Comparison of clinical and radiographic status around dental implants placed in patients with and without prediabetes: 1-year follow-up outcomes

It is known that chronic hyperglycemia negatively influences osseointegration of dental implants, and implant failure is a common manifestation in such patients (Alsaadi et al. 2008, Daubert et al. 2015). Chronic hyperglycemia has also been associated with the delayed cell proliferation and osteoblast differentiation (Colombo et al. 2011). In addition, chronic hyperglycemia has been associated with the dysregulation of bone factors such as transforming growth factor-beta, fibroblast growth factor, osteopontin, osteocalcin and osteoprotegerin in the peri-implant crevicular fluid (Ghiraldini et al. 2015). Although optimal glycemic control in patients with diabetes has been reported to enhance osseointegration (Javed & Romanos 2009), results from a recent clinical trial showed that elevated hemoglobin A1c (HbA1c) levels in patients with type 2 diabetes mellitus (T2DM) were not associated with altered implant success after 1 year of loading (Oates et al. 2014). However, alterations in early bone healing and implant stability were associated with chronic hyperglycemia (Oates et al. 2014). Similar results were reported in another clinical study (Ghiraldini et al. 2015).

Prediabetes, a state of abnormal glucose homeostasis, is characterized by the presence of impaired fasting glucose, impaired glucose tolerance, or both (American Diabetes Association 2015a). Prediabetes designations have been defined by fasting glucose levels of 100–125 milligrams per deciliter (mg/dl), hemoglobin A1c (HbA1c) levels between 5.7% and 6.4% and postglucose challenge levels of 140–199 mg/dl (Olson et al. 2010; American Diabetes Association 2015b). Studies (Javed et al. 2012a, b, 2013, 2014a, b, 2015; Alshehri
& Javed 2015) have shown that scores of periodontal inflammatory parameters [such as bleeding on probing (BOP) and probing pocket depth (PPD)] are higher among patients with prediabetes compared with systemically healthy individuals (controls). Although marginal bone loss (MBL) as measured on radiograph is also higher in prediabetic patients compared with controls [Javed et al. 2014a,b], controversial results have also been reported (Kowall et al. 2015).

As patients with prediabetes exhibit a poorer periodontal [clinical and radiographic] status compared with controls [Javed et al. 2014a,b], it is hypothesized that peri-implant soft tissue inflammation is worse and MBL is higher around dental implants placed in patients with prediabetes compared to healthy subjects. The aim of the present 1-year follow-up case-control study was to assess the clinical and radiographic status around dental implants placed in patients with prediabetes.

Material and methods

Ethical approvals

The study was approved by the Research Ethics Review committee of the College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia. Volunteering individuals were requested to read and sign a consent form.

Inclusion and exclusion criteria

The inclusion criteria were [a] patients with medically diagnosed prediabetes and [b] self-reported systemically healthy controls. The exclusion criteria were as follows: [a] patients with systemic disorders other than prediabetes [such as type 1 diabetes mellitus, T2DM, renal disorders, acquired deficiency syndrome and cardiovascular disorders]; [b] individuals using tobacco products [smokers and tobacco chewers]; [c] pregnant and/or lactating females; [d] patients with a history of antibiotic and/or steroid intake; and [e] use of bone augmentation protocols.

Participants

In total, 24 male patients [12 patients with prediabetes [Group-1] and 12 controls [Group-2]] were included. Patients in Group-1 were requested to present their medical records to confirm the diagnosis of prediabetes in the study population. These individuals were recruited from the Department of Prosthetic Dental Sciences, College of Dentistry, King Saud University, Riyadh, Saudi Arabia. In both groups, patients had implants placed for the replacement of a single premolar tooth in the maxilla or mandible with adjacent teeth intact. All patients underwent full-mouth scaling using an ultrasonic scaler (VivIDENTA, Guangxi, China) prior to implant placement.

Measurement of hemoglobin A1c levels

In both groups, HbA1c levels were measured at the time of surgery, after 6 months and 1 year of follow-up. Venous blood samples were drawn in the morning, and HbA1c levels were determined using the high-performance liquid chromatography method (Bio-Rad Laboratories, Inc., D-10rrn, Hemoglobin Systems, Hercules, CA, USA) (Ozcelik et al. 2010). Individuals with HbA1c levels ranging between 5.7–6.4% and 4–5.5% were categorized as prediabetic individuals and controls, respectively (American Diabetes Association 2015a,b).

Surgical protocol

A 7-day course of wide-spectrum antibiotic (Amoxicillin 500 mg 8 h) was started 3 days before the participants were scheduled for implant surgery. Clindamycin (150 mg 6 h for 7 days) was prescribed as an alternate antibiotic for individuals with a self-reported history of penicillin allergy. Following local anesthesia, a crestal incision was made using a #15 blade and full-thickness mucoperiosteal flaps were raised to expose the bone. A total of 24 bone level implants (12 implants in Group-1 and 12 in Group-2) were placed in the center of the healed alveolar ridge (day 0) using an insertion torque of 30–35 Ncm. The implants used had a diameter of 3.5 mm and ranging in length from 10 to 16 mm (Straumann® Dental Implant System, Institut Straumann, AG Peter Merian-Weg 12 CH-4002 Basel, Switzerland). Healing abutments were connected to the implants using hand torque (day 0). The flaps were sutured around the healing abutment using resorbable sutures (4/0 Vicryl), and digital intraoral postoperative radiographs were taken. After a mean duration of 3.5 months, final impressions were made for the fabrication of a definitive porcelain-fused-to-metal (PFM) implant-supported prosthesis [day 112]. All implants were loaded with screw-retained PFM crowns.

Postoperative management

Participants were advised to complete the 7-day antibiotic course, which had started 3 days before surgery. Analgesics (Ibuprofen 600 mg 6 h for 5 days) were also prescribed for pain control. Acetaminophen (325 mg 6 h for 5 days) was prescribed as an alternate analgesic for individuals who reported to be allergic to ibuprofen. Participants in both groups were instructed to rinse with a 0.12% chlorhexidine gluconate solution (Corsodyl, Boots, Nottingham, UK) twice daily for 2 weeks. Oral hygiene instructions were given to all patients, and they were also enrolled in a 6-month follow-up dental prophylaxis program [ultrasonic cleaning] for 1 year. Patients were advised to maintain their serum glycemic levels and were also suggested to contact their primary care physicians in this regard.

Clinical and radiographic parameters

Peri-implant and full-mouth plaque index (PI), BOP and PPD ≥ 4 mm were assessed among individuals in both groups. These parameters were assessed at six sites per tooth/implant [mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual]. For the assessment of PPD, a metal periodontal probe with a tip diameter of 0.42 mm (Zefferlo, Lascod spa, Sesto Fiorentino, Italy) was inserted into the peri-implant sulcus and the most apically probable distance was recorded in millimeters [Abreu et al. 2007; Zitzmann & Berglundh 2008]. In both groups, evidence of any radiolucency and mesial and/or distal marginal bone loss [MBL] around the implants was determined at 6 and 12 months of follow-up. Digital intraoral radiographs were taken and visualized on a computer screen. Radiographs were analyzed at 20× magnification using a software [CorelDraw 11.0, Corel Corp and Coral Ltd, Ottawa, Canada]. MBL was defined as the distance from the widest supracrestal part of the implant to the crestal bone level [Mumcu et al. 2011].

Criteria for implant success

The criteria for implant success were [a] stable implants and superstructures, [b] no symptoms of pain, [c] no signs of BOP and/or purulent discharge, [d] MBL of ≤ 1 mm around the implant in the first year, and [e] absence of radiolucency around implants.

Statistical analysis

Statistical analysis was performed using a software program [SPSS Version 18, Chicago, IL, USA]. BOP, PPD and MBL among patients
at 6 months and 12 months of follow-up in both groups were compared using the non-parametric Mann–Whitney U-test. P-values less than 0.05 were considered statistically significant.

Results

General characteristics of the study population
The mean age of participants in groups 1 and 2 were 44.5 years [41–49 years] and 43.3 years [39–47 years], respectively. At baseline, the mean HbA1c levels were significantly higher among patients in Group-1 compared to patients in Group-2 (P = 0.002). There was no statistically significant difference in mean HbA1c levels among patients in groups 1 and 2 at 6 and 12 months of follow-up (Table 1). In both groups, all implants were clinically stable with no signs of mobility and/or inflammation. None of the participants were allergic to amoxicillin or ibuprofen.

Full-mouth plaque index, bleeding on probing and probing depth among individuals in groups 1 and 2
At baseline, there was no statistically significant difference of plaque, BOP and PPD ≥ 4 mm among patients in groups 1 and 2. In both groups, there was a statistically significant difference in PI, BOP and PPD ≥ 4 mm at 6 months (P = 0.00) and 12 months (P = 0.00) of follow-up. There was no significant difference in PI, BOP and PPD ≥ 4 mm at 6- and 12-month follow-ups among patients in groups 1 and 2 (Table 2).

Peri-implant plaque index, bleeding on probing and probing depth among individuals in groups 1 and 2 after 6 and 12 months of follow-up
In both groups, there was no clinical evidence of peri-implant pockets with PPD ≥ 4 mm at 6 and 12 months of follow-up. At 6 and 12 months of follow-up, there was no clinical evidence for the presence of plaque, BOP and peri-implant pockets with PPD ≥ 4 mm in both groups.

Marginal bone loss among individuals in groups 1 and 2 after 6 and 12 months of follow-up
There was no radiographic evidence of MBL around implants placed in groups 1 and 2 at 6-month follow-up. At 12-month follow-up, the mean MBL among implants placed in groups 1 and 2 were 0.2 ± 0.1 mm and 0.1 ± 0.01 mm, respectively (P = 0.12).

Discussion

To our knowledge from indexed literature, this is the first study, which assessed the clinical and radiographic parameters status of implants placed in patients with and without prediabetes. We reviewed the patients’ records to determine the date of the most recent assessment of HbA1c, fasting plasma glucose or oral glucose tolerance test which was performed. This was used mainly to confirm the prediabetic state of the participants. However, for the present study, we elected to measure HbA1c levels to have the most updated glycemic levels in the present study. In this study, it was hypothesized that the peri-implant soft tissue inflammation is worse and MBL is higher around dental implants placed in patients with prediabetes compared to controls. This hypothesis was based on the fact that chronic hyperglycemia is associated with an increased formation and accumulation of advanced glycation endproducts in periodontal tissues, which augment inflammation, and if hyperglycemia is left uncontrolled, it may lead to MBL around teeth (Lalla et al. 2000; Chang et al. 2013, 2014). Interestingly, the present results showed that all implants remained clinically stable up to 12 months of follow-up with no signs of soft tissue inflammation. An explanation in this regard could be derived from the fact that all participants were given strict oral hygiene maintenance instructions and were also enrolled in a 6-month dental prophylaxis program. In the dental prophylaxis program, ultrasonic scalers were used to eradicate any stagnated plaque from teeth and implant surfaces, and at every visit, it was clinically ensured that the patients are maintaining good oral hygiene status. It is interesting to note that the overall periodontal status of individuals with and without prediabetes was comparable at 6 and 12 months of follow-up (Table 2). In a 10-year follow-up clinical study, Degidi et al. (2012) found that the long-term bone levels around dental implants can be maintained when levels of oral hygiene are kept adequate. Likewise, clinical results by Lin et al. (2011) demonstrated that a 100% success rate of implants can be achieved provided that oral hygiene maintenance and peri-implant gingival health are ensured. Authors of the present study support the studies by Degidi et al. (2012) and Lin et al. (2011). However, from the present results, it is evident that optimal oral hygiene maintenance not only prevents MBL around implants in systemically healthy individuals, but also in hyperglycemic patients, such as those with prediabetes. It is therefore imperative for clinicians to educate patients about the importance of regular oral hygiene maintenance and its beneficial influences on teeth and implants.

Studies have shown that non-surgical periodontal therapy (NSPT) plays a role in reducing periodontal inflammation and serum glycemic levels among patients with chronic hyperglycemia (Stewart et al. 2001; Simpson et al. 2010; Corbella et al. 2013; Javed et al. 2014a,b). However, it has also been reported that NSPT reduces periodontal inflammation but does not significantly affect metabolic control in hyperglycemic patients (Serrano et al. 2012; Alshehri & Javed 2015). In the present study, a trend toward decrease in HbA1c level was observed among patients with prediabetes (Group-1); however, compared to baseline glycemic levels, HbA1c levels measured at 12-months of follow-up failed to show any statistically significant difference. The present 1-year follow-up results support the study by Oates et al. (2014), which showed that elevated HbA1c levels in patients with type 2 diabetes were not associated with altered implant success 1 year after loading. Moreover, clinical evidence from several investigations has suggested that although glycemic control is an important consideration that may require modifications in the treatment protocols, hyperglycemia may not be as a contraindication to implant therapy in diabetic patients (Oates & Huynh-Ba 2012; Oates et al. 2013, 2014).

Table 1. Mean HbA1c levels among patients in groups 1 and 2 at baseline and after 6 and 12 months of follow-up

<table>
<thead>
<tr>
<th>Study groups (n)</th>
<th>Baseline (mean ± SD)</th>
<th>6 months follow-up (mean ± SD)</th>
<th>12 months follow-up (mean ± SD)</th>
</tr>
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<tbody>
<tr>
<td>Group-1 (n = 12)</td>
<td>6.1 ± 0.4*</td>
<td>5.8 ± 0.2</td>
<td>5.5 ± 0.2</td>
</tr>
<tr>
<td>Group-2 (n = 12)</td>
<td>4.4 ± 0.2</td>
<td>4.4 ± 0.1</td>
<td>4.2 ± 0.1</td>
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*Compared to Group-2 at baseline (P = 0.002).
SD, standard deviation.
It is well-known that a history of periodontal disease is a significant risk factor for peri-implant diseases (peri-implant mucositis and peri-implantitis) (Serino & Ström 2009, Renvert & Quirynen 2015). From the baseline assessment of periodontal inflammatory parameters (PI, BOP and PPD), it is noteworthy that all participants had a relatively good oral hygiene status, with plaque accumulation and periodontal pockets of ≥4 mm in less than 30% and 5% sites, respectively (Table 2). This suggests that participants in both groups had an acceptable oral hygiene status and were most likely maintaining good oral hygiene. However, it is speculated that a history of periodontal disease would have most likely influenced the success of dental implants placed in both groups. Further long-term prospective studies are needed in this regard.

There are a few limitations of the present study. As the present results were based on 1-year follow-up results, it is hypothesized that optimal long-term oral hygiene maintenance among patients with prediabetes would positively influence the success of implants in these patients. Moreover, it is well-established that the outcomes of oral surgical interventions and marginal bone levels are compromised in smokers as compared to non-smokers (Javed et al. 2007, 2012a,b; Kotsakis et al. 2015). It is speculated that regardless of daily oral hygiene maintenance, habitual tobacco smoking jeopardizes the outcomes of implant treatment among patients with and without prediabetes by increasing MBL around implants. In the present study, strict eligibility criteria (such as absence of other systemic diseases, no use of antibiotics/steroids within the past 3 months and absence of tobacco habits) were established for the inclusion of prediabetic patients. It is therefore possible that such factors may have influenced the outcomes of the present study. Furthermore, in the present study, implants were placed in both arches. As the bone density varies between the maxilla and mandible (Fuster-Torres et al. 2011), it is hypothesized that in the long term, jaw location may influence MBL around implants. Further long-term clinical trials are needed to test the aforementioned hypothesis.

### Table 2. Median ± standard deviation full-mouth plaque index, bleeding on probing and probing depth among individuals in groups 1 and 2 after 6 and 12 months of follow-up

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group-1 (n = 12)</th>
<th>Group-2 (n = 12)</th>
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<tbody>
<tr>
<td></td>
<td>Baseline 6-month follow-up 12-month follow-up</td>
<td>Baseline 6-month follow-up 12-month follow-up</td>
</tr>
<tr>
<td>Plaque index (%)</td>
<td>27.3 ± 7.7†</td>
<td>23.2 ± 2.5†‡§</td>
</tr>
<tr>
<td>Bleeding on probing (%)</td>
<td>20.1 ± 2.5†‡</td>
<td>11.2 ± 0.4†§</td>
</tr>
<tr>
<td>Probing depth ≥4 mm (%)</td>
<td>5.1 ± 1.4*‡</td>
<td>2.7 ± 0.5</td>
</tr>
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</table>

*Compared to 6-month follow-up in Group-1 (P = 0.000). †Compared to 12-month follow-up in Group-1 (P = 0.000). ‡Compared to 6-month follow-up in Group-2 (P = 0.000). §Compared to 12-month follow-up in Group-2 (P = 0.000).

### References


### Conflict of interest and financial disclosure

The authors declare no conflict of interest. There was no external source of funding for this study.

### Conclusion

Within the limitations of this study, it is concluded that dental implants inserted in prediabetic and healthy patients have similar success rates and remain clinically and radiographically stable after 1-year follow-up. Regular oral hygiene maintenance plays a potentially vital role for implant therapy in patients with and without prediabetes.


