ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 7317-7322 (2026)
©Biomedical Informatics (2026)

BIOINFORMATION
Discovery at the interface of physical and biological sciences
BIOMEDICAL INFORMATICS
www.bioinformation.net
Volume 22(10)
Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026
DOI: 10.6026/973206300227317

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Declaration on Publication Ethics:
The author's state that they adhere with COPE guidelines on publishing ethics as described elsewhere at https://publicationethics.org/. The authors also undertake that they are not associated with any other third party (governmental or non-governmental agencies) linking with any form of unethical issues connecting to this publication. The authors also declare that they are not withholding any information that is misleading to the publisher in regard to this article.

Declaration on official E-mail:
The corresponding author declares that lifetime official e-mail from their institution is not available for all authors

License statement:
This is an Open Access article which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. This is distributed under the terms of the Creative Commons Attribution License

Comments from readers:
Articles published in BIOINFORMATION are open for relevant post publication comments and criticisms, which will be published immediately linking to the original article without open access charges. Comments should be concise, coherent and critical in less than 1000 words.

Disclaimer:
Bioinformation provides a platform for scholarly communication of data and information to create knowledge in the Biological/ Biomedical domain after adequate peer/editorial reviews and editing entertaining revisions where required. The views and opinions expressed are those of the author(s) and do not reflect the views or opinions of Bioinformation and (or) its publisher Biomedical Informatics. Biomedical Informatics remains neutral and allows authors to specify their address and affiliation details including territory where required.

Edited by Ashwini Dhopte
E-mail: ashwinidhopte@gmail.com
Citation: Yogesh *et al.* Bioinformation 22(10): 7317-7322 (2026)

Evaluating success rate of implants in patients with controlled Diabetes mellitus: A prospective comparative clinical study

Anjana Yogesh[1,*], Pankaj Prakash[2], Divya Vyas[3], Amit Kumar[4], J. Kumari Rathna[5], N. Vatsala[6] & Bhumika Kamal Badiyani[4]

[1]Department of Periodontics, KGF College of Dental Sciences, Kolar Gold Fields, Karnataka, India; [2]Department of Dentistry, Dental Clinic, Air Force Station Darbhanga, Darbhanga, Bihar, India; [3]Department of Pediatric and Preventive Dentistry, MM College of Dental Sciences and Research, Maharishi Markandeshwar, Mullana, Ambala, Haryana, India; [4]Department of Public Health Dentistry, Mumbai, Maharashtra, India; [5]Department of Oral and Maxillofacial Surgery, KGF College of Dental Sciences, Kolar Gold Fields, Karnataka, India; [6]Department of Pediatric and Preventive Dentistry, KGF College of Dental Sciences, Kolar Gold Fields, Karnataka, India; *Corresponding author

ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 7317-7322 (2026)
©Biomedical Informatics (2026)

Affiliation URL:
https://www.kgfdental.com/

Author contact:
Anjana Yogesh - E-mail: anjuyogesh06@gmail.com
Pankaj Prakash - E-mail: pankajbhindwar@gmail.com
Divya Vyas - E-mail: divya.vyas@mmumullana.org
Amit Kumar - E-mail: dramitkumar05@gmail.com
J. Kumari Rathna - E-mail: drrathna2010@gmail.com
N. Vatsala – E-mail: drvatsbds@gmail.com
Bhumika Kamal Badiyani - E-mail: dr.bhumikab@gmail.com

Abstract:
Dental implant therapy in patients with diabetes remains clinically challenging because hyperglycemia can alter bone healing, osseointegration and peri-implant inflammatory responses even when systemic disease is considered controlled. This prospective comparative study evaluated 120 adults receiving a single posterior implant, including 60 participants with controlled type 2 diabetes mellitus (HbA1c 6.5–8.0%) and 60 metabolically healthy controls, with standardized placement and 12-month follow-up. At 12 months, implant survival was 98.3% in the controlled-diabetes group and 100% in controls, while strict implant success was 95.0% and 98.3%, respectively; the between-group differences were not statistically significant ($p>0.05$). Controlled-diabetes participants showed a modestly greater mean marginal bone loss (0.71±0.29 mm vs 0.56±0.24 mm, $p=0.003$) and slightly higher bleeding on probing, but implant stability remained high and no clinically important difference was detected in probing depth or suppuration. Thus, carefully selected patients with controlled type 2 diabetes achieved high implant survival and success, although closer peri-implant maintenance is justified because early crestal bone and inflammatory changes may be greater than in non-diabetic individuals.

Keywords: Dental implants, type 2 diabetes mellitus, HbA1c, implant survival, osseointegration, marginal bone loss

Background:
Dental implants have become a predictable method for restoring partial edentulism, yet systemic conditions capable of modifying immune function and bone metabolism remain important when estimating treatment risk. Diabetes mellitus is particularly relevant because chronic hyperglycemia can impair microvascular perfusion, alter collagen turnover, increase advanced glycation end products, disturb osteoblast function and intensify inflammatory responses. These mechanisms have historically raised concern that implant osseointegration may be delayed or less reliable in diabetic patients. Clinical evidence, however, increasingly indicates that metabolic control is more informative than the diagnosis of diabetes alone when implant therapy is planned **[1]**. Osseointegration is a dynamic healing process in which primary mechanical stability is gradually replaced by secondary biologic stability. Glycemic status can influence this transition. Prospective resonance-frequency observations have shown that patients with higher glycated hemoglobin values can experience a larger early decline in implant stability and a slower return to baseline stability, suggesting a delay rather than an inevitable failure of integration **[2]**. This distinction is clinically important because a patient may ultimately retain a functioning implant despite a slower early healing trajectory. The interpretation of implant outcomes in diabetes has also evolved as researchers have separated survival from success. Survival simply indicates that an implant remains in function, whereas success additionally requires an absence of persistent pain, mobility, peri-implant infection, progressive radiolucency and excessive marginal bone loss. Reviews of the available clinical evidence have emphasized that studies using only implant loss may underestimate more subtle biologic effects of glycemic control on peri-implant tissues **[3]**. Consequently, evaluation of both mechanical and biologic outcomes is necessary when judging treatment predictability. Aggregated evidence has reported conflicting estimates of risk. Some systematic assessments have found a higher probability of implant failure in individuals with diabetes, whereas others have found little or no difference when glycemic control, implant design, loading protocol, smoking and maintenance are considered **[4]**. A recurring observation is that poorly controlled disease is associated with more adverse healing and peri-implant inflammatory findings, while well-controlled patients often approach the results obtained in individuals without diabetes. Contemporary reviews therefore no longer regard controlled diabetes as an absolute contraindication to implant placement. Instead, they recommend individualized risk assessment based on HbA1c, duration of disease, complications, oral hygiene, periodontal history, smoking exposure and the ability to attend maintenance visits. When diabetes is adequately controlled and infection prevention is rigorous, implant treatment is generally considered feasible and clinically predictable **[5]**. Marginal bone behavior remains a particular concern. Even when implant survival is comparable, pooled analyses have suggested that patients with diabetes may exhibit slightly greater peri-implant marginal bone loss than metabolically healthy controls **[6]**. Such differences may not lead

to early failure, but they may signal a biologic environment that requires more intensive plaque control and long-term monitoring. Recent syntheses continue to support high survival in controlled diabetes while emphasizing that outcome reporting is heterogeneous and follow-up is often limited. The literature also indicates that the threshold defining "controlled" diabetes varies among studies, making direct comparisons difficult **[7]**. Meta-analytic evidence further suggests that diabetes may increase implant failure risk at the population level, particularly when poor control and other risk factors are included, but this effect is not uniform across clinical settings **[8]**. Therefore, it is of interest to evaluate the success rate of implants in patients with controlled diabetes mellitus using simultaneous survival, stability, bone and soft-tissue outcomes.

Materials and Methods:

This prospective comparative clinical study was designed as a parallel-group investigation conducted in the Department of Periodontology and Implant Dentistry of a tertiary dental teaching center. Recruitment was planned over 18 months, with each participant observed for 12 months after functional loading. A priori sample-size estimation was based on detecting an anticipated 10% difference in strict implant success between groups with 80% power and a two-sided alpha of 0.05, while allowing for approximately 10% attrition. A minimum of 54 participants per group was estimated; 60 participants were therefore allocated to each cohort. To avoid within-patient clustering, only one study implant per participant was included in the primary analysis, yielding 120 participants and 120 implants. Adults aged 35–70 years requiring a single implant-supported crown in a healed posterior mandibular or maxillary site were eligible. The controlled-diabetes group required a confirmed diagnosis of type 2 diabetes for at least one year, HbA1c from 6.5% to 8.0% measured within four weeks before surgery, stable antidiabetic therapy for at least three months and no acute diabetic complication. Controls required no history of diabetes and an HbA1c below 5.7%. Both groups required adequate keratinized tissue, sufficient native bone for implant placement without simultaneous major augmentation, full-mouth plaque score below 20% and treated or absent active periodontitis. Exclusion criteria were type 1 diabetes, HbA1c above 8.0%, pregnancy, current smoking or tobacco use, untreated periodontitis, uncontrolled hypertension, immunosuppressive therapy, head-and-neck radiotherapy, antiresorptive medication associated with jaw osteonecrosis risk, severe renal or hepatic disease, parafunctional loading that could not be controlled, acute infection at the implant site and a need for simultaneous sinus augmentation or extensive guided bone regeneration. All implants were placed by one experienced operator using a standardized two-stage protocol. After local anesthesia, a mid-crestal incision and minimal full-thickness flap were used. Bone preparation followed the manufacturer's drilling sequence under copious sterile saline irrigation. A bone-level, moderately rough titanium implant 3.5–4.5 mm in diameter and 8–12 mm in length was placed with a target insertion torque of at least 30 Ncm. Perioperative antibiotics were prescribed according to institutional policy and 0.12% chlorhexidine mouthrinse was advised twice daily for one week. Sutures were removed after 7–10 days. Implant stability was recorded using resonance frequency analysis as the implant stability quotient (ISQ) immediately after insertion, at 8 weeks and at loading. Prosthetic loading was performed after approximately 12 weeks in the mandible and 16 weeks in the maxilla when clinical healing was satisfactory and ISQ was at least 65. Each implant received a screw-retained or cement-retained single crown with mutually protected occlusion and elimination of premature contacts. Patients entered an individualized maintenance program at three-month intervals. The primary outcome was implant success at 12 months after loading. Success required implant survival in function, no persistent pain or suppuration, no detectable mobility, no continuous peri-implant radiolucency, probing depth without progressive pathologic increase and marginal bone loss not exceeding 1.5 mm from the loading baseline. Implant survival was defined as the implant remaining in situ and supporting the restoration regardless of minor complications. Secondary outcomes included marginal bone loss, ISQ, probing depth, bleeding on probing, plaque index, peri-implant mucositis and biologic or mechanical complications. Standardized digital periapical radiographs were obtained using a paralleling technique and individualized positioning index at prosthetic loading and 12 months. Mesial and distal crestal bone levels were measured from the implant platform to the first bone-to-implant contact and averaged. Calibration was performed using the known implant length. A blinded examiner repeated measurements in 20 randomly selected radiographs after two weeks; an intraclass correlation coefficient of at least 0.90 was considered acceptable. Data were analyzed with a contemporary statistical package. Continuous variables were checked for normality and summarized as mean±standard deviation or median with interquartile range. Independent-samples t tests or Mann–Whitney U tests were used for continuous group comparisons, while chi-square or Fisher exact tests were used for categorical outcomes. Repeated ISQ measurements were evaluated using mixed or repeated-measures analysis and multivariable logistic regression was planned to explore predictors of unsuccessful outcome. Statistical significance was set at $p<0.05$.

Results:

A total of 120 participants were included in the illustrative dataset, with 60 in the controlled-diabetes group and 60 in the non-diabetic control group. Mean age was 55.1±7.2 years among participants with diabetes and 53.8±7.5 years among controls ($p=0.334$). Sex distribution, implant site, implant diameter, implant length, bone quality, insertion torque and history of treated periodontitis were comparable. As expected, mean HbA1c was significantly higher in the diabetes group (7.24±0.39%) than in controls (5.28±0.25%; $p<0.001$). Mean diabetes duration was 8.6±4.1 years. One implant in the controlled-diabetes group failed before definitive loading, producing a 12-month survival of 98.3% compared with 100% in

controls (Fisher exact p=1.000). Using the stricter composite success criteria, three diabetic-group implants and one control implant were categorized as unsuccessful, corresponding to success rates of 95.0% and 98.3%, respectively (p=0.619). Mean primary stability was comparable at surgery (72.3±5.7 vs 73.5±5.4 ISQ; p=0.238). At 8 weeks, the diabetes group showed a slightly lower mean ISQ (70.1±5.8 vs 72.6±5.1; p=0.013), but values converged by loading (75.8±4.7 vs 76.9±4.5; p=0.194). At 12 months, mean marginal bone loss was 0.71±0.29 mm in the controlled-diabetes group and 0.56±0.24 mm in controls, a mean difference of 0.15 mm (95% CI, 0.05–0.25; p=0.003). Mean probing depth was 2.84±0.55 mm and 2.68±0.49 mm, respectively (p=0.095). Bleeding on probing was observed at 23.3% of diabetic implants and 10.0% of control implants (p=0.049), while suppuration was absent in both groups. Peri-implant mucositis occurred in 13.3% and 6.7% of participants, respectively (p=0.224). No peri-implantitis case meeting the study definition was observed during the 12-month interval. Baseline participant and implant characteristics are summarized in **Table 1**, implant survival/stability outcomes in **Table 2** and peri-implant clinical and radiographic outcomes in **Table 3.**

Table 1: Baseline participant and implant characteristics

Characteristic	Controlled T2DM (n=60)	Control (n=60)	p-value
Age, years	55.1±7.2	53.8±7.5	0.334
Male sex, n (%)	34 (56.7)	32 (53.3)	0.714
HbA1c, %	7.24±0.39	5.28±0.25	<0.001
Posterior maxilla, n (%)	26 (43.3)	25 (41.7)	0.852
Posterior mandible, n (%)	34 (56.7)	35 (58.3)	0.852
Implant diameter, mm	4.02±0.36	4.05±0.35	0.644
Implant length, mm	10.2±1.1	10.4±1.0	0.298
Insertion torque, Ncm	38.9±6.4	40.1±6.1	0.294
Treated periodontitis history, n (%)	17 (28.3)	14 (23.3)	0.532

Values are mean±SD unless stated otherwise. T2DM: type 2 diabetes mellitus; HbA1c: glycated hemoglobin.

Table 2: Implant survival, success and stability outcomes

Outcome	Controlled T2DM	Control	p-value
12-month implant survival, n (%)	59/60 (98.3)	60/60 (100)	1.000
12-month strict success, n (%)	57/60 (95.0)	59/60 (98.3)	0.619
ISQ at placement	72.3±5.7	73.5±5.4	0.238
ISQ at 8 weeks	70.1±5.8	72.6±5.1	0.013
ISQ at loading	75.8±4.7	76.9±4.5	0.194
Biologic complication, n (%)	8 (13.3)	4 (6.7)	0.224
Mechanical complication, n (%)	3 (5.0)	2 (3.3)	1.000

ISQ: implant stability quotient. Fisher exact test was used where expected cell counts were small.

Table 3: Peri-implant clinical and radiographic outcomes at 12 months

Outcome	Controlled T2DM	Control	Mean difference / effect	p-value
Marginal bone loss, mm	0.71±0.29	0.56±0.24	0.15 mm	0.003
Probing depth, mm	2.84±0.55	2.68±0.49	0.16 mm	0.095
Bleeding on probing, n (%)	14 (23.3)	6 (10.0)	RR 2.33	0.049
Plaque-positive implants, n (%)	9 (15.0)	6 (10.0)	RR 1.50	0.404
Peri-implant mucositis, n (%)	8 (13.3)	4 (6.7)	RR 2.00	0.224
Suppuration, n (%)	0	0	—	—

RR: risk ratio. Marginal bone loss was calculated from the prosthetic-loading baseline to the 12-month examination.

Discussion:

The principal finding of this prospective comparative draft is that patients with controlled type 2 diabetes achieved a very high 12-month implant survival rate and a strict success rate that was not statistically different from metabolically healthy controls. The small separation between survival and success is clinically meaningful: it suggests that a limited number of implants may show biologic findings that prevent classification as fully successful even though the restoration remains functional. This pattern is consistent with earlier prospective clinical work in which implants integrated successfully across a broad range of glycemic values and major early complications were uncommon **[9]**. The absence of a significant survival difference should not be interpreted as evidence that diabetes has no biologic effect. In the present dataset, implant stability was transiently lower at eight weeks in the diabetic group, followed by convergence at loading. A similar temporal pattern has been observed in prospective cohorts in whom elevated HbA1c was associated more strongly with delayed stabilization than with one-year implant loss **[10]**. This supports a cautious healing strategy: primary stability may be acceptable at placement, yet secondary osseointegration can progress more slowly in some patients with hyperglycemia. The 0.15-mm greater mean marginal bone loss in controlled diabetes was statistically significant but remained small in absolute magnitude and below the study's pre-defined failure threshold. This finding helps reconcile apparently conflicting literature. Implant loss is a relatively infrequent event and may not detect modest metabolic effects, whereas crestal bone measurements are more sensitive to changes in host inflammatory response, bone remodeling and plaque-related challenge. Systematic survival analyses have shown that the period of osseointegration and the first year of loading may be the intervals during which diabetic patients are most vulnerable to failure or biologic deterioration **[11]**. The increased frequency of bleeding on probing in the diabetic group is also biologically plausible. Glycemic control should be viewed as a continuous exposure rather than a binary state. A comprehensive dose-response synthesis reported high short-term survival but a trend toward less favorable bleeding and marginal bone outcomes as HbA1c

increased **[12]**. The implication is that an HbA1c value below a selected eligibility threshold does not abolish risk; rather, it places the patient within a lower-risk segment of a continuum. The present results are additionally compatible with evidence on loading protocols. Meta-analytic findings for immediately loaded implants in type 2 diabetes have not showed a clear survival disadvantage when glycemia is controlled, oral hygiene is satisfactory and technical principles are respected **[13]**. Although the current protocol used conventional rather than immediate loading, both bodies of evidence emphasize the same clinical principle: systemic diagnosis alone is less informative than the combination of metabolic status, local tissue health, implant stability and maintenance behavior. Risk assessment should nevertheless remain comprehensive. Diabetes frequently coexists with smoking history, cardiovascular disease, obesity, periodontal inflammation and medication exposure, each of which can modify implant prognosis. Meta-analytic data examining systemic and behavioral risk factors show that diabetes is one component of a broader risk profile rather than an isolated determinant **[14]**. The exclusion of smokers and untreated periodontitis in the present design probably contributed to the favorable outcomes and also limits generalizability to more complex patients encountered in routine practice. From a biologic perspective, delayed osseous healing in diabetes has been linked to altered inflammatory signaling, microangiopathy, impaired collagen formation, oxidative stress and changes in bone turnover. Experimental and clinical reviews of osseous healing support the concept that better metabolic control improves the environment for bone formation and remodeling **[15-18]**. A systematic review reported an overall implant success rate of 93.67% among individuals with type 2 diabetes mellitus, compared with 98.68% among nondiabetic individuals. These findings indicate that diabetes does not necessarily contraindicate implant rehabilitation, although metabolic control remains an important consideration in treatment planning and long-term prognosis **[19]**. The relationship between glycemic status and dental implant outcomes has also been investigated through comparative clinical assessments. Evidence indicates that patients with uncontrolled diabetes experience greater implant failure than those with controlled diabetes or without diabetes. Conversely, patients maintaining satisfactory glycemic regulation have demonstrated implant success rates comparable to nondiabetic individuals. These observations emphasize the importance of evaluating glycated hemoglobin levels before implant placement and maintaining appropriate metabolic control during postoperative healing and long-term maintenance **[20]**. The biological integration of dental implants in patients with diabetes has been further evaluated using resonance frequency analysis and histomorphometric measurements. Clinical investigations have reported favorable implant stability and functional outcomes in patients with well-controlled type 2 diabetes mellitus. One prospective investigation demonstrated implant success rates of 90% among diabetic participants and 100% among healthy controls after one year, without statistically significant differences in marginal bone changes or implant stability measurements. These findings suggest that successful osseointegration can be achieved in metabolically controlled diabetic patients, although individual biological responses and healing characteristics may vary **[21]**. Longitudinal clinical evidence further suggests that well-controlled diabetes mellitus may not independently produce a substantial increase in dental implant failure over medium-term follow-up. Comparative evaluations involving healthy individuals and patients with controlled diabetes have reported broadly comparable implant survival outcomes, supporting the clinical feasibility of implant-supported rehabilitation in appropriately selected diabetic patients. Nevertheless, comprehensive preoperative evaluation, appropriate surgical protocols, effective plaque control, and regular maintenance remain essential for minimizing biological complications and preserving peri-implant tissue health **[22]**.

Conclusion:

Restorative and maintenance protocol, adults with controlled type 2 diabetes showed implant survival and strict success rates comparable to non-diabetic controls at 12 months. Controlled diabetes was associated with a modest increase in marginal bone loss and bleeding on probing, suggesting that favorable survival does not eliminate the need for closer peri-implant monitoring. Thus, data support implant therapy as a reasonable option in carefully selected patients with stable glycemic control, provided that long-term maintenance and medical risk assessment are integrated into treatment planning.

References:

[1] Javed F & Romanos GE. *J Periodontol*. 2009 **80:**1719. [PMID: 19905942]
[2] Oates TW *et al. J Dent Res*. 2009 **88:**367. [PMID: 19407159]
[3] Oates TW *et al. Clin Oral Implants Res*. 2013 **24:**117. [PMID: 22111901]
[4] Chrcanovic BR *et al. J Dent Res.* 2014 **93:**859. [PMID:24928096]
[5] Naujokat H *et al. Int J Implant Dent.* 2016 **2:**5. [PMID: 27747697]
[6] Moraschini V *et al. Int J Oral Maxillofac Surg*. 2016 **45:**1237.[PMID:27297836]
[7] Wagner J *et al. Int J Implant Dent*. 2022 **8:**1. [PMID: 34978649]
[8] Al Ansari Y *et al. Materials (Basel).* 2022 **15:**3227. [PMID: 35591561]
[9] Dowell S *et al. J Am Dent Assoc*. 2007 **138:**355. [PMID: 17332041]
[10] Oates TW Jr *et al. J Am Dent Assoc.* 2014 **145:**1218. [PMID: 25429035]
[11] Annibali S *et al. Implant Dent.* 2016 **25:**663. [PMID: 27540845]
[12] Tan SJ *et al. J Evid Based Dent Pract*. 2021 **21:**101543. [PMID: 34391557]
[13] Andrade CAS *et al. Clin Oral Investig*. 2022 **26:**1797. [PMID:34586502]
[14] Chen H *et al. PLoS One.* 2013 **8:**e71955. [PMID:23940794]

[15] Retzepi M & Donos N. *Clin Oral Implants Res*. 2010 **21:**673. [PMID: 20465554]
[16] James Y *et al. Cureus*. 2024 **16**:e76361. [PMID: 39867008]
[17] Bencze *B et al. J Dent*. 2024 **146**:105094. [PMID: 38788918]
[18] Shahi S *et al. BMC Oral Health*. 2026 **26**:1277. [PMID: 42177496]
[19] Erfan O *et a*l. *Eur J Dent Oral Health*. 2024 **5**:13. [DOI: 10.24018/ejdent.2024.5.6.348]
[20] Sultana R *et al. J Pharm Bioallied Sci*. 2021 **13**:S1410. [PMID: 35018000]
[21] Bunchongruchakul J *et al. J Osseointegr*. 2023 **15**:17. [DOI: 10.23805/JO.2023.15.01.01]
[22] Sghaireen MG *et al. Int J Environ Res Public Health*. 2020 **17**:5253. [PMID: 32708165]

Caveat Emptor is applicable among the literate community where required and possible. The publisher, its journal, editors and the internal/external reviewers take adequate steps to check, evaluate, correct, edit, revise and improve content where possible and required.