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Influence of implant location in patients with and without type 2 diabetes mellitus: 2-year follow-up☆

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Abstract. The aim of the present cross-sectional retrospective 2-year follow-up clinical study was to assess the influence of implant location on clinical and radiographic parameters around dental implants placed in patients with and without type 2 diabetes mellitus (T2DM). Twenty-seven patients with T2DM and 25 non-diabetic controls were included. Implants were classified into three zones according to their location: (1) anterior zone: implant/s replacing anterior teeth, (2) middle zone: implant/s replacing premolars, and (3) posterior zone: implant/s replacing molars. Peri-implant bleeding on probing (BOP), probing depth (PD), and crestal bone loss (CBL) were measured. *P*-values less than 0.05 were considered statistically significant. The mean age of patients with T2DM was 42.5 years and that of non-diabetic controls was 40.6 years. The mean fasting blood glucose levels of patients with and without T2DM were 74.5 mg/dl (66–80 mg/dl) and 82.5 mg/dl (79–88.1 mg/dl), respectively. The mean duration of T2DM was 4.3 years. There was no significant difference in BOP, PD, or CBL around implants placed in any of the zones in the jaws of patients with and without T2DM. There is no influence of implant location on clinical and radiographic parameters around dental implants placed in patients with and without T2DM.

Key words: dental implants; osseointegration; alveolar bone loss; type 2 diabetes mellitus.

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According to Albrektsson et al., the crestal bone loss (CBL) around dental implants is a critical outcome variable that determines the overall success of dental implants[1]. They reported that a CBL of up to 1.5 mm around the implant followed by a CBL of 0.2 mm annually is considered normal[1].

A variety of local and systemic factors (such as the location of the implant in the jaws and diabetes mellitus, respectively) have been reported to influence CBL around dental implants[2,3]. In the anterior maxilla, the alveolar process exhibits a

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thin labial and thick palatal cortical plate as compared to the posterior maxilla, which has a thicker buccal Plate[4]. Results from a recent cone beam computed tomography study examining the buccal plate thickness of the maxillary and mandibular dentition showed that the buccal bone thickness is significantly greater from the coronal to the apical direction in the mandibular teeth than in the maxillary dentition[4]. Another zone of the alveolar ridge that is associated with vertical bone deficiency is located at the base of the maxillary sinuses. The placement of dental implants in this zone may require adjunct therapeutic protocols such as guided bone regeneration. Furthermore, it is well known that bone quality (type 1 to type 4) also varies among the jaws. According to Truhlar et al., the densest bone exists in the anterior mandible, followed by the posterior mandible, anterior maxilla, and posterior maxilla[5]. These results suggest that the amount of CBL around osseointegrated dental implants will be influenced by the location of the implants in the jaws.

Several studies have reported that chronic hyperglycemia in patients with diabetes mellitus is a significant risk factor for soft tissue inflammation and CBL around osseointegrated implants and teeth[6–11]. An explanation in this regard is that chronic hyperglycemia has been associated with an increased formation and accumulation of advanced glycation end-products in the systemic and oral tissues, which in turn increase the release of proinflammatory cytokines that enhance CBL around the natural dentition and implants[12–14]. However, it is pertinent to mention that under optimal glycemic control, dental implants can osseointegrate and remain functionally stable over long durations in diabetic patients in a manner similar to that in non-diabetic controls[2].

The present cross-sectional retrospective clinical study was based on the hypotheses that (1) peri-implant soft tissue inflammation and CBL are significantly higher in patients with type 2 diabetes mellitus (T2DM) than non-diabetic controls, and (2) peri-implant soft tissue inflammation and CBL around implants placed in patients with T2DM and controls is independent of the location of the implant in the jaws. Therefore, the aim of the present 2-year follow-up study was to assess the influence of implant location on clinical and radiographic parameters around dental implants placed in patients with and without T2DM.

Materials and methods

Ethical guidelines

The study was approved by the Research Ethics Review Committee of the College of Dentistry, King Saud University, Riyadh, Saudi Arabia. An information sheet (describing the purpose of the study) and a consent form were presented to all participants. Consenting individuals were requested to sign the consent form and were given the freedom to withdraw from the study at any stage of the investigation.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) individuals who had undergone dental implant therapy; (2) individuals with T2DM; (3) at least 2 years of follow-up; (4) signing of the consent form. Third molars, tobacco and smokeless tobacco users, use of bone grafting techniques, individuals with systemic disorders such as AIDS, cardiovascular disorders, and renal disorders, pregnant/lactating females, and individuals who had consumed antibiotics, non-steroidal anti-inflammatory drugs, and/or corticosteroids within the past 6 months were excluded.

Study design and participants

The present 2-year follow-up clinical study was based on a cross-sectional and retrospective design. In total, 27 patients with T2DM and 25 self-reported non-diabetic controls were included in the present study. Patients with T2DM were requested to present their medical records for verification of the diagnosis of T2DM.

Classification of implants according to their location in the jaws

Depending upon the location of the implant in the maxilla and mandible, the implants were classified into three zones as follows: (1) anterior zone: implant/s replacing anterior teeth (numbers 11–13, 21–23, 31–33, and/or 41–43), (2) middle zone: implant/s replacing premolars (numbers 14, 15, 24, 25, 34, 35, 44, and/or 45), and (3) posterior zone: implant/s replacing molars (numbers 16, 17, 26, 27, 36, 37, 46, and/or 47).

Clinical and radiographic parameters

All participants were requested to visit an oral healthcare clinic in a fasting state for clinical and radiographic evaluation. All clinical and radiographic assessments were performed by a single trained and calibrated examiner (TA). The kappa value for intra-examiner reliability was 0.91. Peri-implant bleeding on probing (BOP) and probing depth (PD) were measured around all implants placed in patients with and without T2DM. Both BOP and PD were investigated at six sites per implant (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual). The long-cone paralleling technique was used to take digital full-mouth radiographs[15]. In brief, patients were seated upright with the floor parallel to the Frankfort horizontal plane. To standardize the angulation between the X-ray beam and the film, a film holder was used (Dentsply Rinn, York, PA, USA). The central X-ray beam was directed perpendicular to the film and long axis of the implant. All radiographs were viewed on a computer screen at 20 × magnification using CorelDraw 11.0 software (Corel Corp. and Coral Ltd, Ottawa, Canada). For the determination of CBL, the linear distance from the implant platform to the most coronal portion of the alveolar crest (on the mesial and distal surface) was recorded in millimeters[16]. CBL was defined as the distance from the widest supracrestal part of the implant to the alveolar crest[17].

Measurement of fasting blood glucose levels

Fasting blood glucose (FBG) levels were measured in patients with and without T2DM at the time of clinical and radiographic examination using a digital glucometer (OneTouch Verio; Johnson & Johnson Co., Milpitas, CA, USA).

Dental prophylaxis

All participants were enrolled in a biannual dental prophylaxis program (every 6 months for 2 years of follow-up), which involved mechanical plaque and calculus removal from all teeth and/or implant surfaces using an ultrasonic scaler (VV Dental, Guangxi, China).

Statistical analysis

The statistical analysis was performed using SPSS version 18 software (SPSS Inc., Chicago, IL, USA). BOP, PD, and CBL were assessed within and between the groups (patients with and without T2DM) using one-way analysis of variance (ANOVA). For multiple comparisons, the Bonferroni post-hoc test was used. A power analysis was performed using computer software nQuery Advisor 5.0 (Statistical Solutions, Saugus, MA,

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Table 1. Peri-implant clinical parameters in the maxillary and mandibular anterior, middle, and posterior zones in patients with and without type 2 diabetes mellitus; mean ± standard deviation values.

	Patients with type 2 diabetes mellitus			Patients without type 2 diabetes mellitus		
	Anterior zone	Middle zone	Posterior zone	Anterior zone	Middle zone	Posterior zone
Implants placed in the maxilla, *n*	13	17	22	15	18	20
Bleeding on probing (%)	7.5 ± 2.7	7.4 ± 1.3	8.5 ± 2.4	4.1 ± 0.3	3.3 ± 0.4	3.5 ± 0.2
Probing depth (%)	2.7 ± 0.4	2.5 ± 0.1	2.8 ± 0.3	2.1 ± 0.1	2 ± 0.2	2.3 ± 0.1
Implants placed in the mandible, *n*	9	14	20	11	16	21
Bleeding on probing (%)	3.3 ± 1.1	3.5 ± 0.6	4.1 ± 0.7	4.4 ± 0.5	4 ± 0.4	4.3 ± 0.6
Probing depth (%)	2.1 ± 0.2	2.4 ± 0.4	2.8 ± 0.5	1.7 ± 0.1	2.1 ± 0.4	2.3 ± 0.2

USA). The power analysis was performed on the supposition that a mean difference of 0.5 mm in PD should be detected between the groups at a significance level of 0.05 and a desired study power of at least 80%. It was estimated that a sample size of at least 25 individuals per group would achieve 90% power with a 0.05 two-sided significance level.

Results

General characteristics of the study population

The mean age of the patients with T2DM ($n = 27$) was 42.5 years (range 39–51 years) and that of the non-diabetic controls ($n = 25$) was 40.6 years (range 35–46 years). The mean fasting blood glucose levels of patients with and without T2DM were 74.5 mg/dl (range 66–80 mg/dl) and 82.5 mg/dl (range 79–88.1 mg/dl), respectively. The mean duration of T2DM was 4.3 years (range 2–5 years). All patients with T2DM had been prescribed anti-hyperglycemic medications by healthcare physicians for the management of T2DM and were also advised to maintain their glycemic levels via dietary control.

Implant-related characteristics

All implants were platform-switched with diameters of 4.1 mm and lengths ranging from 10 mm to 14 mm. All implants had been placed using insertion torque ranging from 30 N·cm to 35 N·cm. All implants had been loaded at least 3 months after placement (mean 3.3 months, range 3–4 months).

Peri-implant clinical parameters in the maxillary and mandibular anterior, middle, and posterior zones in patients with and without type 2 diabetes mellitus

There was no statistically significant difference in BOP or PD in the maxillary and mandibular anterior, middle, and posterior zones in patients with and without T2DM. There was no statistically significant difference in BOP or PD in the anterior, middle, and posterior zones within each group. These results are shown in Table 1.

Crestal bone loss around dental implants placed in the maxilla and mandible in the anterior, middle, and posterior zones in patients with and without T2DM

There was no statistically significant difference in CBL in the maxillary and mandibular anterior, middle, and posterior zones in patients with and without T2DM. There was no statistically significant difference in CBL in the anterior, middle, and posterior zones within each group. These results are shown in Table 2.

Discussion

The indexed literature lacks a study that has assessed the influence of jaw location on the soft tissue profile and CBL around implants in patients with T2DM. The present study was based on the hypothesis that peri-implant soft tissue inflammation and CBL are significantly greater in patients with type 2 diabetes mellitus (T2DM) and that they are independent of the location of the implant in the jaws. Interestingly, the results showed no statistically significant influence of the location of the implant in the maxilla and mandible on the peri-implant soft tissue profile and CBL in patients with and without T2DM. From these results, it appears that the location of the implant in the jaws does not influence peri-implant inflammatory parameters and crestal bone levels. However, it is noteworthy that a variety of factors may have influenced the current results, as outlined below.

Firstly, strict eligibility criteria were used for the inclusion of participants in the present study. It is known that habitual tobacco smoking is a significant risk factor for oral soft tissue inflammation and CBL[9,18]. Moreover, habitual tobacco smoking has also been reported to jeopardize the outcomes of oral surgical interventions[19,20]. It is therefore possible that habitual tobacco smokers exhibit a significantly higher CBL around implants as compared to non-smokers and this relationship is independent of the location of the implants in the jaws. Further clinical trials are needed to test this hypothesis.

Another explanation for the results reported here is that all patients with T2DM had a relatively short medical history of T2MD (approximately 4 years) and had well-controlled T2DM (mean FBG 74.5 mg/dl). The results from a systematic review showed that under optimal glycemic control, dental implants can osseointegrate and remain functionally stable over long durations in patients with

Table 2. Crestal bone loss around dental implants placed in the maxilla and mandible in the anterior, middle, and posterior zones in patients with and without type 2 diabetes mellitus; mean ± standard deviation values.

	Patients with type 2 diabetes mellitus			Patients without type 2 diabetes mellitus		
	Anterior zone	Middle zone	Posterior zone	Anterior zone	Middle zone	Posterior zone
Implants placed in the maxilla, *n*	13	17	22	15	18	20
Crestal bone loss (in mm)	2.3 ± 1.3	2.3 ± 1.5	2.3 ± 0.8	2.1 ± 0.5	2.2 ± 0.4	2.4 ± 0.3
Implants placed in the mandible, *n*	9	14	20	11	16	21
Crestal bone loss (in mm)	2.1 ± 1.1	2.1 ± 0.6	2.2 ± 0.7	1.9 ± 0.4	2.3 ± 0.7	2.5 ± 0.5

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diabetes in a manner similar to that in non-diabetic individuals[2]. The outcomes of the present clinical study support the results of this systematic review[2]. In addition, it is hypothesized that due to a short duration of T2DM and glycemic control, the intensity of the oral and systemic burden of inflammation was lesser in the diabetic population investigated. This factor may also have contributed to minimizing the CBL around implants placed in both jaws.

It is pertinent to note that all individuals included in this study were within the age range of 35–51 years (mean 41.6 years). According to Javed et al., alveolar bone loss is significantly higher in individuals aged 60 years or more as compared to relatively younger individuals (40 to 45 years old)[9]. Therefore, the contribution of a younger age group in minimizing CBL around implants cannot be disregarded. Further studies are needed to assess the impact of ageing on CBL around implants placed in various locations in the maxilla and mandible.

Furthermore, platform-switched implants were used in the present study. The concept of platform-switching is based on the placement of a narrow diameter implant abutment on a wider diameter implant[21]. Studies have shown that dental implants placed according to this concept undergo significantly less CBL than implants with matching abutment and implant-body diameters[22–26].

It has been reported that the mechanical debridement of plaque and calculus from the surfaces of the teeth not only minimizes oral soft tissue inflammation, but also helps to reduce glycemic levels in patients with chronic hyperglycemia[27–30]. In the present study, all participants were enrolled in a biannual (6-monthly) dental prophylaxis program, in which they underwent full mouth scaling. Mechanical plaque and calculus debridement has been reported to reduce the systemic burden of inflammation (by reducing the levels of proinflammatory cytokines such as interleukin 6 and tumor necrosis factor alpha), which in turn may have contributed to maintaining the glycemic levels in the diabetic population included in this study[27,31,32]. It is speculated that had patients with poorly controlled T2DM been included in the study, there would have been a significantly higher BOP, PD, and CBL around implants in comparison to the results reported here.

Since there were no tobacco smokers, older individuals (over 60 years of age), or patients with hyperglycemia, these factors may be considered as potential limitations of the present study. Another limitation is that FBG was measured in these patients with and without T2DM. It is well established that the measurement of hemoglobin A1c levels is more reliable and provides a 3-month control of diabetes as compared to FBG[29]. This is a critical factor that could have influenced the results reported here. Hence, further clinical trials are needed in this regard. Furthermore, investigations to correlate clinical and radiographic peri-implant parameters with the levels of proinflammatory cytokines in such patients are encouraged.

In conclusion, within the limits of the present study, it is concluded that there is no influence of implant location on clinical and radiographic parameters around dental implants placed in patients with and without T2DM during follow-up of up to 2 years.

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Competing interests

The authors declare no competing interests.

Ethical approval

The study was approved by the Research Ethics Review Committee of the College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia.

Patient consent

Not required.

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