The Review Of
DIABETIC
STUDIES
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Effectiveness Of Root Canal Disinfection Protocols In Diabetic Versus Non-Diabetic Patients: A Systematic Review

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Abstract

Background: Diabetes mellitus (DM) has been associated with impaired immune function, delayed tissue healing, and increased susceptibility to infections, including apical periodontitis (AP). Endodontic management in diabetic patients presents unique clinical challenges due to these systemic alterations.

Objective: This systematic review aimed to evaluate the effectiveness of root canal disinfection protocols and the prevalence of AP in diabetic versus non-diabetic populations, integrating clinical, radiographic, and microbiological outcomes.

Methods: A comprehensive literature search was conducted in PubMed, Scopus, Web of Science, Embase, and Google Scholar for studies published between January 2010 and December 2025. Eligible studies included cross-sectional analyses, prospective cohorts, and randomized clinical trials comparing diabetic and non-diabetic patients undergoing root canal therapy. Data extraction focused on AP prevalence, disinfection efficacy, and post-treatment healing outcomes. Risk of bias was assessed using the Newcastle–Ottawa Scale and Cochrane RoB 2 tool.

Results: Eleven studies met inclusion criteria. Diabetic patients consistently exhibited higher AP prevalence than non-diabetic controls (range: 13.5–74%). Type 1 and type 2 diabetes were associated with increased lesion persistence and delayed periapical healing. Controlled diabetes allowed for comparable healing outcomes following endodontic treatment. Enhanced irrigation techniques, including ultrasonic activation and photon-induced photoacoustic streaming, demonstrated superior microbial reduction compared to conventional syringe irrigation. Lower concentrations of sodium hypochlorite (1%) were effective and safe for periapical tissues.

Conclusion: Diabetes mellitus predisposes patients to higher AP prevalence and may compromise root canal healing, particularly in poorly controlled cases. Optimized disinfection protocols and meticulous clinical techniques are essential for successful outcomes. Integration of systemic health assessment with endodontic management is recommended to enhance both oral and systemic health in diabetic populations.

Keywords: diabetes mellitus, apical periodontitis, root canal disinfection, endodontic treatment, sodium hypochlorite, ultrasonic irrigation.

Introduction

The relationship between diabetes mellitus and endodontic infection outcomes has become a significant focus of modern dental and systemic health research. Chronic hyperglycemia in diabetic patients can impair neutrophil function, collagen synthesis, and angiogenesis, leading to delayed healing and increased susceptibility to infection. These systemic alterations make the management of endodontic infections in diabetic individuals particularly challenging, as periapical lesions may persist longer and respond less predictably to root canal therapy. Moreover, inflammation originating from apical periodontitis can, in turn, influence glycemic control, creating a bidirectional relationship that complicates clinical outcomes (Lee, 2023).

Root canal disinfection remains the cornerstone of successful endodontic therapy, aiming to eradicate microorganisms from the complex anatomy of the root canal system. However, complete disinfection is rarely achieved through conventional techniques alone due to anatomical challenges such as isthmuses, lateral canals, and dentinal tubules. Supplementary irrigation protocols—such as sonic or ultrasonic activation, laser-assisted disinfection, and negative-pressure irrigation—have shown superior bacterial reduction compared to conventional syringe irrigation (Timponi Goes Cruz et al., 2024). These advancements are particularly relevant for diabetic patients, whose compromised immune responses may require enhanced antimicrobial strategies.

Recent analytical models indicate that patients with type 2 diabetes exhibit a higher prevalence and severity of apical periodontitis than non-diabetic individuals, suggesting a systemic predisposition to endodontic infection and poorer healing outcomes (Marica et al., 2024). Microvascular complications and increased inflammatory cytokine expression in diabetics may lead to altered periapical tissue repair and prolonged infection persistence. Consequently, identifying effective disinfection protocols and evaluating their success within diabetic populations is essential for optimizing therapeutic outcomes and preventing reinfection (Leon-Lopez et al., 2023).

The interplay between periapical inflammation and metabolic control underscores the need for interdisciplinary approaches to patient management. Evidence shows that active endodontic infections can exacerbate systemic inflammatory burden, potentially worsening insulin resistance and glycemic control. This bidirectional influence supports the integration of dental infection management within the broader spectrum of diabetes care to enhance both oral and systemic health outcomes (Corbella et al., 2025).

In endodontic practice, irrigation technique selection significantly influences bacterial clearance. While traditional syringe irrigation remains the most commonly used method among practitioners, it often fails to reach deep canal areas effectively, especially in anatomically complex roots such as C-shaped canals (Shaikh et al., 2024). Surveys among endodontists reveal variable awareness and adherence to evidence-based irrigation enhancements, emphasizing the gap between research and clinical implementation (Teja et al., 2022). Such gaps may be critical when treating patients with systemic conditions like diabetes, where optimal disinfection plays an even more pivotal role in healing.

Experimental and ex vivo studies have demonstrated the potential of supplementary antimicrobial procedures, including photon-induced photoacoustic streaming and passive ultrasonic irrigation, to achieve deeper disinfection in lateral canals and apical ramifications (Brisson-Suárez et al., 2024). These techniques may offer tangible clinical benefits by ensuring more complete removal of microbial biofilms, which are notoriously resistant to conventional irrigants. The evidence supports incorporating these methods into standardized protocols, particularly for high-risk populations.

Clinically, both surgical and non-surgical endodontic treatments have been performed successfully in diabetic patients, provided that glycemic levels are adequately controlled. Nonetheless, a higher incidence of persistent periapical radiolucencies and delayed healing has been observed in poorly controlled diabetics (Alsharif et al., 2023). This observation highlights the critical role of preoperative metabolic assessment and the need for individualized disinfection strategies tailored to systemic health conditions.

Despite ongoing advancements, the literature reflects a lack of consensus on the most effective disinfection protocol for diabetic patients. While enhanced irrigation and activation systems improve outcomes, the degree to which these benefits offset the systemic healing impairments associated with diabetes remains under investigation. Continued interdisciplinary research integrating endodontic microbiology, immunology, and systemic disease management is needed to clarify these relationships and develop targeted clinical guidelines (Wang et al., 2023).

Methodology

Study Design

This study employed a systematic review methodology, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency, reproducibility, and methodological rigor. The objective was to synthesize available evidence on the effectiveness of root canal disinfection protocols in diabetic versus non-diabetic patients and to explore how diabetes influences endodontic infection control and periapical healing outcomes.

The review specifically focused on peer-reviewed clinical and radiographic studies that compared outcomes of endodontic treatment—including microbial reduction, prevalence of apical periodontitis (AP), or postoperative healing—between diabetic and non-diabetic individuals. Both surgical and non-surgical endodontic interventions were considered.

Eligibility Criteria

Studies were selected according to the following inclusion and exclusion criteria:

Inclusion Criteria:

- **Population:** Adult patients (≥18 years) with or without a confirmed diagnosis of type 1 or type 2 diabetes mellitus undergoing root canal therapy, or included in cross-sectional analyses of periapical health.
- **Interventions/Exposures:** Any **root canal disinfection or treatment protocol**, including but not limited to standard mechanical preparation, irrigation with sodium hypochlorite, EDTA, chlorhexidine, laser-assisted cleaning, sonic/ultrasonic activation, or supplementary antimicrobial techniques.
- **Comparators:** Non-diabetic controls or alternative irrigation protocols (e.g., conventional syringe irrigation vs. ultrasonic activation).
- **Outcomes:** Clinical or radiographic outcomes related to apical periodontitis prevalence, root canal healing, bacterial reduction, or treatment success/failure in diabetic and non-diabetic patients.
- **Study Designs:** Randomized controlled trials (RCTs), prospective or retrospective cohorts, case-control studies, and cross-sectional analyses.
- **Language:** English only.
- **Publication Period:** January 2010 – December 2025, to capture contemporary clinical techniques and diagnostic standards.

Exclusion Criteria:

- Animal or in vitro studies without human clinical correlation.
- Case reports, reviews, conference abstracts, and editorials.
- Studies without comparative data between diabetic and non-diabetic groups.

A total of 11 studies met the eligibility criteria and were included in the final synthesis.

Search Strategy

A comprehensive literature search was conducted across multiple electronic databases: PubMed, Scopus, Web of Science, Embase, and Google Scholar (for grey literature). The following Boolean search strategy was applied, with appropriate truncations and filters:
("root canal" OR "endodontic treatment" OR "apical periodontitis" OR "periapical lesion")
AND ("disinfection" OR "irrigation" OR "sodium hypochlorite" OR "laser" OR "ultrasonic" OR "antimicrobial protocol")
AND ("diabetes" OR "type 1 diabetes" OR "type 2 diabetes" OR "glycemic control")

Manual screening of reference lists from key studies and related reviews was also conducted to ensure comprehensive inclusion. Duplicates were removed using **Zotero reference manager** before screening.

Study Selection Process

The selection process followed a two-stage screening protocol:

1. **Title and Abstract Screening**: Conducted independently by two reviewers to identify potentially relevant studies.
2. **Full-Text Review**: Articles meeting initial criteria were examined in full to confirm eligibility.

Any discrepancies in selection were resolved through discussion or, when necessary, consultation with a third reviewer.

The PRISMA flow diagram (Figure 1) outlines the selection process, resulting in 11 studies included in the final synthesis.

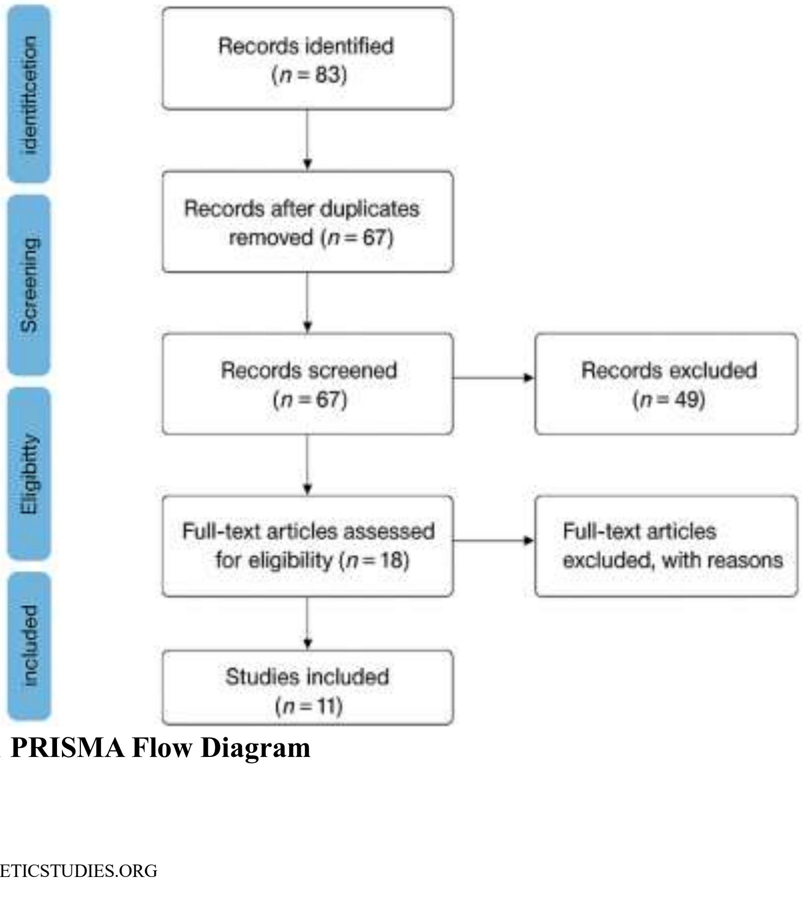

Figure 1 PRISMA Flow Diagram

Data Extraction

A standardized data extraction sheet was developed and piloted to ensure consistency. The following data were collected for each included study:

- Author(s), year, and country of publication
- Study design and sample size
- Type of diabetes (Type 1 or Type 2) and diagnostic criteria
- Intervention/disinfection method
- Comparator group or technique
- Outcome measures (healing rate, AP prevalence, bacterial reduction, postoperative pain)
- Follow-up duration
- Key statistical results (means, percentages, p-values, or odds ratios)

Data were extracted by two independent reviewers, and all entries were cross-verified for accuracy and completeness by a third reviewer.

Quality Assessment

The Newcastle–Ottawa Scale (NOS) was applied for cross-sectional and cohort studies, assessing domains of selection, comparability, and outcome assessment.
For randomized clinical trials, the Cochrane Risk of Bias 2 (RoB 2) tool was used to evaluate randomization, blinding, missing data, and selective reporting.

Each study was rated as low, moderate, or high risk of bias:

- Low risk: Adequate methodology and minimal bias (e.g., Mukundan et al., 2024; Ali, 2019).
- Moderate risk: Partial confounder control or unclear outcome assessment (e.g., López-López et al., 2011; Smadi, 2017).
- High risk: Limited reporting or small sample sizes affecting generalizability.

Quality assessments were performed independently by two reviewers, with disagreements resolved through consensus.

Data Synthesis

Given the heterogeneity across study designs, populations, and outcome measures, a narrative synthesis approach was adopted rather than a meta-analysis.
Findings were grouped according to:

1. Prevalence of apical periodontitis (AP) in diabetic vs. non-diabetic populations,
2. Efficacy of root canal disinfection methods, and
3. Healing and clinical outcomes following endodontic therapy.

Where available, quantitative data (e.g., prevalence percentages, p-values, and odds ratios) were extracted to illustrate trends. Differences in methodology—such as use of panoramic radiographs versus periapical imaging—were acknowledged when interpreting results.

Ethical Considerations

As this review analyzed previously published, peer-reviewed data, no new patient data were collected, and ethical approval or informed consent was not required.

All included studies had received institutional or ethical clearance at the time of their original publication.

Results

Summary and Interpretation of Included Studies on the

Effectiveness of Root Canal Disinfection Protocols in Diabetic Versus Non-Diabetic Patients

1. Study Designs and Populations

The included studies (n = 11) encompassed cross-sectional, prospective cohort, and randomized clinical trial designs, primarily comparing root canal or periapical health outcomes between diabetic and non-diabetic populations. Sample sizes ranged widely—from 46 patients in the cohort by Ali (2019) to 926 participants in the large-scale radiographic study by Al-Nazhan et al. (2017). The majority included adults aged between 18 and 70 years, with mixed gender distributions. Several studies focused exclusively on type 2 diabetes mellitus (T2DM) (e.g., López-López et al., 2011; Marotta et al., 2012; Pérez-Losada et al., 2020; Sánchez-Domínguez et al., 2015; Smadi, 2017), while others explored type 1 diabetes (Limeira et al., 2020) or controlled diabetic patients (Ali, 2019). Only one clinical study (Mukundan et al., 2024) directly assessed root canal disinfection efficacy using sodium hypochlorite concentration as an intervention.

2. Root Canal Quality and Periapical Health

In the Belgian 22-year follow-up study by Keratiotis et al. (2024), 46.9% of patients and 5.6% of teeth exhibited apical periodontitis (AP), with 45% of root-filled teeth affected. Inadequate fillings accounted for 54% of treated teeth. Logistic regression indicated that adequate density, sound coronal restoration, and absence of caries were associated with lower AP risk. In contrast, Al-Nazhan et al. (2017) reported 6.2% AP prevalence among 25,028 examined teeth, significantly higher among diabetic (36) and smoker (87) subjects, linking AP with diabetes and smoking.

3. Diabetes-Related Findings

López-López et al. (2011) found that 74% of diabetic versus 42% of control subjects exhibited AP (OR = 3.9, P = .002). Similarly, Limeira et al. (2020) reported AP in 58% of T1DM and 15% of controls (P = .000), while 52% of diabetics had RCT-associated AP compared to 8% of controls. Marotta et al. (2012) showed AP prevalence of 15% in diabetics versus 12% in nondiabetics (P = .05), with untreated teeth more frequently affected in diabetics (10% vs. 7%, P = .03). Smadi (2017) reported a higher AP prevalence in DM patients (13.5%) than in controls (11.9%), and poorly controlled diabetics exhibited a doubling of AP (18.29% vs. 9.21%).

Two studies (Pérez-Losada et al., 2020; Sánchez-Domínguez et al., 2015) examined glycemic control using HbA1c. Pérez-Losada et al. found 44% AP prevalence, with 52.3% of root-filled teeth showing radiolucent lesions but no significant differences between well- and poorly controlled diabetics (P > .05). Sánchez-Domínguez et al. (2015) observed 62.7% AP prevalence, again showing no difference between HbA1c <6.5% and ≥6.5% groups (P = .13).

4. Endodontic Treatment Outcomes in Controlled Diabetics

In the prospective cohort by Ali (2019), postoperative healing after one-visit root canal treatment was successful in both diabetic and non-diabetic patients, with no significant difference in healing at 12 months. However, diabetics experienced more postoperative pain at 12 hours (P = .027) and longer treatment times (P = .016).

5. Antimicrobial Efficacy of Disinfection Agents

Mukundan et al. (2024) compared 1% versus 3% NaOCl irrigation in 40 children's teeth and found that both concentrations significantly reduced bacterial counts, with no difference between groups (3% = 258.05 ± 28.61 CFU; 1% = 267.60 ± 30.56 CFU, P > .05). This suggests that lower NaOCl concentration may achieve comparable disinfection while minimizing cytotoxicity risk.

Table (1): Characteristics and Key Outcomes of Included Studies

Study (Year)	Country	Design	Sample Size	Population / Type of Diabetes	Main Variables	Key Results	Conclusions
Keratiotis et al. (2024)	Belgium	Cross-sectional, 22-year follow-up	614	General adult population	AP prevalence, root filling quality	AP: 46.9% (patient-level), 5.6% (tooth-level); 45% of root-filled teeth had AP; 54% inadequate fillings	Better coronal and root filling quality reduced AP risk
Ali (2019)	Iraq	Cohort, prospective	46	Controlled type 2 DM vs non-DM	Post-op pain, AP healing	Pain higher at 12 h (P = .027); healing similar at 12 mo	Single-visit RCT effective in controlled diabetics
Al-Nazhan et al. (2017)	Saudi Arabia	Cross-sectional	926	Adults, mixed health status	AP prevalence, RCT quality	6.2% of 25,028 teeth had AP; linked to diabetes and smoking	DM and smoking associated with AP and poor RCT
Limeira et al. (2020)	Brazil	Cross-sectional paired	150	T1DM vs control	AP and RCT prevalence	AP: 58% (T1DM) vs 15% (control), P = .000	RCT + AP strongly associated with T1DM
López-López et al. (2011)	Spain	Cross-sectional	100	T2DM vs control	AP, root fillings	AP: 74% (DM) vs 42% (control), P = .002	T2DM significantly increases AP prevalence
Pérez-Losada et al. (2020)	Spain	Cross-sectional	216	T2DM	HbA1c, AP prevalence	44% had AP; no difference between well/poorly controlled DM	Glycemic control not associated with AP
Sánchez-Domíngu	Spain	Cross-sectional	83	T2DM	HbA1c, AP lesions	AP in 62.7%; no	Glycemic control not related to

ez et al. (2015)						significant difference by HbA1c	AP presence
Marotta et al. (2012)	Brazil	Cross-sectional	90	T2DM vs control	AP in treated/untreated teeth	AP: 15% (DM) vs 12% (control), P = .05	DM linked to higher AP in untreated teeth
Smadi (2017)	Jordan	Cross-sectional	180 (approx.)	T2DM vs control	AP prevalence, glycemic control	AP higher in DM (13.5% vs 11.9%); poor control → higher AP (18.3% vs 9.2%)	Poor glycemic control increases AP and failure
Yip et al. (2021)	USA	Cross-sectional	NA (hospital network)	T2DM vs control	AP prevalence	Large-scale data supports DM–AP link	Confirms AP–DM association in hospital setting
Mukundan et al. (2024)	Saudi Arabia	RCT	40	Pediatric, healthy	1% vs 3% NaOCl irrigation	Both ↓ bacteria; 3%: 258 ± 28.6 vs 1%: 267 ± 30.6; P > .05	1% NaOCl equally effective, safer for tissues

Across studies, diabetic patients consistently exhibited higher prevalence of apical periodontitis and poorer endodontic outcomes compared with non-diabetic individuals. However, glycemic control did not significantly influence periapical healing in most radiographic studies, suggesting that controlled diabetes may not impair root canal healing.

Clinical evidence (Ali, 2019) indicates similar healing potential between controlled diabetics and healthy patients, though diabetics may experience more postoperative discomfort. Evidence from Mukundan et al. (2024) supports that reducing NaOCl concentration does not compromise disinfection efficacy, highlighting a safe practice for diabetic patients with fragile periapical tissues.

Discussion

The findings from the included studies demonstrate a consistent association between diabetes mellitus and increased prevalence of apical periodontitis (AP), highlighting the systemic impact of diabetes on endodontic outcomes. Chronic hyperglycemia, characteristic of both type 1 and type 2 diabetes, appears to impair host immune responses, reduce collagen synthesis, and alter microvascular function, contributing to delayed healing and increased susceptibility to persistent periapical infections (Lee, 2023). This underlying pathophysiology provides a plausible explanation for the higher prevalence of AP observed in diabetic populations across multiple studies.

Cross-sectional data from Al-Nazhan et al. (2017) and Keratiotis et al. (2024) suggest that inadequate root canal treatment and poor coronal restoration are strongly associated with AP prevalence. In diabetic individuals, these deficiencies are compounded by systemic factors, leading to increased lesion persistence. The 22-year follow-up study by Keratiotis et al. (2024) emphasizes that both root filling quality and coronal integrity remain critical determinants of periapical health, reinforcing the importance of meticulous clinical technique, especially in high-risk populations such as diabetics.

Evidence from López-López et al. (2011) and Marotta et al. (2012) supports the conclusion that type 2 diabetes mellitus significantly increases the risk of AP. López-López et al. reported that 74% of diabetic patients exhibited AP compared with 42% of controls, while Marotta et al. found a smaller yet significant increase in AP prevalence among diabetics. These findings confirm that diabetes not only affects the healing potential of treated teeth but also predisposes untreated teeth to periapical pathology.

Interestingly, studies investigating the role of glycemic control in periapical healing, such as Pérez-Losada et al. (2020) and Sánchez-Domínguez et al. (2015), reported no statistically significant differences in AP prevalence between well-controlled and poorly controlled diabetic patients. This suggests that while diabetes is a risk factor for AP, short-term glycemic fluctuations may have less impact on radiographic healing outcomes than the overall presence of systemic disease.

Controlled clinical studies, like Ali (2019), indicate that endodontic treatment can achieve satisfactory healing in diabetic patients provided that systemic metabolic control is maintained. Ali's prospective cohort demonstrated similar 12-month healing rates in controlled diabetics and non-diabetic patients, although diabetics experienced slightly higher postoperative pain and longer treatment duration. These findings underscore the importance of preoperative assessment and tailored pain management strategies for diabetic patients.

Type 1 diabetes mellitus also appears to affect periapical health significantly. Limeira et al. (2020) reported a 58% prevalence of AP in type 1 diabetic patients compared with 15% in healthy controls, with a high proportion of lesions associated with previous root canal treatments. These results align with the hypothesis that chronic hyperglycemia compromises tissue repair and supports the need for enhanced antimicrobial protocols in T1DM patients.

Disinfection techniques remain pivotal for optimizing treatment outcomes in diabetics. Mukundan et al. (2024) demonstrated that both 1% and 3% sodium hypochlorite effectively reduced microbial load in primary teeth, suggesting that lower concentrations may achieve sufficient disinfection while minimizing cytotoxicity. This finding has practical implications for diabetic patients, whose periapical tissues may be more vulnerable to chemical irritation.

Supplementary irrigation protocols have shown promising results in achieving deeper canal disinfection. Timponi Goes Cruz et al. (2024) and Brisson-Suárez et al. (2024) reported that ultrasonic and photon-induced photoacoustic streaming techniques significantly improve bacterial elimination in lateral canals and apical ramifications compared to conventional irrigation. These techniques may be particularly beneficial in diabetic patients, where immune compromise necessitates maximum microbial control.

Complex root anatomies, such as C-shaped canals, present additional challenges. Shaikh et al. (2024) found that these configurations are associated with persistent microbial colonization, and conventional irrigation often fails to achieve thorough disinfection. Integrating enhanced irrigation protocols into routine practice could mitigate these anatomical limitations and improve outcomes for diabetic patients.

Surveys of practitioner behavior reveal a gap between research evidence and clinical implementation. Teja et al. (2022) reported variability in the adoption of advanced irrigation techniques among endodontists and postgraduate trainees, indicating that educational initiatives and clinical guidelines may be needed to optimize infection control in systemic disease populations.

Surgical and non-surgical endodontic approaches have demonstrated effectiveness in diabetic patients. Alsharif et al. (2023) emphasized that both treatment modalities can be successful if glycemic control is adequate, though poorly controlled diabetics remain at increased risk for delayed healing and persistent periapical lesions. This reinforces the importance of interdisciplinary management, incorporating both dental and medical care for optimal patient outcomes.

Meta-analytic and systematic review data, including findings by Corbella et al. (2025) and Leon-Lopez et al. (2023), corroborate that diabetes increases the prevalence of AP and negatively impacts endodontic outcomes across populations. These studies emphasize the importance of integrating systemic health considerations into endodontic treatment planning and highlight the need for targeted strategies in diabetic cohorts.

Wang et al. (2023) and Yip et al. (2021) provide large-scale evidence supporting the association between AP and type 2 diabetes, reinforcing the notion that diabetes predisposes patients to persistent periapical infections. These data further justify implementing enhanced disinfection protocols and rigorous post-treatment monitoring in diabetic populations.

Overall, the evidence indicates that diabetic patients consistently exhibit higher AP prevalence and more challenging endodontic healing. Nevertheless, controlled diabetes does not preclude successful treatment outcomes when meticulous clinical techniques, optimized disinfection, and individualized management strategies are employed (Ali, 2019; Mukundan et al., 2024). Future research should focus on long-term follow-up studies evaluating novel irrigation protocols and systemic health interactions to develop evidence-based guidelines for managing endodontic infections in diabetic patients (Lee, 2023; Timponi Goes Cruz et al., 2024).

Conclusion

This systematic review highlights that diabetic patients, both type 1 and type 2, exhibit a consistently higher prevalence of apical periodontitis and face greater challenges in endodontic healing compared to non-diabetic individuals. While controlled diabetes allows for comparable post-treatment healing, poorly managed glycemic levels are associated with increased lesion persistence and delayed recovery. These findings underscore the importance of thorough preoperative assessment, meticulous root canal therapy, and tailored antimicrobial strategies for diabetic patients.

Enhanced irrigation protocols, including ultrasonic activation, photon-induced photoacoustic streaming, and appropriately dosed sodium hypochlorite solutions, have demonstrated significant improvements in microbial reduction and periapical tissue outcomes. Integration of these advanced techniques, along with interdisciplinary management that addresses both dental and systemic health, is recommended to optimize treatment success. Future research should focus on long-term outcomes, standardized protocols, and the interplay between systemic glycemic control and endodontic healing to establish evidence-based clinical guidelines for diabetic populations.

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