CLINICAL ORAL IMPLANTS RESEARCH

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Comparison of clinical and radiographic parameters around short (6 to 8 mm in length) and long (11 mm in length) dental implants placed in patients with and without type 2 diabetes mellitus: 3-year follow-up results

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Abstract

Objective: To compare the clinical and radiographic parameters around short (6 to 8 mm in length) and long (11 mm in length) dental implants placed in patients with and without type 2 diabetes mellitus (T2DM).

Material and Methods: Forty-five male patients with T2DM (Group-1) and 42 male non-diabetic controls (Group-2) who had undergone implant therapy in the posterior mandible were included. Depending upon the length of the implant, patients were divided into two subgroups: (a) patients with short implants (6–8 mm long) and (b) patients with long implants (11 mm long). Peri-implant plaque index (PI), bleeding on probing (BOP), probing depth (PD) and crestal bone loss (CBL) were measured at 18 and 36 months of follow-up in both groups. Hemoglobin A1c (HbA1c) levels were measured at baseline and after 18 and 36 months of follow-up in both groups. *P*-values less than 0.05 were considered statistically significant.

Results: The mean age of patients in groups 1 and 2 was 42.5 and 40.6 years, respectively. The mean HbA1c levels at baseline among patients in groups 1 and 2 were 7.7% and 4.5%, respectively. At 18 and 36 months of follow-up, the mean HbA1c levels among patients in groups 1 and 2 were 6.6% and 4.5% and 6.5% and 4.4%, respectively. The mean duration of T2DM among patients that received short and long implants was 4.3 years and 4.1 years, respectively. There was no significant difference in PI, BOP, PD and CBL around implants placed in both groups at 18 and 36 months of follow-up. Success rate of short and long dental implants was 100% in both groups.

Conclusion: Short implants can demonstrate clinical and radiographic stability in a manner similar to conventional long implants in patients with and without T2DM. The role of oral hygiene and glycemic maintenance in this scenario cannot be disregarded.

Maintenance of crestal bone height plays an important role in the overall success of dental implant therapy (Albrektsson et al. 1986). However, according to Albrektsson et al. (Albrektsson et al. 1986), crestal bone loss (CBL) of up to 1.5 mm around the implant followed by a CBL of 0.2 mm annually is considered normal. A variety of factors (such as tobacco smoking, poor oral hygiene status and chronic hyperglycemia) have been reported to influence CBL around dental implants (Tolstunov 2007; Javed & Romanos 2009).

Traditionally, dental implants used for the replacement of missing teeth are at least 10 mm in length (Frenken et al. 2010; Cochran et al. 2011). However, implant placement in areas with a compromised alveolar bone height may challenge clinicians. Under such circumstances, additional surgical procedures (such as bone grafting) may be warranted before the placement of implants (Nakahara et al. 2016; Sakkas et al. 2016). To minimize the possibility of adjunct surgical procedures (such as bone grafting and sinus

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augmentation), short dental implants (6–8 mm in length) have been developed. It has been proposed that the success rate of short dental implants is comparable to that of standard-length implants (≥10 mm). According to Tutak et al. (Tutak et al. 2013), the risk of fracture is higher in short implants with length less than 8 mm as compared to long implants; however, studies (Nedir et al. 2004; Tutak et al. 2013) have also reported that implant surface morphology is a more critical factor that influences the success or failure of dental implant therapy. In the study by Nedir et al. (Nedir et al. 2004), failure rates of short dental implants with machined surfaces were 5–10% higher than longer alternatives (≥10 mm). Furthermore, results from a systematic review reported that short implants can successfully be placed in partially edentulous individuals and their prognosis is better in the mandible of non-smoking patients (Telleman et al. 2011).

Several studies (Javed et al. 2007; Gomez-Moreno et al. 2015; Aguilar-Salvatierra et al. 2016) have reported that chronic hyperglycemia in patients with poorly controlled diabetes mellitus is a significant risk factor for soft tissue inflammation and CBL around osseointegrated implants and teeth. An explanation in this regard is that chronic hyperglycemia is associated with an increased formation and accumulation of advanced glycation end products in the systemic and oral tissues, which in turn increase the release of proinflammatory cytokines that enhance CBL around the natural dentition and implants (Javed et al. 2011; Nowotny et al. 2015; Piperi et al. 2015). However, it is pertinent to mention that under optimal glycemic control, dental implants can osseointegrate and remain functionally stable over long durations in diabetic patients in a manner similar to non-diabetic controls (Javed & Romanos 2009).

Following a vigilant review of indexed literature, it was noted that the peri-implant clinical and radiographic status remains uninvestigated around short and long implants among patients with type 2 diabetes mellitus (T2DM). It is therefore hypothesized that there is no statistically significant difference in scores of peri-implant plaque index (PI), bleeding on probing (BOP), probing depth (PD) and CBL around short and long implants among patients with and without T2DM. The aim of the present 3-year follow-up study was to compare the clinical and radiographic parameters around short (6–8 mm in length) and long (≥10 mm in length) dental implants placed in patients with and without T2DM.

Material and methods

Ethical guidelines

The study was approved by the research ethics review committee of the College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia. An information sheet (which described the purpose of the study) and a consent form were presented to all participants. Consenting individuals were requested to sign the consent form and were given the freedom to resign from this study at any stage of the investigation.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (a) individuals having undergone dental implant therapy in the posterior mandible; (b) individuals with T2DM; (c) self-reported systemically healthy individuals; (d) at least 3 years of follow-up; and (e) signing of the consent form. Third molars, tobacco and smokeless tobacco users, use of bone grafting techniques, individuals with bruxism or systemic disorders such as acquired immune deficiency syndrome, cardiovascular disorders and renal disorders, pregnant/lactating females and individuals who had consumed antibiotics, non-steroidal anti-inflammatory drugs and/or corticosteroids within the past 6 months were excluded.

Participants

In total, 45 patients with T2DM and 42 self-reported non-diabetic controls were included in this study.

Diagnosis of type 2 diabetes mellitus and measurement of hemoglobin A1c levels

Patients with T2DM were requested to present their medical records for verification of the diagnosis of T2DM. In both groups, HbA1c levels were measured at baseline (preoperatively) and at 18 and 36 months of follow-up using an HbA1c analyzer kit (Quo-Test, EKF Diagnostics, Magdeburg, Germany).

Surgical protocol and implant-related characteristics

All implants (OsseoSpeed, DENTSPLY Implants, Waltham, MA, USA) were 4 mm in diameter. Depending upon their length, implants were classified as either short implants (6–8 mm in length) or long implants (11 mm in length) (Malmstrom et al. 2015). Full-thickness mucoperiosteal flaps were raised under local anesthesia using a no. 15 surgical blade. In both groups, platform-switched implants with moderately rough surfaces were placed in the areas of missing mandibular premolar or molar teeth. A prefabricated surgical guide was used to ensure proper placement of the implants in both groups. Postoperative antibiotics (amoxicillin 500 mg three times daily for 7 days) and analgesics (ibuprofen 600 mg for as long as required) were prescribed to all patients. Oral hygiene instructions were given, and the patients were advised to start rinsing with an essential-oil-based mouthwash (Listerine Zero, Johnson & Johnson Middle East FZ – LLC) twice daily for 2 weeks, after 24 h of surgery.

Clinical and radiographic parameters

All clinical and radiographic assessments were performed by a single, trained and calibrated clinician who was blinded to the study groups. The *kappa* for intraexaminer reliability was 0.91. PI, BOP and PD were measured around all implants placed in both groups. PI, BOP and PD were investigated at six sites per implant (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual) at 18 and 36 months of follow-up using a plastic periodontal probe (Plast-o-Probe, Dentsply Maillefer, ON, USA). In both groups, the mean mesial and distal CBL was recorded in millimeters on digital radiographs (Belmont ACURAY 071A Intra Oral X-Ray System, Hudson, FL, USA) using a software program (Scion Image, Scion Corp., Fredrick, MD, USA). The radiographs were taken at 18 and 36 months of follow-up and were viewed on a computer screen at ×20 magnification using software (CorelDraw 11.0, Corel Corp and Coral Ltd, Ottawa, Canada). The software was calibrated before each measurement using the predefined implant length. The radiographic paralleling technique was standardized using a film holder as a guiding device for X-ray beams (Dentsply Rinn, PA, USA). Crestal bone loss was defined as the distance from the widest supracrestal part of

***Table 1.* Mean (range) hemoglobin A1c levels in patients with type 2 diabetes mellitus (group 1) and non-diabetic controls (group 2) at baseline and at 18 and 36 months of follow-up**

HbA1c	Group-1 (n = 45)	Group-2 (n = 42)
Baseline	7.7% (7.2–8.5)	4.5% (4.2–4.7%)
18-month follow-up	6.4% (6.0–6.7%)*	4.5% (4.2–4.8%)
36-month follow-up	6.5% (6.2–6.7%)*	4.4% (4–4.5%)

*Significantly different from baseline ($P < 0.05$).

the implant to the alveolar crest (Mumcu et al. 2011).

Dental prophylaxis

All participants were enrolled in a biannual dental prophylaxis program in which they received mechanical plaque and calculus removal from all teeth and/or implant surfaces using an ultrasonic scaler (VV DENTA, Guangxi, China).

Statistical analysis

Statistical analysis was performed using software program (SPSS Version 18, Chicago, IL, USA). In both groups, PI, BOP, PD, CBL and HbA1c were assessed within and between the groups using the one-way analysis of variance. For multiple comparisons, the Bonferroni *post hoc* test was used. *P*-values less than 0.05 were considered statistically significant.

Results

General characteristics of the study population

In group 1 ($n = 45$ males), 22 patients received short implants and 23 patients received long implants in the posterior mandible. In group 2 ($n = 42$ males), 24 patients received short implants and 18 patients received long implants. All implants were placed at bone level using an insertion torque of 35 Ncm. Implants loading took place after 3.2 ± 0.1 months and 3.1 ± 0.3 months in groups 1 and 2, respectively. The mean ages of patients in groups 1 and 2 were 45.5 years and 43.6 years, respectively. The mean duration of T2DM among patients who received short and long implants was 4.3 years (2–5 years) and 4.1 years (range 3–5 years), respectively. All patients with T2DM had been prescribed antihyperglycemic medications by their physicians for the management of T2DM and were also advised to maintain their glycemic levels via dietary control.

Hemoglobin A1c levels

The mean levels and ranges of HbA1c in both groups at baseline and at 18 and 36 months of follow-up are presented in Table 1. The mean HbA1c levels at baseline among patients in groups 1 and 2 were 7.7% (7.2–8.5) and 4.5% (4.2–4.7%), respectively. At 18 and 36 months of follow-up, the mean HbA1c levels among patients in groups 1 and 2 were 6.4% (6–6.7%) and 4.5% (4.2–4.8%) and 6.5% (6.2–6.7%) and 4.4% (4–4.5%), respectively. In group 1, there was a statistically significant reduction in the mean HbA1c levels at 18 ($P < 0.05$) and 36 months ($P < 0.05$) of follow-up compared to their respective baseline HbA1c levels. There was no statistically significant difference in the mean HbA1c levels among individuals in group-2 at both time intervals compared to baseline.

Peri-implant clinical parameters at 18 and 36 months of follow-up

At 18 months of follow-up, the mean scores of PI around short and long implants placed in groups 1 and 2 were 20.6% (18.4–22.4%) and 19.3% (15.2–25.4%) and 22.5% (20.3–24.1%) and 23.6% (21.5–26.4%), respectively. The mean scores of BOP among short and long implants placed in groups 1 and 2 were 21.4% (18.4–25.5%) and 24.1% (21.7–26.6%) and 26.8% (20.5–30.6%) and 23.4% (19.6–28.7%), respectively. The mean PD around short and long implants placed in groups 1 and 2 were 2.1 (1–3 mm) mm and 2.2 (1–3.2 mm) mm and 2.2 (1.5–2.5 mm) mm and 2.3 (1.5–3.2 mm), respectively. There was no statistically significant difference in the mean scores of PI, BOP and PD around short and long implants among patients in both groups (Table 2).

At 36 months of follow-up, the mean scores of PI around short and long implants placed in groups 1 and 2 were 24.2% (20.5–27.4%) and 21.5% (18.6–23.3%) and 25.5% (20.7–28.4%) and 27.8% (22.3–30.4%), respectively. The mean scores of BOP were 23.4% (19.3–29.4%) and 22.8% (18.3–28.5%) and 22.2% (15.6–27.2%) and 20.5% (14.3–22.5%), respectively. The mean PD around short and long implants placed in groups 1 and 2 were 2.2 mm (1.5–2.5 mm) and 2.4 (2–3 mm) and 2.3 mm (2–3.2 mm) and 2.3 mm (2–3 mm), respectively. There was no statistically significant difference in the mean scores of PI, BOP and PD around short and long implants among patients in both groups (Table 2).

Peri-implant radiographic parameters at 18 and 36 months of follow-up

At 18 months of follow-up, the mean CBL around short and long implants in groups 1 and 2 was 0.25 mm (0.2–0.3 mm) and 0.2 mm (0–0.4 mm) and 0.2 mm (0–0.4 mm) and 0.2 mm (0–0.4 mm), respectively. At 36 months of follow-up, the mean CBL around short and long implants in groups 1 and 2 was 0.3 mm (0.1–0.5 mm) and 0.25 mm (0–0.4 mm) and 0.25 mm (0.2–0.5 mm) and 0.3 mm (0.2–0.5 mm), respectively. There was no statistically significant difference in the mean CBL around short and long implants among patients in both groups at 18 and 36 months of follow-up (Table 3).

Table 2. **Peri-implant clinical parameters around short and long dental implants placed in patients with type 2 diabetes mellitus (group 1) and non-diabetic controls (group 2) at 18 and 36 months of follow-up**

	18-month follow-up				36-month follow-up			
	Group 1 (*n* = 45)		Group 2 (*n* = 42)		Group 1 (*n* = 45)		Group 2 (*n* = 42)	
	Short implants	Long implants	Short implants	Long implants	Short implants	Long implants	Short implants	Long implants
No. of implants placed	22	23	24	18	22	23	24	18
Mean plaque index in percentage (range)	20.6 (18.4–22.4)	19.3 (15.2–25.4)	22.5 (20.3–24.1)	23.6 (21.5–26.4)	24.2 (20.5–27.4)	21.5 (18.6–23.3)	25.5 (20.7–28.4)	27.8 (22.3–30.4)
Mean bleeding on probing in percentage (range)	21.4 (18.4–25.5)	24.1 (21.7–26.6)	26.8 (20.5–30.6)	23.4 (19.6–28.7)	23.4 (19.3–29.4)	22.8 (18.3–28.5)	22.2 (15.6–27.2)	20.5 (14.3–22.5)
Mean probing depth in millimeters (range)	2.1 (1–3)	2.2 (1–3.2)	2.2 (1.5–2.5)	2.3 (1.5–3.2)	2.2 (1.5–2.5)	2.4 (2–3)	2.3 (2–3.2)	2.3 (2–3)

Table 3. **Mean (range) crestal bone loss around short and long dental implants placed in patients with type 2 diabetes mellitus (group 1) and non-diabetic controls (group 2) at 18 and 36 months of follow-up**

	18-month follow-up				36-month follow-up			
	Group 1 (n = 45)		Group 2 (n = 42)		Group 1 (n = 45)		Group 2 (n = 42)	
	Short implants	Long implants	Short implants	Long implants	Short implants	Long implants	Short implants	Long implants
No. of implants placed	22	23	24	18	22	23	24	18
Mean crestal bone loss in millimeters (range)	0.25 (0.2–0.3)	0.2 (0–0.4)	0.2 (0–0.4)	0.2 (0–0.4)	0.3 (0.1–0.5)	0.25 (0–0.4)	0.25 (0.2–0.5)	0.3 (0.2–0.5)
Mean mesial crestal bone loss in millimeters (range)	0.1 (0–0.2)	0	0.1 (0–0.2)	0.1 (0–0.3)	0.1 (0–0.2)	0.1 (0–0.3)	0.1 (0–0.3)	0.2 (0–0.5)
Mean distal crestal bone loss in millimeters (range)	0.4 (0.2–0.6)	0.4 (0–0.6)	0.3 (0.2–0.5)	0.3 (0–0.5)	0.5 (0.3–0.8)	0.4 (0–0.5)	0.4 (0.2–0.6)	0.4 (0.2–0.6)

Discussion

In the present study, it was hypothesized that there is no statistically significant difference in peri-implant scores of clinical (PI, BOP, PD) and radiographic (CBL) parameters around short and long implants placed in patients with and without T2DM. The results showed no significant difference in PI, BOP, PD and CBL around short and long implants placed in both groups at 18 and 36 months of follow-up. It is therefore postulated that short as well as long dental implants can osseointegrate and remain functionally stable in systemically healthy and immunocompromised patients, such as those with well-controlled T2DM. Various explanations may be posed to elucidate the presented results. Firstly, it is pertinent to mention that a substantial amount of primary stability (PS) is essential for the osseointegration and success of dental implants. Short and long implants used in the present study had moderately rough surfaces (Calvo-Guirado et al. 2016). It follows the same concept as that applied for the reduction of fractured bones; that is, avoidance of any form of movement to facilitate healing (Perren 2002). According to Butz et al. (Butz et al. 2006), the bone integrated to the rough-surfaced implants is stiffer than bone integrated to machined surfaces. Moreover, studies (Tabassum et al. 2009, 2010) have also reported that implant surface roughness enhances osseointegration and success of dental implants by facilitating the attachment of osteoprogenitor cells to the implant surfaces. Experimental results by Soskolne et al. (Soskolne et al. 2002) showed an increased adherence of monocytes to titanium disks with moderately rough surfaces as compared to plastic surfaces. A recent longitudinal clinical study demonstrated that implant length was not associated with the primary and secondary stability of self-tapping dental implants (Gomez-Polo et al. 2016). Although bone quality and PS at the time of implant insertion remained uninvestigated in the present study, it is hypothesized that both groups exhibited a considerable amount of PS and favorable bone type. Further long-term (5 years of follow-up or longer) clinical trials are warranted to assess the influence of bone quality and PS on the success and survival of short and long implants.

Other factors that could have influenced the present results are (a) the well-controlled glycemic status of patients with T2DM and (b) the strict oral hygiene maintenance protocol that were followed throughout the study period. It has been reported that mechanical debridement of plaque and calculus from teeth surfaces not only minimizes oral soft tissue inflammation, but also helps to reduce glycemic levels in patients with chronic hyperglycemia (Javed et al. 2014a,b Javed et al. 2015; Qadri et al. 2015). In the present study, all participants received a biannual dental prophylaxis in which, they underwent full-mouth scaling. Mechanical plaque and calculus debridement has been reported to reduce the systemic burden of inflammation (by reducing the levels of proinflammatory cytokines such as interleukin-6 and tumor necrosis factor-alpha), which in turn may have contributed to maintaining the glycemic levels in the diabetic population included in the present study (Chen et al. 2012; Artese et al. 2015). It is speculated that in case patients with poorly controlled T2DM were included in the present study, there may have been a significantly higher BOP, PD and CBL around implants in comparison with the results reported in the present investigation.

It is known that habitual tobacco smoking is a significant risk factor for oral soft tissue inflammation and CBL (Javed et al. 2007). Moreover, habitual tobacco smoking has also been reported to jeopardize the outcomes of oral surgical interventions (Javed et al. 2012; Kotsakis et al. 2015). It is therefore possible that habitual tobacco smokers exhibit a significantly higher CBL around implants as compared to non-smokers. It is hypothesized that CBL is significantly higher around short and long implants in smokers as compared to non-smokers. Further clinical trials are needed to test this hypothesis. In the present study, it is shown that all patients with T2DM had a relatively short medical history of T2MD (~4 years). Moreover, a marked reduction in HbA1c levels was noticed at 18 and 36 months of follow-up among patients in group 1. Results from clinical trials (Javed et al. 2014a,b Javed et al. 2016) have shown that non-surgical mechanical plaque debridement plays an essential role in reducing oral soft tissue inflammation as well as chronic hyperglycemia. Results from a systematic review showed that under optimal glycemic control, dental implants can osseointegrate and remain functionally stable over long durations in patients with diabetes in a manner similar to non-diabetic individuals (Javed & Romanos 2009). The outcomes of the present clinical study support the results of this systematic review (Javed & Romanos 2009). However, it is hypothesized that due to a short duration of T2DM and glycemic control, the intensity of oral and systemic burden of inflammation was lesser in the diabetic population investigated. Furthermore, investigations are encouraged to correlate clinical and radiographic peri-implant parameters with the levels of proinflammatory cytokines in such patients.

A limitation of the present study is that all implants replaced a mandibular molar or premolar. The posterior mandible is superior to the maxilla in bone quality and quantity. In the anterior maxilla, the alveolar processes exhibit a thin labial and thick palatal cortical plate as compared to the posterior maxilla which has a thicker buccal plate (Temple et al. 2015). Another zone of the alveolar ridge that is associated with vertical bone deficiency is located at the base of maxillary sinuses. Short implants are more often indicated when a considerable amount of bone loss has taken place, requiring an excessive crown height and leading to poor crown/implant ratio (Malmstrom et al. 2015). Such implant and prosthesis overloading has been described as a concern due to unfavorable biomechanics (Misch et al. 2006). Moreover, all implants were placed in male subjects. It has been reported that hormonal imbalances particularly in females in the post-menopausal phase influences oral soft tissue status and bone density (Scardina & Messina 2012). Therefore, it is hypothesized that there might be a difference in peri-implant soft tissue status and CBL around short and long implants placed in females compared with males. Further long-term (at least 5 years of follow-up) split-mouth randomized controlled clinical trials are needed in this regard. In the present study, the Quo-test kit was used to determine HbA1c levels in the study population. The present results suggest that the Quo-test kit is a reliable tool for the assessment of HbA1c levels. It is important to note that the Quo-kit is a useful point-of-care kit; however, it cannot be used for the diagnostic purposes (Wan Mohd Zin et al. 2013).

Conclusion

Within the limits of the present 36-month follow-up study, it is concluded that short implants can demonstrate clinical and radiographic stability in a manner similar to conventional long implants in patients with and without T2DM. However, in addition to a proper case selection, the contribution of oral hygiene maintenance and glycemic control is mandatory. The evidence from this clinical study supports the use of short implants in controlled diabetic patients and suggests further investigation.

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Conflict of interest and financial disclosure

The authors declare that they have no conflict of interest.

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