Received: 14 November 2018 | Revised: 11 December 2018 | Accepted: 15 December 2018

DOI: 10.1111/cid.12715

WILEY

ORIGINAL ARTICLE

Survival of adjacent-dental-implants in prediabetic and systemically healthy subjects at 5-years follow-up

Mohammed Alrabiah MSD, FRCDC[1] | Ali Alrahlah BDS, PhD[2,3] | Rana Sulaiman Al-Hamdan BDS, MSc[2] | Khulud Abdulrahman Al-Aali BDS, CAGS, DScD[4] | Nawaf Labban BDS, MSD, PhD[1] | Tariq Abduljabbar BDS, MSc, DMSc[1,3]

[1]Department of Prosthetic-Dental-Science, College-of-Dentistry, King-Saud-University, Riyadh, Saudi-Arabia

[2]Department of Restorative-Dental-Science, College-of-Dentistry, King-Saud-University, ArRiyadh, Saudi-Arabia

[3]Eng. Abdullah Bugshan Research Chair for Dental and Oral Rehabilitation, King Saud University, Riyadh, Saudi Arabia

[4]Department of Prosthodontics, College-of-Dentistry, College-of-Dentistry, Princess-Nourah-Bint-Abdulrahman-University, ArRiyadh, Saudi-Arabia

Correspondence
Tariq Abduljabbar, Department of Prosthetic-Dental-Science, College-of-Dentistry, King-Saud-University, PO Box- 60169, Ar-Riyadh 11545, Saudi Arabia
Email: tajabbar@ksu.edu.sa

Abstract

Background: Long-term survival of adjacent dental implants (ADI) in prediabetic patients remained uninvestigated.

Purpose: This 5 years' follow-up clinical study compared the survival of adjacent implants in prediabetic and nondiabetic subjects.

Materials and Methods: Prediabetic (group-A) and nondiabetic (group-B) subjects having undergone dental rehabilitation using ADI were assessed. Data about sex, age treatment and period (in years) since diagnosis of prediabetes, and family history of diabetes was gathered and haemoglobin A1c (HbA1c) levels were recorded. Dental implant related data (dimensions, loading protocol, surface characteristics, restoration type, and duration in function) was recorded. Depth of probing (PD), bleeding-on-probing (BOP), and plaque index (PI) were measured and mesial and distal crestal bone loss (CBL) were recorded. *P* values less than .05 were contemplated as statistically-significant.

Results: Seventy-nine male individuals (39 in group-A and 40 in group-B) were included. Subjects in groups -A and -B were 54.3 ± 3.6 and 51.2 ± 2.4 years old, respectively. In group-A, subjects were diagnosed with prediabetes 5.4 ± 0.2 years ago. Patients in group-A more often had a family history of diabetes than group-B. Thirty-nine and 40 ADI were placed in patients in groups -A and -B, respectively. Tooth-brushing once daily was reported by 79.5% and 82.5% individuals in groups -A and -B, respectively. Peri-implant PI ($P<.001$), BOP ($P<.001$), PD ($P<.001$), mesial ($P<.001$), and distal ($P<.001$) CBL and HbA1c levels ($P<.001$) were higher in group-A than group-B. The implant survival rate in group-A and group-B was 100% and 100%, respectively.

Conclusion: Although ADI can survive in prediabetic patients in the long-term; soft-tissue inflammation and CBL are worse around adjacent implants in these patients compared with non-diabetic controls.

KEYWORDS

alveolar bone loss, prediabetes, dental implant, gingival bleeding, probing depth

1 | INTRODUCTION

Long-term implant survival is associated with factors such as (1) primary stability;[1,2] (2) oral hygiene maintenance;[3] and (3) prevention of tissue inflammation and maintenance of alveolar bone height around the implant.[3,4] Crestal bone loss (CBL) of 2 mm within the first year of implant placement tailed by a CBL of 0.2 mm every year is acceptable.[5–7] Arches with missing adjacent dentition are often restored using nonsplinted dental implants;[8] however, a complication in such cases is formation of an inter-proximal "black-triangle" in the space between the implant-supported restorations.[9]

Chronic hyperglycemia (CH) is a risk-factor for peri-implant diseases (peri-implantitis and peri-implant mucositis), which is often seen among subjects with impaired-glucose-tolerance.[10–14] Prediabetes is characterized by impaired-fasting-glucose of 100 to 125 mg/dL.[15] A state of CH is associated with deposition of advanced-glycation-endproducts (AGEs) in tissues, including the periodontium.[14] Once AGEs interact with their specific receptors, proinflammatory cytokines such as interleukin (IL)-1β and

tumor-necrosis-factor-α (TNF-α) are produced that accumulate in the blood and gingival crevicular fluid (GCF).[14–17] These proinflammatory cytokines worsen periodontal inflammation, which may lead to alveolar bone loss around dentition and implants.[18,19] Long-term follow-up studies assessing the survival of adjacent dental implants (ADI) in prediabetic subjects are not yet reported. We therefore hypothesize that inflammatory parameters (depth of probing [PD], plaque index [PI], and bleeding-on-probing [BOP]) and mesial and distal CBL are higher around ADI placed in prediabetic subjects as compared to systemically healthy individuals (controls).

This 5 years' follow-up clinical study compared the survival of ADI in prediabetic and nondiabetic subjects.

2 | MATERIALS AND METHODS

2.1 | Ethical guidelines

The present study was performed following guidelines recognized by the Declaration of Helsinki as revised in 2013 for experimentation involving human patients. All volunteering individuals were requested to read and sign a consent form. All participants reserved the right to withdraw at any phase without penalty.

2.2 | Study strategy and subjects

The present cross-sectional observational clinical study was performed at the Specialist-Dental-Practice, ArRiyadh, Saudi-Arabia.

2.3 | Eligibility criteria

Patients with prediabetes (group-A), systemically healthy individuals (group-2), and patients having undergone dental rehabilitation using ADI were included. Exclusion criteria were: (1) individuals using nicotine products; (2) subjects habitually consuming alcohol; (3) nondiabetic subjects with self-reported systemic diseases such as hepatic and renal disorders, acquired immune deficiency syndrome (AIDS), HIV-positive individuals, and patients with cardiac, patients that reported had used steroids and/or nonsteroidal antiinflammatory medications, antibiotics, probiotics, and bisphosphonates within the past 8-weeks and patients that had previously undergone treatment of periodontal diseases.

2.4 | Questionnaire

A structured questionnaire written in Arabic and English was used to gather sociodemographic information including age, sex, duration of prediabetic state, diagnosis of diabetes in relatives, treatment strategy for the management of prediabetic state and daily tooth-brushing and flossing. The questionnaire was presented by a trained researcher (TA).

2.5 | Characteristics of ADI

With reference to implant related characteristics, the following data was collected by one trained investigator (TA): (1) protocol adopted for implant placement (early implant placement in extraction sites); (2) diameter and length of implants; (3) implant-geometry; (4) implant surface features (roughness); (5) implant loading (immediate or delayed); (6) prosthetic fixation protocol (screw- versus cement-retained); (7) jaw location; and (8) period for which, the ADI were in function.

2.6 | Peri-implant clinical and radiological statuses

One investigator (TA) (*kappa* 0.87) performed the clinical and radiographic examinations. During the clinical evaluation, PI,[20] BOP,[20] and PD[20] were measured at mid-lingual/mid-palatal, disto-palatal/disto-lingual, disto-buccal, mesio-lingual/mesio-palatal mesio-buccal, and mid-buccal sites around all ADI in both jaws. Peri-implant PD was gauged using a graded-probe (Hu-Friedy, Illinois). One author (TA; *kappa* 0.85) measured the distal and mesial CBL digital bitewing radiographs (Kodak, Ektaspeed plus, New York). Linear distance from a reference point at the edge of the platform of implant to the bone crest was gauged mesially and distally using a software (Scion Image, Fredrick, Scion Corp, Maryland).[21]

2.7 | Haemoglobin A1c

A haemoglobin A1c (HbA1c) measuring equipment (Clover A1c Self Analyzer, Infopia Co, Kyunggi, Korea) was used by one trained investigator (KAA) to determine the glycemic status of subjects in both groups.

2.8 | Statistical analysis

Statistical analysis was done using the S.P.S.S., Ver. 18, Chicago, Illinois, software. The one-way analysis of variance and Kruskal-Wallis tests were used to compare peri-implant PD, PI, BOP, and distal and mesial CBL in subjects in group-A and group-B. Means and standard were reported for age and duration of prediabetes; Glycemic (HbA1c) levels were presented as mean and range. Sample-size estimation was performed using a software (Statistical-Solutions, nQuery-Advisor, Saugas, Massachusetts). It was estimated that inclusion of at least 38 patients per group would give a power of 89%. *P* values less than .05 were contemplated as statistically-significant.

3 | RESULTS

3.1 | Characteristics of study groups

Seventy-nine male subjects (39 in group-A and 40 in group-B) were included. The mean age (in years) of individuals in group-A and group-B were 54.3 ± 3.6 and 51.2 ± 2.4 years, correspondingly. Mean HbA1c levels in group-A (6.1% [5.9-6.3%]) were significantly higher than group-B (4.1% [4-4.8%]) (*P*<.001). In group-A, the mean duration of prediabetes was 5.4 ± 0.2 years. Subjects in group-A (53.8%) more often had a family history of diabetes than group-B (22.5%). In group-A and group-B, 79.5% and 82.5% subjects, respectively brushed their teeth once a day (Table 1).

3.2 | Implant related parameters

Thirty-nine (78 implants in total) and 40 (80 implants in total) pairs of platform-switched adjacent delayed-loaded implants with moderately

TABLE 1 Demographics of individuals in groups 1 and 2

Parameters	Group-A	Group-B
Number of participants (*n*)	39	40
Gender (male)	39	40
Age in years (mean ± SD)	54.3 ± 3.6 years	51.2 ± 2.4 years
Duration of prediabetes in years	5.4 ± 0.2 years	Not applicable
Family history of diabetes (*n*, %)	21, 53.8%	9, 22.5%
Hemoglobin A1c (%) (mean [range])	(6.1% [5.9-6.3%])*	(4.1% [4-4.8%])
Twice daily tooth-brushing (%)	31, 79.5%	33, 82.5%

*Compared with group-2 (*P*<.01).

rough surfaces were placed at bone-level among patients in groups -A and -B, respectively. Screw-retained and nonsplinted restorations were used in the areas of missing premolar and molar teeth in the upper and lower jaws. In groups -A and -B, the ADI were in function since 5.5 ± 0.3 and 5.7 ± 0.5 years, respectively. In both groups, distance between the ADI was 3 mm. Lengths and diameters of the ADI ranged between 4.1to 4.8 mm and 11 to 13 mm, correspondingly (Table 2).

3.3 | Clinical and radiological inflammatory parameters

The PI (*P*<.001), BOP (*P*<.001), PD (*P*<.001); and distal (*P*<.001) and mesial (*P*<.001) CBL at 5-years' follow-up were higher in group-A than group-B (Table 3). In groups -A and -B, there was no difference in clinical and radiological parameters around ADI in relation to jaw location (Figures 1 and 2). The implant survival rate in group-A and group-B was 100% and 100%, respectively.

4 | DISCUSSION

The results of the present study support the proposed hypothesis since PD, BOP, PI, and CBL were amplified around implants in prediabetic patients (group-A) than controls (group-B). Our results showed that HbA1c levels at nearly 5-years' after implant therapy were nearly 1.5 times elevated in group-A than group-B. It is well-reported that persistent hyperglycemia induces oxidative stress in tissues by increasing the formation and accumulation of AGEs.[14–17] Moreover, interactions between these endproducts and their receptors enhances the expression of proinflammatory cytokines including TNF-α, IL-1β, and IL-6 in the bodily fluids including serum and GCF.[14–17] Accumulation of such proinflammatory cytokines in the GCF and peri-implant sulcular fluids increases inflammation in the periodontal and peri-implant tissues, correspondingly;[18,19,22,23] and may ultimately lead to loss of supporting bone around natural teeth and dental implants.[18,19,23] Nevertheless, when glycemic levels are strictly maintained (by medications and/or dietary control), dental implants can osseointegrate and remain functionally stable in diabetic subjects in a way comparable with systemically healthy individuals.[24,25] There is abundant evidence in indexed literature that has shown that implants can demonstrate survival rates of 100% among patients with well-controlled diabetes.[25–28] It is therefore recommended that hyperglycemic patients, such as those with prediabetes and diabetes mellitus undergoing dental implant therapy should be encouraged to regularly monitor and maintain glycemic levels within normal ranges. This may help attain long-term stability of dental implants and improved overall health status in these individuals.

Studies[29,30] have reported that the method used for fixation of prosthesis (screw-retained [SR] or cement-retained [CR]) following

TABLE 3 Peri-implant soft tissue status and crestal bone levels in groups 1 and 2

Peri-implant parameters	Group-A	Group-B
Plaque index (% of sites)	46.7 ± 4.4	24.4 ± 4.7
Bleeding on probing (% of sites)	48.2 ± 3.7	22.6 ± 2.4
Probing depth (in mm)	4.6 ± 0.2 mm	2.2 ± 0.3 mm
Crestal bone loss		
Mesial (in mm)	5.2 ± 0.4 mm	2.3 ± 0.1 mm
Distal (in mm)	5.3 ± 0.2 mm	2.3 ± 0.1 mm

Data are presented as mean ± standard deviation.

TABLE 2 Dental-implant related characteristics of the study participants

Parameters	Group-A	Group-B
Number of individuals	39	40
Total number of adjacent implants	78 implants (39 pairs)	80 implants (40 pairs)
Maxilla*	32 implants (16 pairs)	38 implants (19 pairs)
Mandible*	46 implants (23 pairs)	42 implants (21 pairs)
Depth of placement	BL	BL
Implant design	PS with moderately rough surfaces	PS with moderately rough surfaces
Implant length and diameter (range in mm)	11-13 mm and 4.1-4.8 mm	11-13 mm and 4.1-4.8 mm
Implant loading after placement	3.9 ± 0.3 months	3.4 ± 0.2 months
Type of restoration	SR	SR
Inter-implant distance	3 mm	3 mm
Duration of adjacent implants in function	5.5 ± 0.3 years	5.7 ± 0.5 years

BL = bone-level; mm = millimeters; PS = platform-switched; SR = screw-retained.
*All adjacent implants were placed in the area of missing premolars or molars.

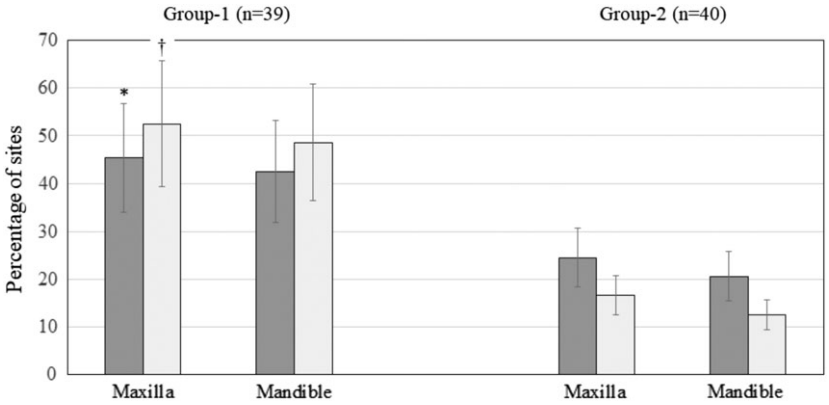

FIGURE 1 Plaque index (dark grey bars) and bleeding on probing (white bars) around adjacent dental implants (ADI) placed in the maxilla and mandible of individuals in groups -A and -B. Data is presented as mean ± 2 standard deviations. *Compared with plaque index around ADI placed in the maxilla of individuals in group-B (P<.001); †Compared with bleeding on probing around ADI placed in the maxilla of individuals in group-B (P<.001); ‡Compared with plaque index around ADI placed in the mandible of individuals in group-B (P<.001); §Compared with bleeding on probing around ADI placed in the mandible of individuals in group-B (P<.001)

implant placement influences implant survival. Although screw- and CR implant restorations have been used in implant-retained restorations, neither methodology is shown to be advantageous over the other.[30,31] Nevertheless, a disadvantage associated with CR restorations is the risk of cement stagnation in the peri-implant sulcular space that may incite inflammatory conditions such as peri-implant mucositis.[32] Since SR-restorations were used in all groups in the present study, there was no risk of cement stagnation in the peri-implant tissues. This factor may have contributed towards the 100% implant survival in both groups.

Bone density and quality differs between the maxilla and mandible due to the presence of sinuses in posterior upper jaw.[33] The Ozgur study[33] showed higher peri-implant CBL in posterior maxilla in comparison to dental implants placed in the mandibular arch. The current results showed no difference in peri-implant CBL in either jaw in groups -A and -B. With reference to group-A, there is a likelihood that the state of persistent hyperglycemia compromised the alveolar bone height in both jaws. Regarding individuals in group-B, it seems that the overall oral hygiene status and systemic health minimized CBL in both arches. It is hypothesized that routine oral hygiene care in conjunction with glycemic control may help minimize CBL in both jaws among prediabetic patients. Further studies are needed to test this hypothesis.

Although strict inclusion and exclusion criteria were adopted, there are some limitations of the present study. Firstly, tobacco-product users (such as smokers and individuals chewing smokeless-tobacco) and subjects with systemic diseases such as renal and hepatic disease, AIDS, and CVD were not sought. According to Kanjevac et al.[34] complications in bone mineral metabolism are occasionally in patients with kidney diseases compared with individuals without kidney-related disorders. Likewise, CBL around dental implants has been reported among tobacco-smokers and patients with AIDS, CVD, and liver diseases compared with healthy nonsmoking controls.[35–37] We therefore speculate that tissue inflammation and CBL are significantly higher around ADI placed in immunocompromised patients and tobacco-smokers compared with systemically healthy never-smokers. Furthermore, all participants were male. It is speculated that hormonal

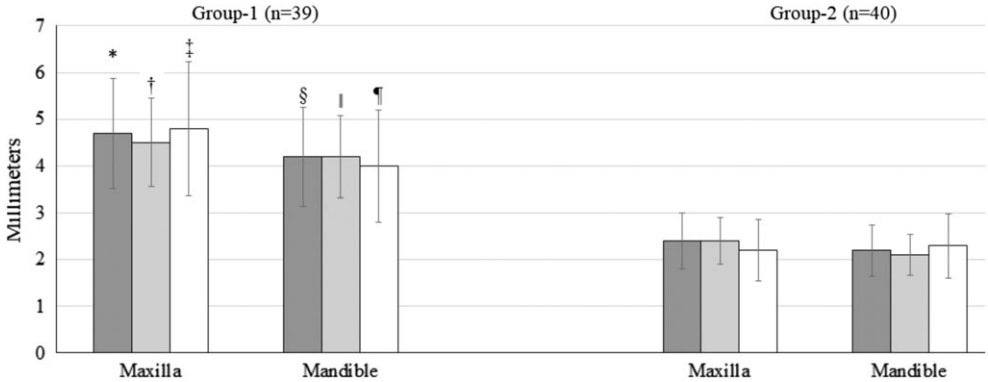

FIGURE 2 Probing depth (dark grey bars), mesial crestal bone loss (CBL; light grey bars) and distal CBL (white bars) around adjacent dental implants (ADI) placed in the maxilla and mandible of individuals in groups -A and -B. Data is presented as mean ± 2 standard deviations. *Compared with probing depth around ADI placed in the maxilla of individuals in group-B (P<.001); †Compared with mesial CBL around ADI placed in the maxilla of individuals in group-B (P<.001); ‡Compared with distal CBL around ADI placed in the maxilla of individuals in group-B (P<.001); §Compared with probing depth around ADI placed in the mandible of individuals in group-B; (P<.001) ‖Compared with mesial CBL around ADI placed in the mandible of individuals in group-B (P<.001); ¶Compared with distal CBL around ADI placed in the maxillae of individuals in group-B (P<0.001)

alterations in females may affect the oral soft and hard tissue status around ADI. Further research is required to assess these hypotheses.

5 | CONCLUSION

Although ADI can survive in prediabetic patients in the long-term; peri-implant tissue inflammation and CBL are worse around ADI in these patients compared with nondiabetic controls.

ACKNOWLEDGMENT

The authors are grateful to the Deanship of Scientific Research, King Saud University for funding through Vice Deanship of Scientific Research Chairs, Engr. Abdullah Bugshan research chair for Dental and Oral Rehabilitation.

ORCID

Mohammed Alrabiah https://orcid.org/0000-0003-0665-3734
Nawaf Labban https://orcid.org/0000-0002-2587-325X
Tariq Abduljabbar https://orcid.org/0000-0001-7266-5886

REFERENCES

1. Javed F, Romanos GE. The role of primary stability for successful immediate loading of dental implants. A literature review. *J Dent*. 2010;38(8):612-620.
2. Javed F, Ahmed HB, Crespi R, Romanos GE. Role of primary stability for successful osseointegration of dental implants: Factors of influence and evaluation. *Interv Med Appl Sci*. 2013;5(4):162-167.
3. Schmidt KE, Auschill TM, Sculean A, Arweiler NB. Clinical evaluation of non-surgical cleaning modalities on titanium dental implants during maintenance care: a 1-year follow-up on prosthodontic superstructures. *Clin Oral Investig*. 2018. https://doi.org/10.1007/s00784-018-2640-6.
4. Wallner G, Rieder D, Wichmann MG, Heckmann SM. Peri-implant bone loss of tissue-level and bone-level implants in the esthetic zone with gingival biotype analysis. *Int J Oral Maxillofac Implants*. 2018;33(5):1119-1125.
5. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants*. 1986;1(1):11-25.
6. Albrektsson T, Buser D, Sennerby L. On crestal/marginal bone loss around dental implants. *Int J Oral Maxillofac Implants*. 2012;27(4):736-738.
7. Albrektsson T, Buser D, Sennerby L. On crestal/marginal bone loss around dental implants. *Int J Prosthodont*. 2012;25(4):320-322.
8. Vigolo P, Mutinelli S, Zaccaria M, Stellini E. Clinical evaluation of marginal bone level change around multiple adjacent implants restored with splinted and nonsplinted restorations: a 10-year randomized controlled trial. *Int J Oral Maxillofac Implants*. 2015;30(2):411-418.
9. Kois JC. Predictable single-tooth peri-implant esthetics: five diagnostic keys. *Compend Contin Educ Dent*. 2004;25(11):895-896. 898, 900 passim; quiz 906-897.
10. Al Amri MD, Abduljabbar TS, Al-Kheraif AA, Romanos GE, Javed F. Comparison of clinical and radiographic status around dental implants placed in patients with and without prediabetes: 1-year follow-up outcomes. *Clin Oral Implants Res*. 2017;28(2):231-235.
11. Abduljabbar T, Al-Sahaly F, Al-Kathami M, Afzal S, Vohra F. Comparison of periodontal and peri-implant inflammatory parameters among patients with prediabetes, type 2 diabetes mellitus and non-diabetic controls. *Acta Odontol Scand*. 2017;75(5):319-324.
12. Abduljabbar T, Javed F, Malignaggi VR, Vohra F, Kellesarian SV. Influence of implant location in patients with and without type 2 diabetes mellitus: 2-year follow-up. *Int J Oral Maxillofac Surg*. 2017;46(9):1188-1192.
13. Alaskar M, Ajlan S, Alomar N, Al-Daghri NM. Clinical and radiographic peri-implant parameters and whole salivary interleukin-1 beta and interleukin-6 levels among type-2 diabetic and non-diabetic patients with and without peri-implantitis. *Med Princ Pract*. 2018;27(2):133-138.
14. Al-Sowygh ZH, Ghani SMA, Sergis K, Vohra F, Akram Z. Peri-implant conditions and levels of advanced glycation end products among patients with different glycemic control. *Clin Implant Dent Relat Res*. 2018;20(3):345-351.
15. Duarte PM, Miranda TS, Lima JA, et al. Expression of immune-inflammatory markers in sites of chronic periodontitis in patients with type 2 diabetes. *J Periodontol*. 2012;83(4):426-434.
16. Singhal S, Pradeep AR, Kanoriya D, Garg V. Human soluble receptor for advanced glycation end products and tumor necrosis factor-alpha as gingival crevicular fluid and serum markers of inflammation in chronic periodontitis and type 2 diabetes. *J Oral Sci*. 2016;58(4):547-553.
17. Takeda M, Ojima M, Yoshioka H, et al. Relationship of serum advanced glycation end products with deterioration of periodontitis in type 2 diabetes patients. *J Periodontol*. 2006;77(1):15-20.
18. Abduljabbar T, Al-Sahaly F, Kellesarian SV, et al. Comparison of peri-implant clinical and radiographic inflammatory parameters and whole salivary destructive inflammatory cytokine profile among obese and non-obese men. *Cytokine*. 2016;88:51-56.
19. Dogan SB, Kurtis MB, Tuter G, Serdar M, Watanabe K, Karakis S. Evaluation of clinical parameters and levels of proinflammatory cytokines in the crevicular fluid around dental implants in patients with type 2 diabetes mellitus. *Int J Oral Maxillofac Implants*. 2015;30(5):1119-1127.
20. Javed F, Al-Kheraif AA, Rahman I, et al. Comparison of clinical and radiographic periodontal status between habitual water-pipe smokers and cigarette smokers. *J Periodontol*. 2016;87(2):142-147.
21. Javed F, Nasstrom K, Benchimol D, Altamash M, Klinge B, Engstrom PE. Comparison of periodontal and socioeconomic status between subjects with type 2 diabetes mellitus and non-diabetic controls. *J Periodontol*. 2007;78(11):2112-2119.
22. Abduljabbar T, Akram Z, Vohra F, Warnakulasuriya S, Javed F. Assessment of interleukin-1beta, interleukin-6, and tumor necrosis factor-alpha levels in the peri-implant sulcular fluid among waterpipe (narghile) smokers and never-smokers with peri-implantitis. *Clin Implant Dent Relat Res*. 2018;20(2):144-150.
23. Javed F, Al-Daghri NM, Wang HL, Wang CY, Al-Hezaimi K. Short-term effects of non-surgical periodontal treatment on the gingival crevicular fluid cytokine profiles in sites with induced periodontal defects: a study on dogs with and without streptozotocin-induced diabetes. *J Periodontol*. 2014;85(11):1589-1595.
24. Rocha M, Nava LE, Vazquez de la Torre C, Sanchez-Marin F, Garay-Sevilla ME, Malacara JM. Clinical and radiological improvement of periodontal disease in patients with type 2 diabetes mellitus treated with alendronate: a randomized, placebo-controlled trial. *J Periodontol*. 2001;72(2):204-209.
25. Javed F, Romanos GE. Impact of diabetes mellitus and glycemic control on the osseointegration of dental implants: a systematic literature review. *J Periodontol*. 2009;80(11):1719-1730.
26. Agrawal KK, Rao J, Anwar M, Singh K, Himanshu D. Flapless vs flapped implant insertion in patients with controlled type 2 diabetes subjected to delayed loading: 1-year follow-up results from a randomised controlled trial. *Eur J Oral Implantol*. 2017;10(4):403-413.
27. Al Amri MD, Kellesarian SV, Al-Kheraif AA, Malmstrom H, Javed F, Romanos GE. Effect of oral hygiene maintenance on HbA1c levels and peri-implant parameters around immediately-loaded dental implants placed in type-2 diabetic patients: 2 years follow-up. *Clin Oral Implants Res*. 2016;27(11):1439-1443.
28. Al Amri MD, Abduljabbar TS, Al-Johany SS, Al Rifaiy MQ, Alfarraj Aldosari AM, Al-Kheraif AA. 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. *Clin Oral Implants Res*. 2017;28(10):1182-1187.
29. Al Amri MD. Management of a fractured multiunit maxillary implant-supported fixed prosthesis with stripped abutment screws using a hybrid cement-retained and screw-retained design: a 5-year follow-up clinical report. *J Prosthodont*. 2015. https://doi.org/10.1111/jopr.12433.

30. Crespi R, Cappare P, Gastaldi G, Gherlone EF. Immediate occlusal loading of full-arch rehabilitations: screw-retained versus cement-retained prosthesis. An 8-year clinical evaluation. *Int J Oral Maxillofac Implants*. 2014;29(6):1406-1411.
31. Vigolo P, Givani A, Majzoub Z, Cordioli G. Cemented versus screw-retained implant-supported single-tooth crowns: a 4-year prospective clinical study. *Int J Oral Maxillofac Implants*. 2004;19(2):260-265.
32. Korsch M, Walther W, Bartols A. Cement-associated peri-implant mucositis. A 1-year follow-up after excess cement removal on the peri-implant tissue of dental implants. *Clin Implant Dent Relat Res*. 2017;19(3):523-529.
33. Ozgur GO, Kazancioglu HO, Demirtas N, Deger S, Ak G. Risk factors associated with implant marginal bone loss: A retrospective 6-year follow-up study. *Implant Dent*. 2016;25(1):122-127.
34. Kanjevac T, Bijelic B, Brajkovic D, Vasovic M, Stolic R. Impact of chronic kidney disease mineral and bone disorder on jaw and alveolar bone metabolism: a narrative review. *Oral Health Prev Dent*. 2018;16(1):79-85.
35. May MC, Andrews PN, Daher S, Reebye UN. Prospective cohort study of dental implant success rate in patients with AIDS. *Int J Implant Dent*. 2016;2(1):20.
36. Yoon DL, Kim YG, Cho JH, Lee SK, Lee JM. Long-term evaluation of teeth and implants during the periodic maintenance in patients with viral liver disease. *J Adv Prosthodont*. 2016;8(4):321-328.
37. Ting M, Craig J, Balkin BE, Suzuki JB. Peri-implantitis: a comprehensive overview of systematic reviews. *J Oral Implantol*. 2018;44(3):225-247.

How to cite this article: Alrabiah M, Alrahlah A, Al-Hamdan RS, Al-Aali KA, Labban N, Abduljabbar T. Survival of adjacent-dental-implants in prediabetic and systemically healthy subjects at 5-years follow-up. *Clin Implant Dent Relat Res*. 2019;1–6. https://doi.org/10.1111/cid.12715