Comparison of Self-Perceived Oral Health, Periodontal Inflammatory Conditions and Socioeconomic Status in Individuals With and Without Prediabetes

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Abstract: Introduction: The aim was to compare the self-perceived oral health, periodontal inflammatory conditions and socioeconomic status (SES) in patients with and without prediabetes. Methods: Thirty-nine individuals [19 patients with prediabetes (test group) and 20 control individuals (control group), at least 20 years old were included. Plaque index, bleeding on probing, probing depth (4 to <6 mm and ≥6 mm) and number of missing teeth were recorded. Fasting blood glucose levels were recorded, and marginal bone loss was measured on radiographs. SES, education status, self-perceived oral health, family history of diabetes and tobacco habits were also investigated. Results: Mean ages of individuals in the test and control groups were 40.6 and 42.3 years, respectively. Plaque index, bleeding on probing, probing depth (4 to <6 mm and ≥6 mm) and number of missing teeth were higher in the test group as compared with the control group (P < 0.05). Premolar and molar marginal bone loss was higher in the test group as compared with the control group (P < 0.001). Self-perceived bleeding gums was more often reported by individuals in the test group as compared with the control group. A poor SES and education status was higher among individuals in the test group as compared with the control group (P < 0.001). Conclusions: Self-perceived gingival bleeding and clinical periodontal inflammation were severe in patients with prediabetes as compared with controls. An underprivileged SES aggravated periodontal conditions in patients with prediabetes.

Key Indexing Terms: Bleeding on probing; Marginal bone loss; Periodontal inflammation; Prediabetes; Self-perceived. [Am J Med Sci 2012;344(2):100–104.]

A relationship between periodontal inflammation and systemic conditions has been reported.1–5 Several studies1–5 have reported that periodontal inflammatory conditions are worse in individuals with poorly controlled diabetes mellitus (or diabetes) as compared with individuals with well-controlled diabetes and medically healthy controls. Simultaneously, it has also been reported that presence of chronic periodontitis may also be indicative of diabetes and prediabetes in undiagnosed individuals.6

In the year 2004, there were approximately 171 million individuals with diabetes worldwide; however, this number is expected to increase to approximately 370 million by the year 2030.7 This suggests that the number of individuals with impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT) are increasing globally. Prediabetes has been defined as a state of abnormal glucose homeostasis characterized by the presence of IFG, IGT or both. The prediabetes designations of IFG and IGT are defined by a fasting glucose level of 100 to 125 mg/dL and a postglucose challenge of 140 to 199 mg/dL, respectively.8 According to the latest statistics from the American Diabetes Association—National Diabetes Fact Sheet 2011,9 there are approximately 80 million individuals with prediabetes in the United States. Benjamin et al10 reported that several individuals with prediabetes develop type 2 diabetes within a decade. The sustained hyperglycemia in individuals with prediabetes may trigger periodontal disease by increased production of proinflammatory cytokines, reactive oxygen species and advanced glycation end products (AGEs) in the periodontal tissues.11–16, however, these parameters are now considered to be associated with several other systemic conditions including cardiovascular disorders, obesity and hypertension and not solely diabetes.17,18

It is known that an underprivileged socioeconomic status (SES) and illiteracy are significant risk factors for diabetes.1 It may therefore be hypothesized that these risk factors (underprivileged SES and poor education status) may also contribute in aggravating periodontal inflammatory conditions in patients with prediabetes. To our knowledge from indexed literature, the roles of these parameters are yet to be investigated in patients with prediabetes. Though a limited number of clinical studies19–21 have investigated periodontal inflammatory conditions in patient with and without prediabetes; however, self-perceived oral health status in individuals with and without prediabetes remains undetermined. The aim of the present study was to compare the self-perceived oral health, periodontal inflammatory conditions and SES in patients with and without prediabetes.

MATERIALS AND METHODS

Ethical Guidelines

The study was approved by the research ethics review board of the College of Dentistry, King Saud University, Riyadh, Saudi Arabia. An information sheet was provided to the participants that explained the aims, objectives and methods of the present investigation. Individuals willing to participate in the present study were presented a consent form. It was mandatory for the study participants to carefully read and sign the consent form before being included in this study.

Recruitment of Study Participants

Patients with prediabetes (test group) were recruited from the diabetes care unit of a hospital in Karachi, Pakistan, whereas the self-reported healthy subjects (control group) were randomly recruited from a residential area located in the vicinity of the hospital. In both groups, the subjects were requested
to present their medical records to verify the presence or absence of prediabetes in these individuals.

Thirty-nine individuals (19 patients in the test group and 20 individuals in the control group) were included in the present study. The mean ages of individuals in the test group and control group were 41 years (range, 34–48 years) and 39.5 years (range, 32–50 years), respectively.

Inclusion and Exclusion Criteria

Individuals aged at least 20 years were included. Only individuals with medically diagnosed prediabetes were included in the present study. The exclusion criteria encompassed the following: (a) self-reported systemic conditions including cardiovascular disorders, epilepsy, hepatic disorders and AIDS; (b) recent antibiotic and/or steroid therapy; (c) crowding of teeth, dental malocclusion, occlusal trauma and/or temporomandibular joint disorders; (d) bilateral maxillary and mandibular third molars and (e) edentulous individuals.

Interview Questionnaire

Individuals in the test group were presented the questionnaires at the local medical center, whereas responses from individuals in the control group were retrieved at their door steps. The questionnaire included queries regarding duration of prediabetes, family history of diabetes, medical history, self-perceived oral health status, self-perceived dry mouth (dryness in mouth during meals), SES, education level, tobacco habits [smoking and tobacco-chewing (gutka)], habitual alcohol consumption and daily oral hygiene maintenance regimes.

Monthly salary was initially recorded in Pakistani currency (rupees) and then converted into U.S. dollars. One U.S. dollar corresponded to 84.31 Pakistani rupees. Cigarette smokers were defined as individuals who had been smoking at least 1 cigarette daily since at least 12 months.7

Individuals chewing smokeless tobacco at least once a day since at least 1 year were defined as tobacco chewers.5

Individuals who had never smoked tobacco in any form or had never consumed smokeless tobacco were classified as non-smokers and nonchewers, respectively. Alcohol users were defined as individuals who had been consuming alcohol at least once daily since at least 12 months.

Individuals in the test and control groups were invited to an oral healthcare center for clinical periodontal and radiological examination and measurement of fasting blood glucose levels (FBGL). Early morning appointments (between 7:00 AM and 8:30 AM) were given, and the participants were requested to visit the oral healthcare centre in a nil per os state.

FBGLs in Subjects With and Without Prediabetes

A digital glucometer (ACCU-CHEK ACTIV, Roche Diagnostics, Mannheim, Germany) was used to measure the FBGL in subjects with and without prediabetes. The participants were categorized into 2 groups as follows: (a) healthy controls: individuals with FBGL <100 mg/dL (5.6 mmol/L) and (b) patients with prediabetes: individuals with FBGL of ≥100 mg/dL but <126 mg/dL (7.0 mmol/L).9–11

Periodontal Examination

Periodontal examinations were performed by a single examiner who was blinded to the test and control groups. The overall kappa value for interexaminer reliability was 0.78. A full-mouth plaque index (PI), bleeding on probing (BOP) and probing depth (PD) (4 to < 6 mm and ≥ 6 mm) were measured at 4 sites (mesial, distal, buccal and lingual/palatal) on all maxillary and mandibular teeth (excluding bilateral maxillary and mandibular third molars), as described previously.1 PD was measured to the nearest millimeter with a graded probe (Hu-Friedy Manufacturing, Chicago, IL).1 The numbers of missing teeth were recorded. Fractured teeth with embedded root remnants were considered missing.

Panoramic Radiographs

Digital panoramic radiographs were taken using a panoramic tomography machine (KODAK 8000C System, Carestream Dental LLC, Atlanta, GA). The radiographs were viewed on a calibrated computer screen (Samsung SyncMaster digital TV monitor, Korea) using a software program (Image Tool version 3.0 Program, Department of Dental Diagnostic Science, University of Texas Health Science Center, San Antonio, TX). Marginal bone loss (MBL) was measured on bilateral maxillary and mandibular premolars and molars by a single investigator (FJ). MBL was considered as the vertical distance from 2 mm below the cementoenamel junction to the most apical part of marginal bone.1 MBL was measured in pixels and converted into mm. One pixel was calibrated as 0.385 mm. Tooth surfaces at which the cementoenamel junction and/or the bone crest were not visible because of technical reasons (including dental restorations, interproximal caries, overlapping of teeth and/or poor radiographic quality) and bilateral maxillary and mandibular third molars were excluded.

Statistical Analysis

Statistical analyses were performed using the SPSS software program (SPSS version 18, SPSS Inc., Chicago, IL). One-way analysis of variance (ANOVA) was used to assess the association between periodontal inflammatory conditions (PI, BOP, PD and MBL), self-perceived oral health (bleeding gums, bad breath and dry mouth), age, gender and habits (smoking, use of smokeless tobacco and alcohol intake) in patients with and without prediabetes. MBL on the mesial and distal aspects of premolars and molars from both arches was used as an independent variable and was expressed as a mean with a 95% confidence interval.

RESULTS

Questionnaire

The mean monthly income among individuals in the test and control groups were $92,80 and $168,10, respectively (P < 0.001). In the test and control groups, the percentage of individuals with graduate level education was 21% and 65%, correspondingly (P < 0.001). There was no significant difference in cigarette smoking habit in individuals with and without prediabetes (Table 1). In the test and control groups, the individuals had been smoking cigarettes since 8.1 years (range, 3–10 years) and 3.4 years (range, 1–5 years), respectively. Gutka-chewing habit was more often reported by patients in the test group (52.6%) as compared with those in the control group (10%) (P < 0.001). In the test and control groups, the individuals had been using gutka since 7.4 years (range, 4–10 years) and 2.5 years (range, 1–4 years), respectively (Table 1). A family history of diabetes was reported by 13 individuals in the test group (68.4%) and 3 individuals in the control group (15%) (P < 0.001).

All patients in the test group were prescribed dietary control regimes for glycemic control. Fifteen individuals (78.9%) in the test group and 14 individuals (70%) in the control group reported to brush their teeth once a day; however, there was no significant difference between the groups regarding oral hygiene maintenance regimes.
TABLE 1. Fasting blood glucose levels and sociodemographic information in individuals with and without prediabetes (healthy controls)

<table>
<thead>
<tr>
<th></th>
<th>Patients with prediabetes</th>
<th>Healthy controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age/range (yr)</td>
<td>41/34–48</td>
<td>39.5/32–50</td>
</tr>
<tr>
<td>Gender</td>
<td>14 males, 5 females</td>
<td>16 males, 4 females</td>
</tr>
<tr>
<td>Mean FBGL (mg/dL) (range)</td>
<td>143.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>92.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Education status</td>
<td>21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Education status</td>
<td>(graduate level) (%)</td>
<td></td>
</tr>
<tr>
<td>Monthly salary (U.S. Dollars)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>$92.80&lt;sup&gt;d&lt;/sup&gt;</td>
<td>$168.10&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tobacco smoking (%)</td>
<td>63.1</td>
<td>65</td>
</tr>
<tr>
<td>Tobacco chewing (%)</td>
<td>52.6&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> P < 0.001.
<sup>b</sup> P < 0.001.
<sup>c</sup> The monthly salary was documented in Pakistani currency (rupees) and converted into U.S. dollars. One U.S. dollar was equivalent to 84.31 Pakistani rupees.
<sup>d</sup> P < 0.001.
<sup>e</sup> P < 0.001.

FBGL, fasting blood glucose levels.

Self-Perceived Oral Health Status

Self-perceived gingival bleeding was more often reported by patients in the test group (71.7%) as compared with individuals in the control group (30%) (P < 0.001). Self-perceived dry mouth was reported by 68% of the patients in the test group; there were no reports of dry mouth from individuals in the control group (P < 0.001). There was no significant difference in self-perceived bad breath between individuals in the test and control groups.

Fasting Blood Glucose Levels

The mean FBGL among subjects in the test and control groups were 143.3 mg/dL (range, 135–150 mg/dL) and 87.7 mg/dL (range, 85–98 mg/dL), respectively (P < 0.001). The mean duration of prediabetes in the test group was 4.7 months (range, 3–6 months). None of the individuals in the control group had impaired FBGL.

PI, BOP, PD, MBL and Missing Teeth in Subjects With and Without Prediabetes

PI (P < 0.001), BOP (P < 0.001), PD (4 to <6 mm) (P < 0.01) and PD (≥6 mm) (P < 0.05) were significantly higher in patients in the test group as compared with those in the control group. These results are summarized in Figure 1. The mean bilateral maxillary and mandibular premolar and molar MBL was significantly higher in the test group as compared with the control group (P < 0.001) (Figure 2). The mean numbers of missing teeth were significantly higher in patients with prediabetes (mean 3.4; range, 0–6 teeth) as compared with healthy controls (mean 1.65; range, 0–5 teeth). There was no significant effect of age and gender on the severity of periodontal inflammatory conditions between the groups.

DISCUSSION

The present study showed significant differences in various parameters of periodontal inflammation [especially self-perceived gingival bleeding, PI, BOP, PD (4 to <6 mm and ≥6 mm) and MBL] among patients with prediabetes and healthy controls. The present clinical study support the experimental results by Pontes Andersen et al<sup>12</sup> in which the authors showed periodontal inflammatory conditions and MBL to be directly associated with worsening of prediabetes.

Chronic hyperglycemia has been associated with an accumulation of glucose-mediated AGEs in the gingival tissues impairing the chemotactic and phagocytic function of polymorphonuclear leukocytes and produce proinflammatory cytokines, thereby leading to periodontal inflammation and bone. Accumulation of AGEs in the gingival tissues has also been associated with an increased production and accumulation of proinflammatory cytokines in these tissues thereby triggering periodontal disease.<sup>22,23</sup> Although the intensity of hyperglycemia in patients with prediabetes may not be as intense as in patients with poorly controlled diabetes; however, the possibility of formation and accumulation of AGEs in the gingival tissues cannot be disregarded. Nevertheless, a limitation of the present study is that the glycated hemoglobin A1C levels in patients were not measured. However, it is notable that in the present study, the patients had diabetes since nearly 5 months and simultaneously presented with symptoms of periodontal inflammation. It may therefore be hypothesized that elevated FBGL in these subjects may have contributed in the formation of AGEs in these individuals.

In the present study, education status and SES in healthy controls was significantly higher as compared with individuals with prediabetes. It has been reported that illiteracy and underprivileged living standards are risk factors of poorly controlled diabetes.<sup>3</sup> An underprivileged SES has also been recognized as significant risk factor for periodontal disease.<sup>1,24</sup> An underprivileged SES has also a significant risk factor for IGT.<sup>25</sup> It has been reported that under psychological stress, the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system

![FIGURE 1. PI, BOP and probing depth (4 to <6 mm and ≥6 mm) in individuals with and without prediabetes.](image)
These hormones have been reported to influence glucose metabolism, activate immune cells and modulate subclinical inflammation. Results by Nowotny et al showed a significant rise in blood glucose levels in individuals after exposure to stress as compared with the respective controls. Similarly, Eriksson et al also reported that psychological stress increases the risk of prediabetes and type 2 diabetes. It may therefore be postulated that the IFG levels in patients with prediabetes may be associated with psychological stress in these subjects due to their underprivileged SES and poor education status. A poor education status may also compel individuals to ignore their oral and systemic health statuses and strive to attain basic standards of living. An interesting finding in the present study was that there was no significant difference on daily oral hygiene maintenance regimes in subjects with and without prediabetes; yet, individuals with prediabetes had a poorer periodontal health status as compared with healthy controls. A possible explanation for this may be that the characteristics of the gingival crevicular fluid and the oral biofilm may vary in subjects with and without prediabetes. In the study by Engebretson et al, individuals with chronic hyperglycemia displayed higher concentrations of IL-1beta (a proinflammatory cytokine) in the GCF as compared with individuals with glycemic levels in the normal range. Likewise, according to the study by Ebersole et al, the subgingival plaque in subjects with hyperglycemia harbored higher quantities of periodontal pathogens (including Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans and Campylobacter species) as compared with individuals with normal glycemic levels. This may explain our results where despite having similar oral hygiene maintaining frequencies, self-perceived oral health and periodontal inflammatory conditions were poorer in subjects with prediabetes as compared with healthy controls. Efforts to reduce the SES and education inequality among public masses should be directed at the early life course to reduce (if not prevent) the progression of oral and systemic conditions. It is well known that habitual tobacco smoking has deleterious effects health, however, habitual use of smokeless tobacco may also jeopardize oral health. Gutka is a form of smokeless tobacco that mainly comprises of powdered tobacco, areca nut (a fruit of Areca catechu tree), slaked lime and artificial sweeteners. Habitual use of smokeless tobacco has been associated several oral inflammatory conditions including periodontal disease and oral cancer. Slaked lime and areca nut have been associated with oral mucosal inflammation and suppression of growth of human gingival fibroblasts. This may be an explanation for the more severe periodontal conditions and oral symptoms in smokeless tobacco users as compared with individuals to using tobacco in any form. Nevertheless, the hazardous effects of smokeless tobacco are not merely restricted to the oral cavity and may also jeopardize systemic health. It has been reported that habitual areca nut use is associated with several systemic conditions including epilepsy, cardiovascular disease, metabolic syndrome and diabetes. Area nut (an essential components in gutka)-derived nitrosamines have been reported to be diabetogenic and may jeopardize the islet beta-cell glucose receptors. In the present study, habitual gutka use was more often reported by patients with prediabetes, and these individuals were also exposed to the chewing insult for a longer duration as compared with subjects with healthy controls. It may therefore be hypothesized that habitual gutka-chewing habit may play a role in the development of prediabetes among its consumers; however, further studies are warranted in this regard. Thus, it seems that the accumulation of AGEs in the gingival tissues due to hyperglycemia coupled with habitual gutka chewing may intensify the severity of periodontal inflammation in patients with prediabetes as compared with healthy controls. This may also be an explanation for the increased self-perceived gingival bleeding in patients with prediabetes as compared with healthy individuals. Nevertheless, the role of psychological stress, illiteracy and deprived living conditions that may also trigger periodontal inflammation cannot be overlooked. In the study by Javed et al, habitual gutka users reported that the chewing habit helped them to attain a frame of mind that they termed “mental peace” and the habit also helped them to control hunger. In the present study, digital panoramic radiographs were used to investigate MBL in individuals with and without prediabetes. In the present study, the mean bilateral maxillary and mandibular premolar and molar MBL was significantly higher in the test group as compared with the control group. Although in prediabetes this association has not been well established previously, it is in accordance with other reports that have related a highly increased alveolar bone loss ratio in patients with diabetes as compared with medically healthy.
The present results support previous reports that have suggested that panoramic radiographs can be substituted for full-mouth intraoral radiographs.

In conclusion, self-perceived gingival bleeding BOP, PD (4 to < 6 mm and ≥ 6 mm) and MBL are higher in individuals with prediabetes as compared with healthy controls. An underprivileged SES aggravates periodontal inflammatory conditions in patients with prediabetes.

REFERENCES