Original Article

Crestal Bone Resorption Around Dental Implants in Diabetic and Non-Diabetic Patients: A retrospective cohort Study at Shiraz Dental School (2019–2024)

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Abstract

Background and Aim: The present study was conducted to investigate the amount of crestal bone resorption around dental implants in diabetic patients compared to non-diabetic patients referred to Shiraz Dental School.

Materials and Methods: In the present study, 30 patients with type 2 diabetes (T2DM) and 30 non-diabetic patients requiring implant surgery, who were referred to Shiraz Dental School between the beginning of 2018 and the end of 2019, were included. Crestal bone loss was assessed at three time points—on the day of surgery, at six months, and at one year postoperatively—using standard periapical radiography (PA), and the results were compared between the diabetic and non-diabetic groups. An independent t-test was used to compare crestal bone resorption between the case and control groups. Additionally, changes in bone resorption across the three time points were analyzed using a repeated measures statistical test.

Results: The mean HbA1c level was significantly higher in the T2DM group (6.19) compared to the non-diabetic group (4.08) ($P < 0.001$). No significant difference in mean crestal bone loss was observed between groups immediately after surgery ($P = 0.063$). However, at both six and twelve months postoperatively, crestal bone loss was significantly greater in diabetic patients ($P < 0.001$ for both time points). A significant increase in crestal bone resorption was noted over time in both groups ($P < 0.001$), with intergroup differences also reaching statistical significance ($P < 0.001$).

Conclusion: Crestal bone resorption was significantly greater in diabetic patients than in non-diabetic counterparts at both 6 and 12 months after implant surgery.

Key Words: Type 2 diabetes mellitus, implant, crestal bone loss, surgery

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Introduction

Bone loss is among the most commonly reported complications affecting the peri-implant structure. Larger lesions are associated with greater difficulty in achieving optimal treatment outcomes (1). The bone resorption around the implant happens gradually and continues to a point that might cause implant failure (2). The highest levels of stress on the implant are concentrated in the crestal region (2) and are primarily classified as shear stress (3). This stress is most pronounced at the polished crest of the implant. Consequently, bone loss around the implant is directly influenced by the implant's crestal design; an appropriate crestal design can help reduce the risk of crestal bone resorption (4).

The average amount of bone loss around the neck of a functioning implant is approximately 2 mm in the first year after placement, with an average bone loss of about 0.2 mm in the following years (5, 6). After years of function, total bone loss may cause concern; healthy bone is necessary to prevent failure of the prosthetic system. The two factors that cause bone loss around the implants are the supporting tissues of the implant and traumatic forces that cause excessive stress in the bone and implant complex (7). Several factors such as the patient's systemic conditions, smoking, parafunctional habits, local factors like the number of teeth adjacent to the extracted tooth, cavity conditions of extracted tooth, and the dimensional changes of the bone after tooth extraction are considered effective on the bone loss rate around implants (8, 9). If marginal bone loss around the implant is less than 1.5 mm in the first year and less than 0.2 mm annually in the following years, the treatment is considered successful (10). Multiple factors influence osseointegration and the overall success of implant treatment. These factors are typically classified into three categories: patient-related factors (e.g., systemic diseases, bone density, and bone loss); surgical and implant placement factors; and implant design characteristics. The macro and microstructural features of the implant—including shape, length, diameter, and surface roughness—directly affect osseointegration and the recruitment of osteogenic cells at the implant site (11).

Type 2 diabetic mellitus (T2DM) is a chronic disease characterized by hyperglycemia and metabolic disorders (12, 13) which leads to various serious complications such as blindness, renal failure, neuropathy, and myocardial infarction. Chronic hyperglycemia causes micro and macrovascular diseases, delayed wound healing, impaired bone metabolism, and periodontitis (14). Due to these complications observed in diabetes, some researchers consider it as a relative contraindication or risk factor for dental implant treatment. Therefore, the success of dental implants in diabetic patients has been the subject of many paraclinical and clinical studies (14-16). Several studies have reported gingival and systemic increases in the formation and accumulation of advanced glycation end products (AGEs) in patients with chronic hyperglycemia (17). AGEs interact with RAGE (receptors for advanced glycation end products) and lead to the formation of pro-inflammatory cytokines such as interleukin-1β (IL-1β) and tumor necrosis factor-alpha (TNF-α) and increase oxidative stress (18, 19). These mechanisms are associated with increased inflammatory response around the implant. AGEs levels in the peri-implant crevicular fluid were significantly higher in patients with prediabetes and uncontrolled type 2 diabetes compared to patients without diabetes (20). Previous studies revealed that increasing gingival index (GI), probing depth (PD), and crestal bone loss (CBL) around dental implants in diabetic patients, and impaired glycemic status endangers the osseointegration and stability of the implant (21). However, under optimal glycemic control, dental implants can demonstrate successful secondary stability and osteointegration, similar to healthy individuals (22). As a contemporary treatment modality, dental implants require evaluation of the impact of chronic diseases such as diabetes mellitus on their success rates to optimize clinical outcomes; Therefore, the present study was conducted to investigate the amount of crestal

bone loss in dental implants in diabetic patients compared to non-diabetic individuals referred to Shiraz Dental School.

Materials and Methods

This study was approved by the Research Ethics Committee of Shiraz Dental School under the ethical approval code IR.SUMS.DENTAL.REC.1402.032. The present investigation is a retrospective cohort study. Data sources of study including; HbA1c, FBS (fasting blood sugar), and 2hpp (two-hour postprandial) were used to detect subjects with T2DM. Patients with T2DM were selected from those who were referred to the dental school of Shiraz University of Medical Sciences. The number of subjects whom they meeting necessary criteria were 60. All of them underwent two-stage implant insertion according to submerged protocol (23) in the posterior area of the mandible (24). Thirty subjects were assigned to each group as the case and the control groups. Surgical procedures for both groups were the same. Both groups were matched for variables such as age, sex, and body mass index (BMI), with diabetes being the only distinguishing factor, categorized based on blood glucose levels (25).

Diabetic status was assessed using FBS, 2HPP, and HbA1c levels. Individuals with an FBS ≥126 mmol/dL and a 2HPP ≥200 mmol/dL were classified as diabetic. However, HbA1c levels were used as the main inclusion criterion for considering subjects as diabetics in this study. For those with HbA1c levels of more than 7.5%, implant surgery had not been performed due to uncontrolled blood glucose levels. However, HbA1c levels between 5.5% to 7.5% were considered controlled diabetes and they received implant treatment in the name of the case group. Moreover, HbA1c levels less than 5.5% were considered as non-diabetic and were considered as the control group.

The inclusion criteria for the case group were determined as an age limit between 20-60 years of age and a controlled blood glucose level that was determined by HbA1C of 5.5-7.5. Exclusion criteria for both case and control groups include the presence of incomplete information in the patient file, failure to record periapical radiographic findings after implant surgery, history of head and neck radiation therapy, use of bone graft for implantation, having parafunctional habits such as bruxism periapical osteolysis, erosion, and pregnancy at the time of implantation. The inclusion criteria for the control group include non-T2DM patients, which is defined as HbA1c of less than 5.5%, who need implants, without bone grafting.

The data was collected using a checklist prepared from the patient's records. The checklist had two parts. The first part was related to demographic information such as age, weight, height, and gender. The second part was related to the amount of crestal bone resorption, which was measured using parallel periapical radiography (PA).

Each patient who was a candidate for implant surgery that met the inclusion criteria was included in the study and their files were analyzed. In the following steps, using the national code of each patient, the researcher examined their periapical radiographic images by a radiologist and recorded the exact amount of crestal bone resorption in our checklist. All implant surgeries in the case and the control groups were performed by a surgery specialist with more than 5 years of experience in implant surgery. Study subjects were matched based on body mass and implant location. Equalization for BMI was done by measuring the weight and height of the patients. BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Neodent dental implants (Neodent, Brazil) were also utilized in all case and control participants.

The amount of crestal bone resorption was measured using parallel periapical radiography (PA). To measure the amount of crestal bone resorption, parallel PA radiographs were taken at three different times; the day of surgery, six months after the surgery at the day of healing abutment placement, and one year after the surgery. The bone loss at the mesial and distal of each implant was noted in every radiograph. Parallel periapical radiographs were taken under the same conditions and conducted by

the same radiologist and the same radiography device. All radiographs were taken using parallel XCP devices (Zt Dental Positioning Kit, China) and the Planmeca intraoral radiography device (Planmeca, Helsinki, Finland) using the following exposure criteria: kvp=70, the exposure time ranging from 6 to 10 mAs according to the studied tooth and on Kodak E speed dental x-ray film; (Carestream Health, USA). Radiographies were taken by a maxillofacial radiology technician who had ten years of experience with fore mentioned devices. In each radiograph, the greatest amount of bone loss observed in either the mesial or distal aspect of the implants was recorded.

Statistical Analysis

An independent t-test was performed to compare the mean crestal bone resorption between the case and control groups. Additionally, to assess the trend in mean crestal bone resorption across the three measured time points, a repeated measures statistical test was employed. Statistical analyses were conducted using SPSS version 23.0 (SPSS Inc., Chicago, IL, USA), with the alpha level set at 0.05.

Results

In this study, 60 patients were selected, 30 with T2DM and 30 non-T2DM patients. The mean age of the subjects was 53.98 with a standard deviation of 7.22 years. The oldest patient was 60 years old and the youngest was 39 years old. Of the participants, 21 (35%) were women and 39 (65%) were men. The mean HbA1c level was 6.19 ± 0.79 in patients with T2DM and 4.08 ± 1.14 in the control group, with the difference being statistically significant ($P < 0.001$). Table 1 presents the frequency distribution of demographic variables in the case and control groups. While the mean age and BMI were higher in the case group compared to the control group, the differences were not statistically significant. Similarly, no significant difference was observed in gender distribution between the two groups.

Figure 1 shows the distribution of the number of missing teeth in the case and the control groups. In both groups, most patients needed 1 tooth implant, and the percentage of diabetic patients who needed more than two implants was higher. However, no significant difference was observed between the two groups (P=0.84). Table 2 shows the mean crestal bone loss on the day of surgery, six months, and one year after surgery in patients with and without diabetes. According to the results of table 2, immediately after the surgery, the average amount of crestal bone loss in diabetic patients was higher than in non-diabetic patients, but the difference was not statistically significant (P=0.063). At both 6 and 12 months post-surgery, diabetic patients exhibited significantly greater crestal bone loss compared to non-diabetic patients ($P < 0.001$ for both time points). Furthermore, the results of table 2 show that the mean difference of crestal bone resorption in both diabetic and non-diabetic patients increased significantly during the follow-up period ($P<0.001$ for both groups).

As shown in Table 2, both the case (T2DM) and control (non-T2DM) groups exhibited a significant increase in crestal bone loss one year postoperatively. Furthermore, the difference in bone loss between the two groups was statistically significant ($P<0.001$). To better visualize this finding, figure-2 illustrates the pattern of changes in crestal bone resorption during the follow-up period. The T2DM group showed a noticeably faster rate of bone loss over time compared to the non-T2DM group. Although the variation in individual rates was not statistically significant, the overall trend suggests that patients with T2DM experience more accelerated crestal bone resorption throughout the observation period. (0.065mm per month bone loss in the case group and 0.0258 mm per month bone loss in the control group).

Discussion

This study demonstrated that crestal bone resorption was significantly greater in patients with T2DM compared to healthy controls. Crestal bone resorption was evaluated at three time points—immediately after surgery, six months, and one-year post-surgery—and the

Table 1. Frequency distribution of demographic variables in patients with and without diabetes

-	-	T2DM	Healthy	P
age		55.03±7.94	53.46±5.46	0.37
sex	**Female**	9(30.0%)	11(36.7%)	0.58
	male	21(70.0%)	19(63.3%)	
BMI		27.25±3.90	25.77±3.46	0.12
BMI (N, %)	**<25**	7(23.3%)	12(40.0%)	0.11
	25-30	14(46.7%)	15(50.0%)	
	>30	9(30.0%)	3(10.0%)	

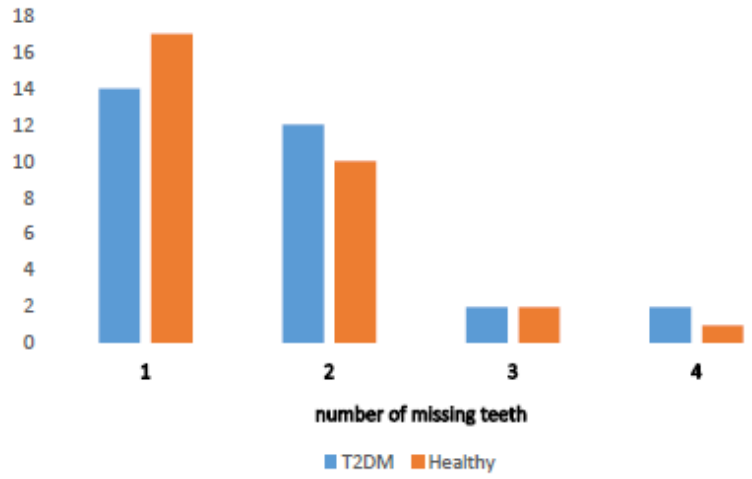

Figure 1. Distribution of the number of missing teeth in patients with T2DM versus healthy individuals

Table 2. Mean crestal bone resorption at surgery, 6 months, and 1 year postoperatively in diabetic and non-diabetic patients

Group	Surgery day		6 months		12 months		P
	Mean	SD	Mean	SD	Mean	SD	
T2DM	0.19	0.08	0.63	0.21	0.97	0.19	<0.001
non-T2DM	0.14	0.09	0.25	0.10	0.46	0.21	<0.001
P	0.063		<0.001		<0.001		

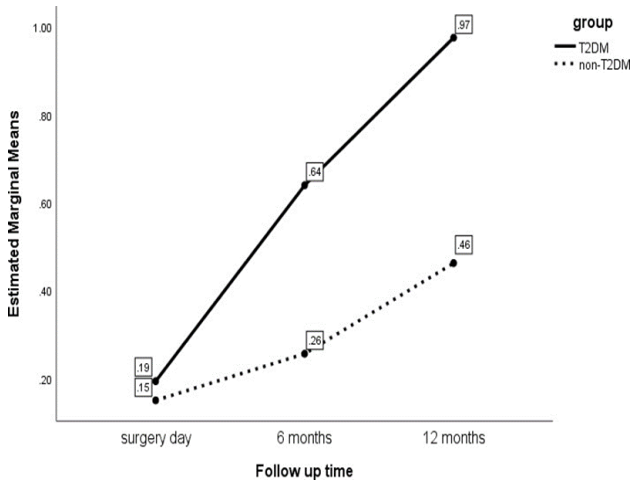

Figure 2. The trend of changes in crestal bone resorption during the follow-up period

results revealed a significant increase over time in T2DM patients. These findings align with previous research, indicating that early bone integrity around implants is compromised in patients with T2DM patients, even when glycemic control is well-maintained (26-28). Similarly, other studies have reported that marginal bone loss is greater in diabetic individuals compared to non-diabetic counterparts (28). Notably, research by Saeed Al Zahrani et al. (27) found that poorly controlled diabetes was associated with significantly greater crestal bone resorption compared to well-controlled diabetes. In addition to diabetes, other chronic systemic conditions, such as cardiovascular disease (29) and liver cirrhosis (30) , are also associated with increased crestal bone loss around implants when compared to healthy subjects (31, 32). Supporting this, Alasqah et al. (33), reported that T2DM patients with coexisting systemic diseases exhibited significantly more soft tissue inflammation and crestal bone resorption compared to those with T2DM alone. T2DM impacts the periodontium through several mechanisms, ultimately leading to bone loss around teeth and implants. It decreases collagen fiber gene expression (34) and disrupts collagen structure and function (35). resulting in connective tissue degradation and attachment loss (27, 36). Moreover, the accumulation of advanced glycation end products (AGEs) in diabetic patients, and their interaction with the receptor for advanced glycation end products (RAGE), triggers oxidative stress and the production of pro-inflammatory cytokines, such as interleukin-1 (IL-1), interleukin-6 (IL-6), IL-1β, tumor necrosis factor-alpha (TNFα), and matrix metalloproteinases (MMPs) (34, 37-39). This hyperinflammatory state exacerbates the deterioration of periodontal tissues, initiates a pro-inflammatory response in bone (40), and impairs wound healing (34) all of which are critical for successful osseointegration and peri-implant health. Elevated cytokine levels in T2DM patients further enhance osteoclastic activity while reducing osteoblastic activity, contributing to accelerated bone resorption (41). These pathological processes compromise both collagen and crestal bone integrity. Additionally, studies have shown that patients with poorly controlled glycemic levels, as indicated by elevated HbA1c, exhibit higher levels of AGEs in serum and peri-implant crevicular fluid. These elevated AGEs contribute to poor peri-implant attachment and increased crestal bone loss (17, 39). Thus, controlling and maintaining optimal glycemic parameters is critical to improving the success of implant therapy in diabetic patients (42, 43). In clinical point of view dental professionals should integrate these findings into treatment planning for diabetic patients, emphasizing preoperative glycemic assessment and glycemic control to possibly achieve better result. The current study supports prior research showing that chronic hyperglycemia affects bone function and integrity. By examining crestal bone resorption in relation to HbA1c levels, this study emphasizes the importance of glycemic control in minimizing peri-implant bone loss and enhancing implant success. However, this study has several limitations. It did not account for the duration of diabetes, the impact of glycemic control, or the influence of oral and dental hygiene on crestal bone resorption in T2DM patients. Additionally, only crestal bone resorption was analyzed, whereas other

peri-implant clinical parameters, such as peri-implant probing depth and attachment loss, were not assessed. Future research should include these variables to provide a more comprehensive understanding of the factors contributing to crestal bone loss in diabetic patients.

Conclusion

Our study showed that the amount of crestal bone loss in diabetic patients was significantly higher than in non-diabetic patients one year after implant surgery.

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Conflicts of Interest

The authors declare no conflict of interest.

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