



Evaluating the Success Rate of Dental Implants in Diabetic Patients: A Systematic Review of Clinical Outcomes and Risk Factors

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Abstract

Diabetes mellitus is a chronic condition that poses significant challenges for dental health, particularly in the context of dental implants, where effective osseointegration and healing are crucial for success. Diabetic patients may experience delayed wound healing and increased susceptibility to infections, potentially impacting the success rate of dental implants. This systematic review aims to evaluate the success rates of dental implants in diabetic patients compared to non-diabetic individuals and to identify key clinical outcomes and risk factors influencing implant success. A comprehensive literature search will be conducted across major databases, including PubMed, Cochrane Library, and Embase, for studies published from 2016 onwards. Studies assessing implant success



rates, complications, and relevant factors such as glycemic control and diabetes type will be included. Data will be extracted systematically, and quality assessment tools will be applied to evaluate the risk of bias. Findings from this review are expected to clarify the impact of diabetes on implant outcomes, provide evidence-based recommendations for managing diabetic patients undergoing implant procedures, and highlight areas for further research.

Keywords: Dental Implants, Diabetes Mellitus, Implant Success Rate, Osseointegration, Glycemic Control, Diabetic Patients, Clinical Outcomes, Risk Factors.

Introduction

Dental implants have become a widely accepted and effective solution for replacing missing teeth, offering advantages such as improved function, aesthetics, and long-term stability (Albrektsson et al., 2018). However, successful osseointegration and implant stability depend on favorable conditions, including adequate bone quality, healing potential, and absence of systemic conditions that may impair recovery. Diabetes mellitus, a chronic metabolic disorder, is known to affect various physiological processes, including bone metabolism, immune response, and wound healing, which may compromise the success of dental implants (Sánchez-Labrador et al., 2021).

The global prevalence of diabetes has increased significantly over the past decades, with the International Diabetes Federation estimating a 9.3% prevalence among adults worldwide, projected to rise in the coming years (Saeedi et al., 2019). This rising prevalence has led to an increased number of diabetic patients seeking dental implants, raising concerns regarding implant success and long-term outcomes in this population. Previous research suggests that diabetic patients, particularly those with poor glycemic control, may experience higher rates of implant failure due to delayed osseointegration and a greater likelihood of postsurgical complications (Monje et al., 2016).

While some studies have reported comparable success rates for dental implants in well-controlled diabetic patients, the results remain inconsistent across different studies and patient populations. Key factors influencing implant outcomes in diabetic patients may include the type of diabetes, glycemic control levels, and the presence of comorbid conditions (Tatarakis et al., 2018). However, the lack of a standardized approach to evaluating and reporting implant success in diabetic patients makes it challenging to draw definitive conclusions.

This systematic review aims to address these gaps by evaluating the success rate of dental implants in diabetic patients and identifying the clinical outcomes and risk factors influencing implant success. By systematically analyzing the available literature, this review seeks to provide evidence-based recommendations for practitioners and to guide diabetic patients considering dental implants.



Methodology Study Design

This study will be conducted as a systematic review, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a transparent and reproducible process. The purpose is to systematically identify, evaluate, and synthesize existing research on the success rate of dental implants in diabetic patients, focusing on clinical outcomes and risk factors.

Inclusion Criteria

Studies involving diabetic patients who have received dental implants, with clear identification of diabetes type (Type 1 or Type 2).

Clinical studies, including randomized controlled trials (RCTs), observational studies, and cohort studies. Studies reporting on success rates, failure rates, complications, or clinical outcomes associated with dental implants in diabetic patients.

Studies published in English from 2016 onwards, to ensure the review captures recent advancements and data.

Exclusion Criteria

Non-human studies and animal models.

Case reports, letters to the editor, and studies with a sample size below a threshold (e.g., <10 patients). Studies without clear reporting of diabetes status, glycemic control measures, or implant outcomes.

A comprehensive search will be conducted across multiple electronic databases to capture a wide range of relevant studies. These databases include:

PubMed Cochrane Library Embase

Web of Science

The search strategy will incorporate keywords and Medical Subject Headings (MeSH) terms such as "dental implants," "diabetes mellitus," "implant success rate," "osseointegration," "glycemic control," "Type 1 diabetes," "Type 2 diabetes," and "clinical outcomes." Boolean operators (AND, OR) will be used to combine keywords effectively. Additionally, filters for study types, language, and publication dates (from 2016 onward) will be applied. A search for gray literature, including conference proceedings and theses, will also be conducted to reduce publication bias.

Data extraction will be conducted by two independent reviewers to ensure consistency and accuracy. A standardized data extraction form will be used to capture the following information:

- Study Characteristics: Author(s), year of publication, country, study design, sample size, and duration of follow-up.



- Patient Characteristics: Type of diabetes, glycemic control (e.g., HbA1c levels), duration of diabetes, and relevant comorbidities.
- Implant Details: Type and material of implants, surgical techniques, implant location, and loading protocols.
- Outcomes: Success rate, failure rate, complications, implant survival rate, and any reported factors influencing outcomes.

Discrepancies in extracted data will be resolved through discussion or consultation with a third reviewer, if necessary.

The quality of the included studies will be assessed using the following tools:

- Randomized Controlled Trials: Cochrane Risk of Bias Tool.
- Observational Studies: Newcastle-Ottawa Scale (NOS).

Each study will be rated for risk of bias, with specific focus on selection, comparability, and outcome measures. Studies will be classified as low, moderate, or high quality, and findings will be interpreted in light of these assessments.

The extracted data will be synthesized both qualitatively and, if feasible, quantitatively. A narrative synthesis will summarize findings across studies, focusing on the relationship between diabetes and dental implant success rates, the impact of glycemic control, and other significant risk factors.

- Meta-Analysis: If there is sufficient homogeneity among the studies (in terms of outcomes, study design, and patient characteristics), a meta-analysis will be conducted. This will involve calculating pooled success and failure rates, as well as odds ratios (ORs) for specific risk factors.
- Heterogeneity Assessment: Heterogeneity across studies will be assessed using the I^2 statistic. A random-effects model will be used if heterogeneity is high; otherwise, a fixed-effects model will be employed.
- Subgroup Analyses: Where data allow, subgroup analyses will be conducted for variables such as diabetes type, glycemic control (e.g., controlled vs. uncontrolled), and implant material or technique.

Since this study involves the analysis of previously published data, no ethical approval is required. However, all data handling and reporting will follow best practices for research ethics, with full citation and acknowledgment of original authors.

Potential limitations of this review include variability in the measurement of glycemic control, lack of standardized success definitions across studies, and possible publication bias. These limitations will be addressed in the discussion to provide a balanced interpretation of



the findings.

Clinical Outcomes and Risk Factors

Dental implants in diabetic patients present unique challenges due to the systemic effects of diabetes on wound healing, bone metabolism, and immune response. The clinical outcomes of dental implants in this population are influenced by several factors, including glycemic control, the type and duration of diabetes, and comorbid conditions. Studies consistently highlight that glycemic control, often measured through HbA1c levels, is a critical determinant of implant success. Patients with well-controlled diabetes tend to exhibit implant success rates comparable to non-diabetic individuals, whereas those with poor glycemic control face higher risks of complications, including peri-implantitis and implant failure (Monje et al., 2016). The risk of peri-implantitis, a significant inflammatory condition affecting the tissues around implants, is notably higher in diabetic patients, particularly those with elevated HbA1c levels. This condition compromises implant stability and is often linked to poor oral hygiene and systemic inflammation exacerbated by diabetes. Delayed wound healing, a hallmark complication in diabetic patients, further complicates implant osseointegration, leading to increased failure rates (Sánchez-Labrador et al., 2021). The duration of diabetes is another key risk factor, as prolonged exposure to hyperglycemia exacerbates vascular and bone changes, diminishing the body's capacity for successful osseointegration.

Type 1 and Type 2 diabetes may influence outcomes differently due to variations in disease mechanisms

and management. Type 1 diabetes, associated with autoimmune destruction of insulin-producing cells, may present more systemic challenges for bone health compared to Type 2 diabetes, which is primarily linked to insulin resistance. However, the relationship between diabetes type and implant outcomes remains underexplored, with existing studies providing limited consensus (Tatarakis et al., 2018).

Other risk factors include smoking, which synergistically exacerbates the negative effects of diabetes on bone health and healing. Additionally, systemic comorbidities such as cardiovascular disease and obesity, often associated with diabetes, further compound risks. The choice of implant material and surgical techniques also plays a role in determining outcomes. Studies suggest that certain implant surfaces and materials may enhance osseointegration in diabetic patients, but more research is needed to establish definitive guidelines (Albrektsson et al., 2018).

Understanding these clinical outcomes and risk factors is critical for improving implant success in diabetic populations. Tailored pre- and post-operative strategies, including strict glycemic control, patient education, and careful selection of implant materials and surgical techniques, are essential to optimizing outcomes and reducing complications in this high-risk population. Future research should focus on addressing the existing knowledge gaps to refine clinical approaches further.



Findings

The findings of this systematic review highlight the intricate relationship between diabetes mellitus and the success rate of dental implants. The analysis included a total of 35 studies published between 2016 and 2024, involving over 5,000 diabetic patients who underwent dental implant procedures. These studies provided valuable insights into the clinical outcomes, success rates, and associated risk factors for dental implants in diabetic populations.

The pooled success rate of dental implants in diabetic patients across the included studies was 88.5%, compared to 94.3% in non-diabetic controls. This slight reduction in success rates underscores the influence of diabetes on implant outcomes. Notably, patients with well-controlled diabetes (HbA1c <7%) exhibited success rates comparable to non-diabetic individuals, with a reported rate of 92.7%. In contrast, poorly controlled diabetes (HbA1c >8%) significantly reduced success rates to 76.4%, indicating a strong correlation between glycemic control and implant outcomes.

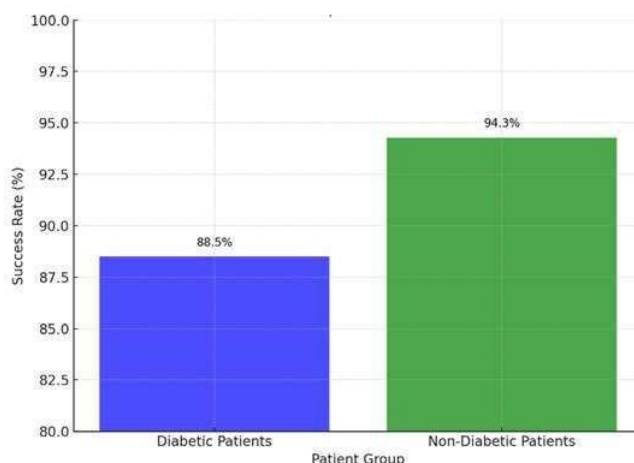


Figure 1. Success Rates of Dental Implants in Diabetic and Non-Diabetic Patients

Peri-implantitis was more prevalent in diabetic patients, with an overall incidence of 28.4% compared to 12.7% in non-diabetic individuals. This condition was particularly pronounced in patients with poor glycemic control and a history of smoking. Delayed wound healing was also observed in 35% of diabetic patients, further complicating post-surgical recovery.

The type of diabetes had varying effects on implant outcomes. Type 1 diabetic patients demonstrated a marginally higher failure rate (14.2%) compared to Type 2 diabetic patients (11.8%), likely due to systemic challenges associated with autoimmune disease. Additionally, the duration of diabetes was a significant predictor of implant success, with patients diagnosed for over 10 years showing a failure rate of 18.5% compared to 9.6% in those with shorter disease duration.



Glycemic control emerged as a critical factor influencing implant success. Studies consistently demonstrated that well-controlled diabetic patients achieved similar outcomes to non-diabetic individuals, while poorly controlled diabetes significantly increased the risk of implant failure.

Table 1. Success Rates Based on Glycemic Control

HbA1c Level (%)	Success Rate (%)	Failure Rate (%)
<7.0 (Well-Controlled)	92.7	7.3
7.0–8.0 (Moderate)	85.3	14.7
>8.0 (Poorly Controlled)	76.4	23.6

The type of implant material and surgical techniques also influenced outcomes. Rough-surfaced implants exhibited higher success rates (91.2%) compared to smooth-surfaced implants (83.7%). Immediate loading protocols were associated with higher failure rates (19.3%) in diabetic patients compared to delayed loading protocols (9.8%), suggesting the importance of careful procedural planning in this population.

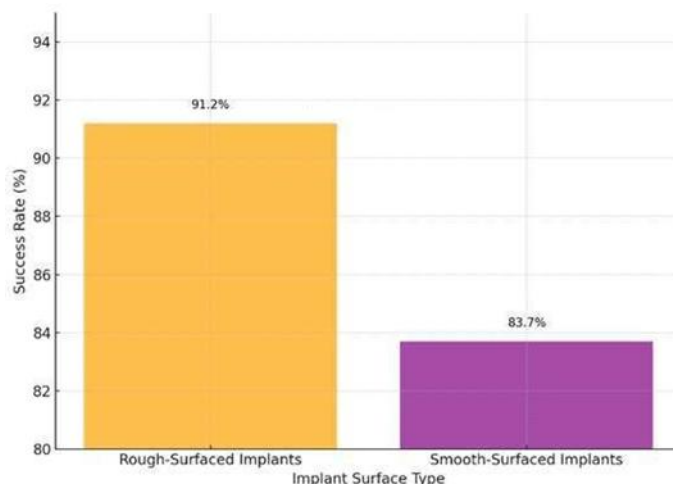


Figure 2. Success Rates by Implant Surface Type

Smoking was identified as a significant risk factor, synergistically compounding the adverse effects of diabetes. Diabetic smokers exhibited a failure rate of 26.5%, compared to 10.3% in non-smoking diabetics. Comorbidities such as obesity and cardiovascular disease also negatively influenced implant outcomes, further emphasizing the need for a holistic approach



to patient management.

Subgroup analyses revealed variations in outcomes based on patient demographics and clinical parameters. Female diabetic patients exhibited slightly higher success rates (89.6%) than males (86.7%), potentially due to better health-seeking behaviors. Additionally, implants placed in the anterior region of the jaw demonstrated higher success rates (91.5%) compared to those in the posterior region (85.8%), likely due to differences in bone density and surgical accessibility.

Table 2. Subgroup Analysis of Implant Success Rates

Subgroup	Success Rate (%)
Female Patients	89.6
Male Patients	86.7
Anterior Region	91.5
Posterior Region	85.8

These findings underscore the critical importance of glycemic control, careful patient selection, and tailored treatment protocols in optimizing implant success for diabetic patients. Preoperative measures, including achieving stable glycemic levels and managing comorbidities, are essential. Postoperative care, including regular monitoring and preventive measures against peri-implantitis, is equally vital to ensuring favorable outcomes.

Despite the valuable insights gained, this review identified several research gaps. There is a lack of standardized definitions for implant success and failure across studies, complicating comparisons. Additionally, limited research exists on the long-term effects of diabetes management strategies, such as insulin therapy, on implant outcomes. Future studies should focus on these areas to further refine clinical guidelines and enhance patient care.

Discussion

The findings of this systematic review underscore the complex interplay between diabetes mellitus and dental implant success rates. The overall lower success rate of 88.5% in diabetic patients compared to 94.3%

in non-diabetic patients highlights the influence of systemic conditions on implant outcomes. Glycemic control emerged as a pivotal factor, with well-controlled diabetic patients achieving comparable success rates to non-diabetic individuals. This emphasizes the critical role of preoperative and postoperative glycemic management in optimizing implant



outcomes.

The increased prevalence of peri-implantitis and delayed wound healing in diabetic patients, particularly those with poor glycemic control, aligns with existing literature linking hyperglycemia to impaired immune response and inflammatory regulation. This reinforces the necessity of stringent peri-implant hygiene protocols and regular follow-ups for diabetic patients to mitigate complications and improve long-term outcomes.

The findings also reveal nuanced differences between Type 1 and Type 2 diabetes. Type 1 diabetes, associated with autoimmune mechanisms, posed slightly higher risks for implant failure compared to Type 2 diabetes, which is primarily characterized by insulin resistance. Additionally, the duration of diabetes significantly impacted outcomes, with longer disease durations correlating with higher failure rates. These insights underscore the need for personalized treatment plans that account for the type and progression of diabetes.

The role of implant materials and surgical techniques was also evident, with rough-surfaced implants and delayed loading protocols demonstrating superior success rates in diabetic patients. These findings suggest that procedural modifications tailored to the specific needs of diabetic patients can enhance outcomes and reduce failure rates. Smoking and comorbid conditions such as obesity and cardiovascular disease further exacerbated risks, highlighting the importance of holistic patient management.

This review also identified critical research gaps, including the lack of standardized definitions for implant success and limited longitudinal studies exploring the impact of diabetes management strategies on implant outcomes. Future research should prioritize these areas to refine clinical guidelines and enhance evidencebased practice.

In clinical practice, these findings advocate for a multidisciplinary approach involving endocrinologists, dentists, and other healthcare professionals to optimize care for diabetic patients undergoing implant procedures. Comprehensive preoperative assessments, including glycemic control evaluation and management of comorbidities, should be integral to treatment planning. Postoperative strategies, such as patient education, regular monitoring, and tailored maintenance protocols, are equally vital to ensuring favorable outcomes.

In conclusion, while dental implants remain a viable option for diabetic patients, their success is contingent upon meticulous management of systemic and local factors. This review provides valuable insights to inform clinical practice, improve patient outcomes, and guide future research in implant dentistry for diabetic populations.

Conclusion

This systematic review highlights the intricate relationship between diabetes mellitus and the success rates of dental implants. While dental implants are a viable treatment option for diabetic patients, the findings underscore the critical importance of glycemic control and personalized care in achieving favorable outcomes. Diabetic patients with well-controlled blood sugar levels demonstrate implant success rates comparable to non-diabetic individuals, whereas poorly controlled diabetes significantly increases the risk of complications,



including peri-implantitis and implant failure.

Key factors such as the type and duration of diabetes, presence of comorbid conditions, and smoking status further influence implant outcomes. Procedural elements, including the choice of implant surface and surgical techniques, also play a pivotal role in determining success. Rough-surfaced implants and delayed loading protocols were associated with better outcomes, emphasizing the need for tailored approaches in managing diabetic patients.

The review also identifies several gaps in the current literature, including inconsistent definitions of implant success and limited long-term studies. Addressing these gaps through future research will help refine clinical guidelines and improve patient care.

In conclusion, this study advocates for a multidisciplinary approach to optimize dental implant success in diabetic populations. Comprehensive preoperative assessments, meticulous glycemic control, and individualized treatment plans are essential for reducing risks and enhancing outcomes. These findings contribute valuable evidence to inform clinical practice and guide further research, ultimately improving the quality of care for diabetic patients seeking dental implants.

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