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Review Article

# Dental implant osseointegration in individuals with diabetes: An in-depth analysis

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ABSTRACT

Diabetes, a chronic ailment with systemic implications, extends its influence to oral health, notably contributing to periodontal disease that ranks as the sixth major diabetic complication, often resulting in tooth loss. While dental implants have gained favour for their convenience and long-term viability, their success in diabetic individuals is hampered by compromised osseointegration due to reduced healing-associated bone formation. Successful implant outcomes in such cases hinge on meticulous patient selection, appropriate implant design, and effective restorative strategies, underpinned by stringent glycemic control and oral hygiene. Innovative solutions encompass implant-supported removable dentures and hydroxyapatite-coated implants that foster bone growth and implant-bone integration. In sum, navigating diabetes-related challenges for dental implants entails a comprehensive approach encompassing careful procedural considerations and advanced interventions to bolster the chances of success.



## 1. Introduction

Diabetes mellitus stands as a chronic condition affecting carbohydrate metabolism, marked by elevated blood sugar levels (hyperglycemia). This condition signifies an underlying physiological disruption in how tissues utilise glucose, as well as the liver's glucose release, and the production and release of hormones from the pancreatic anterior pituitary and adrenocortical sources.[1]

Diabetes mellitus stands as a persistent metabolic irregularity triggering elevated blood sugar levels (hyperglycemia), which in turn results in intricate complications involving microangiopathy and macroangiopathy. Individuals with diabetes experience a higher likelihood of developing periodontitis and tooth loss, encountering slower wound healing, and exhibiting diminished ability to respond to infections.[2]

Recent research conducted in China and India reveals that the prevalence of diabetes surpasses the figures projected by IDF-2009. In 2010, approximately 285 million individuals globally were diagnosed with diabetes, and this number is anticipated to escalate to 438 million by the year 2030.[1]

Currently, dental implants serve as a prominent method for replacing lost teeth. Advancements in implant design, surface attributes, and surgical techniques have transformed implantation into a secure and foreseeable process, yielding an average 10-year survival rate of 94.6% and a success rate of 89.7%. The continued viability of implants hinges on the achievement of effective osseointegration following their initial installation.[2] Any disruptions to this biological process can detrimentally impact the results of treatment. As a result, following the restoration and utilisation of the implant, the process of bone remodelling in response to the functional stresses associated with implant rehabilitation and supporting bone assumes a significant role in sustaining

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the implant's viability. The crucial interconnection between implant longevity and bone metabolism necessitates a thorough assessment of distinct risk elements.[2]

These patterns underscore the necessity for enhanced comprehension of diabetes and its implications on both management and dental implant recovery. While diabetes was traditionally perceived as a relative risk factor for dental implants, contemporary perspectives are undergoing a transformation. Current research is indicating potential benefits for patients with diabetes through oral rehabilitation utilising dental implant therapy. Tooth loss often prompts dietary alterations as individuals avoid foods necessitating more rigorous chewing, potentially resulting in compromised nutritional well-being due to inadequate metabolic control. Through appropriate dental rehabilitation, patients could enhance both their nutritional status and metabolic regulation. However, uncertainties persist regarding how the caliber of diabetes treatment and the disease's duration interact with dental implant success. The capability to anticipate outcomes holds a crucial role in risk mitigation during dental implant procedures. This involves the identification of factors that heighten the likelihood of complications, allowing surgeons to make well-informed decisions and tailor treatment strategies to optimize end results.[2]

## 2. Effects of Diabetes Mellitus on Oral Tissues

Recent investigations and advancements in research have highlighted that diabetes exerts varying degrees of influence on all bodily tissues, whether through direct or indirect pathways, often manifesting through delayed consequences. This impact extends to oral tissues, with a notable consideration of its interplay with diabetes. Specifically, periodontal disease has been identified as the sixth significant complication associated with diabetes.[3]

Nevertheless, multiple hypotheses have emerged proposing elements like heightened glycation end products, alterations in collagen status, and shifts in immune functionality, all potentially contributing to the malfunction of polymorphonuclear leukocytes. These factors might play a role in the persistence of bacteria within tissues and the buildup of advanced glycation end products – compounds stemming from prolonged and chronic hyperglycemia. This condition also leads to escalated secretion of inflammatory cytokines such as tumour necrosis factor-$\alpha$ and prostaglandin E-2. The heightened activity of collagenase in conjunction with reduced collagen synthesis adversely impacts collagen metabolism, resulting in the degradation of periodontal tissues and hampered wound healing.[2]

With the advancement of gum inflammation, the emergence of periodontal pockets occurs, leading to the separation of gums from the tooth's surface. These pockets become a breeding ground for bacteria and their harmful byproducts. As the condition deteriorates, these pockets grow deeper, transporting plaque down to the alveolar bone. Over time, the alveolar bone succumbs to damage, resulting in the erosion of periodontal attachment. This sequence of events, widely observed, triggers the degradation of periodontal tissue, the depletion of alveolar processes, and eventually culminates in tooth loss.[2]

## 3. Out-turns of Diabetes on Bone and Osseointegration

Sustained hyperglycemia observed in individuals with diabetes impedes the functionality of osteoblasts, disrupts the parathyroid hormone's role in regulating Calcium and Phosphorus metabolism, diminishes collagen production during callus formation, triggers apoptosis in bone lining cells, and amplifies osteoclast activity owing to prolonged inflammatory responses. Furthermore, it adversely impacts bone matrix, curtailing the expansion and accumulation of extracellular matrix. As a result, the process of bone formation during the healing phase experiences a decline.[4]

In individuals with diabetes, bone formation is compromised as the condition disrupts the expression of transcription factors responsible for overseeing the osteoblastic process. This reduction in bone formation is particularly evident among those reliant on insulin, as insulin treatment serves to counteract impaired bone healing.[5]

Similarly, the synthesis of matrix proteins is diminished, leading to a notable decrease in the production of type X collagen during the phase of endochondral bone formation. This decline in bone matrix production might be influenced by the lowered expression of IGF-1 or basic fibroblast growth factor. Moreover, the augmented fragility observed in diabetic bones could be attributed to microstructural irregularities.[6]

In individuals with diabetes, the control of Dlx5 (distal-less homeobox 5) and Cbfa1 (core binding factor subunit alpha 1) / Runx-2 (Runt related transcription factor 2) genes experiences reduced activity, leading to impaired transformation of immature mesenchymal cells into fully developed osteoblasts.[7]

An investigation conducted by J.C. Krakauer and colleagues unveiled distinct findings concerning bone loss among diabetic patients. The study revealed that individuals with Type 1 diabetes experienced regular bone loss, while those with Type 2 diabetes exhibited a decelerated rate of bone loss. Notably, the bone mineral density was higher in Type 2 diabetes in comparison to Type 1. The pace of bone loss in Type 2 diabetes was observed to be notably slower compared to that seen in Type 1 diabetes.[8]

## 4. Dental implants: Success/Failure in Diabetic Patients

The effectiveness of dental implants can be influenced by systemic factors, including conditions like diabetes. The use

of osseointegrated dental implants for tooth replacement stands as a reliable approach, supported by evident implant survival rates that span from 93% to 97% over a span of five years.[9]

Implant-supported overdentures are strategically crafted to provide tissue relief and enhance prosthesis stability, thereby enhancing patient comfort. Consequently, implant-supported overdentures emerge as a highly favourable choice. A research analysis focusing on mandibular overdentures supported by implants indicated an impressive 5-year survival rate exceeding 95%. Additional studies underscore the heightened masticatory efficacy and overall contentment observed among implant recipients.[9]

The achievement of successful dental implant outcomes is influenced by both local and systemic factors. Vital components encompass suitable patient screening, meticulous treatment planning, optimal implant design, appropriate material selection, proficient surgical methods, and effective restorative management. Nevertheless, potential challenges can arise from factors like compromised wound healing, metabolic bone disorders, and smoking habits. As the prevalence of implant surgery and subsequent prosthetic rehabilitation rises, the popularity of implant-supported overdentures is anticipated to grow accordingly.[9]

Evidence indicates a noteworthy 30% decrease in bone interaction and a 50% reduction in bone thickness surrounding implants among diabetic individuals. Microscopic examination unveils that collagen fibers in diabetic cases display diminished healing reactions. In efforts to counteract this, osseointegrated bone implants coated with hydroxyapatite are applied in diabetic patients, aiming to enhance bone generation around implants and thereby improve the bond between bone and implant.[9]

Greater instances of implant failure have been noted in individuals with Type 1 diabetes due to the deficiency of insulin within tissues. Conversely, the presence of insulin within tissues among patients with Type 2 diabetes might mitigate the adverse consequences associated with elevated blood sugar levels.[9]

Effective glycemic management demonstrates a robust correlation with heightened survival rates and reduced complications of dental implants within individuals having Type 2 diabetes. In assessing glycemic status among T2DM patients, Fasting Plasma Glucose (FPG) and HbA1c (glycosylated haemoglobin) serve as the most prevalent indicators. Notably, HbA1c is deemed more dependable as it encapsulates the average glycemic condition of T2DM patients over a three-month span due to the lifespan of red blood cells. Consequently, solely T2DM patients maintaining well-regulated glycemic control and exhibiting an HbA1c level below 8% were encompassed in this study. Both clinically and histologically, all implants demonstrated successful integration within the alveolar bone.[10,11]

## 5. Measures to Improve the Success of Dental Implants in Diabetic Patients

Attaining favourable preoperative and postoperative glycemic management is crucial for enhancing osseointegration among diabetic patients. The administration of prophylactic antibiotics has proven efficacious in bolstering the triumph of dental implants in diabetic individuals, with the incorporation of 0.12% chlorhexidine yielding additional improvements in success rates. Notably, modifying surface characteristics by employing implants coated with bioactive substances, along with augmenting implant dimensions (length and width), has demonstrated a capacity to heighten implant success rates within the diabetic patient population.[12]

In individuals with well-managed Type 2 diabetes, favourable osseointegration translates to improved implant survival rates. The efficacy of dental implants within diabetic individuals mirrors that of the general population. However, the presence of prolonged hyperglycemia fosters the emergence of microvascular complications, which in turn can lead to premature or delayed implant failure.[13]

Researchers have noted a positive impact when administering aminoguanidine systemically, as it effectively mitigated the adverse effects of diabetes on osseointegration. Moreover, there is emerging evidence indicating the potential benefits of adiponectin, an insulin-sensitive adipokine. This molecule exhibits the capacity to enhance osseointegration in individuals with diabetes. It accomplishes this by either systemic administration or local application. Notably, adiponectin's anti-inflammatory properties are robust, and it has demonstrated the ability to heighten bone density. This is achieved by fostering the development of osteoblasts while simultaneously curbing the formation of osteoclasts.[14]

For patients undergoing implant surgery, the recommended antibiotic is amoxicillin (2 grams orally taken one hour prior). This choice is rooted in the fact that the leading culprits behind postoperative complications are Streptococci, Gram-positive anaerobes, and Gram-negative anaerobes. Alternatively, clindamycin (600 mg orally taken one hour prior), azithromycin, or clarithromycin (both at 500 mg orally taken one hour prior) can also be employed. In specific cases, for diabetic patients scheduled for implant surgery, it's advisable to consider first-generation cephalosporins (like cephalexin or cefadroxil: 2 grams orally taken one hour prior). However, this option should be reserved for patients with no history of anaphylactic allergic reactions to penicillin.[15]

## 6. Conclusion

Among patients with effectively managed diabetes, dental implant survival rates closely mirror those of the broader population. Specific approaches and interventions can

additionally enhance the longevity of implants in diabetic patients. In cases where diabetes is inadequately controlled, it is advisable to delay implant placement. Further investigations are warranted to gain a deeper comprehension of diabetes' implications for the success of dental implants.

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## 8. Conflict of Interest

None.

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