# Architecture and Amount of Alveolar Bone Loss in Patients with Chronic Periodontitis Modified by Diabetes Mellitus Type 2: a Retrospective Study

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**Abstract**

The objective is to evaluate the amount and types of alveolar bone loss in patients with chronic periodontitis and diabetes mellitus type 2. This retrospective study was done by examining 43542 patient folders attended the Faculty according to the faculty's ethics approval from year 2006 to 2016. Inter-examiner, intra-examiner calibration session performed.

Fifty diabetes mellitus type 2 and 50 with chronic periodontitis were randomly selected. Radiographic linear measurement procedure software was used on their panoramic radiographs (OPGs) to evaluate the amount and types of the alveolar bone loss in mesial and distal for all posterior teeth were measured from the most apical point to the cemento-enamel junction (CEJ) in the form of millimetres and percentile of the root length. Horizontal and vertical bone loss of a total 2628 sites was measured for both groups. Data was statistically analysed using SPSS V23 with significant at $p<0.05$ using ANCOVA, One-way ANOVA and Independent t-tests.

There was no significant difference in total alveolar bone loss in experimental group and control group ($p=0.343$). It was more in the experimental (40.59 ± 35.09,46.09) compared to control group (36.78 ± 31.28,42.28). There was significant difference ($p<0.001$) in horizontal bone loss in experimental compared to control group (4.84 ± 4.48,5.203; 3.79 ± 3.43,4.15). There was no significant bone loss in relation to the duration of diabetes mellitus.

Higher amount of bone loss found in patients with diabetes mellitus which reflect the local destruction of the alveolar bone caused by the disease.

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## Introduction

Periodontal disease is induced by bacterial plaque that stimulates a host response in the adjacent gingiva that leads to the destruction of connective tissue and bone.[1,2] The progression of periodontal disease may be affected by systemic conditions, such as diabetes mellitus.[3] Diabetes Mellitus is a systemic disease commonly associated with periodontal diseases and numerous studies have shown a link among diabetes and the increased risk for gingivitis, periodontitis, and loss of tooth attachment. The prevalence of periodontitis is higher, and its symptoms are more severe in individuals with diabetes, compared with non-diabetics.[4]

Diabetes mellitus is classified according to its aetiology as Type 1 Diabetes Mellitus (T1DM), Type 2 Diabetes Mellitus (T2DM), gestational diabetes (GDM) and other specific types. T1DM results from destruction of beta-cells within the Islets of Langerhans of the pancreas, which results in a complete insulin deficiency; it can be immune-mediated or have an idiopathic aetiology. T2DM ranges from an insulin resistance which progresses into an insulin deficiency due to a secondary failure in the pancreatic beta-cells. GDM is defined as any degree of glucose intolerance with onset or first recognition during pregnancy. Lastly, the category "other specific types" comprehends a group of several types of diabetes mellitus with different aetiologies.[5]

Periodontitis is the consequence of local infections in the oral cavity resulting in irreversible destruction of the tooth attachment

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apparatus (i.e., alveolar bone, root cementum, and the periodontal ligament).[6] One clinical manifestation of periodontitis is the appearance of periodontal pockets, enabling further microbial colonization and challenge. Other manifestations include redness and gingival swelling, pain, and tooth hypermobility. Periodontitis is considered as one of the major reasons for adult tooth loss. Based on the 1999 American Association of Periodontology (AAP) classification, periodontitis can be further divided into six categories: (1) aggressive periodontitis; (2) chronic periodontitis; (3) periodontitis as a manifestation of systemic diseases; (4) necrotizing periodontal diseases; (5) periodontitis associated with endodontic lesions; and (6) periodontitis from the developmental or acquired deformities and conditions [7]. Chronic periodontitis is the most common form of periodontitis, which is most commonly detected in adults, but its onset may be demonstrated at any age [8]. Relation of periodontitis with diabetes was identified in the early 1990s, which it was sometimes referred to as the 'sixth complication of diabetes' and in 2003 the American Dental Association (ADA) acknowledged that periodontal disease is often found in people with diabetes [9].

Diabetes is characterized by an increased susceptibility to infection, poor wound healing, and increased morbidity and mortality associated with disease progression. It also of of the important risk factor for more severe and progressive periodontitis, infection or lesions resulting in the destruction of tissues and supporting bone that form the attachment around the tooth [10]. Diabetes may influence the pathogenesis of periodontitis similar to other macro- and micro-vascular complications of diabetes [11]. Patients with diabetes show evidence of increase pro-inflammatory cytokines within gingival crevicular fluid and gingival tissues compared to periodontitis without diabetes [12].
Radiography is a powerful auxiliary tool for the diagnosis of periodontal diseases [13,14]. Careful comparative analysis of clinical and radiographic parameters permits a more accurate diagnosis. Radiographs are used to assess severity and pattern of bone loss, root length, anatomy and position, and detect pathologic lesions and the consequences of excessive occlusal load [15,16].

Signs such as enlargement of the periodontal ligament space, absence of the lamina dura, bone defects (vertical or horizontal) and a diffuse image in the furcation area, associated with clinical signs, are suggestive of the presence of periodontal disease.
The findings from periodontal diagnostic procedures can be extremely useful in evaluating treatment outcomes. The appropriate assessment of the periodontal patient is a cornerstone in the successful treatment of an individual [17]. Overall, it can be stated that, diabetes affects all periodontal parameters, including gingival bleeding, probing depth, and attachment loss by various mechanisms. There are several mechanisms through diabetes can act as modifying the nature of periodontal disease; includes changes in subgingival environment, altered tissue homeostasis and wound healing, and changes in host immuno-inflammatory response. The recording of systematically collected data could provide better understanding about the 2 ways relationship between chronic periodontitis and diabetes mellitus [18].

## Materials and methods

Ethics approval from the UITM research ethics committee was obtained (600-IRMI (5/1/16) REC/183/17, 26 May 2017) to conduct this retrospective study. Patients' records involving 43,542 folder cases of patients attended Faculty of Dentistry, Universiti Teknologi Mara (UiTM), Selangor from period of year 2006 to year 2016 that was conducted from January 2017 until March 2018. The minimum required sample size, to have 80% statistical power and a significant level of 5%, for estimating a significant unadjusted association between the variables of interest in this study was 50 for each sample group. Of 43,542 cases, 831 were diagnosed as chronic periodontitis. 50 samples for each group were chosen to meet the inclusion criteria.

Inclusion criteria for enrolment were patient is diagnosed with chronic periodontitis, control group, patients are healthy and is not diagnosed with any systemic illness, diabetic group, patient is diagnosed with diabetes mellitus type 2 without other complicating medical condition that might affect the periodontium.

Data on patient's periodontal status was obtained through a retrospective dental record review of fully documented dental records belonging to the selected students and dental

officers in the faculty. Patient's demographic information were retrieved from the folders including age, sex, education, medical status, etc.

The dental panoramic radiograph (OPG) of the patient was used as the basis in measuring the architecture of alveolar bone loss. Radiographic linear measurement procedure software was used to evaluate the amount and types of the alveolar bone loss in mesial and distal for all posterior teeth that were measured from the most apical point to the cemento-enamel junction (CEJ) in the form of millimetres and percentile of the root length. Horizontal and vertical bone loss of a total 2628 sites was measured for both groups. The inclusion criteria of the OPG will be 1- high quality with adequate brightness and contrast and 2- the anatomical landmarks used to measure the bone loss patterns which are the cement-enamel junction (CEJ), alveolar crest (AC) and bony defects (BD) must be clearly shown in the radiograph.

For each radiograph, the measurements were taken from two sides: mesial and distal, of each posterior tooth. Posterior teeth consist of first premolar, second premolar, first molar and second molar. Four teeth from each quadrant, making up a total of 16. 16 teeth have both mesial and distal site, therefore 32 sites were measured for the bone loss in each sample. Optimally, 3200 sites should be counted as the total number of sites to be measured, however, in periodontal cases, some samples used might have lost a number of teeth that has reduced the measurements for the collection of data that were to be evaluated. Alveolar bone loss (ABL) for premolars, first and second molars will be measured from its most apical point to the CEJ as a percent of the root length and the total ABL percentage for each jaw was average, then ABL percentage for full mouth was the average ABL percentage of both jaws. This data will contribute to the average of total bone loss for each of the controlled or experimental group. As final data collection, 2628 sites were used as final diagnostic measurement.

Data was entered and analysed using SPSS program version 23.0 (Statistical Package for Social Sciences). Univariate analyses were performed using *ANCOVA, One-way ANOVA* and *Independent t-test*. Data was computed to assess, the comparison of bone loss between healthy individuals with diabetic individuals.

## Results

Training of inter and intra examiner calibration session was conducted. Kappa test was used to test the performance of the examiner. 5 OPGs were used for the calibration. This is to eliminate any bias or inconsistency of measuring procedures that would affect the discrepancies of the results.

| Group | n | Mean | Mean difference (95% CI) | p-value |
|---|---|---|---|---|
| **Experimental** | 50 | [a]40.42 (16.48) | -3.63 (-11.22, 3.96) | 0.345[b] |
| **Control** | 50 | [a]36.86 (21.44) | | |
| **Experimental** | 50 | 40.59 (35.09, 46.09) | 3.81 (-4.12, 11.74)[c] | 0.343[d] |
| **Control** | 50 | 36.78 (31.28, 42.28) | | |

[a] Mean (standard deviation)
[b] Independent t-test applied
[c] Adjusted mean difference (95% confidence interval) with Bonferroni adjustment
[d] ANCOVA applied (adjusted for age)

**Table 1.** Comparison of total bone loss in experimental and control group.

Demographic characteristics of the selected samples are shown in Table 1. Table 2 shows the values of total alveolar bone loss. Of 831 cases, 50 samples were taken in for each study group; experimental and diabetic groups. In experimental group, the mean is (40.42 $\pm$ 16.48)% whereas in controlled group, the mean is (36.86 $\pm$ 21.44)%. When applying independent t-test, the mean difference is insignificant with value of $p \geq 0.05$. Data were then analysed with ANCOVA, controlling the age group. The mean value for the experimental group is (40.59 $\pm$ 35.09,46.09), whereas for control group is (36.78 $\pm$ 31.28, 42.28). The analysis interprets that the health status does not affect the higher level of total bone destruction.

When comparing, individuals that are diagnosed with diabetes or individuals that claimed to be fit and healthy do not show any higher degree of bone loss caused by chronic periodontal condition. Both groups portray the same pattern and extension of total bone loss.

| Group | n | Mean | Mean difference (95% CI) | p-value |
|---|---|---|---|---|
| Experimental | 50 | [a]4.82 (1.46) | -1.03 (-1.52, -0.53) | 0.000[b] |
| Control | 50 | [a]3.80 (1.00) | | |
| Experimental | 50 | 4.84 (4.48, 5.20) | 1.05 (0.53, 1.56)[c] | 0.000[d] |
| Control | 50 | 3.79 (3.43, 4.15) | | |

[a] Mean (standard deviation)
[b] Independent t-test applied
[c] Adjusted mean difference (95% confidence interval) with Bonferroni adjustment
[d] ANCOVA applied (adjusted for age)
Overall assumptions were fulfilled.

**Table 2.** Comparison of horizontal bone loss in experimental and control group.

| Duration | n | Mean | p-value |
|---|---|---|---|
| **0 – 4 years** | 21 | [a]39.27 (13.29) | 0.387[b] |
| **5 – 9 years** | 7 | [a]34.29 (15.23) | |
| **10 years and above** | 11 | [a]47.41 (22.63) | |

[a] Mean (standard deviation)
[b] One-way ANOVA applied

**Table 3.** Duration of having Diabetes Mellitus in Experimental group.

Table 3 shows the results of horizontal pattern of bone loss. Independent t-test was used to calculate the mean of the pattern in both of experimental and controlled groups. The experimental shows mean of (4.82 $\pm$ 1.46) mm whereas in controlled group has mean of (3.80 $\pm$ 1.00) mm. The comparison of both groups is significant. Using ANCOVA analysis, the age of samples was controlled. The result is significant with value of $p < 0.05$. Statistics evaluated that in terms of horizontal pattern of bone loss, chronic periodontitis causes higher degree and amount of the destruction in individuals that are diagnosed with diabetes mellitus compared to that of in individuals that are fit and healthy. This shows that both groups would have the same pattern, however, in horizontal loss, the result is more significant in diabetic group.

Table 4 shows the results of vertical pattern of bone loss. Independent t-test was used to calculate the mean of the pattern in both of experimental and controlled groups. No significant difference was found on the mean between experimental and control group (1.52 ± 2.43; 1.91 ±2.64) mm. Same results was achieved when ANCOVA was used where the age of the samples was controlled. Result is not significant with p=>0.05. Statistics evaluated that in terms of vertical pattern of bone loss, the amount of the destruction in individuals that are diagnosed with diabetes mellitus compared to that of in individuals that are fit and healthy are same.

| Group | n | Mean | Mean difference (95% CI) | p-value |
|---|---|---|---|---|
| **Diabetes Mellitus** | 50 | [a]1.52(2.43) | 0.40 (-0.61, 1.40) | 0.436[b] |
| **Fit & Healthy** | 50 | [a]1.91 (2.64) | | |
| **Diabetes Mellitus** | 50 | 1.52 (0.79, 2.64) | 0.39 (-0.66, 1.43)[c] | 0.468[d] |
| **Fit & Healthy** | 50 | 1.91 (1.18, 2.25) | | |

[a] Mean (standard deviation)
[b] Independent t-test applied
[c] Adjusted mean difference (95% confidence interval) with Bonferroni adjustment
[d] ANCOVA applied (adjusted for age)

**Table 4.** Comparison of vertical bone loss between diabetic patients and fit & healthy patients.

Table 5 shows the comparison of bone loss within diabetic group. Out of 50 samples in the experimental group, there were 39 data that provided the information for the data to be evaluated. The group was subclassified to three durations; 0-4 years, 5 to 9 years, 10 years and above. The mean values for each group respectively were (39.27$\pm$13.29), (34.29$\pm$15.23) and (47.41$\pm$22.63). One-way ANOVA was applied, and the *p*-value is insignificant with $p \geq 0.05$. The analysis interprets that the duration of diabetes mellitus does not have any difference in the pattern and amount of bone loss.

| Duration | n | Mean | p-value |
|---|---|---|---|
| **0 – 4 years** | 21 | [a]39.27 (13.29) | 0.387[b] |
| **5 – 9 years** | 7 | [a]34.29 (15.23) | |
| **10 years and above** | 11 | [a]47.41 (22.63) | |

[a] Mean (standard deviation)
[b] One-way ANOVA applied

**Table 1.** Duration of total bone loss on different diabetic duration.

## Discussion

Relationship of diabetes and periodontal disease is somehow unclear. However, in our retrospective study we were able to compare between the experimental and control group by using a radiographic linear measurement procedure (Planmeca Romexis version 2.9.2 software) on the selected panoramic radiographs (OPGs). This enable us to evaluate and measure the amount and types of the alveolar bone loss in posterior teeth in the form of millimetres and percentile of the root length. This study was undertaken to assess the amount of bone loss experience in chronic periodontitis patient with T2DM patients as compared with non-diabetic patients.

ANCOVA test was used for the first comparison. The mean score was higher in experimental as compared to control group. Even though the result is not statistically significant (p=0.343), it shows that there is still slightly increased in the amount of total bone loss in diabetic patients. Same test was conducted for the second comparison and it shows that there is statistically significant (p=0.000) between the amount of horizontal bone loss in experimental compared to control group. Our findings were in accordance with several earlier studies.

Liu et al., carried out experimental study on type-2 Zucker diabetic fatty (ZDF) rat, to investigate whether diabetes primarily affects periodontitis by enhancing bone loss or by limiting osseous repair. Result of their study showed that the diabetic rats continued to lose bone and had significantly impaired capacity to repair lost bone. The type 2 diabetic group had significantly higher osteoclast numbers and activity and the amount of new bone formation following resorption was 2.4- to 2.9- fold higher in normo-glycemic compared to diabetic rats [2.] Rajhans et al., reported that the prevalence of periodontal disease in diabetic patients was 86.8% (gingivitis 27.3% and periodontitis 59.5%) and complete edentulousness was 10.7% [19]. The higher in percentage showed that diabetes is one of the risk factors of periodontal disease. Emrich et al. also reported that the diabetic status was significantly and strongly related to both prevalence and severity of periodontal disease [20].

Demmer et al., concluded that both uncontrolled T2DM and T1DM were statistically significantly associated with progression of attachment loss relative to diabetes-free participants [21]. Their study shows that the diabetic status of the patient, controlled or uncontrolled will also affect the severity of periodontal disease. These results could explain that diabetes has effects on osteoclast and osteoblasts activities in the periodontium in different ways, such as by increasing the expression of inflammatory mediators. The process of bone remodelling starts with the resorption of bone by osteoclasts, followed by new bone formation by osteoblasts in the resorption lacunae. Under physiological conditions, these two activities are coupled; however, the two processes are uncoupled in pathological process [22].

In relation to duration of diabetes, the one-way ANOVA test revealed a higher mean score in duration (10 years and above) compared to 2 other groups. Even though the result is not statistically significant, it still shows that when the duration of diabetes increases, the severity of periodontal disease also increases which explain the way effects of both diseases. This result was in accordance with the study performed by Hove [23]. Apoorva et al., revealed the same result as our study. They concluded that the mean of community periodontal index (CPI) score and severity of periodontal disease increased with duration of diabetes increases (> 10 years) [24]. Rajhans et al. also reported the same result, they demonstrated that the duration of diabetes mellitus was statistically correlated (P<0.01) with the prevalence and severity of periodontal disease [25].

Previous study done by Cerda et al. and Firatli et al. also had concluded that the duration of diabetes was a significant factor for the severity of periodontal disease.

Our study is more focussed on the pattern and variant of alveolar bone loss in T2DM patients. However, we were unable to compare the vertical bone loss in both groups as most of the selected radiograph shows less to none sign of vertical bone loss. Horizontal bone loss was more prominent, and it was used as the main tool in comparing in both groups.

Another factor that would take in place is that from the data obtained, most of the diabetic patients are under medication of anti-hyperglycaemic agent. Though the diabetic patients are in hyperglycaemic stage, the use of anti-hyperglycaemic would alter the severity of bone loss. Tervonen and Karjalainen followed diabetic patients and nondiabetic controls for 3 years. They found that the level of periodontal health in diabetic patients with good or moderate control of their condition was similar to that in the nondiabetic controls. Those with poor control had more attachment loss and were more likely to exhibit recurrent disease [26]. This phenomenon has been pointed out by other researchers [27]. Previous studies suggest that the association between diabetes and periodontitis and our data are limited by a lack of information on glycaemic control [28].

## Conclusions

Higher amount of bone loss found in patients with diabetes mellitus which reflect the local destruction of the alveolar bone caused by the disease.

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## Declaration of Interest

The authors report no conflict of interest.

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