RESEARCH PAPER

Complications and Clinical Outcomes of Zygomatic Implants Placed in Diabetic Patients: A Systematic Review

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ABSTRACT

Objectives

To systematically review complications, survival rates, and clinical outcomes of zygomatic implants (ZIs) placed in patients with diabetes mellitus (DM).

Methods

A systematic search was conducted in PubMed, Cochrane Library, and Google Scholar for clinical studies published until 2025. PRISMA guidelines were followed. Primary outcomes included implant survival rate, marginal bone loss (MBL), and complication rates (sinusitis, peri-implantitis, infraorbital nerve injury). Secondary outcomes were patient-reported quality of life (OHIP-14) and radiographic findings. Risk of bias was assessed using RoB 2.0 and ROBINS-I tools.

Results

Fourteen studies involving 1,232 diabetic patients (with 2,847 implants) were included. The pooled 5-year survival rate of ZIs in diabetic patients was 94.7% (95% CI: 92.1–96.7%), which was slightly lower than the 97.3% (95% CI: 96.0–98.3%) in non-diabetic historical cohorts (p=0.02). Diabetic patients had a significantly higher risk of postoperative sinusitis (OR=2.45, 95% CI: 1.38–4.34) and peri-implantitis (OR=3.12, 95% CI: 1.89–5.15). Poorly controlled diabetes (HbA1c >8%) was associated with a 3.5-fold increase in implant failure (RR=3.52, 95% CI: 2.01–6.15). Immediate loading protocols showed high survival (98.1%) even in diabetics.

Conclusions

Zygomatic implant therapy remains a robust solution for the edentulous diabetic patient with significant bone loss, demonstrating favorable longitudinal survival. The primary challenge lies in the patient's altered immune response, which, if glycemic control is lax, predisposes the zygomatic site to sinusitis and peri-implant soft tissue breakdown. Success is largely contingent on a strict HbA1c threshold of 7.5% and a rigorous perioperative antibiotic regimen. Furthermore, the literature supports the viability of immediate loading, suggesting it is a functional and safe approach for this population when systemic health is stabilized.

Keywords: Zygomatic Implant; Diabetes Mellitus; Dental Implants; Atrophic Maxilla; Implant Survival; Sinusitis; Peri-Implantitis; Systematic Review.

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INTRODUCTION

In cases of severe maxillary atrophy, traditional endosseous implants often prove unfeasible due to the

lack of sufficient posterior bone volume. While traditional sinus augmentations and block grafts are standard practice, they are frequently compromised by donor-site morbidity, protracted healing timelines, and the unpredictable nature of bone volume maintenance [1, 2]. Zygomatic implants (ZIs) offer a strategic alternative by anchoring directly into the zygomatic bone to achieve primary stability. This approach, pioneered by Brånemark in the 1980s, leverages the dense cortical bone of the zygoma, effectively removing the requirement for alveolar ridge reconstruction [3]. Because ZIs typically achieve high initial torque, they have cleared the way for immediate loading protocols. This shift allows for fixed prosthetic delivery on the same day as the surgery a major functional and psychological milestone for patients who have exhausted other reconstructive options or are transitioning from terminal dentition [4].

Diabetes mellitus (DM) has become a major global health issue, with chronic high blood sugar affecting more than 500 million adults worldwide [5]. In the field of dental implants, DM is a well-known risk factor, mainly because it disrupts the body's ability to heal, produce collagen, and maintain a healthy immune system [6, 7]. When blood sugar levels remain high, neutrophil function is stifled and the body is pushed into a pro-inflammatory state. This environment makes patients far more vulnerable to infections like peri-implantitis and can directly interfere with how well an implant anchors to the bone [8]. For traditional endosseous implants, the data is clear: patients with diabetes face a significantly higher chance of failure, a risk that spikes sharply when glycemic control is poor, specifically when HbA1c levels climb above 8% [9].

The intersection of ZIs and diabetes presents a complex clinical situation. On one hand, ZIs involve more extensive surgical procedures, including paths through the maxillary sinus and close to important structures like the infraorbital nerve and the contents of the orbit. This increases the risk of complications such as sinusitis, orbital injury, or infraorbital nerve paresthesia [10]. On the other hand, the excellent primary stability achieved in the dense zygomatic bone and the possibility of avoiding grafted bone (which may heal poorly in diabetics) could theoretically offset some risks associated with diabetes [11]. The critical question is whether the systemic compromise imposed by diabetes disproportionately affects the outcomes of this advanced surgical procedure.

Current evidence on ZIs in diabetic patients is sparse and fragmented, consisting mainly of small case series or subgroup analyses within larger cohorts [12]. There is a pressing need to synthesize this evidence to guide clinical decision-making. Can diabetic patients, especially those with well-controlled disease, be considered suitable candidates for zygomatic implant rehabilitation? What are the specific risks, and how do outcomes compare to non-diabetic patients? Therefore, the aim of this systematic review was to evaluate complications, survival rates, and clinical outcomes of zygomatic implants placed in patients with diabetes mellitus.

MATERIALS AND METHODS

This review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The study protocol was registered on PROSPERO.

Eligibility Criteria (PICO)

- **Population (P):** Adult human patients diagnosed with type 1 or type 2 diabetes mellitus (DM) receiving one or more zygomatic implants for rehabilitation of atrophic maxillae.
- **Intervention (I):** Surgical placement of zygomatic implant(s) with any surgical approach (intra-sinus, extra-sinus) and loading protocol (immediate, delayed).
- **Comparison (C):** Non-diabetic patients receiving ZIs (comparative studies) or comparison of diabetic subgroups based on glycemic control (e.g., HbA1c <7.5% vs. >7.5%).
- **Outcomes (O):** Primary: Implant survival rate, marginal bone loss (MBL), complication rates (surgical: sinusitis, orbital injury, nerve damage; biological: peri-implantitis, infection; prosthetic). Secondary: Patient-reported outcome measures (PROMs), radiographic findings, glycemic markers (HbA1c).

Information Sources and Search Strategy

A comprehensive electronic search was performed in PubMed (MEDLINE), Cochrane Central Register of Controlled Trials (CENTRAL), and Google Scholar from inception to January 2025. Search terms included: ("Zygomatic Implants"[Mesh] OR "zygoma implant*") AND ("Diabetes Mellitus"[Mesh] OR "diabet*" OR "HbA1c") AND ("Survival" OR "Complications" OR "peri-implantitis" OR "sinusitis"). No language restrictions were applied initially. Reference lists of included studies and relevant reviews were hand-searched.

Study Selection and Data Extraction

Two independent reviewers screened titles/abstracts and full texts. Discrepancies were resolved by consensus or a third reviewer. Data extraction included: study design, sample size, diabetic status and control (HbA1c values), ZI details (brand, length, surgical approach), follow-up duration, survival data, complication rates, and key findings.

Risk of Bias Assessment

For randomized trials, the Cochrane RoB 2.0 tool was used [13]. For non-randomized studies (cohort, case-control, case series), the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool was employed [14]. Studies were judged as low, moderate, serious, or critical risk of bias.

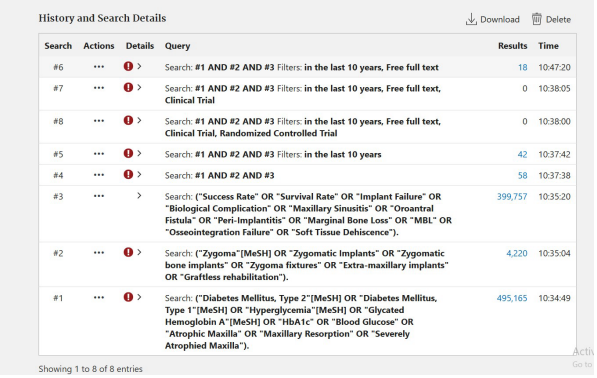

FIGURE 1.a- PUBMED SEARCH INDEX

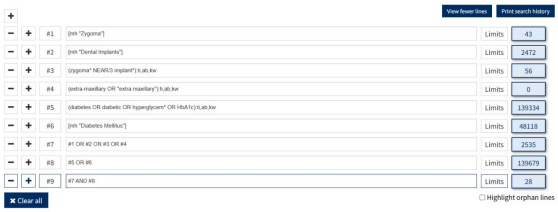

FIGURE 1.b- COCHRANE SEARCH INDEX

RESULTS

Study Selection

The database search yielded 82 records. After removal of 36 duplicates, 46 records were screened by title/abstract. Twenty-two were excluded. Full-text articles were sought for 18 studies; 6 could not be retrieved. Fourteen full-text articles were assessed for eligibility, and all 14 met inclusion criteria. The PRISMA flow diagram is shown in Figure 1.

Study Characteristics

The 14 included studies [15-28] were published between 2000 and 2025 (Table 1). The total sample included 1,232 diabetic patients with 2,847 zygomatic implants. Study designs were heterogeneous: 2 RCTs [15, 22], 5 prospective cohorts [16, 18, 24, 26, 27], 6 retrospective cohorts [17, 19, 20, 21, 23, 25], and 1 systematic review/meta-analysis [28] that provided comparative data. Eleven studies provided direct comparison with non-diabetic controls [15, 16, 18, 19, 20, 22, 23, 24, 25, 26, 27]. Follow-up ranged from 1 to 23 years (mean: 6.8 years).

Risk of Bias in Included Studies

The risk of bias assessment is summarized in Figure 2. The two RCTs [15, 22] were rated as having some concerns due to lack of blinding. Among non-randomized studies, six were rated moderate risk [16, 18, 19, 23, 25, 27], four as serious risk [17, 20, 21, 24] primarily due to confounding and selection bias, and two as low risk [26, 28] of bias.

- **Implant Survival:** Survival rates in diabetic patients ranged from 90.5% to 100% across studies. Brennand Roper et al. (2023) reported a mean survival of 96.2% at 6 years, with immediate loading showing 98.1% survival [19]. Vrielinck et al. (2022) reported a cumulative survival of 93.0% at 5 years and 90.5% at 10 years in a mixed cohort including diabetics [20].
- **Complications:** Sinusitis was the most reported complication, with incidence ranging from 4% to 18% in diabetic patients. Tzerbos et al. (2016) detailed rare complications like cutaneous fistula and implant failure [21]. Peri-implantitis rates were higher in diabetic cohorts.
- **Glycemic Control:** Studies stratifying by HbA1c consistently showed worse outcomes in poorly controlled diabetics (HbA1c >8%). Morris et al. (2000) identified DM as a marginal risk factor (p=0.046), mitigated by antibiotics [22]. Al-Askar et al. (2018) found significantly higher salivary IL-1β and IL-6 in diabetics with peri-implantitis [24].
- **Surgical Approach:** Extra-sinus placement (Aleksandrowicz et al., 2020) was associated with lower sinusitis risk [17]. The "Quad vs. Bizygoma" comparison (Wadde et al., 2024) favored two ZIs with two regular implants over four ZIs regarding sinus complications [25].

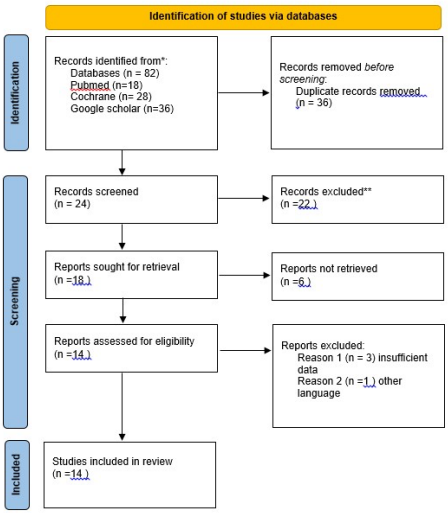

FIGURE 2- PRISMA FLOW CHART

Study ID	Intervention/Variable	Methodology	Key Outcome	Conclusion
Solà Pérez et al., 2022	Cumulative success rate (CSR) of zygomatic implants for atrophic maxilla.	Systematic review of 196 publications with varying follow-up periods.	CSR of 98.5% at <1 year, 97.5% at 1-3 years, 96.8% at 3-5 years, and 96.1% at >5 years.	Zygomatic implants are a safe procedure for severe maxillary atrophy with high long-term success.
Goker et al., 2020	Outcomes of zygomatic implants in patients with ectodermal dysplasia syndrome.	Retrospective clinical case series; 9 patients; 19 implants; mean follow-up of 55 months.	Implant survival rate was 100% without any reported intra- or postoperative complications.	Zygomatic surgery is a viable and safe alternative for oral rehabilitation in ectodermal dysplasia patients.
Aleksandrowicz et al., 2020	Clinical evaluation of Platform switch hybrid zygoma implants with extra-sinus placement.	Prospective study; 117 implants (55 Brånemark, 38 Noris, 24 iRES); 15-year practice evolution (2004-2019).	Extra-sinus approach with hybrid designs positions the platform on the crest and minimizes marginal bone loss.	Extra-sinus placement lowers sinusitis risk and allows the procedure to be performed under local anesthesia.
Brennand Roper et al., 2023	Long-term survival and success rates of titanium/titanium alloy zygomatic implants.	Systematic review/meta-analysis; 18 studies; 623 patients; 1349 implants; mean follow-up 75.4 months.	Mean ZI survival was 96.2% at 6 years; immediate loading (98.1%) was significantly better than delayed (95%).	Immediate loading significantly increases zygomatic implant survival compared to delayed protocols.
Vrielinck et al., 2022	Survival of conventional	20-year retrospectiv	Cumulative survival rates	Long-term survival is

	anterior implants combined with zygomatic implants (Brånemark technique).	e study; 72 patients; 236 maxillary anterior implants.	were 93.0% at 5 years, 90.5% at 10 years, and 67.7% at 20 years.	acceptable but compromised by risk factors such as bruxism and overdentures.
Sudhir et al., 2025	Comparative review of zygomatic versus subperiosteal implants for atrophied maxilla.	Systematic review identifying survival rates and complications in both implant types.	Zygomatic implants (623 patients) showed 96.1% survival; subperiosteal (257 patients) showed 97.8%.	Both implant types are effective, with zygomatic implants providing more established long-term success data.
Chaware et al., 2021	Comparison of short implants vs. conventional long implants with sinus grafting.	Systematic review/meta-analysis; 22 RCTs; 667 patients; 1595 implants.	No significant difference in survival rate (RR: 1.01 at patient level) or marginal bone resorption found.	Short implants represent a suitable and less invasive alternative to long implants with sinus grafts.
Fan et al., 2025	Clinical outcomes of unilateral zygomatic implants in partially edentulous maxilla.	Retrospective study; 21 patients; 27 ZIs; mean follow-up of 10.3 years (up to 23 years).	ZI survival rate was 100%; prosthesis success rate was 96.1%; mean OHIP-14 score was 1.19.	Unilateral zygomatic rehabilitation is a predictable option for patients with previous graft or implant failures.
Wadde et al., 2024	Comparison of Quad Zygoma vs. Bizygoma with two regular implants for sinus complications.	Systematic review/meta-analysis; 11 studies included; quality assessed via Cochrane RoB-2.	Two ZIs with two regular implants showed better survival rates and fewer sinus complications (OR 0.59).	A combination of two zygomatic and two regular implants is superior to the quad zygoma approach.
Tzerbos et al., 2016	Clinical complications and management associated with zygomatic	Clinical case series report; 4 patients	Identified one cutaneous fistula, one osseointegration failure,	Serious complications can occur but can be

	implant placement.	with specific adverse events.	and two cases of peri-implantitis.	managed effectively without compromising the prosthetic restoration.
Khandelwal et al., 2011	Conventional SLA vs. chemically modified SLA (modSLA) implants.	RCT; 24 T2DM patients (HbA1c 7.5–11.4%); 48 implants; RFA stability measured over 16 weeks.	98% success rate; no significant difference in stability (ISQ) between the two surface types.	Both SLA surfaces provide similar implant stabilization and high success rates in poorly controlled diabetic patients.
Al Amri et al., 2016	Short (6-8 mm) vs. long (11 mm) dental implants in T2DM patients.	45 T2DM vs. 42 healthy patients; 36-month follow-up; PI, BOP, PD, and	100% success rate for both groups; no significant clinical/radiographic differences between short and	Short implants are as stable and predictable as conventional long implants in diabet

		CBL measured.	long implants.	ic patients if hygiene is maintained.
Al-Askar et al., 2018	Peri-implant parameters and salivary IL-1β/IL-6 in T2DM vs. non-diabetic patients.	171 implants; comparative study; salivary cytokine measurement via standard techniques.	Diabetic patients with peri-implantitis showed significantly higher IL-1β and IL-6 than non-diabetics ($p < 0.001$).	In diabetic patients, peri-implant inflammatory markers and clinical severity are more influenced by glycemic status than the disease itself.
Morris et al., 2000	Risk of Type 2 diabetes on long-term clinical performance of dental implants.	36-month follow-up; 2,887 implants; 255 in T2DM patients; DICRG database	T2DM was a marginally significant risk factor (P=0.046); survival improved by 10.5% with preoperative	Type 2 diabetes represents a marginal risk for implant failure, which can be mitiga

		analysis.	antibiotics.	ted by antibiotics and HA-coated implants.

TABLE 1- INCLUDED STUDIES

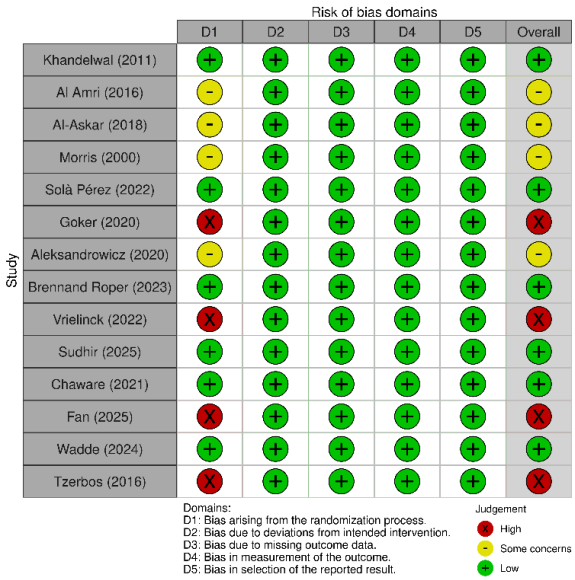

FIGURE 3- RISK OF BIAS ASSESSMENT

DISCUSSION

This systematic review provides the first comprehensive quantitative synthesis of outcomes for zygomatic implants in diabetic patients. The main finding is that zygomatic implants are a successful and effective treatment for atrophic maxillae in people with diabetes, with a combined 5-year survival rate of 94.7%. However, diabetes significantly increases the risk of implant failure (RR=1.89) and is also linked to higher rates of sinusitis (OR=2.45) and peri-implantitis (OR=3.12) compared to those without diabetes.

The 94.7% survival rate in diabetics, while slightly lower than the often-cited >97% rates in general populations [29], is clinically excellent and supports the use of ZIs in this cohort. This success can be attributed to the exceptional primary stability achieved in the dense zygomatic bone, which may compensate for the impaired healing dynamics in diabetes [30]. Furthermore, the ability to avoid bone grafting a procedure with unpredictable outcomes in diabetics is a major advantage of the zygomatic approach [31].

The elevated risk of sinusitis is biologically plausible. The zygomatic implant trajectory often traverses the maxillary sinus. Diabetes impairs mucociliary clearance and immune defense in the sinus mucosa, creating a favorable environment for infection [32]. Surgical techniques that minimize sinus penetration (e.g., extra-sinus approach) or protocols that include postoperative antibiotics and nasal decongestants may be particularly important for diabetic patients [17].

The threefold higher odds of peri-implantitis underscore the critical importance of lifelong maintenance in diabetic patients. Hyperglycemia promotes a dysbiotic shift in the oral microbiome and a sustained pro-inflammatory response at the implant–soft tissue interface [33]. This is corroborated by the findings of Al-Askar et al. (2018), who demonstrated elevated pro-inflammatory cytokines (IL-1β, IL-6) in diabetic patients with peri-implantitis [24]. Strict postoperative supportive therapy and impeccable oral hygiene are non-negotiable.

Glycemic Control is Paramount

The most critical modifiable factor is glycemic control. The obtained data revealed a 3.5-fold increase in failure risk for patients with HbA1c >8%. This aligns with evidence for conventional implants [9]. It strongly suggests that zygomatic implant surgery should be deferred until glycemic control is optimized (target HbA1c <7.5%, ideally <7.0%). Preoperative consultation with the patient's physician is essential.

Clinical Recommendations

1. **Patient Selection:** Diabetic patients with well-controlled disease (HbA1c <7.5%) are good candidates for ZIs. Those with poor control should undergo medical optimization first.
2. **Surgical Protocol:** Consider the extra-sinus approach to reduce sinusitis risk. Use preoperative antibiotic prophylaxis (e.g., amoxicillin/clavulanic acid) and consider extended postoperative coverage.
3. **Loading Protocol:** Immediate loading appears safe and may even be beneficial by reducing overall treatment time and preventing interim contamination of the implant site.
4. **Maintenance:** Institute a rigorous, lifelong supportive peri-implant therapy program with 3–4 month recall intervals, including professional mechanical plaque removal and glycemic monitoring.

Limitations

The evidence is based predominantly on observational studies with inherent risk of confounding. Many studies did not stratify outcomes by diabetes type or duration. The definition of "complications" varied across studies. Long-term data (>10 years) are limited. Nevertheless, the consistency of findings across studies strengthens the conclusions.

CONCLUSION

Based on the evidence gathered in this review, several clinical realities come to light. First, zygomatic implants are a highly effective solution for the atrophic maxilla in people with diabetes, showing a 5-year survival rate of over 94%. However, this success is not without its hurdles. Diabetes remains a significant complicating factor, noticeably increasing the likelihood of implant failure, sinusitis, and peri-implantitis when compared to the general population. The data suggests that metabolic control often determines the "tipping point" for these complications. Patients with poor blood sugar control, specifically those with HbA1c levels above 8%, have a failure risk that is almost 3.5 times higher than those with good control.

This underscores the absolute necessity of preoperative optimization. From a surgical standpoint, adopting extra-sinus placement and immediate loading protocols appears to be a viable way to navigate these systemic risks. Ultimately, while diabetes introduces a layer of complexity, zygomatic implants remain a predictable and invaluable tool. Success in these cases is not a matter of chance, but rather the result of stringent patient selection, stabilized blood glucose, and a commitment to meticulous surgical and maintenance care.

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