Research Article

Survival Outcomes of Immediate Dental Implant Placement in Infected Versus Non-Infected Extraction Sockets: An Umbrella Review

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Abstract

Background: Immediate implant placement (IIP) in infected extraction sockets remains controversial because residual infection and biofilm may compromise osseointegration. Existing systematic reviews have reported inconsistent findings, highlighting the need for higher-level evidence synthesis.

Objectives: To evaluate implant survival, success, marginal bone loss (MBL), peri-implant outcomes, and complications following IIP in infected compared with non-infected extraction sockets.

Methods: This umbrella review was conducted according to PRISMA 2020 guidelines (PROSPERO: CRD420251110840). Ten databases were searched through August 2025. Eligible studies were systematic reviews and meta-analyses of human clinical studies comparing infected and non-infected sockets. Methodological quality was assessed using AMSTAR-2 and QATSDD, overlap by the corrected covered area (CCA), and certainty of evidence using GRADE.

Results: Fifteen reviews involving several thousand implants were included. Implant survival rates ranged from 94% to 100%, with most meta-analyses showing no significant difference between infected and non-infected sites. MBL remained consistently below 1 mm and was comparable between groups. Soft-tissue outcomes and complication rates were generally similar, although a slight reduction in keratinized mucosa was reported in some infected cohorts. Evidence certainty was moderate for survival outcomes and low for complications.

Conclusions: When thorough debridement, appropriate antimicrobial measures, and adequate primary stability are achieved, IIP in infected sockets demonstrates clinical outcomes comparable to those in non-infected sites. However, heterogeneity among studies and the limited number of randomized trials reduce confidence in the overall evidence.

Keywords: Immediate implant placement; infected socket; implant survival; umbrella review; osseointegration.

Introduction

Immediate implant placement (IIP) involves inserting a dental implant directly into the extraction socket at the time of tooth removal, eliminating the need for a healing interval before implant placement [1]. During the past two decades, this approach has gained widespread acceptance because it shortens treatment duration, reduces the number of surgical procedures, and helps preserve peri-implant hard and soft tissues. These advantages are particularly important in the anterior aesthetic region, where post-extraction ridge resorption can adversely affect both function and appearance [2].

The biological basis for IIP in non-infected sockets is well established. In the absence of microbial contamination, physiologic socket healing and bone remodelling promote intimate bone-to-implant contact and predictable osseointegration [3,7]. However, many teeth indicated for extraction present with active or residual infection, including chronic periapical lesions, periodontal disease, failed endodontic therapy, or acute suppurative conditions [4]. Such infections may alter the local healing environment through the release of inflammatory mediators, bacterial endotoxins, and other by-products that stimulate osteoclastic activity and potentially interfere with new bone formation around the implant surface [6,7]. Residual infection has also been implicated in retrograde peri-implantitis, a condition characterized by apical bone loss despite maintained coronal osseointegration [8].

To address these concerns, several adjunctive measures have been proposed, including meticulous mechanical debridement, antiseptic irrigation, systemic antibiotic therapy, guided bone regeneration (GBR), and biologic agents such as platelet-rich fibrin [9,10]. Despite these interventions, clinical protocols remain heterogeneous and lack standardization. Differences in infection definitions, decontamination procedures, implant systems, grafting approaches, and follow-up durations have contributed to inconsistent findings across published systematic reviews [4,5,11-24].

An umbrella review provides a valuable method for synthesizing evidence from multiple systematic reviews and meta-analyses. By integrating findings across reviews, evaluating methodological quality, assessing overlap among primary studies, and grading the certainty of evidence, this approach offers a comprehensive and clinically relevant overview of the available literature.

Therefore, the aim of this umbrella review was to synthesize evidence from published systematic reviews and meta-analyses to determine whether infection at the time of tooth extraction represents a significant risk factor for implant failure following immediate implant placement. Secondary objectives were to evaluate implant success, marginal bone loss,

peri-implant soft-tissue outcomes, and biological complications associated with implant placement in infected compared with non-infected extraction sockets.

MATERIALS AND METHODS

Protocol and Registration

This umbrella review was prospectively registered on PROSPERO (registration number: CRD420251110840; registered 28 July 2025) and reported in accordance with the PRISMA 2020 guidelines [25]. The protocol was submitted before data collection to enhance transparency and minimize bias.

Eligibility Criteria

Systematic reviews and meta-analyses of human clinical studies were eligible when they: (i) evaluated immediate implant placement (IIP) in extraction sockets with active or residual infection, including periapical lesions, periodontal disease, suppuration, or radiographic pathology; (ii) compared outcomes with IIP in non-infected sockets; and (iii) reported at least one relevant clinical outcome, such as implant survival rate, implant success rate, marginal bone loss (MBL), peri-implant disease, or biological complications. Narrative reviews, scoping reviews, case series, animal studies, in vitro investigations, conference abstracts, and grey literature were excluded.

Search Strategy

A comprehensive electronic search was conducted across MEDLINE (PubMed), Embase (Ovid), Scopus, Science Citation Index, the Cochrane Library (CENTRAL and CLIB), CINAHL, EBSCOHost, ScienceDirect, and Google Scholar up to 21 August 2025. The search strategy combined Medical Subject Headings (MeSH) and free-text keywords related to immediate implant placement, infected and non-infected extraction sockets, implant survival, and review study designs. Boolean operators (AND/OR), phrase searching, and truncation were used where appropriate to maximize retrieval sensitivity. Manual screening of reference lists and forward citation searching were also performed to identify additional relevant studies.

Study Selection and Data Extraction

Retrieved records were exported into reference management software and duplicate entries were removed. The remaining records were screened independently by two reviewers using Rayyan. Title and abstract screening was followed by full-text assessment of potentially eligible articles.

Data extraction was undertaken using standardized and pilot-tested forms. Information collected included bibliographic characteristics, review methodology, databases searched, number of included primary studies, availability of meta-analysis, participant and clinical characteristics, definitions of infected and non-infected sockets, duration of follow-up, reported outcome measures, and adjunctive treatment protocols. Data extraction was performed independently by two reviewers, and any disagreements were resolved through discussion and consensus.

Quality Assessment and Evidence Certainty

Methodological quality was assessed using the AMSTAR-2 tool and the Quality Assessment Tool for Studies with Diverse Designs (QATSDD). Overlap among primary studies included within the reviews was quantified using the corrected covered area (CCA) method [26]. The certainty of evidence for each outcome was evaluated using the GRADE approach and categorized as high, moderate, low, or very low certainty.

RESULTS

Study Selection

A total of 1,982 records were identified through database searching. After removal of 570 duplicates, 1,412 unique records remained for screening. Following title and abstract screening, 1,327 records were excluded. Eighty-five full-text articles were assessed for eligibility. Of these, 70 articles were excluded for the following reasons: outcome not assessed (n = 12), case reports and case series (n = 21), original studies (n = 25), and narrative reviews (n = 12). Ultimately, 15 systematic reviews and meta-analyses met the eligibility criteria and were included in the qualitative synthesis. The study selection process is summarized in the PRISMA flow diagram (Figure 1).

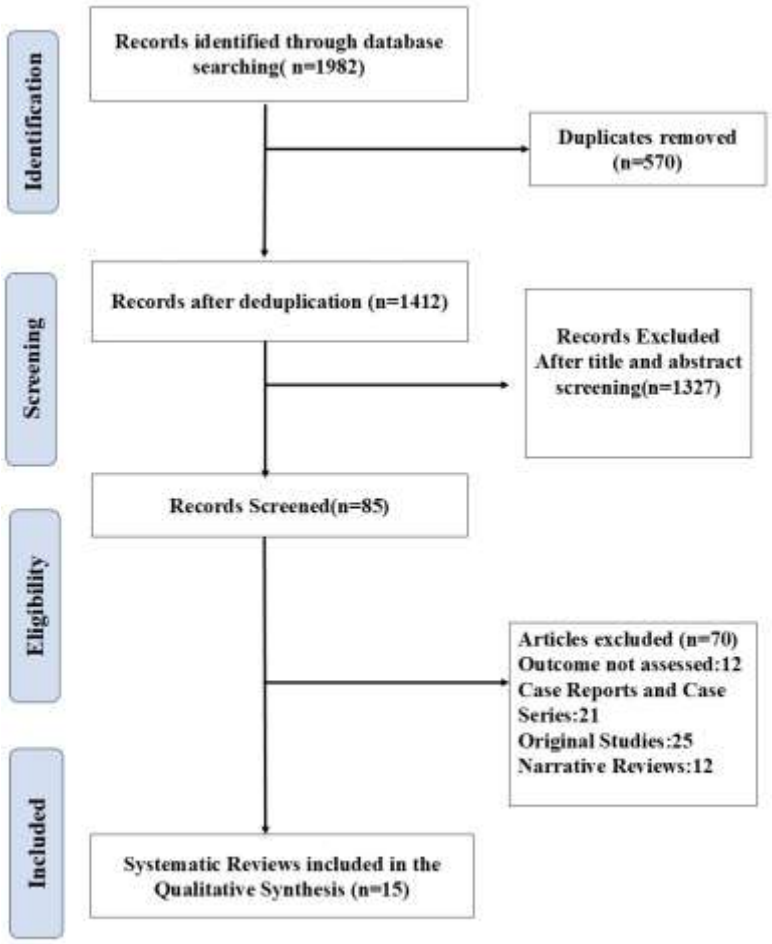

Figure 1: PRISMA flowchart describing workflow of study selection

Characteristics of Included Reviews

The 15 included reviews were published between 2010 and 2024 and collectively analysed evidence from several thousand patients and implants. Sample sizes ranged from 251 implants (Pranckeviciene et al. [22]) to over 5,100 implants (Amid et al. [20]). Definitions of infected sockets encompassed periapical lesions, active periodontal disease, sinus tracts, abscesses, endodontic-periodontal lesions, and radiographic periapical radiolucencies. Follow-up periods ranged from 6 months to 10 years, and underlying primary study designs included randomized controlled trials, controlled clinical trials, prospective and retrospective cohort studies, case series, and observational studies [4,5,11-23]. Adjunctive measures such as surgical debridement, systemic antibiotics, chlorhexidine rinses, guided bone regeneration (GBR), platelet concentrates, and laser-assisted disinfection were variably applied across studies.

Table 1. Characteristics and outcomes of systematic reviews evaluating immediate implant placement in infected extraction sockets

Author(s) (Year)	Studies (Qual)	Studies (Quant)	Population	Infected Socket Def.	Non-Infected Socket Def.	FU Duration	Survival	Success	MBL	Peri-Implantitis / Mucositis	Complications	Adjuncts	Meta-Analysis	Subgroups
Waasdorp JA et al.	12	0	Humans + anim	Periapical, perio-endodonti	Healthy soc	7–72 mo	92–100 %	High	Minimal	Some suppurati	Rare	Debridement,	Narrative	Not done

(2010) [11]			als	c, cysts	kets					on		antibiotics, GBR		
Álvarez-Camino JC et al. (2013) [4]	16	0	Humans & animals	Chronic periapical, fistula, radiolucent	Healthy	≥6 mo –48 mo	High	NR	Similar	No implant infection	Rare (antibiotic colitis)	Curettage, antibiotics, GBR	None	None
Chrcanovic BR et al. (2015) [5]	28	0	Humans + animals	Periapical, sinus tract, perio-endodontic	Healthy	6 mo –17 yrs	>95 %	Similar	0.4 – 0.8 mm	Rare	Retrograde peri-implantitis	Debridement, antibiotics	None	Narrative
Lee CT et al. (2015) [12]	3	3	Adults	Periapical pathology	Non-infected sockets	1–5 yrs	96.2 % vs 97.4 %	ICOI success	≤0.5– 2.0 mm	Small changes	Rare suppuration	Antibiotics, GBR	KM only	Immediate vs delayed
Zhao D et al. (2016) [13]	7	7	935 pts	Periapical/ periodontal	Healthy	≥12 mo	Failures 2.2 % vs 1.1 %; RR= 2.16 (NS)	High	MD −0.04 mm (NS)	Not reported	Minimal	Debridement, antibiotics	RR 2.16; MD −0.04	Lesion type, FU
Chen H et al. (2018) [14]	9	9	1735 pts	Esthetic zone infections	Healthy	≥1 yr (to 146 mo)	97.6 % vs 98.4 %	NR	MD +0.03 mm (NS)	NR	NR	Curettage, GBR, PRGF	RR 0.99	Bone loss by time
Lee J et al. (2018) [15]	5 (3 pooled)	3	538 implants	Periapical/ periodontal	Healthy	1–5 yrs	98.2 % vs 99.1 %	Similar	WMD 0.32 mm	No sig.	Rare	Antibiotics, GBR	RD −0.02	Acute vs chronic
de Oliveira-Neto OB et al. (2019) [16]	8	8	935 implants	Acute/chronic infection	Healthy	1–4 yrs	RR= 2.99 failure risk	NR	MD −0.03 mm (NS)	NR	NR	Antibiotics	RR 2.99	None
Saijeva A, Juodzbalys G. (2020) [17]	9	9	1346 pts	Periapical/ periodontal	Healthy	12–60 mo	97.6 % vs 98.6 %	High	MD −0.03 mm (NS)	NS	Failures minimal	Curettage, GBR	RR 0.99	FU subgroups
Kaur J et al. (2021)	23	14	1164 infected	Periapical, perio, endo-	Healthy	12–93 mo	RR= 0.99 (~9	Similar	MD 0.01	NS	Minimal	Antibiotics, GBR,	RR 0.99	FU <36 vs

[18]			vs 1621 healthy	perio			8% survival)		mm (NS)			PRGF		>36 mo
Mickevicius I et al. (2023) [19]	7	0	259 pts, 663 implants	Periapical, granulation	Healthy	3–60 mo	94.4–100 %	High	Minimal	Low incidence	Mild	Curettage, CHX, GBR, PRGF, laser	None	None
Amid R et al. (2023) [20]	44 (13 pooled)	13	3436 pts, 5148 implants	Periapical, periodontal, buccal defect	Healthy	8–120 mo	96.8 % vs 98.7 %	Similar	NS (highest in perio lesions)	NR	Few	Antibiotics, GBR	RR 0.99	Subgroups by socket type
Ganapathy V et al. (2024) [21]	7	7	Adults	Periapical/ periodontal	Healthy	≥5 yrs–10 yrs	94–100 %	≥90 %	Stable	Minimal	Minor	Antibiotics, GBR, PRF	Narrative	Stage/load subgroups
Pranckeviciene A et al. (2024) [22]	6	6	271 pts, 251 implants	Periapical pathology	Healthy	1–5 yrs	99.6 %	High	BIC diff −0.01 mm	No sig.	Minimal	Curettage, GBR, antibiotics	KM diff 0.22 mm	Acute vs chronic
AlMugeiren O et al. (2024) [23]	10	10	849 pts	Apical/periapical pathology	Healthy	1–5 yrs	OR= 2.08 (favoring infected)	95–100 %	NS	Retrograde not seen	No ↑ complications	PRGF, GBR, lasers	OR= 2.08; PI RR 0.59	None

Implant Survival

Implant survival was consistently high in both infected and non-infected groups, ranging from 94.4% to 100% across reviews. Most pooled meta-analyses demonstrated no statistically significant difference between infected and healthy extraction sockets. Saijeva and Juodzbalys [17] reported survival rates of 97.6% and 98.6%, respectively, while Kaur et al. [18] observed a pooled relative risk close to unity (RR ≈ 0.99). Similar findings were reported by Chen et al. [14] (97.6% vs. 98.4%) and Pranckeviciene et al. [22], who found survival rates approaching 99.6% regardless of socket condition. Kaplan–Meier analyses conducted by Lee et al. [12] likewise demonstrated comparable long-term survival probabilities between implants placed in infected and non-infected sites.

Two reviews suggested a possible increase in failure risk among implants placed in infected sockets. De Oliveira-Neto et al. [16] reported a relative risk of failure of 2.99 (95% CI: 1.04–8.56), whereas Zhao et al. [13] identified a borderline non-significant risk increase (RR = 2.16; 95% CI: 0.97–4.80). However, the absolute number of failures remained low, confidence intervals were wide, and heterogeneity among included studies limited the certainty of these findings.

Implant Success, Marginal Bone Loss, and Soft-Tissue Outcomes

Implant success rates, where reported using ICOI or comparable criteria, ranged from 90% to 100% and showed no significant differences between infected and non-infected groups [12,18,20]. Long-term evidence synthesized by Ganapathy et al. [21] demonstrated success rates exceeding 90% after 5–10 years of follow-up, even among periodontally compromised patients.

Marginal bone loss (MBL) was consistently minimal and generally remained below 1 mm. Meta-analyses found no statistically significant differences between groups, including Zhao et al. [13] (MD −0.04 mm), Chen et al. [14] (MD +0.03

mm), Lee et al. [15] (WMD 0.32 mm), Kaur et al. [18] (MD 0.01 mm), and Pranckeviciene et al. [22] (BIC difference −0.01 mm). Subgroup analyses based on follow-up duration likewise failed to demonstrate clinically meaningful differences, and long-term crestal bone stability was maintained for up to a decade [21].

Soft-tissue outcomes, including probing depth, plaque accumulation, bleeding indices, and gingival recession, were generally comparable between groups. Some studies reported slightly reduced widths of keratinized mucosa around implants placed in infected sockets [15,17], although the differences were small and inconsistently reported. In the esthetic zone, satisfactory esthetic outcomes were achieved when meticulous surgical protocols and appropriate hard- and soft-tissue management were implemented [14].

Biological Complications

The overall incidence of biological complications was low. Retrograde peri-implantitis was reported infrequently and showed no consistent association with implant placement in infected sockets [5,8]. AlMugeiren et al. [23] found no increased risk of peri-implant disease and reported a reduced relative risk for peri-implantitis in pooled analyses. Across reviews, peri-implantitis and peri-implant mucositis occurred at similarly low frequencies in infected and non-infected groups [17,23]. Most complications were minor and manageable, with overall complication rates generally below 5%.

One review documented a serious antibiotic-related adverse event (pseudomembranous colitis) following prophylactic antibiotic administration [4]. Occasional reports of postoperative suppuration were successfully managed through local treatment without implant loss [4,11].

Adjunctive Protocols

All reviews emphasized that successful immediate implant placement in infected sockets depends on effective infection control and meticulous surgical technique. Commonly reported measures included mechanical debridement and curettage of granulation tissue, systemic antibiotic prophylaxis, chlorhexidine irrigation or rinses, and achievement of primary implant stability [4,5,11-23].

Guided bone regeneration using xenografts and collagen membranes was frequently employed in the presence of socket defects. Additional biologic adjuncts such as platelet-rich fibrin (PRF) and plasma rich in growth factors (PRGF), together with laser-assisted disinfection, were reported in selected studies [18,19,23]. Nevertheless, no systematic review demonstrated a statistically significant benefit of these adjunctive interventions beyond that achieved through thorough mechanical debridement and standard infection-control measures [9,19].

Methodological Quality and Certainty of Evidence

Risk of Bias Assessment

Risk-of-bias assessment of the included reviews is presented in Table 2. Overall, most reviews demonstrated a low risk of bias for randomization processes, management of incomplete outcome data, and other sources of bias. However, concerns were frequently identified in allocation concealment, blinding of participants and personnel, blinding of outcome assessment, and selective reporting. Earlier reviews generally exhibited higher risks of bias due to limited methodological reporting and reliance on lower levels of evidence, whereas more recent systematic reviews demonstrated improved methodological rigor.

Table 2. Risk-of-bias assessment of included reviews

Study (Year)	Randomization Process	Allocation Concealment	Blinding of Participants & Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting	Other Bias
Waasdorp JA et al. (2010)[11]	Low	High	Some concerns	Low	High	Low	Low
Álvarez-Camino JC et al. (2013)[4]	Low	High	Some concerns	Low	High	Low	Low
Chrcanovic BR et al. (2015)[5]	Low	Low	Low	High	Some concerns	High	Some concerns
Lee CT et al. (2015)[12]	Low	Low	Some concerns	High	Low	Low	Some concerns
Zhao D et al. (2016)[13]	Low	Low	Low	High	Some concerns	High	Some concerns
Chen H et al. (2018)[14]	Some concerns	Some concerns	Some concerns	Some concerns	High	Some concerns	Some concerns
Lee J et al. (2018)[15]	Some concerns	High	Low	Low	Some concerns	Low	Low
de Oliveira-	Low	Low	Low	Low	Low	Some	Low

Neto OB et al. (2019)[16]						concerns	
Saijeva A, Juodzbalys G. (2020)[17]	Some concerns	Some concerns	Some concerns	Some concerns	High	Some concerns	Some concerns
Kaur J et al. (2021)[18]	Low	Low	Low	Low	Low	High	Low
Mickevičius I et al. (2023)[19]	Low	Low	High	Low	Low	High	Low
Amid R et al. (2023)[20]	Low	Low	Low	Low	Low	Some concerns	Low
Ganapathy V et al. (2024)[21]	Low	Low	Some concerns	Some concerns	Low	Low	Some concerns
Pranckeviciene A et al. (2024)[22]	High	Low	Some concerns	Some concerns	Low	Low	Some concerns
AlMugeiren OM et al. (2024)[23]	Low	High	Some concerns	Some concerns	Low	Low	Some concerns

Quality Assessment (QATSDD)

QATSDD assessment scores ranged from 22 to 40 out of 42, with a mean score of 26.5 (SD 3.76) and excellent inter-rater agreement (κ = 0.91; 95% CI: 0.84–0.98). Frequently identified methodological limitations included limited stakeholder involvement, inadequate reporting of theoretical frameworks, and incomplete descriptions of measurement validity and reliability. Conversely, the strongest domains included clear alignment between research questions and methods, detailed recruitment procedures, and appropriate statistical analyses.

Table 3. QATSDD quality assessment criteria

Quality Criterion	Mean Score (SD, Range)
Evidence of user involvement in design	0.78 (0.2, 0–2)
Explicit theoretical framework	0.9 (0.5, 0–2)
Evidence of sample size considered in terms of analysis	2.1 (1.4, 0–3)
Statistical assessment of reliability and validity of measurement tools	1.8 (0.9, 1–3)
Strengths and limitations critically discussed	1.3 (0.8, 0–3)
Good justification for method of analysis	2.3 (1.4, 0–3)
Clear description of research setting	2.0 (1.7, 1–3)
Description of procedure for data collection	1.9 (1.3, 1–3)
Statement of aims/objectives in body of report	2.2 (1.4, 1–3)
Detailed recruitment data	2.3 (1.6, 1–3)
Representative sample of reasonable size	2.1 (0.9, 1–3)
Rationale for choice of data collection tool	2.0 (1.1, 1–3)
Fit between research question and method of data collection	2.5 (1.2, 1–3)
Fit between research question and method of data analysis	2.3 (1.2, 1–3)

AMSTAR-2 evaluation classified the most recent reviews, particularly those by AlMugeiren et al. [23] and Pranckeviciene et al. [22], as moderate-to-high quality. Earlier reviews, including Waasdorp et al. [11] and Zhao et al. [13], received lower ratings owing to the absence of formal risk-of-bias assessment tools and inclusion of lower-level evidence such as case series.

Corrected Covered Area (CCA) analysis demonstrated moderate overlap among primary studies included within the systematic reviews, indicating some redundancy of evidence. Consistent with recommendations regarding overlap in evidence syntheses [26], cumulative estimates should therefore be interpreted cautiously. Applying the GRADE framework [25], certainty of evidence was rated as moderate for implant survival outcomes because of consistent findings across reviews, but low for soft-tissue outcomes, esthetic parameters, and long-term complication rates owing to heterogeneous outcome measures, limited reporting, and variable follow-up durations.

DISCUSSION

The principal finding of this umbrella review is that IIP in infected extraction sockets can achieve implant survival and success rates comparable to those in non-infected sockets, provided strict infection-control protocols and meticulous

surgical technique are applied. This conclusion is supported by the majority of included meta-analyses reporting pooled survival rates within the 97-99% range without significant inter-group differences [12,15,21], consistent MBL below 1 mm [17,20], and low biological complication rates [11]. These findings align with current evidence in implant dentistry suggesting that host biology and protocol quality are more decisive determinants of outcome than the pre-existing infection itself [7,10].

From a mechanistic perspective, the ability to achieve favourable outcomes in infected sockets reflects the capacity of thorough mechanical debridement to eliminate residual biofilm and granulation tissue, transforming an unfavourable environment into one compatible with osseointegration [5,18]. The fresh extraction socket, even after infection clearance, retains biological potential: blood clot formation, growth factor release, and bone remodelling are initiated promptly after atraumatic extraction and meticulous socket preparation [3,7]. Systemic antibiotics reduce residual bacterial load, and antiseptic irrigation assists decontamination of socket walls before implant insertion [10].

Nonetheless, two meta-analyses detected a potentially meaningful increase in failure risk in infected sockets [13,24]. De Oliveira-Neto et al. [13] reported a relative risk of 2.99, and Zhao et al. [24] reported a borderline non-significant relative risk of 2.16. Although the absolute number of failures remained low and confidence intervals were wide, these data serve as important reminders that infection may act as a conditional risk modifier whose impact is amplified when infection control is incomplete, primary stability is suboptimal, or case selection is inappropriate [27,28]. Clinicians should therefore avoid interpreting the overall positive evidence as a blanket endorsement for IIP in all infected sockets regardless of context.

Infection aetiology appears to modulate predictability. Periapical lesions—particularly chronic and well-circumscribed ones—consistently showed outcomes comparable to non-infected sockets [16,20]. Sockets with a periodontal aetiology, especially in patients with aggressive periodontitis, posed greater challenges, including slightly higher marginal bone loss in one meta-analysis [19], likely reflecting ongoing immunological susceptibility rather than a direct socket infection effect [22,29]. This aligns with the broader implant literature emphasising that residual periodontal disease and smoking are among the strongest risk factors for peri-implant bone loss [22].

Soft-tissue findings were largely reassuring, though a minor reduction in keratinized mucosa width was noted in infected cohorts in some reviews [17,21]. While clinical significance remains uncertain, this may be particularly relevant in the aesthetic zone where keratinized tissue is essential for peri-implant stability and gingival contour [2,12]. Surgeons should account for this through appropriate soft-tissue management—connective tissue grafts, palatal flap repositioning, or tunnel techniques—when operating in esthetically sensitive sites or patients with a thin periodontal biotype.

The role of adjunctive measures warrants specific comment. Thorough mechanical debridement was universally highlighted as the most critical determinant of success [18,20]. Biologic adjuncts (PRF, PRGF) and laser-assisted disinfection showed variable benefit without consistent statistical advantage [11,14], and may therefore be considered supplementary refinements pending more robust evidence. GBR was widely applied in cases with buccal defects and has been associated with favourable bone and soft-tissue outcomes in compromised sockets [19].

Several limitations of the current evidence base must be acknowledged. First, definitions of infected socket varied widely across reviews, ranging from radiographic periapical radiolucency to overt suppuration and mixed endodontic-periodontal lesions [4,13,24,29]. Second, most included primary studies were observational in design, with few well-powered RCTs, limiting causal inference and increasing susceptibility to confounding by indication [16,27]. Third, surgical and antimicrobial protocols varied considerably across studies, obscuring which specific combination of measures is most effective [19,21]. Fourth, CCA analysis confirmed moderate overlap of primary studies across reviews, creating potential for overestimation of cumulative data. Finally, English-language restriction and publication bias may have led to selective representation of positive outcomes.

Future research should address these limitations through multicentre RCTs with harmonised infection definitions encompassing aetiology, severity, and microbial characterisation, standardised surgical and antimicrobial protocols, and follow-up periods of at least 5 years. Prespecified subgroup analyses should address infection aetiology (periapical vs. periodontal), site location (anterior vs. posterior; maxilla vs. mandible), and patient risk profile (periodontal history, smoking status, systemic disease) [14,29]. Patient-reported outcomes—including esthetic satisfaction, quality of life, and cost-effectiveness—should be systematically incorporated [2].

Conclusion

This umbrella review of 15 systematic reviews and meta-analyses indicates that immediate implant placement in infected extraction sockets achieves survival and success rates comparable to non-infected sites, with minimal marginal bone loss and low complication rates when thorough debridement, infection control, and primary stability are achieved. These findings support the use of immediate implants in carefully selected patients. However, evidence quality remains moderate to low due to methodological heterogeneity, highlighting the need for well-designed randomized controlled trials with standardized protocols and long-term follow-up.

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