Original Article

The effects of diabetes mellitus on peri-implant marginal bone loss in the posterior maxilla

Mustafa Ozay Uslu[1], Mustafa Karaca[2], Arife Sabanci[1]

[1]Inonu University Faculty of Dentistry Department of Periodontology, Malatya, Turkey
[2]Mehmet Akif Ersoy University, Faculty of Dentistry, Department of Periodontology, Burdur, Turkey

Abstract

Aim: The aim of this retrospective study was to evaluate the effects of Diabetes Mellitus on peri-implant marginal alveolar bone loss in sinus lifted well-controlled diabetic patients at long term.

Materials and Methods: Thirty eight patients with 77 dental implants were included the study. The study consists of 2 groups; control group (C) and diabetes mellitus group (DM). The dental implants were placed after open window maxillary sinus lifting surgery at maxillary posterior region. After conventional loading process patients were followed periodically for bone loss and clinical parameters. The peri-implant marginal bone loss was assessed at minimum 3 years after functional loading. Standardized panoramic radiographs were obtained at the baseline and maintenance which were used for evaluating the marginal bone loss and clinical and anatomical crown to implant ratio. The Student-t test and Mann Whitney-U test were used to analyse any significant differences between two groups (p<0.05). The Kruskal Wallis test was used for inter-group comparisons of parameters and Chi-square test, Fisher's Exact Chi-square test and Continuity (Yates) correction were used to compare qualitative data. Spearman's rho correlation analysis was used to examine the relationships between parameters with non-normal distribution.

Results: A total of 77 dental implants were followed up for at least 36 months. The mean follow-up was 43.47±10.30 months. 2 implants were failed in DM group. The mean marginal bone loss in DM and C group were 1.35±1.22 mm and 0.91±1 mm respectively. There was no statistically significance in terms of marginal bone loss between the two groups (p>0.05).

Conclusion: Within the limitations of this study, it was shown that long-term follow-up results of dental implants in well-controlled diabetic patients were similar to those of healthy individuals and DM did not increase the peri-implant marginal bone loss.

Keywords: Crown to implant ratio; diabetes mellitus; marginal bone loss; sinus lifting.

INTRODUCTION

Dental implants have been successfully applied over the past years for dental restoration in cases of partial or complete edentulism (1). When compared to dental prostheses, it was known that dental implants, which had become an alternative treatment to restore missing teeth, offer more satisfactory and superior results in terms of aesthetics, comfort and function (2).

Although dental implant procedures were a promising treatment modality, the efficacy of this treatment depends on successful osseointegration at the time of healing (3). Osseointegration could be defined as a direct functional and structural integration between the living bone and the implant surface, characterized by a direct formation of the bone matrix and osteoblasts on the implant surface, with no soft and fibrous tissue on the bone-implant junction surface (4,5).

Most experimental studies had shown that in diabetic patients, bone formation around dental implants may be deficient or delayed, and that the newly formed bone was immature and poorly regulated (6). Hyperglycemia caused a decrease in the level of osseointegration of the implant due to its negative effects on bone formation and remodeling (7). Soft tissues were also affected by microvascular complications of hyperglycemia, vascularization of the tissues was decreased, healing was delayed, and the wound became vulnerable to infection. In

relation to these conditions, the rate of failure in implant therapy for diabetic patients was increasing (1). According to various retrospective studies, implant success rate in diabetic patients varies between 85% and 94.3% (2,3).

Clinically, an ideal implant application is a complicated operation terminated by an ideal prosthetic restoration within biomechanical factors as well as oral surgery and periodontal limitations. The crown length, together with the crown/implant ratio, was a key factor in reducing stress on the implant. Determination of this ratio, which was important in detection of the present bone height, affects the appearance of the prosthetic restoration and the distribution of forces to be transmitted to the bone. It was known that the forces on the bone tissue in the crest region were directly proportional to the crown/implant ratio. Therefore, this ratio should be determined correctly to regulate the force to be applied to the bone and thus to ensure implant success (8).

The protection of the peri-implant bone plays a crucial role in long-term implant success. A good stabilization of the implants was achieved when the jawbone has bone quality at the desired level. However, if the cortical bone was thin and the spongious bone did not have adequate resistance and was at low density, implant stabilization was significantly impaired. Peri-implant pathology and excessive occlusal load were two main factors in late-stage implant failure (9). In particular, severe alveolar bone loss in the maxillary posterior region and maxillary sinus pneumatization may cause mandatory short implant placement, while long crown restorations to compensate for bone loss and restore the occlusal vertical dimension may result in a consequent increase in the crown/implant ratio. When exposed to lateral loads as a result of increased crown/implant ratio, the crown length acts as a vertical lever and thus increases the stress at the bone-implant interface. As the length of the crown increases, the momentum was larger due to the horizontal component of the force (10,11). In some cases, severely resorbed alveolar crests and anatomical borders may prevent implants from being inserted at the desired crown/root ratio, which may result in marginal bone loss (11).

A clinically stable implant was associated with a radiographic appearance of a normal bone with tight contact at the implant surface. Strid reported in 1985 (12) that marginal bone loss could occur during bone healing and at the time of loading afterwards. This bone loss in tissues surrounding a healthy implant was occured as a result of bone's reaction to the loading applied through physiological remodeling and implants. The total loss in the marginal bone was about 1.2 mm from the time of implant insertion to the first year of the loading period in the Branemark implant system, which was usually at the level of the first thread of the implant. In the follow-up period, mean annual bone loss was reported to be 0.1 mm (13). Strid reported in 1985(12) abnormally high annual marginal bone loss of about 3 mm in cases of mechanical failures of the implant itself or of its components

due to irregular stress distribution or overloading.

The purpose of this retrospective study was to evaluate the effect of Diabetes Mellitus on the marginal bone loss in implants with sinus augmentation remaining functional for a long time.

MATERIAL and METHODS

This study was approved by the Malatya Clinical Research Ethics Committee (Protocol code 2018/8-20) and study was conducted according to the principles of the Declaration of Helsinki. Individuals selected in accordance with the study criteria were informed in detail about the purpose and method of study, and a written informed consent was obtained from each participant.

Patient selection

This study was designed as a long-term controlled study and performed in Type 2 Diabetes Mellitus (DM) and healthy individuals receiving dental implant treatment after sinus lift surgery at the Department of Periodontology of Faculty of Dentistry, Inonu University between 2010 and 2015. The study included a total of 77 implants in 38 patients ranging in age from 48 to 61 years, 21 (55.3%) males and 17 (44.7%) females. The mean age of the participants was 51.45±9.50 years.

Inclusion criteria

History of open window sinus lift procedure and without any complications related with sinus surgery

- Having at least one dental implant
- Having implants functioning for at least 3 years
- For the DM group, good glycemic control (HbA1c<7%,) according to American Diabetes Society diagnostic criteria (14), with at least 5 years of DM history
- For the control group, no systemic disease that may affect periodontal parameters

Exclusion criteria

- Patients with poor or un-controlled glycemic condition
- History of chronic systemic disease (other than DM)
- History of oral cancer or non-healing lesion
- Osteoporosis-osteopenia or any bone malformation
- Complete edentation
- Inability to take measurements due to radiographic distortion
- Acute - chronic sinus infection
- Use of antibiotics and steroids within the last 3 months

Research protocol

In accordance with the study protocol, a detailed systematic anamnesis was taken from the participants and then they were divided into 2 groups: patients with diabetes mellitus (DM group) and healthy controls (control group).

In order to make retrospective evaluations on the implants and oral health of the participants, Metasoft DentAssist and Planmace Romexis software packages were used to access detailed records of the participants before and after implantation and their follow-up panoramic radiographs. Clinical index measurements of all implants and teeth were

performed, and radiographic evaluations were made to evaluate each participant's periodontal health and implant crown type, crown/implant ratio, and marginal bone loss.

Radiographic measurements of graft width, graft height, distance between sinus floor and crest, length of crown, abutment length were also recorded, along with the diameter and length of the implants.

Error of the method
Intra-examiner error was evaluated by obtaining the 15 randomly selected implant sites. The beginning and the last measurement were performed within one month interval. All measurements including pre-operation, maintenance visits and the last one were performed by the same investigator (MK).

Evaluation of periodontal status
The periodontal status of participants was classified as follows:

Healthy: No clinical signs of inflammation, no radiographic bone loss, and no loss of attachment

Gingivitis: Clinical manifestations of inflammation (bleeding on probing, changes in the colour of gums from red to blue, edema), no loss of attachment, and no bone loss on radiographic examination

Periodontitis: Findings of inflammation, as well as attachment loss and radiographic bone loss

Radiographic evaluation
Clinical index measurements as well as panoramic radiographs were taken from the participants included in the study. Exposure parameters for panoramic radiographs were 5 mA, 66 kV with an exposure time of 18 seconds (Planmeca Proline XC Panoramic X-Ray Unit, HELSINKI, FINLAND).

Measurement of marginal bone loss
Two panoramic radiographs taken (first one taken immediately after placement of the implants and the second one taken at the last follow-up visit) and were transferred to digital media by means of a scanner. Then, the length of the implants was measured on the panoramic radiographs. The extent of magnification of the panoramic radiograph was calculated by comparing the implant size detected on the radiograph with the actual length of the implant. The mean marginal bone levels measured from the mesial and distal points with reference to the neck of the implant was determined according to the amount of magnification. The difference between marginal bone levels obtained from first and last digital panoramic radiographs was noted as bone loss (Figure 1). The mean bone level percentage for an implant was calculated by taking the mean value of the mesial and distal measurements ((M+D)/2) (15,16).

Measurement of crown/implant ratio
The crown/implant ratio was the proportion of the anatomical crown length (the distance between the most coronal point of the restoration and the implant-abutment connection) to the anatomical implant length (the distance between the implant's apex and the implant-abutment connection (17) (Figure 2). Statistical Analysis

In the evaluation of the findings obtained in this study, statistical analysis of the research data was carried out on the software package called IBM SPSS Statistics 22 (SPSS IBM, Turkey). The normal distribution of parameters was evaluated by the Shapiro-Wilk test. Student t test was used for comparison between two groups of normal distribution parameters, Mann-Whitney U test was used for comparison between two groups of non-normal distribution parameters, as well as descriptive statistical methods (mean, standard deviation, frequency) as well as quantitative data. The Kruskal Wallis test was used for inter-group comparisons of parameters showing non-normal distribution. Chi-square test, Fisher's Exact Chi-square test and Continuity (Yates) correction were used to compare qualitative data. Spearman's rho correlation analysis was used to examine the relationships between parameters with non-normal distribution. P values of less than 0.05 (p<0.05) were regarded as statistically significant.

RESULTS

The study included a total of 77 implants in 38 patients, 21 (55.3%) male and 17 (44.7%) female, ranging in age from 48 to 61 years. The mean age of the participants was 51.45±9.50 (Table 1). The follow-up period ranged from 36 months to 72 months, with a mean period of 43.47±10.30 months and a median of 37 months. Study data were analyzed under two groups: "DM group" (n=21) and "control group" (n=56). Only two implants (2.6%) had a failure.

The mean age of the diabetic group was significantly higher than that of the control group (p:0.005; p<0.05); there was no statistically significant difference between groups in terms of gender distribution (p>0.05) (Table 1).

There was no significant difference between the groups in terms of mesial, distal and mean bone loss, follow-up time, single-unit / bridge ratios and crown/implant ratios (p>0.05). And also there was no significant difference in the incidence of implant failure and periodontal disease between the groups (p>0.05) (Table 2).

The mean abutment length in the diabetic group was significantly higher than in the control group (p: 0.030, p<0.05) (Figure 3). The mean graft width in the diabetic group was statistically higher than in the control group (p: 0.012; p<0.05) (Figure 4). The mean distance between sinus floor and crest in the diabetic group was significantly lower than in the control group (p:0.030, p<0.05) (Figure 5).

There was no significant difference between groups in terms of implant diameter, implant length, crown length and graft height (p>0.05) (Table 3). There was no significant relationship between age and mean marginal bone loss in both control and diabetic groups (p>0.05) (Table 4).

There was no significant difference in mean marginal bone loss between genders in both control and diabetic groups (p>0.05). There was no significant difference between

mean marginal bone loss levels in both control group and diabetic group according to prosthesis type (p>0.05). There was no significant difference between mean marginal bone loss levels in both control and diabetic groups according to periodontal disease (p>0.05). There was no significant difference between the mean marginal bone loss levels according to crown/implant ratio in both control and diabetic groups (p>0.05) (Table 5).

Table 1. Age and gender distrubution in control and DM groups.				
	Control	**DM**	**Total**	**p**
Age Mean±SD (median)	51.30±9.21 (52)	56.62±3.81 (57)	52.75±8.42 (55)	10.005*
Gender n,%				
Male	32 (%57.1)	13 (%61.9)	45 (%58.4)	20.906
Female	24 (%42.9)	8 (%38.1)	32 (%41.6)	
[1]Mann Whitney U Test [2]Continuity (Yates) correction *Indicating statistical significance (p<0.05)				

Table 2. Comparisons of marginal bone loss and clinical parameters between control and DM groups.				
	Control	**DM**	**Total**	**p**
	Mean±SD (median)	**Mean±SD (median)**	**Mean±SD (median)**	
Follow-up Time (month)	44.39±10.47 (41)	41±9.65 (36)	43.47±10.3 (37)	[1]0.126
Mesial MBL	0.82±1.02 (0.3)	1.37±1.47 (0.7)	0.97±1.17 (0.5)	[1]0.134
Distal MBL	1.01±1.02 (0.7)	1.32±1.15 (1)	1.09±1.06 (0.7)	[1]0.266
Mean MBL	0.91±1 (0.5)	1.35±1.22 (1)	1.03±1.07 (0.6)	[1]0.147
Failure n,%	0 (%0)	2 (%9.5)	2 (%2.6)	[2]0.072
Periodontal Disease n,%				
Generalized Chronic Periodontitis	30 (%53.6)	16 (%76.2)	46 (%59.7)	[3]0.197
Lokalized Chronic Periodontitis	10 (%17.9)	2 (%9.5)	12 (%15.6)	
Gingivitis	16 (%28.6)	3 (%14.3)	19 (%24.7)	
Prosthetic Type n,%				
Single Unit	22 (%39.3)	5 (%23.8)	27 (%35.1)	[4]0.318
Bridge				
Crown/Implant Ratio n,%				
<0.75	20 (%35.7)	6 (%28.6)	26 (%33.8)	[3]0.835
0.75-1	21 (%37.5)	9 (%42.9)	30 (%39.0)	
>1	15 (%26.8)	6 (%28.6)	21 (%27.3)	
[1]Mann Whitney U Test　　　　　[2]Fisher's Exact Test　[3]Ki-kare test　　　[4]Continuity (Yates) correction MBL:Marginal bone loss				

Table 3. Comparisons of surgical and site related parameters between control and DM groups

	Control Mean±SD (median)	DM Mean±SD (median)	Total Mean±SD (median)	p
Implant Diameter(median)	4.35±0.53 (4.3)	4.47±0.43 (4.5)	4.39±0.51 (4.4)	[1]0.434
Implant Length	11.45±1.37	12.03±1.09	11.61±1.32	[2]0.086
Abutment Length	1.93±0.61	2.3±0.72	2.03±0.66	[2]0.030*
Crown Length	7.53±1.38	7.86±1.39	7.62±1.38	[2]0.356
Graft Height	6.65±5.03	7.95±2.22	7.02±4.44	[2]0.147
Graft Width	11.63±8.92	16.38±5.64	12.98±8.36	[2]0.012*
Distance between sinus floor and crest	4.95±1.97	3.9±1.52	4.67±1.9	[2]0.030*

[1]Mann Whitney U Test [2]Student t Test *Indicating statistical significance (p<0.05)

Table 4. The correlation between age and mean marginal bone loss in groups

	Age-Mean MBL	
	Control	DM
r	-0.110	0.055
p	0.420	0.814

Spearman's rho korelasyon testi

Table 5. The evaluation of mean marginal bone loss in relation with gender, prosthetic type, periodontal disease and crown/implant ratio in groups

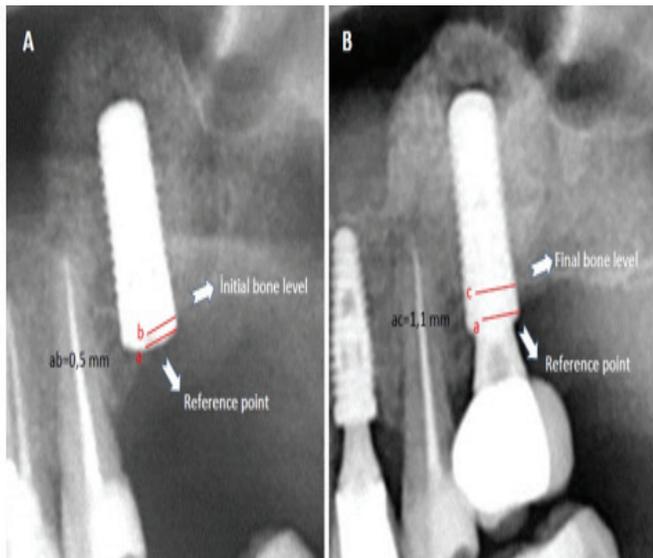|		Mean Marginal Bone Loss	
		Control Mean±SD (median)	DM Mean±SD (median)
Gender	Male	1.01±1.13 (0.5)	1.06±1.07 (0.7)
	Female	0.76±0.79 (0.4)	1.81±1.37 (1.5)
	[1]p	0.375	0.192
Prosthetic Type	Single Unit	1.02±1.24 (0.4)	1.12±1.11 (1)
	Bridge	0.84±0.82 (0.5)	1.42±1.28 (1.2)
	[1]p	0.814	0.836
Periodontal Disease	Generalized Chronic Periodontitis	1.06±1.22 (0.6)	1.43±1.38 (0.8)
	Lokalized Chronic Periodontitis	0.71±0.6 (0.4)	0.75±0.35 (0.8)
	Gingivitis	0.74±0.66 (0.3)	1.27±0.36 (1.5)
	[2]p	0.636	0.906
Crown/Implant Ratio	<0.75	0.67±0.58 (0.4)	1.65±1.05 (1.5)
	0.75-1	1.11±1.14 (0.8)	1.54±1.36 (1)
	>1	0.93±1.2 (0.4)	0.74±1.14 (0.4)
	[2]p	0.345	0.167

[1]Mann Whitney U Test   [2]Kruskal Wallis Test

Figure 1. Illustration of measurement of marginal bone loss. A. Radiograph at the day of implant placement. B. Radiograph at the last follow-up visit. Marginal bone loss calculated as the difference between the ac and ab lines.
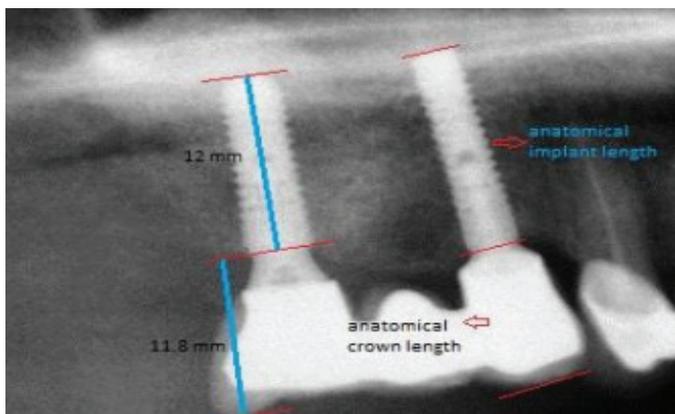

Figure 2. Illustration of measurement of crown/implant ratio. The crown/implant ratio was the proportion of the anatomical crown length to the anatomical implant length
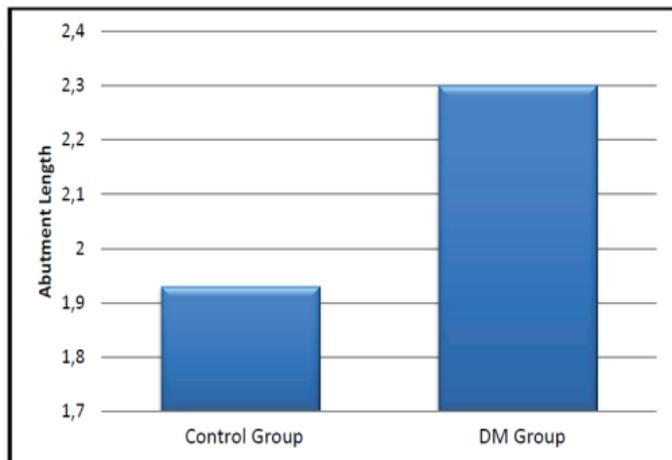

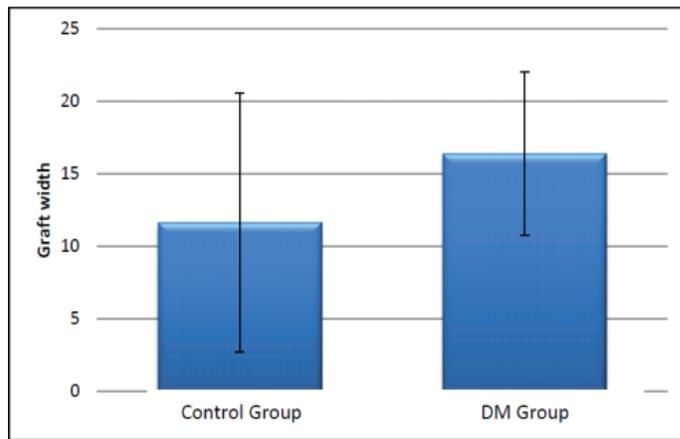**Figure 3.** The comparison of mean abutment length in the diabetic group and control group

Figure 4. The comparison of the mean graft width in the diabetic group and control group
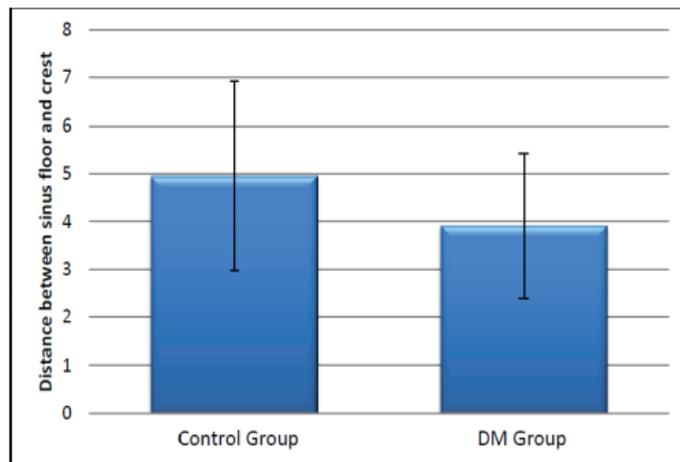

Figure 5. The comparison of mean the mean distance between sinus floor and crest in the diabetic group and control group.

DISCUSSION

Over recent years, dental implant applications have become an alternative treatment option to traditional prosthetic applications in eliminating dental deficiencies. The primary requirement for the success of dental implants was achievement of osseointegration, which may be affected by several factors, such as the health of the patient, the density and amount of bone to receive implants, the shape and surface characteristics of the implant, the surgical method, oral hygiene status, and designs in implant-abutment connections (18). Besides, maintaining the marginal bone level at the same level for a long period of time was an important factor in achieving success in implant treatment. For the assessment of implant therapy, certain parameters like the quality and quantity of alveolar bone around the implant could provide an insight into the success of implant treatment (19). Dental implant therapy in diabetic patients is a controversial issue due to the negative effects of hyperglycemia on osseointegration, and the impact of diabetes on the success of dental implant therapy remains a matter of interest for researchers (20). According to many studies, the success rates of implants were increased in diabetic

patients under good glycemic control in the preoperative period (20). Experimental studies had suggested that bone formation in the peri-implant region may be missing or delayed in patients with DM, and that the newly formed bone was immature and poorly regulated (6,21). Chronic hyperglycemia induces the formation of bone resorption by creating an inflammatory effect. In a study conducted by McCraken et al. in diabetic rats, large volumes of bone tissue were reported to form around dental implants. However, this bone tissue consisted of poorly regulated bone (21). In our study, maxillary sinus augmented more in the crestal direction in the DM group and thus the distance between sinus floor and crest was significantly shorter than in the control group. Balshi et al. reported that 94.3% of the implants in diabetic patients under good glycemic control was successful at the initial stage, and 177 implants followed in the long-term had a survival rate of 99.9% (22). Fiorellini et al. reported 85.6% implant success rates in diabetic individuals who were followed for longer than 6.5 years, (23) and Farzad et al. reported this rate as 96.3% at the end of one year and 94.1% at the end of 10 years (24). Abdulwassie et al. stated that implant success rate was 95.7% in the third year and that after the completion of the prosthetic restorations, there was no implant failure (25). In our study, only two implants in the DM group failed in long-term follow-up, which caused no statistical difference between the groups. In this regard, our results were consistent with the results of studies showing high implant success in DM patients. The lowest bone quality in the mouth was observed especially in the posterior region of the upper jaw. The highest clinical failures were reported to occur in this region, as the bone in this region was weaker than the other regions in the mouth (26). Preservation of the existing cortical bone was of vital importance so that the stresses were not destructive. In order to reduce the stress levels in the implant system, dentists should avoid using long crowns (27,28). Therefore, placement of longer implants by sinus lift surgery instead of short implants in the upper jaw posterior region clinically provides marginal bone preservation by providing an ideal crown/implant ratio (29). In several studies, marginal bone loss was measured from the mesial and distal sides of each implant (15-17). For this reason, marginal bone loss in our study was calculated by taking the mean bone loss in the mesial and distal parts of the radiographs. We believe that the crown/implant ratio below 2 in our study reduced the destructive stress around the implant. As a result, there was not a statistically significant difference between the DM group and the control group in terms of marginal bone loss (MBL), and the mean MBL level in the long term was low. The bone support in maxillary implants includes graft material that is less rigid than natural bone after sinus lift surgery. Therefore, after functional loading, the stress level at the crestal bone level was increased, which was associated with marginal bone loss (30). In our study, mean MBL in patients scheduled to receive sinus lift surgery was 0.91 mm in control group and 1.35 mm in DM group and we suggest that MBL can be regarded as normal in relation to

the graft material used sinus lifting at long term follow-up. The previous research in this field utilized both periapical radiographs and panoramic radiographs to determine marginal bone loss for the assessment of implant success (15-17). Although periapical radiographs taken through parallel technique were the best method of measurement for marginal bone loss, we preferred to use panoramic radiographs in our study, as all previous implant therapies had been planned based on panoramic radiography and they allowed better evaluation of the relationship of implants with all adjacent anatomical formations and neighboring teeth (31). However, the lack of a more accurate method of measuring peri-implant marginal bone loss, such as CBCT, was one of the limitations of our study. Radiographic evaluation with today's computer-assisted measurements allows a more accurate assessment of the peri-implant region. In a clinical study, Moberg et al. utilized computer-assisted measurements to determine the level of bone around the implants. During the measurement, each radiograph was evaluated by comparing the radiographic and actual dimensions of the implants in order to rule out the errors caused by the magnification differences (32). Wyatt et al. pointed out that the computer-assisted measurement of the bone level around the implant is more advantageous, indicating that in measurements using magnifiers different perspectives between researchers could cause changes in the results (33). In our study, calibrated computer-assisted measurements were also carried out to maximize the precision of the results obtained. It was a well known issue that forces on the implants create stress on the crestal bone at the implant neck. From an anatomic and clinical perspective, the relationship between crown length/implant length ratio and bone loss was linearly proportional. A linear correlation between marginal bone loss and high crown length/implant length ratio was shown by Rangert et al. (34). Despite of results of Rangert et al, Schneider et al. evaluated the crown/implant ratio of the patients they monitored for 5 years in two groups as those with crown/implant ratio of above 1 and below 1, and they found that implant success rates were similar in both groups (35). Malchiodi et al. evaluated the effect of the crown/implant ratio on bone loss in 259 implants, reporting a positive relationship between the increase in the crown/implant ratio and marginal bone loss (36). However, in our study there was no significant relationship between mean marginal bone loss and crown/implant ratio in both the control and DM groups. The current literature appeared to contain two measurement methods used to determine the crown/implant ratio. Some researchers preferred anatomic crown/implant ratio, while others used clinical crown/implant ratio (17). The anatomical crown/implant ratio was the proportion between the anatomical crown length (the distance between the implant-abutment connection and the most coronal point of restoration) and the anatomical implant length (the distance between the implant's apex and the implant-abutment connection) (17). The clinical crown/implant ratio, on the other hand, was the proportion between the clinical crown length (the distance between

the most coronal point of the restoration and the most coronal point of the bone-implant interface) and the clinical implant length (the portion of the implant in the alveolar bone). We preferred to use anatomic crown/implant ratio in our study, because it revealed a more accurate picture of the biomechanical status depending on smaller lever arm effect, and a change in clinical crown/implant ratio with bone loss would complicate the assessments (37). Clinical parameters and radiographic methods were employed in the routine follow-up of dental implants. Cohen stated that periodontal parameters should be used in the peri-implant tissue examination (38). In their literature review, Quirynen et al. reported that oral hygiene and periodontal status had a significant impact on the stability of marginal bone around the implants (39). Contrary to these studies, marginal bone levels did not change significantly according to periodontal status in both DM and control groups, which could be attributed to the fact that patients receiving implant therapy were on strict periodontal monitoring, and thus gum diseases were kept under good control. Snauwaert et al. examined patients using implant-based full prosthesis, fixed-crown, and fixed bridge prosthesis for two years in order to investigate the impact of prosthesis type on implant failure, however they failed to establish a correlation between prosthesis types and implant success (40). In our study, there was no statistically significant relationship between marginal bone levels and single-unit crowns or bridges in both DM and control group, which corroborates with the findings of the previous work in the literature.

CONCLUSION

Within the limitations of this study, it was seen that long-term follow-up results of dental implants which were placed in diabetic patients with a history of maxillary sinus lift procedures, were similar to those of healthy individuals and the low anatomical C/I ratio does'nt increase the peri-implant marginal bone loss.

Mustafa Ozay Uslu ORCID: 0000-0002-9707-1379
Mustafa Karaca ORCID: 0000-0001-5853-2366
Arife Sabanci ORCID: 0000-0002-0956-1600

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