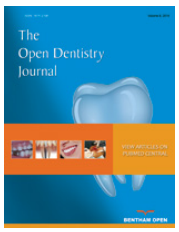

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RESEARCH ARTICLE

Prevalence of Bone Loss in Mandibular Future Abutment Teeth among Diabetic and Non-Diabetic Patients: A Retrospective Case-Control Study

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Abstract:

Objective:

This study aimed to compare the prevalence of bone loss in lower permanent premolars and canines, which can serve as abutments for future prostheses, among diabetic and non-diabetic patients.

Materials and Methods:

In this retrospective case-control study, records of patients who visited the dental clinics of Imam Abdulrahman Bin Faisal University were used. Inclusion criteria were the presence of a complete periodontal chart, full mouth radiographs, and past medical history (presence of DM, hypertension, and/or coronary heart disease). The criteria for exclusion were the reporting of malignancy, pregnancy, breastfeeding, or taking of the medications that affect bone turnover, periodontal surgery within the past year, absence of radiographs with good quality, and antibiotic use within 3 months prior to the dental visit. Demographical data, including gender and age, past medical history (diabetic state), and periodontal diagnosis, were collected. The severity of periodontal disease, radiographic bone loss (RBL), and its pattern were also assessed.

Results:

Out of 400 records, 363 patient files were included. Of those, almost 36% were males and 64% were females. The patients' age was ranging from 16 to 82 years. About 34% of the patients were diagnosed with generalized periodontitis while 22% had localized periodontitis. With regards to the severity of the cases, the prevalence was equally distributed between mild (37%) and moderate periodontitis (38%), while 25% were diagnosed with severe periodontitis. A total of 22% of the patients were diabetic, which showed an increase in the severity of bone loss by an average of 31% across the selected teeth (mandibular canines and premolars). The pattern of bone loss was higher in the mandibular incisors, followed by the canines and the premolars. Multiple regression models showed that non-diabetics were significantly less likely to have bone loss in all the selected teeth and the male patients had 2 times the likelihood of having bone loss. Although the mandibular canines have the highest root length in the mandible, they were the most affected by bone loss in diabetic patients with periodontitis.

Conclusion:

Results of this study suggested that mandibular premolars were the teeth least affected by bone loss in both, diabetic and non-diabetic groups. Therefore, they can be considered the most suitable teeth to be used as abutments for the future prosthesis.

Keywords: Bone loss, Diabetes mellitus, Abutment teeth, Periodontal disease, Mandibular premolars, Periodontitis.

Article History	Received: August 8, 2021	Revised: December 28, 2021	Accepted: January 12, 2022

1. INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disease characterized by hyperglycemia which results either from a defect in insulin secretion by pancreatic β cells, reduction of insulin sensitivity, or both [1]. In 2010, the number of affected adults with diabetes mellitus (type 1 and type 2) was estimated at 285 million worldwide and the numbers are expected to rise to 438 million by 2030 [2]. Overall, it has been anticipated that the Middle East and North Africa account for having the highest prevalence of DM. However, the Kingdom of Saudi

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Arabia (KSA) is not excluded from this global epidemic, since diabetes is the most challenging health problem faced by the country. The KSA Ministry of Health reported that in less than two decades, the incidence rate of diabetes had increased by 2.7 times. In 1992 and 2010, 0.9 million and 2.5 million people were affected by diabetes, respectively [1].

Systemic health has an influence on oral health. Among systemic diseases, DM is considered one of the most commonly encountered chronic diseases in dental practice [3]. Recently, alongside the five identified complications of DM (retinopathy, nephropathy, neuropathy, macrovascular disease, and poor wound healing), chronic periodontitis has become its sixth complication [1]. Periodontal disease (PD) is a chronic microbially induced inflammatory disease that affects teeth' supporting tissues. PD is characterized by inflammation of the gingiva, formation of periodontal pockets, loss of connective tissue attachment, and alveolar bone resorption, ultimately resulting in tooth loss [4].

Since 1960, several reports have been demonstrated an association between DM and PD [5]. This relation was found to be bidirectional. Patients with diabetes have an altered immune cell function, causing an increase in the production of proinflammatory cytokines and promoting periodontal tissue destruction and weaker elimination of periopathogens [3]. On the other hand, PD can adversely contribute to insulin resistance, thus negatively affecting glycemic control [3]. Even though DM is considered a well-known risk factor for developing PD, the exact mechanisms are not fully understood [6].

Tooth loss is a multifactorial process and molars are found to be at a higher risk for developing periodontal destruction, resulting in their loss compared to single-rooted teeth [7, 8]. Results of the multiple studies explained that the reason for the increased risk of tooth loss in molars is due to the involvement of furcation and poor response of molars to periodontal therapy [9, 10]. Among molars, maxillary molars are found to be at a higher risk of mobility and tooth loss compared to mandibular molars [11]. Thus, single-rooted mandibular teeth, mainly premolars and canines, have been used as abutments for removable partial dentures as well as for overdenture prosthesis [12 - 14].

The study aimed to compare the prevalence of bone loss in mandibular permanent premolars and canines, which can serve as abutments for future prosthesis, among diabetic and non-diabetic patients.

2. MATERIALS AND METHODS

This retrospective case-control study was conducted based on medical records of patients who visited the dental clinics of Imam Abdulrahman Bin Faisal University from September 2018 to September 2021. The study protocol was approved by the Imam Abdulrahman Bin Faisal University, the Institutional Review Board, IAU (IRB-2021-02-034). Written informed consent was obtained from all participants.

The current study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Inclusion criteria were the presence of a complete periodontal chart, full mouth radiographs, and past medical history (presence of DM, hypertension, and/or coronary heart disease). The criteria for exclusion were the reporting of malignancy, pregnancy, breastfeeding, or taking of the medications that affect bone turnover, periodontal surgery within the past year, absence of radiographs with good quality, and antibiotic use within 3 months prior to the dental visit.

Sample size calculation was estimated for the regression model prior to the start of the study. The following assumptions were used: an estimated effect size of 0.2%, with three predictors in the regression model, 5% of alpha error, and 80% power (https://www.statskingdom.com/sample_size_regression.html). The study had to have a minimum of 277 records to obtain sufficient statistical power.

Demographical data, including gender and age, were collected. Smoking habits were also recorded; current smokers were defined as subjects who smoked or stopped smoking less than 12 months prior to being enrolled in the study. Former smokers were subjects who quit smoking more than 12 months ago.

The collected periodontal parameters were periodontal pocket depth (PPD), clinical attachment loss (CAL) on six sites per tooth excluding third molars, and the number of missing teeth due to periodontal disease.

The severity of periodontal disease (localized or generalized) was defined based on Caton *et al.*'s 2018 classification [15].

PD was defined as having more than 2 detectable interproximal CAL. It was further defined as follows:

Initial PD (Stage I): the greatest interproximal CAL=1-2 mm, and radiographic bone loss/RBL <15%,

Moderate periodontitis (Stage II): CAL=3-4 mm and RBL=15-33%, and

Severe periodontitis (Stage III and IV): CAL≥5 mm and RBL ≥30%- 50%.

A pattern of RBL (vertical or horizontal) and the amount of RBL were measured on standardized radiographs taken at the time of dental examination.

A digital software (MiPACS Dental Enterprise Viewer 3.1.1404) was used to measure the radiographic bone loss for the mandibular, such as:

Second left premolar (#20), first left premolar (#21), left canine (#22), left lateral incisor (#23), left central incisor (#24), right central incisor (#25), right lateral incisor (#26),

right canine (#27), first right premolar (#28), and second right premolar (#29).

To set the scale for the measurements, a radiograph of an implant with known width was used. All the measurements were calibrated with the same reference radiograph. A straight line was delineated on the mesial as well as the distal side of the tooth parallel to the long axis of each tooth from the most apical part of CEJ to the most coronal part of the alveolar crest

to measure the RBL.

The amount of RBL was calculated as the distance between the cementoenamel junction (CEJ) and the alveolar bone crest subtracted by 2 mm. The mesial and distal bone levels were calculated for all mandibular incisors, canines, and premolars. The mean mesial and distal bone loss was considered the mean bone loss for every tooth. The mean bone loss of 1-2 mm was considered mild, > 2 - 4 mm was considered moderate, and ≥ 5mm was considered severe.

2.1. Statistical Analysis

IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY: IBM Corp.) was used to analyse the data. Frequencies (N) and percentages (%) were calculated for all study variables. A Chi-square test was performed to detect the difference in bone loss by diabetes status in lower incisors, canines, and premolars. Multiple (adjusted) logistic regression was performed to assess the effect of diabetes on the bone in lower incisors, canines, and premolars after adjusting for other variables. All analyses were performed at a 5% significance level.

3. RESULTS

3.1. Characteristics of the Study Sample and Periodontal Disease Severity

Of 400 records, 363 files of patients were included in the final analysis. Out of them, 36.1% were males and 63.9% were females. The patients' age ranged from 16 to 82 years (mean age: 39.9±14.0 years). The distribution of the patients' demographical diagnostic variables is presented in Table **1**. Most of the subjects were females (63.9%), non-diabetics (88%), and non-smokers (78%). About 34% of the patients were diagnosed with generalized periodontitis while 22% had localized periodontitis. With regards to the severity of the cases, the prevalence was equally distributed between mild (37%) and moderate (38%), while only 25% were diagnosed with severe periodontitis.

Bone loss (vertical or horizontal) was recorded for each individual abutment tooth (mandibular premolars, canines, and incisors) and was compared between diabetic and non-diabetic patients, as shown in Table **2**. In general, the pattern of bone loss was higher in the mandibular incisors, followed by the canines and then the premolars. This pattern was seen in diabetic and non-diabetic patients alike. However, the prevalence of bone loss in mandibular incisors, canines, and premolars was found to vary greatly in diabetic *versus* non-diabetic patients, with a higher prevalence in diabetic patients across all teeth. The difference in bone loss between diabetic and non-diabetic patients for the same teeth was statistically significant among all the tested teeth used as abutments.

Table **3** shows the distribution of vertical and horizontal bone loss of different severities in the lower incisors, canines, and premolars. The highest prevalence of bone loss was noticed in the lower incisors followed by the premolars, while canines had the least recorded bone loss. The majority of the bone loss reported was horizontal among all teeth and it was mostly mild.

3.2. Results of Logistic Regression Analysis

Table **4** shows multiple regression models predicting bone loss in lower incisors, canines, and premolars with respect to patients' gender, diabetes, and smoking statuses. In comparison to diabetic patients, non-diabetics were significantly less likely to have bone loss in all the selected teeth used in the models. However, for tooth #28, this relationship was not statistically significant. Being a male patient increased the likelihood of having bone loss in all the tested teeth included in the models. These relationships were statistically significant for all the teeth except #21, which showed a non-significant relationship. Although non-smokers were less likely to have bone loss in any of the teeth, the relationship was found to be non-significant. However, the relationship between smoking and bone loss was reversed for teeth #23 and #29, where non-smoking increased the likelihood of having bone loss. The severity of periodontitis was excluded from the final models due to an insignificant effect on the overall fit of the models.

Table 1. Distribution of study variables.

Demographics	Frequency	%
Gender(n=363)		
Male	131	36.10%
Female	232	63.90%
Diabetes (n=362)		
Non-Diabetic	320	88.40%
Diabetic	42	11.60%
Smoking (n=287)		
Non-smoker	223	77.70%
Smoker	64	22.30%
Diagnosis (n=363)		
Gingivitis	159	43.80%
Localized periodontitis	79	21.80%
Generalized periodontitis	125	34.40%
Severity (n=204)		
Stage I (mild)	79	37.50%

(Table 1) contd.....

Demographics	Frequency	%
Stage II (moderate)	80	37.90%
Stage III and IV(severe)	52	24.60%

Table 2. Distribution of bone loss in mandibular incisors, canines, and premolars in diabetic *versus* non-diabetic patients.

Bone Loss n (%)										
Tooth number#	**#20**	**#21**	**#22**	**#23**	**#24**	**#25**	**#26**	**#27**	**#28**	**#29**
Diabetic (N=42)	19 (45.2%)	23 (54.8%)	26 (61.9%)	30 (71.4%)	33 (78.6%)	33 (78.6%)	33 (78.6%)	31 (73.8%)	17 (40.5%)	20 (47.6%)
Non-Diabetic (N=320)	50 (15.6%)	49 (15.3%)	64 (20.0%)	91 (28.4%)	95 (29.7%)	96 (30.0%)	93 (29.1%)	66 (20.6%)	57 (17.8%)	63 (19.7%)
p-value	0.000 *	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.001*	0.000*

The number of teeth (their percentage) having bone loss in diabetic and non-diabetic patients.
#The universal tooth numbering system for the mandibular:
Second left premolar (#20), first left premolar (#21), left canine (#22), left lateral incisor (#23),
left central incisor (#24), right central incisor (#25), right lateral incisor (#26),
right canine (#27), first right premolar (#28), and second right premolar (#29).
*Statistically significant p≤0.05

Table 3. Distribution of the prevalence of bone loss in lower incisors, canines, and premolars.

Tooth #	No bone loss n (%)	Vertical bone loss n (%)			Horizontal bone loss n (%)		
		Mild	**Moderate**	**Severe**	**Mild**	**Moderate**	**Severe**
#20 (N=156)	122 (78.2)	3 (1.9)	3 (1.9)	1 (0.6)	15 (9.6)	10 (6.4)	2 (1.3)
#21 (N=161)	128 (79.5)	3 (1.9)	5 (1.9)	1 (0.6)	11 (6.8)	11 (6.8)	4 (2.5)
#22 (N=167)	135 (80.8)	0	3 (0)	0	14 (8.4)	10 (6)	5 (3)
#23 (N=166)	119 (71.7)	0	1 (0.6)	2 (1.2)	20 (12)	13 (7.8)	11 (6.6)
#24 (N=166)	116 (69.9)	2 (1.2)	1 (0.6)	2 (1.2)	19 (11.4)	14 (8.4)	12 (7.2)
#25 (N=166)	115 (69.3)	0	1 (0.6)	4 (2.4)	21 (12.7)	14 (8.4)	11 (6.6)
#26 (N=168)	117 (69.6)	0	0	2 (1.2)	20 (11.9)	16 (9.5)	13 (7.7)
#27 (N=169)	129 (76.3)	0	1 (0.6)	1 (0.6)	20 (11.8)	12 (7.1)	6 (3.6)
#28 (N=162)	125 (77.2)	3 (1.9)	2 (1.2)	0	17 (10.5)	11 (6.8)	4 (2.5)
#29 (N=163)	123 (75.5)	5 (3.1)	2 (1.2)	2 (1.2)	18 (11)	11 (6.7)	2 (1.2)

*Statistically significant p≤0.05.

Table 4. Multiple regression models predicting bone loss in mandibular incisors, canines, and premolars in diabetic *versus* non-diabetic patients after adjusting for gender and smoking status (N=362).

Variables	OR (95% CI)									
	#20	#21	#22	#23	#24	#25	#26	#27	#28	#29
Gender										
Males	2.41(1.26-4.60)*	2.07(1.09-3.96)	1.92(1.06-3.47)*	2.16(1.24-3.75)*	2.23(1.28-3.89)*	2.26(1.3-3.94)*	2.09(1.2-3.65)*	1.96(1.08-3.55)*	2.18(1.18-4.05)*	2.93(1.61-5.33)*
Females (ref)	-	-	-	-	-	-	-	-	-	-
Diabetes										
Non diabetics	0.39(0.19-0.80)*	0.25(0.12-0.5)*	0.26(0.13-0.52)*	0.27(0.13-0.57)*	0.2(0.09-0.44)*	0.2(0.09-0.44)*	0.19(0.09-0.42)*	0.15(0.07-0.32)*	0.51(0.25-1.05)	0.43(0.21-0.86)*
Diabetic (ref)	-	-	-	-	-	-	-	-	-	-
Smoking										
Non smoker	0.71	0.6	0.71	1.05	0.87	0.98	0.89	0.71	0.73	1.07
	(0.36-1.43)	(0.30-1.21)	(0.36-1.39)	(0.54-2.01)	(0.45-1.68)	(0.51-1.9)	(0.46-1.71)	(0.36-1.40)	(0.37-1.43)	(0.55-2.1)
Smokers (ref)	-	-	-	-	-	-	-	-	-	-

4. DISCUSSION

Periodontal disease is considered a part of the global burden of chronic diseases, especially among adults over their forties [16]. PD is considered the main contributing factor leading to tooth loss, due to the destruction of the attachment of periodontal ligaments and alveolar bone loss [17].

Restoring the lost teeth by either removable or fixed partial dentures will express more stress and occlusal load on the

remaining natural teeth. In the current study, we evaluated the amount of RBL in mandibular teeth that are considered abutment teeth in future prosthetic rehabilitation in PD patients with and without DM. The results showed that bone loss was lower in premolars followed by canines and incisors. Being diabetic increased the amount of bone loss compared to non-diabetics in all examined teeth.

Bidirectional relation between periodontal disease and diabetes has been observed [18]. Periodontitis is a chronic inflammatory disease characterised by the destruction of the teeth supporting tissues that has several negative impacts on quality of life. Epidemiological results validated that diabetes is a major risk factor for periodontitis, and susceptibility to periodontitis is increased by approximately threefold in people with diabetes [19, 20].

Metabolic Syndrome (MetS) includes a set of risk factors for cardiovascular disease and type 2 diabetes mellitus [21]. Previous studies have shown that MetS (such as obesity, impaired glucose tolerance, and hyperinsulinemia) increases with age, leading to an increased risk of periodontitis [22]. Diabetes increases inflammation in the periodontal tissues as well as the presence of periodontal pathogens that have a major role in the establishment of pathological processes affecting periodontal tissue [18, 23, 24].

A two-fold higher odds for an increased number of missing teeth for type 1 DM subjects was revealed compared to non-diabetic subjects after adjustment for confounders. Kaur *et al*. [25] observed in their population-based study that after adjustment for confounders, diabetic patients have double the risk for tooth loss than non-diabetic patients. The relationship between type 2 DM and tooth loss is also complicated by the fact that disease onset generally occurs in middle and late age, coinciding with the time point when the periodontal disease becomes more prevalent.

Previous studies [25 - 27] have reported significant tooth loss in subjects with DM compared to non-diabetic subjects, especially in younger age groups. In contrast, Oliver and Tervonen [28] reported that tooth loss was similar in Minnesota diabetic subjects and the United States employed adults. In this study, the effect of gender on bone loss demonstrated that male patient has an increased likelihood of having bone loss in all the tested teeth.

The aetiopathogenesis of periodontal disease is complex. Several factors are probably responsible for the increased risk of periodontal disease in diabetic subjects. Systemic inflammation and hyperglycaemia are believed to play an important role in the pathogenesis of periodontal disease in diabetic subjects [29]. This agrees with previous studies that showed increased attachment loss and periodontal destruction among males rather than females [30, 31]. However, other studies did not observe this association [32, 33].

The results showed that almost 44% of the examined samples were suffering from gingivitis, while periodontitis severity showed almost similar to 30% in the periodontitis patients.

Furthermore, its prevalence varies across different regions, developed and developing countries. Globally, about 20–50% of the population has periodontal diseases [34]. In Saudi Arabia, the prevalence of gingivitis is demonstrated to be 58.4%, whereas PD is present in 23.4% of the patients [35]. Furthermore, according to AlQahtani *et al*. [36], localized and generalized chronic periodontitis ranges from 4.2% to 12% and 3.1% to 14.7%, respectively. Chen *et al*. [37] observed that periodontitis correlated with increased levels of glycated haemoglobin (HbA1c) and CRP in diabetic patients.

In patients with periodontitis, the risk of teeth loss is high, especially in molars [11]. Hirschfeld *et al*. [38] showed after 22 years of follow-up that molars were at a 6-time higher risk compared to single-rooted teeth, while Helal *et al*. [7] observed a 4-time higher risk. In a study on a population aged between 55-64 years old, molars were lost in 82% compared to 49% teeth lost in anterior teeth [11]. In a longitudinal study that spanned 17 years, the teeth that had a higher incidence of bone loss were upper molars and lower incisors [39].

The results showed that non-smokers were less likely to have bone loss in any of the teeth. One study reported an association between smoking and tooth loss and more extensive CAL. On the other hand, smoking cessation will improve oral condition. It was observed that after smoking cessation for short time, the periodontal condition improved [40]. The long-term comparison revealed that PPD and CAL between non-smokers and former smokers were similar but significantly lower than in active smokers [40].

A limitation of the study was that missing teeth were counted as not having bone loss which might have introduced misclassification bias. The misclassification is non-differential among cases and controls which could cause a shift in the results towards the null. However, since the results strongly suggest a significant relationship between diabetic status and bone loss, this bias does not seem to affect the results greatly. Also, we did not differentiate between teeth with vertical and horizontal bone loss due to the small number of cases in each category. Future studies should investigate if the pattern of bone loss could have an influence on the relationship between bone loss in diabetic and non-diabetic patients in a larger sample size.

CONCLUSION

Based on the prevalence of bone loss in diabetic patients, mandibular premolars might be the most suitable teeth used as abutments for overdentures. However, bone loss severity needs to be initially assessed to further confirm their suitability.

Large, multi-center clinical studies are needed to further validate these findings as well as include the maxillary teeth in the assessment.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Review Board of IAU, Saudi Arabia (IRB-2021-02-034).

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human

experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

All participants received written and verbal information regarding the nature of the study and written consent was obtained from all subjects, prior to examination.

STANDARDS OF REPORTING

STROBE guidelines and methodologies were followed.

AVAILABILITY OF DATA AND MATERIALS

All data supporting the findings of this study will be available from the corresponding author [M.M] upon request.

FUNDING

This study was supported by the deputyship of research and innovation, Ministry of Education, Kingdom of Saudi Arabi, by funding through the project number IF-2020-006-Dent, at the Imam Abdulrahman Bin Faisal University, College of Dentistry.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

The authors would like to extend their appreciation to the deputyship of research and innovation, Ministry of Education, Kingdom of Saudi Arabia.

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