Effect of Glycemic Control on Self-Perceived Oral Health, Periodontal Parameters, and Alveolar Bone Loss Among Patients With Prediabetes

Fawad Javed,* Ali Saad Thafeed AlGhamdi, † Toshinari Mikami, ‡ Abid Mehmood, § Hameeda Bashir Ahmed, i Lakshman P. Samaranayake, ¶ and Howard C. Tenenbaum #

Background: The effect of glycemic control on severity of periodontal inflammatory parameters in patients with prediabetes is unknown. The aim of the present study is to assess the effects of glycemic control on self-perceived oral health, periodontal parameters, and marginal bone loss (MBL) in patients with prediabetes.

Methods: A total of 303 individuals were included. Hemoglobin A1c (HbA1c) and fasting blood glucose levels (FBGLs) were recorded. Participants were divided into three groups: 1) group A: 75 patients with prediabetes (FBGLs = 100 to 125 mg/dL [HbA1c ≥5%]); 2) group B: 78 individuals previously considered prediabetic but having FBGLs <100 mg/dL (HbA1c <5%) resulting from dietary control; and 3) control group: 150 medically healthy individuals. Self-perceived oral health, socioeconomic status, and education status were determined using a questionnaire. Plaque index (PI), bleeding on probing (BOP), probing depth (PD), and clinical attachment loss (AL) were recorded. Premolar and molar MBLs were measured on panoramic radiographs.

Results: Periodontal parameters (PI, BOP, PD, and AL) (P <0.01) and MBL (P <0.01) were worse among individuals in group A than those in group B. Self-perceived gingival bleeding (P <0.001), pain on chewing (P <0.001), dry mouth (P <0.001), and oral burning sensations (P <0.05) were worse among patients in group A than those in group B. There was no difference in periodontal parameters, MBL, and self-perceived oral symptoms among patients with prediabetes in group B and healthy controls.

Conclusions: Self-perceived oral health, severity of periodontal parameters, and MBL are worse in patients with prediabetes than controls. Glycemic control significantly reduces the severity of these parameters as well as the state of prediabetes in affected individuals. J Periodontol 2014;85:234-241.

KEY WORDS
Alveolar bone loss; hyperglycemia; periodontal disease; prediabetic state.

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Periodontal disease has been suggested as the “sixth complication of diabetes.” Studies have reported that periodontal inflammatory parameters and marginal bone loss (MBL) are worse in patients with poorly controlled diabetes compared with healthy controls. In addition, recent studies have reported that patients with impaired glucose tolerance (prediabetes) demonstrated more severe periodontal inflammatory parameters than healthy individuals. Although the exact mechanism through which hyperglycemia (in patients with diabetes and prediabetes) promotes periodontal inflammation remains unclear, it has been proposed that an interaction between the advanced glycation end products (AGEs) (produced as a result of hyperglycemia) and their receptors (RAGEs) in the periodontal tissues impairs the chemotactic and phagocytic function of polymorphonuclear leukocytes and produces proinflammatory cytokines, thereby leading to periodontal inflammation and bone loss in these individuals. In addition, function of potential cells involved in immunoinflammatory responses is impaired under chronic hyperglycemia. Manoucher-Pour et al. reported that chronic hyperglycemia impairs the chemotactic and phagocytic function of neutrophils that may prevent breakdown of bacteria in periodontal pockets, thereby increasing periodontal breakdown.

Diabetes is an important risk factor for periodontal inflammation, and severity of periodontal inflammatory parameters varies depending on the maintenance of blood glucose levels. In a previous clinical study, the authors of the present study demonstrated that periodontal inflammatory parameters were worse in patients with poorly controlled type 2 diabetes (T2D) compared to well-controlled T2D and healthy controls. Likewise, in another study, self-perceived gingival bleeding was reported more often in children with poorly controlled type 1 diabetes (T1D) compared with those with well-controlled T1D or medically healthy controls. Moreover, periodontal measures made in patients without diabetes and well-controlled patients with diabetes have been reported to be quite similar to one another. Therefore, it is postulated that the production of hyperglycemia-related AGEs and induction of the secretion of proinflammatory cytokines in the periodontal tissues of patients with well-controlled diabetes are significantly lower than those in patients with poorly controlled diabetes. This may be a part of the biologic rationale for the significant differences in periodontal inflammation in patients with well-controlled diabetes compared to those in patients with poorly controlled diabetes. However, with respect to prediabetes, studies in the indexed literature that focused on the effects of glycemic control on the severity of periodontal inflammatory parameters in patients with prediabetes could not be found.

In the present study, the following is hypothesized: 1) good glycemic control in patients with prediabetes correlates to status of self-perceived oral health and severity of periodontal inflammation compared with patients with prediabetes with poor glycemic control; and 2) the periodontal status of patients with prediabetes maintaining their serum glucose levels within or at least closer to the normal range will have self-rated oral health statuses and periodontal conditions similar to those found in medically healthy individuals. Therefore, the aim of the present study is to investigate the effects of glycemic control on self-perceived oral health, periodontal parameters, and MBL in patients with prediabetes.

**MATERIALS AND METHODS**

**Recruitment of Study Participants**

A cross-sectional study involving patients with and without prediabetes was conducted from January 2011 to October 2011 in Karachi, Pakistan. In total, 303 individuals (196 males and 107 females, aged 39 to 46 years, mean age: 42.5 years) were included. Participants were divided into three groups: 1) group A: 75 patients with prediabetes per the American Diabetes Association (ADA) standards; 2) group B: 78 individuals previously considered prediabetic per ADA standards but having fasting blood glucose levels (FBGLs) <100 mg/dL (hemoglobin A1c [HbA1c] <5%) resulting from dietary control; and 3) control group: 150 self-reported medically healthy individuals. Individuals in groups A and B were recruited from the diabetes care unit of Jinnah Hospital, Karachi, Pakistan. Their hospital records were evaluated to determine the date of the most recent test for HbA1c. Self-reported healthy controls were recruited from a residential area situated in the vicinity of the hospital. Patients with and without prediabetes were invited to an oral health care center at approximately 8:00 am for measurement of FBGL and periodontal examination.

**Inclusion and Exclusion Criteria**

Only individuals with medically diagnosed prediabetes (FBGLs = 100 to 125 mg/dL [5.6 to 6.9 mmol/L] and HbA1c = 5.7% and 6.4%) were included. Exclusion criteria were as follows: 1) self-reported systemic conditions, including human immunodeficiency virus infection/acquired immunodeficiency syndrome, cardiovascular disorders, epilepsy, hepatic disorders, and renal disorders; 2) recent history of antibiotic or steroid therapy; 3) crowding of teeth or occlusal trauma; 4) edentulous individuals; 5) habitual tobacco smoking or chewing; and 6) habitual alcohol consumption.
Interview Questionnaire
Using a questionnaire, a trained interviewer (AM) masked to whether the study participants had prediabetes performed the clinical periodontal examination. The overall k value for intraexaminer reliability was 0.78. Full-mouth plaque index (PI), 15 bleeding on probing (BOP), 16 probing depth (PD), 17 and clinical attachment loss (AL) 18 were measured at six sites (mesio-buccal, mid-buccal, disto-buccal, disto-lingual/palatal, mid-lingual/palatal, and mesio-lingual/palatal) on all maxillary and mandibular teeth (excluding third molars). PD was measured to the nearest millimeter with a graded probe. 2,5 Fractured teeth with embedded root remnants were excluded.

Digital panoramic radiographs, taken using a digital panoramic tomography machine, 11 were viewed on a calibrated computer screen 14 using a software program 88 for analysis of MBL. MBL was defined as the vertical distance from 2 mm below the cemento-enamel junction (CEJ) to the most apical part of marginal bone. 2 One investigator (AM) gauged the MBL on bilateral maxillary and mandibular premolars and molars. Third molars and teeth surfaces on which the CEJ or the bone crest were not visible because of technical reasons (such as caries, dental restorations, malocclusion [overlapping teeth], or poor radiographic quality) were excluded.

Determination of FBGLs and Most Recent HbA1c Levels
Among individuals with and without prediabetes, FBGLs were measured using a digital glucometer. 11 For patients in groups A and B, hospital records were assessed to determine the most recent levels of HbA1c.

Statistical Analyses
Statistical analysis was performed using a software program. 14 One-way analysis of variance was used to assess the FBGL and periodontal inflammatory parameters (PI, BOP, PD, AL, and MBL) among individuals with and without prediabetes. For multiple comparisons, the Bonferroni post hoc test was used. Odds ratios for the risk of periodontal inflammation in individuals with and without prediabetes were also calculated with 95% confidence intervals. Statistical significance was set at P < 0.05.

Ethical Guidelines
The study was reviewed and approved by the research ethics committee of the Jinnah Postgraduate Medical Center, Karachi, Pakistan. An information sheet was provided to the participants that explained the objectives and methods of the present investigation and that the individuals could reserve the right to retire from the project at any stage without penalty. Volunteers signed a consent form.

RESULTS
Sociodemographic Characteristics
There was no significant difference in age among individuals with prediabetes (40.4 ± 1.7 years) and controls (39.1 ± 2.5 years) (Table 1). Education status (P < 0.05) and SES (P < 0.001) were significantly higher among healthy controls compared with patients having prediabetes. Most of the individuals in the study population were male. Among patients with prediabetes, SES (P < 0.01) and education status (P < 0.01) were significantly higher in patients in group B compared with those in group A (P < 0.01).

There was no significant difference in SES and education status among patients with prediabetes in group B and healthy controls (Table 1).

Self-Perceived Oral Symptoms
Self-perceived gingival bleeding (P < 0.001), pain on chewing (P < 0.001), dry mouth (P < 0.001), and burning sensation in the mouth (P < 0.001) were reported more often by patients with prediabetes, particularly in group A compared with those in group B (Table 2). Self-perceived gingival bleeding (P < 0.01), pain on chewing (P < 0.001), dry mouth (P < 0.001), and burning sensation in mouth (P < 0.01) were reported more often by patients with prediabetes in group A compared with healthy controls (Table 2). There was no statistically significant difference in the reporting of self-perceived oral symptoms among patients with prediabetes in group B when compared with healthy controls (Table 2).

** Hu-Friedy, Chicago, IL.
†† Kodak 8000C System, Carestream Dental, Atlanta, GA.
‡‡ SyncMaster digital television monitor, Samsung, Suwon City, Gyeonggi Do, Korea.
§§ Image Tool v.3.0, Department of Dental Diagnostic Science, University of Texas Health Science Center, San Antonio, TX.
¶¶ ACCU-CHEK Active, Roche Diagnostics, Mannheim, Germany.
¶¶¶ SPSS v.18, IBM, Chicago, IL.
Periodontal Parameters

PI (P < 0.001), BOP (P < 0.001), PD (P < 0.01), and AL (P < 0.001) were significantly higher in patients with prediabetes (group A + group B) compared with healthy controls. Compared with patients in group B, PI (P < 0.01), BOP (P < 0.001), PD (P < 0.01), and AL (P < 0.001) were significantly higher among patients with prediabetes in group A. Compared with healthy controls, PI (P < 0.001), BOP (P < 0.001), PD (P < 0.001), and AL (P < 0.001) were significantly higher among patients with prediabetes in group A. There were no statistically significant differences in the periodontal parameters among patients with prediabetes in group B and healthy individuals (Table 3).

MBL

MBL was significantly higher in patients with prediabetes (group A + group B) than in healthy controls (P < 0.01). Compared with patients in group B and controls, MBL was significantly higher among patients with prediabetes in group A (P < 0.01). There was no statistically significant difference in MBL among individuals in group B and healthy controls (Table 3).

FBGLs

In general, FBGL was significantly higher among patients with prediabetes (group A + group B) (111.3 ± 5.2 mg/dL) compared with controls (72.2 ± 2.3 mg/dL) (P < 0.01). The mean FBGLs (119.4 ± 3.6 mg/dL) were significantly higher among patients in group A compared with individuals in group B (74.1 ± 4.5 mg/dL) (P < 0.01) and controls (72.2 ± 2.3 mg/dL) (P < 0.01). There was no statistically significant difference in FBGL among patients with prediabetes in group B and controls (Table 1).

A dietary control regimen for the management of hyperglycemia was recommended by health care providers for all patients with prediabetes (Table 1). Overall, the mean duration of prediabetes (since

### Table 1.

**Demographics of the Study Cohort**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Patients With Prediabetes (n = 153) (mean ± SD)</th>
<th>Patients With Prediabetes in Group A (n = 75) (mean ± SD)</th>
<th>Patients With Prediabetes in Group B (n = 78) (mean ± SD)</th>
<th>Healthy Controls (n = 150) (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>130 males</td>
<td>67 males</td>
<td>63 males</td>
<td>89 males</td>
</tr>
<tr>
<td>Age (years)</td>
<td>40.4 ± 1.7</td>
<td>42.3 ± 2.2</td>
<td>40.1 ± 1.2</td>
<td>39.1 ± 2.5</td>
</tr>
<tr>
<td>Education status (%) (college-graduate)</td>
<td>39.7 ± 5.5*</td>
<td>27.5 ± 4.2†‡</td>
<td>79.6 ± 5.8†</td>
<td>84.5 ± 7.6‡†</td>
</tr>
<tr>
<td>SES (monthly income in USD)</td>
<td>345.2 ± 98.2§</td>
<td>284.5 ± 118.2¶†‡</td>
<td>632.4 ± 85.4¶</td>
<td>700.5 ± 79.6¶‡</td>
</tr>
<tr>
<td>Duration of prediabetes (months)</td>
<td>8.4 ± 1.9</td>
<td>10.2 ± 1.1</td>
<td>6.4 ± 0.8</td>
<td>—</td>
</tr>
<tr>
<td>FBGL (mg/dL)</td>
<td>111.3 ± 5.2#</td>
<td>119.4 ± 3.6**†‡</td>
<td>74.1 ± 4.5**</td>
<td>72.2 ± 2.3#†‡</td>
</tr>
</tbody>
</table>

**Type of treatment recommended by health care providers for prediabetes management**

<table>
<thead>
<tr>
<th></th>
<th>Patients With Prediabetes in Group A (n = 75) (mean ± SD)</th>
<th>Patients With Prediabetes in Group B (n = 78) (mean ± SD)</th>
<th>Healthy Controls (n = 150) (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allopathic (%)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Homeopathic (%)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Herbal (%)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Dietary control (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Others (%)</td>
<td>—</td>
<td>—</td>
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</tr>
</tbody>
</table>

In 2011, the average monthly income of Pakistani individuals residing in urban Sindh was USD 351.21.35

* P < 0.05.
† P < 0.01.
‡ P < 0.001.
§ P < 0.01.
¶ P < 0.001.
# P < 0.01.
** P < 0.05.
†† P < 0.01.
diagnosis) among the study participants was 8.4 years ± 1.9 months. There was no significant difference in the mean duration of prediabetes between individuals in either group A or group B (Table 1).

HbA1c
Hospital records showed that the mean HbA1c levels among patients in groups A and B were 6.1% (43 mmol/mol estimated average glucose) and 4.5% (26 mmol/mol estimated average glucose) (P <0.05), respectively. In these patients, the latest HbA1c measurements were performed 50.3 and 62.1 days before the present investigation.

**DISCUSSION**

Although to the best of the authors’ knowledge this is the first clinical study that has investigated the effects of glycemic control on periodontal inflammatory parameters and self-perceived oral symptoms in patients with prediabetes, previous studies\(^\text{19,20}\) have shown that prediabetes and impaired glucose tolerance worsens periodontal disease. The ADA lowered the cutoff point separating normal from elevated FBGL from <6.1 mmol\(^{-1}\) (110 mg/dL) to <5.6 mmol\(^{-1}\) (HbA1c <5%).\(^\text{14}\) The present findings are in accordance with the criteria proposed by the ADA\(^\text{14}\) because clinical (PI, BOP, PD, and AL) and radiographic (MBL) measures of periodontal inflammation and self-perceived oral symptoms were worse in patients with prediabetes in group A (patients with prediabetes with FBGL from 100 to 125 mg/dL) compared with patients previously considered prediabetic with FBGL <100 mg/dL or HbA1c <5%) and healthy controls. In this regard, it is proposed that HbA1c of 5% could be considered the threshold level for the upregulation of periodontal inflammation in patients with prediabetes.

It has been reported that RAGEs are found on the surface of smooth muscle cells, endothelial cells, neurons, monocytes, macrophages, and gingival

### Table 2.

**Effect of Glycemic Control on Self-Perceived Oral Symptoms in the Study Cohort**

<table>
<thead>
<tr>
<th>Self-Perceived Oral Symptoms</th>
<th>Yes</th>
<th>No</th>
<th>Odds Ratios (95% confidence interval)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding gums</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>61</td>
<td>14</td>
<td>18.3 (11.2 to 23.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>15</td>
<td>63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>61</td>
<td>14</td>
<td>13.8 (10.5 to 15.2)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>36</td>
<td>114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>15</td>
<td>63</td>
<td>0.7 (0.4 to 0.9)</td>
<td>NS</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>36</td>
<td>114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain on chewing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>67</td>
<td>8</td>
<td>17.7 (10.2 to 26.81)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>25</td>
<td>53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>67</td>
<td>8</td>
<td>18.9 (11.2 to 21.6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>46</td>
<td>104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>25</td>
<td>53</td>
<td>0.8 (0.1 to 0.9)</td>
<td>NS</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>46</td>
<td>104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry mouth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>71</td>
<td>4</td>
<td>59.2 (23.3 to 67.42)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>18</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>71</td>
<td>4</td>
<td>37.7 (20.5 to 48.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>48</td>
<td>102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>18</td>
<td>60</td>
<td>0.6 (0.3 to 0.7)</td>
<td>NS</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>48</td>
<td>102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burning sensation in mouth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>64</td>
<td>11</td>
<td>6.4 (3.1 to 8.8)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>20</td>
<td>58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group A</td>
<td>64</td>
<td>11</td>
<td>14.0 (11.5 to 20.7)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>44</td>
<td>106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with prediabetes in group B</td>
<td>20</td>
<td>58</td>
<td>0.8 (0.2 to 0.9)</td>
<td>NS</td>
</tr>
<tr>
<td>Healthy controls</td>
<td>44</td>
<td>106</td>
<td></td>
<td></td>
</tr>
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</table>

NS = non-significant (P >0.05).
In this regard, low SES and poor education among individuals with prediabetes in group A was associated with more severe parameters of disease as measured clinically and even by self-report. However, the underlying mechanisms of this effect are not known. An interesting finding was that no significant differences in periodontal inflammatory parameters and MBL were observed when comparing patients with prediabetes in group B with healthy controls. Therefore, it is hypothesized that the intensity of oxidative stress in periodontal tissues of individuals with prediabetes with normal FBGL (<100 mg/dL) is not high enough to aggravate periodontal inflammation and MBL compared with individuals with prediabetes with raised FBGL (100 to 125 mg/dL). In addition, it is also notable that there was no significant difference in the SES and education levels among patients with prediabetes in group B compared with healthy controls.

Overall, the findings reported in this investigation are in agreement with data reported by others. In general, it is already known that parameters of periodontal inflammatory diseases are worse among patients with poorly controlled diabetes compared with those with well-controlled diabetes and healthy individuals. Along these lines, the present authors have shown that parameters of periodontal disease (clinical, radiographic, and self-reported, etc.) are worse in patients with prediabetes who do not control their level of glucose and patients with prediabetes who do control their glucose level well. Although the present findings may seem to be expected, to date...

Table 3.
Periodontal Disease in Patients With Poorly Controlled and Well-Controlled Prediabetes and Healthy Controls

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Patients With Prediabetes (n = 153) (mean ± SD)</th>
<th>Patients With Prediabetes in Group A (n = 75) (mean ± SD)</th>
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<th>Healthy Controls (n = 150) (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI (%)</td>
<td>40.8 ± 20.4*</td>
<td>44.5 ± 13.7††</td>
<td>21.2 ± 4.5†</td>
<td>16.4 ± 8.1*††</td>
</tr>
<tr>
<td>BOP (%)</td>
<td>46.7 ± 22.6§</td>
<td>52.8 ± 11.9‖‖</td>
<td>12.6 ± 5.1‖</td>
<td>9.6 ± 3.1§‖‖</td>
</tr>
<tr>
<td>PD (4 to 6 mm) (%)</td>
<td>11.3 ± 7.2§</td>
<td>14.5 ± 4.6†**</td>
<td>1.7 ± 3.4†</td>
<td>1.1 ± 2.2§**</td>
</tr>
<tr>
<td>AL (up to 4 mm) (%)</td>
<td>10.7 ± 4.5††</td>
<td>12.6 ± 3.4‖‖</td>
<td>1.2 ± 2.2‖</td>
<td>1.0 ± 0.8††††</td>
</tr>
<tr>
<td>MBL (mm)</td>
<td>3.5 ± 1.5§§</td>
<td>4.6 ± 1.7‖‖‖</td>
<td>1.8 ± 0.7†</td>
<td>0.9 ± 0.4§§§§</td>
</tr>
</tbody>
</table>

* P <0.001. † P <0.01, significant between groups A and B. †† P <0.001. § P <0.001, significant between groups A and B. ¶ P <0.001. # P <0.01. ** P <0.001. †‡ P <0.001. §§ P 0.01. ‖‖ P <0.001. §§§ P <0.01. ″‖‖ P <0.001.
and to the best of the authors’ knowledge, there is no scientific indexed information to prove this notion. Therefore, the findings reported here not only describe important differences among the population with prediabetes but also parallel and further confirm findings related to the relationships between diabetes and periodontitis in general. The findings of the present study further imply that it is important to subdivide the population of patients with prediabetes into two distinct subgroups when their disease loads are being investigated: 1) patients with “poorly controlled” prediabetes (FBGL = 100 to 125 mg/dL); and 2) patients with “well-controlled” prediabetes (FBGL <100 mg/dL). However, additional studies on the severity of periodontal disease in patients with prediabetes (with emphasis on glycemic control) are warranted to validate this proposition.

The HbA1c test is a reliable and non-fluctuant indirect test for serum glucose management that reflects or correlates with the average blood glucose levels during the past 3 months.14 Hospital records of the patients with prediabetes included in the present investigation revealed that the most recent HbA1c levels were measured within the last 3 months of the present investigation; for this reason, HbA1c levels in patients with prediabetes were not retested. However, a limitation of the present investigation is that the body mass index (BMI) of the study population was not investigated. It is well-known that an elevated BMI is a significant risk factor of periodontal disease.32-34 Another limitation is that self-reported healthy individuals included in the present investigation are categorized as “non-hyperglycemic” merely on the basis of FGBL. FBGL may fluctuate hourly, meaning that some patients with prediabetes could have been missed. Nevertheless, as noted above, clear differences were still evident between the patients with prediabetes and healthy controls, as well as the two subgroups of the population with prediabetes.

Although most physicians usually depend on blood chemistry values for the diagnosis and management of hyperglycemia, it is highly recommended that patients with prediabetes (particularly those with FBGL >100 mg/dL and with complaints of the onset of gingival bleeding) should also be referred to oral health care providers because these patients are more susceptible to periodontal breakdown compared with patients with prediabetes maintaining FBGL <100 mg/dL. Therefore, the present study provides evidence on the importance of glycemic control, oral hygiene maintenance, and regular medical and dental check-ups, which may eventually benefit the oral and overall health in patients with prediabetes.

CONCLUSIONS
Within the limits of the present investigation, it is concluded that self-perceived oral health status, severity of periodontal parameters, and MBL are worse in patients with prediabetes than controls. Glycemic control significantly reduces the severity of these parameters and the state of prediabetes in affected individuals.

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