow-diameter implant supporting splinted crowns, BL: bone-level, SR: screw-retained, CR: cement-retained.

Table III. Peri-implant clinical and radiographic status among nondiabetic and diabetic groups.

Peri-implant parameters	Non-diabetic		T2DM	
	NDISC	NDISP	NDISC	NDISP
Plaque index (% of sites)	25.4 ± 5.8^{A}	28.3 ± 6.6^{A}	36.7 ± 8.1^{B}	39.5 ± 7.1^{B}
Bleeding on probing (% of sites)	12.3 ± 2.6^{A}	$15.6 \pm 2.9A^{A}$	26.8 ± 6.3^{B}	28.2 ± 6.9^{B}
Probing depth (in mm)	3.3 ± 0.4^{A}	3.1 ± 0.3^{A}	3.9 ± 0.5^{B}	3.8 ± 0.6^{B}
Crestal bone levels (in mm)				
Mesial	1.13 ± 0.03^{A}	1.05 ± 0.05^{A}	1.67 ± 0.08^{B}	1.62 ± 0.09^{B}
Distal	1.19 ± 0.06^{A}	1.11 ± 0.04^{A}	1.59 ± 0.09^{B}	1.71 ± 0.09^{B}

Dissimilar upper-case letters (A and B) indicate statistical significance at $p<0.05$.

diabetic group, the PI and BoP were recorded as 36.7% and 26.8% and 39.5%, and 28.2% around NDISCs and NDISPs, respectively. The mean PD in the non-diabetic group was 3.3 mm and 3.1 mm around NDISCs and NDISPs, respectively whereas in the diabetic group it was 3.9 mm and 3.8 mm around NDISCs and NDISPs, respectively. The mesial crestal bone level in the non-diabetic group was 1.13 mm and 1.05 mm around NDISCs and NDISPs, respectively whereas in the T2DM group it was 1.67 mm and 1.62 mm around NDISCs and NDISPs, respectively. The distal crestal bone level in the non-diabetic group was recorded as 1.19 mm and 1.11 mm around NDISCs and NDISPs, respectively whereas in the T2DM group it was recorded as 1.59 mm and 1.71 mm around NDISCs and NDISPs, respectively. All the clinical readings showed no significant difference when an inter-group comparison between NDISC and NDISP was made. However, there was a significant difference in all parameters between the non-diabetic and T2DM groups.

Table IV demonstrates the technical complications and peri-implant bone loss in the two types of prosthesis in diabetics and non-diabetics. Chipping and loosening of crowns were the commonest reported technical complication. In the non-diabetic group, 39.2% of participants with single crowns and 15.6% of participants with splinted crowns reported technical complications while in the diabetic group, 26.3 % of participants with single crowns and 8.1% of participants with splinted crowns reported technical complications, showing a significant difference in both groups. The peri-implant loss was insignificant in the non-diabetic (1.08 and 1.13 in single and splinted crown, respectively) and T2DM (1.61 and 1.68 in single and splinted crown respectively) groups.

Table IV. Influence of type of prostheses on technical complications and peri-implant bone loss.

	Technical complications	Peri-implant bone loss
Non-diabetic		
Single crown	39.2%	1.08 ± 0.03
Splinted crown	15.6%	1.13 ± 0.02
p-values	0.039	0.91
T2DM		
Single crown	26.3%	1.61 ± 0.06
Splinted crown	8.1%	1.68 ± 0.05
p-values	0.025	0.84

Table V. Overall patient satisfaction.

	Satisfied patients (%)	Unsatisfied patients (%)
Esthetics	88.3%	13.6%
Function	74.5%	28.9%
Overall satisfaction (mean VAS and SD)	14.7 ± 4.55	

Table V shows the overall patient satisfaction. 88.3% of the patients were satisfied with the esthetics of the implants while 74.5% of the patients showed satisfaction with function. 13.6% of the patients were not happy with the esthetics whereas 28.9 % of the patient's showed dissatisfaction with the function of the implants.

Discussion

This cross-sectional study was carried out with the aim to assess and compare the patient contentment, peri-implant parameters, bone loss, and technical complications involved with NDISCs and NDISPs in T2DM patients and non-diabetics. The results of the current study depicted appreciable patient satisfaction with minimal technical complications contributing to the overall success of the implants. Although all the implants were nearly placed for more than a decade, the peri-implant parameters were quite sound reflecting scrupulous oral hygiene habits followed by the study subjects[14,15]. Kaplan-Meier survival analysis could have given an exact figure of implant survival rates and hence, the functioning of NDISCs and NDISPs at large[16].

All the clinical parameters (PI, BoP, and PD) were significantly different between diabetics and non-diabetics. The significantly greater readings in the T2DM are in line with previous studies[17-19] and can be explained by the proposal that a sustained inflammatory activity concomitant with diabetes mellitus increases the polymorphonuclear leucocytes and other inflammatory mediators[20], leading to an accelerated rate of periimplantitis. Additionally, the elevated glycosylated hemoglobin levels in T2DM patients negatively alter the maturation and maintenance of extracellular matrix and collagen in the peri-implant tissues causing further tissue destruction[21]. It has been reported that the duration of hyperglycemia is strongly linked with the severity of periodontal inflammation[7]. The average duration of diabetes in the present study was 8.6 years which may be considered to be responsible for the increased peri-implant parameters. Chronic hyperglycemia and advanced glycation end-products are connected with the augmented synthesis of proinflammatory cytokines namely interleukins and metalloproteinases[8]. The current study, however, did not carry out the molecular analysis of either the gingival crevicular fluid or the peri-implant sulcular fluid. Therefore, the cause and relation cannot be established on the basis of clinical and radiographic data alone.

Interestingly, the brushing habits were stringent among the non-diabetics, with almost double the percentage of subjects brushing twice a day compared to the diabetics. This could have possibly contributed to the worsened peri-implant parameters in the T2DM group.

The clinical and radiographic recordings of NDISCs and NDISPs were insignificantly different. These findings corroborated with those of previous studies[22,23], which reported a minimal difference in the MBL between the splinted and non-splinted groups. This is a possible indication that both NDISCs and NDISPs are equally effective in preventing peri-implant marginal bone loss.

In both the non-diabetics and T2DM groups, the technical complications around NDISCs were significantly higher compared to those around NDISPs. The loss of implant retention and chipping was commonly seen in the NDISCs, a finding corroborating with previous research[23,24]. A possible explanation for the difference could be a better stress distribution in the splinted restoration reducing the risks of fracture and loss of retention and eventually preventing bone resorption[25].

Limitations

There were some limitations in the current study. It was a cross-sectional study, and all the parameters were recorded at one point in time. A follow-up study using Kaplan-Meier survival analysis for the NDIs could have yielded more accurate results. The smoking history of the subjects was not known which is a proven factor in determining clinical and radiographic peri-implant parameters[26,27]. In addition to clinical and radiographic parameters, microbiologic analysis of the sulcular fluid could have yielded better results. Future studies could also carry out the cytokine analysis of the sulcular fluid to accurately evaluate the extent of inflammation.

Conclusions

Narrow-diameter implants with single and splinted crowns had a satisfactory clinical response among non-diabetic and diabetic patients. However, clinical, and radiographic parameters were worse in type 2 diabetes mellitus patients when compared to the non-diabetics.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

Data of the study is available upon reasonable request from corresponding author.

Informed Consent

After the approval from the review board, informed consent was taken from each participant with the right to withdraw from the study at any moment without any consequences.

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References

1) Jiang X, Zhu Y, Liu Z, Tian Z, Zhu S. Association between diabetes and dental implant complications: a systematic review and meta-analysis. Acta Odontol Scand 2021; 79: 9-18.
2) Nazir MA, AlGhamdi L, AlKadi M, AlBeajan N, Al-Rashoudi L, AlHussan M. The burden of diabetes, its oral complications and their prevention and management. Open Access Maced J Med Sci 2018; 6: 1545-1553.
3) Dubey RK, Gupta DK, Singh AK. Dental implant survival in diabetic patients; review and recommendations. National J Maxillofac Surg 2013; 4: 142.
4) King S, Klineberg I, Levinger I, Brennan-Speranza TC. The effect of hyperglycaemia on osseointegration: a review of animal models of diabetes mellitus and titanium implant placement. Arch Osteoporosis 2016; 11: 1-11.
5) Iacopino AM. Periodontitis and diabetes interrelationships: role of inflammation. Ann Periodontal 2001; 6: 125-137.
6) Akram Z, Alqahtani F, Alqahtani M, Al-Kheraif AA, Javed F. Levels of advanced glycation end products in gingival crevicular fluid of chronic periodontitis patients with and without type-2 diabetes mellitus. J Periodontol 2020; 91: 396-402.
7) Alasqah M, Mokeem S, Alrahlah A, Al-Hamoudi N, Abduljabbar T, Akram Z, Vohra F, Javed F. Periodontal parameters in prediabetes, type 2 diabetes mellitus, and non-diabetic patients. Braz oral Res 2018; 6: 32.
8) Courtney Jr MW, Snider TN, Cottrell DA. Dental implant placement in type II diabetics: a review of the literature. J Mass Dent Soc 2010; 59: 12-14.
9) Chambrone L, Palma LF. Current status of dental implants survival and peri-implant bone loss in patients with uncontrolled type-2 diabetes mellitus. Curr Opin Endocrinol Diabetes Obes 2019; 26: 219-222.
10) Galindo-Moreno P, Nilsson P, King P, Becktor J, Speroni S, Schramm A, Maiorana C. Clinical and radiographic evaluation of early loaded narrow diameter implants–1-year follow-up. Clin oral Implants Res 2012; 23: 609-616.
11) Trbakovic A, Bongenhielm U, Thor A. A clinical and radiological long-term follow-up study of narrow diameter implants in the aesthetic area. Clin Implant Dent Relat Res 2018; 20: 598-605.
12) Aguiar Junior FAD, Tiossi R, Macedo AP, Mattos MDGCD, Ribeiro RF, Rodrigues RCS. Importance of a distal proximal contact on load transfer by implant-supported single adjacent crowns in posterior region of the mandible: a photoelastic study. J Appl Oral Sci 2013; 21: 397-402.
13) Al Amri MD, Kellesarian SV, Al-Kheraif AA, Malmstrom H, Javed F, Romanos GE. Effect of oral hygiene maintenance on HbA1c levels and peri-implant parameters around immediately loaded dental implants placed in type-2 diabetic patients: 2 years' follow-up. Clin Oral Implants Res 2016; 27: 1439-1443.
14) Tecco S, Grusovin MG, Sciara S, Bova F, Pantaleo G, Capparé P. The association between three attitude-related indexes of oral hygiene and secondary implant failures: A retrospective longitudinal study. Int J Dent Hyg 2018; 16: 372-379.
15) Klinge B, Klinge A, Bertl K, Stavropoulos A. Peri-implant diseases. Eur. J. Oral Sci. 2018; 126: 88-94

16) Chuang SK, Tian L, Wei LJ, Dodson TB. Kaplan-Meier analysis of dental implant survival: a strategy for estimating survival with clustered observations. J Dent Res 2001; 80: 2016-2020.
17) Shang R, Gao L. Impact of hyperglycemia on the rate of implant failure and peri-implant parameters in patients with type 2 diabetes mellitus: systematic review and meta-analysis. J Am Dent Assoc 2021; 152: 189-201.
18) Alberti A, Morandi P, Zotti B, Tironi F, Francetti L, Taschieri S, Corbella S. Influence of diabetes on implant failure and peri-implant diseases: a retrospective study. Dent J 2020; 8: 70.
19) Al-Sowygh ZH, Ghani SM, Sergis K, Vohra F, Akram Z. Peri-implant conditions and levels of advanced glycation end products among patients with different glycemic control. Clin Implant Dent Relat Res 2018; 20: 345-351.
20) Nascimento GG, Leite FR, Vestergaard P, Scheutz F, Lopez R. Does diabetes increase the risk of periodontitis? A systematic review and meta-regression analysis of longitudinal prospective studies. Acta Diabetol 2018; 55: 653-667.
21) Chambrone L, Palma LF. Current status of dental implants survival and peri-implant bone loss in patients with uncontrolled type-2 diabetes mellitus. Curr Opin Endocrinol Diabet Obesity 2019; 26: 219-222.
22) Vigolo P, Mutinelli S, Zaccaria M, Stellini E. Clinical evaluation of marginal bone level change around multiple adjacent implants restored with splinted and nonsplinted restorations: a 10-year randomized controlled trial. Int J Oral Maxillofac Implants 2015; 30: 411-418.
23) Shi JY, Xu FY, Zhuang LF, Gu YX, Qiao SC, Lai HC. Long-term outcomes of narrow diameter implants in posterior jaws: A retrospective study with at least 8-year follow-up. Clin Oral Implants Res 2018; 29: 76-81.
24) Al-Aali KA, ArRejaie AS, Alrahlah A, AlFawaz YF, Abduljabbar T, Vohra F. Clinical and radiographic peri-implant health status around narrow diameter implant-supported single and splinted crowns. Clin Implant Dent Relat Res 2019; 21: 386-390.
25) Lemos CAA, Verri FR, Santiago Junior JF, de Souza Batista VE, Kemmoku DT, Noritomi PY, Pellizzer EP. Splinted and nonsplinted crowns with different implant lengths in the posterior maxilla by three-dimensional finite element analysis. J Healthcare Eng 2018; 2018; 5: 1-7.
26) Akram Z, Vohra F, Bukhari IA, Sheikh SA, Javed F. Clinical and radiographic peri-implant parameters and proinflammatory cytokine levels among cigarette smokers, smokeless tobacco users, and nontobacco users. Clin Implant Dent Relat Res 2018; 20: 76-81.
27) Akram Z, Alqahtani F, Alqahtani M, Al-Kheraif AA, Javed F. Levels of advanced glycation end products in gingival crevicular fluid of chronic periodontitis patients with and without type-2 diabetes mellitus. J Periodontol 2020; 91: 396-402.