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Literature Review: Complications and Prevention Strategies in Peri-Implantitis

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Abstract: Dental implants are an effective solution for oral rehabilitation; however, complications such as peri-implant mucositis and peri-implantitis are common. These conditions are triggered by bacterial plaque, smoking, systemic diseases, and prosthetic errors, with a prevalence of up to 22% among patients. Prevention plays a crucial role in ensuring the long-term success of dental implants.This study aims to provide a comprehensive understanding of the biological, technical, and systemic factors influencing implant success while emphasizing the importance of early detection, continuous care, and a multidimensional approach to maintaining peri-implant tissue health and long-term implant stability.Peri-implantitis management involves a comprehensive approach, including diagnosis, prevention, and both non-surgical and surgical therapy. Clinical examinations include bleeding on probing (BoP), pocket depth, and marginal bone radiography. Prevention focuses on plaque control, patient education, and regular visits every 3–6 months. Non-surgical therapy includes debridement, antiseptics, laser, and local antibiotics, while surgical therapy employs biomaterials such as DBBMC and EMD. Success is influenced by risk factor control and long-term maintenance. Effective peri-implantitis therapy reduces BoP, pocket depth, and stabilizes alveolar bone. Combining mechanical therapy, laser, and photodynamic therapy decreases inflammation by up to 86% and improves bone stability by 92%. Radiographic evaluation shows superior bone regeneration with combination therapy. Regular plaque control and professional maintenance every 3–6 months reduce recurrence by 60%, ensuring long-term peri-implant health.

Keywords: Implant complications; Peri-implantitis; Peri-implant strategies; Prevention

Introduction

Peri-implantitis is one of the serious biological complications that occur in dental implants, characterized by inflammation of the soft tissues around the implant (perimucocytes), and if left untreated, extends to progressive loss of alveolar bone around the implant (bone loss) (Cheung et al., 2021). These complications not only threaten the structural stability of the implant, but also have an aesthetic impact, patient comfort, and increased cost of care (Wang et al., 2025).

Several factors exacerbate the risk of peri-implantitis: the patient's general health status such as diabetes, smoking habits, a previous history of periodontal disease, as well as local characteristics such as prosthetic design, the quality of soft tissue closures, and rough implant surfaces (Tallarico et al., 2025). In addition, technical errors such as cement residue from restoration, improper installation (malposition), excessive mechanical load (*occlusal overload*), and damage to the abutment-implant connection are also important contributors to peri-implantitis incidents (Sahrmann et al., 2020)

Complications that can arise if peri-implantitis is not prevented or treated properly include: significant bone loss, soft tissue recession, formation of pathological pockets, implant mobility, suppuration, even implant failure and must be removed (de Avila et al., 2020). Often there is also a recurrence after therapy, even if a surgical or non-surgical procedure has been performed. For example, in a retrospective study, it was found that about 20% of patients experienced disease recurrence at the patient level and 10% at the implant level after

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supportive *peri-implant therapy* (SPIT) (Carra et al., 2023). In addition, the very rough surface of the implant can increase microbial colonization and accelerate the deterioration of the surrounding bones (Bohara & Suthakorn, 2022).

Seeing the severity of the effects of complications, prevention strategies become very important. Prevention can be categorized into stages-primordial, primary, secondary, and tertiary. The primordial stage aims to prevent the emergence of risk factors such as smoking habits or systemic disease control (diabetes) (Berglundh et al., 2024). The primary stage is concerned with the application of oral hygiene practices and biofilm control in patients with healthy peri-implant tissue, including the use of professional hygiene techniques and patient self-care instructions. The secondary stage involves early detection and treatment of peri-implant mucositis so that it does not develop into peri-implantitis (Atieh et al., 2021). The tertiary stage focuses on preventing further complications after the disease has already occurred, such as slowing the rate of bone loss, preventing implant failure, and maintaining existing tissue (Garaicoa-Pazmino et al., 2019).

A variety of specific strategies have been proposed and researched. One of them is the design of implant *surface modifications* to reduce adhesion and proliferation of pathogenic microbes, for example the use of antimicrobial coatings, metal nanoparticles, or special biomaterial materials as coatings (Astolfi et al., 2022). The use of *imaging such as Cone Beam* CT (CBCT) also helps in implant planning, anatomical evaluation, and optimal implant placement thereby minimizing uneven mechanical load or malposition (Roccuzzo et al., 2023). Controlling systemic factors such as blood sugar control in patients with diabetes and smoking cessation are important interventions. In addition, good prosthetics and restorative design that take into account hygiene accessibility, emergence profiles, and the selection of restoration materials that do not trap plaque are also highly relevant (Kwon et al., 2022).

Also important are post-therapy maintenance protocols, including routine checkups, professional prophylaxis, re-cleaning of implant surfaces, and monitoring of clinical indications such as probing depth, bleeding, and suppuration (Smeets et al., 2014). Studies on the effects of SPIT show that even if treatment is successful, without maintenance there is often a recurrence, even implant failure of up to ~12% in some reports (Sarmiento et al., 2016).

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Method

Based on the results of the literature that has been reviewed, the method of handling and applying therapy in patients with peri-implantitis is carried out through a comprehensive approach that includes the stages of diagnosis, prevention, and therapeutic interventions, both non-surgical and surgical. The treatment process begins with a clinical examination that includes bleeding on probing (BoP), peri-implant pocket depth, and radiography to assess marginal bone loss. Early detection of peri-implant mucositis is an important step to prevent progression to irreversible peri-implantitis. At the prevention stage, strict plaque control, patient oral hygiene, education, and regular visits every 3-6 months are standard procedures that have been proven to reduce the risk of disease by up to 40%. For cases that already show active inflammation, non-surgical approaches such as mechanical debridement, the use of antiseptics (chlorhexidine), and adjuvant therapies such as lasers, photodynamic therapy (PDT), and local antibiotics are often applied to lower plaque index, bleeding, and pocket depth. If bone destruction has occurred, surgical interventions such as open flap debridement (OFD), resective therapy (RT), or augmentative/regenerative therapy (AT) with biomaterials such as deproteinized bovine bone mineral (DBBMC), enamel matrix derivative (EMD), or platelet concentrate (CGF) are performed to promote bone regeneration. In addition, pre-surgical analysis using CBCT is important to determine the ideal position of the implant and prevent anatomical complications such as penetration into the maxillary sinuses. Overall, the success of therapy is strongly influenced by the control of the patient's risk factors, the selection of appropriate techniques, and long-term post-treatment maintenance.

Result and Discussion

Assessment of success in peri-implantitis therapy is generally based on clinical and radiographic parameters that reflect the stability of the hard and soft tissues around the implant. Based on the results of a review of various studies, the most commonly used success indicators are a reduction in inflammation (bleeding on probing/BoP), a reduction in the depth of the pocket (probing depth/PD), and an improvement in the integrity of the alveolar bone seen through radiography (Miriam Ting & Jon B. Suzuki, 2014). Assess the success of peri-implantitis prevention through a combination of plaque control, systemic disease surveillance, and regular patient maintenance that is able to reduce the incidence of complications by up to 14.3% of the at-risk population. The effectiveness of therapy also increases

significantly when non-surgical procedures are combined with surgical interventions, which demonstrates the importance of a multimodal approach in controlling this chronic inflammatory disease (Ting & Suzuki, 2024).

Bacterial plaque is the primary cause that directly affects the success rate of therapy. An evaluation of success was performed by looking at decreased microbial colonization, bone stability, and decreased clinical signs of inflammation after combination mechanical, antiseptic, and surgical therapy (Rokaya et al., 2020). However, bone regeneration outcomes are not entirely predictable, so long-term control and maintenance are decisive factors for long-term success. In line with that. Clinical success relies heavily on early detection and routine plaque control every three to six months. Such periodic examinations were able to reduce recurrence by up to 60%, which suggests that success is measured not only by the initial post-therapy results but also by the long-term stability of the tissues (Berglundh et al., 2024).

Therapeutic success of early diagnosis ability through clinical signs of BoP and radiographic changes of marginal bone ≥0.5 mm (Stiesch et al., 2023). If this condition can be controlled without further inflammatory progression, then the patient is considered to have achieved successful peri-implant stability. Regular checks with gentle probing techniques are an important part of maintaining this stability. Meanwhile, a meta-analysis approach was used to compare the effectiveness of various additional therapies such as lasers, photodynamic therapy (PDT), and local antibiotics. The results showed that the combination of mechanical and laser therapy significantly improved clinical outcomes compared to the single method, with a decrease in the prevalence of peri-implantitis by up to 40% (Łotowska et al., 2023).

Success based on a decrease in BoP of up to 86% and bone stability of 92.5% after combination regenerative therapy (DBBMC + EMD + doxycycline) (Wijesundara et al., 2023). This shows that quantitative indicators such as BoP and bone stability are the standard standards in assessing clinical success. The importance of primary prevention through peri-implant management of mucositis is a key determinant of long-term success, as peri-implantitis is almost always preceded by untreated mucositis. Evaluation was carried out by monitoring the patient's oral hygiene and the results of periodic professional examinations (3–6 months) (Jepsen et al., 2015).

Diagnostic definition by combining clinical (BoP, suppuration) and radiographic criteria (bone loss >2 mm) (Astolfi et al., 2022). Success is assessed if there are no signs of active inflammation and no progression of bone loss on repeated examinations. This assessment is considered the global consensus standard for assessing peri-implant health. In the Indonesian context, the success of implants is determined not only by biological parameters, but also by mechanical management such as occlusion correction and effective annual controls in preventing complications such as screw loosening and implant disintegration (Sidjaja, 2000).

Regular plaque control and oral maintenance every 3–6 months are the main predictors of success. Although the prevalence of peri-implantitis was still quite high (20.95% per patient), they assessed the success of the patient's quality of life aspect that did not decrease significantly after the preventive intervention was carried out (Ang et al., 2025). In the case of more severe complications, such as implant penetration into the maxillary sinuses, Rachmawati et al. (2019) assessed the success through the use of Cone Beam Computed Tomography (CBCT) to ensure that there is no further inflammation, thickening of the sinus mucosa, or repeated invasion of the implant.

A review of RCTs showed that a combination of mechanical therapy and antimicrobial photodynamic therapy (aPDT) was effective in significantly lowering PD, BoP, and Plaque Index without side effects. Clinical effects last for at least six months, which is an indicator of medium-term success(Bahrami et al., 2024). Non-surgical therapy combined with patient education provides optimal results when accompanied by good oral hygiene (Susanna Halim, Florenly, Mellisa Winata, Marco Luman, 2025). Meanwhile, the effectiveness *of Concentrated Growth Factor* (CGF) in bone regeneration as the main radiographic parameter of the success of peri-implantitis therapy (Maitimu & Suwandi, 2024).

A classification system of peri-implantitis etiology that allows the assessment of success based on the dominant cause whether it is caused by biofilms, iatrogenic irritants, or external pathologies (Sarmiento et al., 2016). With this approach, the therapeutic outcome becomes more specific, and the prognosis improves by up to 78.8% in cases with biofilm etiology. Overall, the success of peri-implantitis treatment was assessed through a combination of clinical aspects (BoP, PD, suppuration), radiographic (bone loss), functional (implant stability), and patient behavior (hygiene and routine control). Long-term maintenance and a multidisciplinary approach are key to ensuring continued success in the therapy and prevention of peri-implantitis.

Table 1. Literatur Review

Author & Year	Method	Key Results / Findings	Data base
(Miriam Ting & Jon B. Suzuki, 2014)	Design : Narrative Review Sample: Relevant scientific articles, clinical reports, systematic reviews, and meta-analyses related to etiology, prevalence, risk factors, microbiology, and peri-implantitis therapy.	Peri-implantitis is a multifactorial chronic inflammatory complication. Major risk factors include a history of periodontitis, smoking, systemic diseases, and semen residues. Prevention through plaque control, routine maintenance, patient education, and systemic disease surveillance can reduce incidence by up to 14.3%. A combination of non-surgical and surgical approaches increases the success of therapy.	MDPI
(Rokaya, D., Srimaneepong, V., Wisitrasameewon, W., Humagain, M., & Thunyakitpisal., 2020)	Desain : Narrative review (Study compilation from 2010–2020) Sampel: Relevant scientific articles, clinical reports, systematic reviews, and meta-analyses related to etiology, prevalence, risk factors, microbiology, and peri-implantitis therapy.	Peri-implantitis has a multifactorial etiology with bacterial plaque as the main cause. Systemic risk factors (smoking, periodontitis, diabetes) increase the prevalence by 2–3 times. The most effective therapeutic approaches are a combination of mechanical, antiseptic, and surgical interventions. Bone regeneration is not yet fully predictable, so long-term maintenance is highly recommended.	PubMed
(Schwarz, F., Derks, J., Monje, A., & Wang, H. L. (2018)	Desain : Comprehensive review. Sampel: Relevant scientific articles, clinical reports, systematic reviews, and meta-analyses related to etiology, prevalence, risk factors, microbiology, and peri-implantitis therapy.	Globally, 22% of patients and 9.25% of implants developed peri-implantitis. This disease progresses faster than periodontitis because the inflammatory infiltration is more extensive. History of periodontitis, smoking, and poor oral hygiene are the main risk factors. Prevention and early detection through plaque control and periodic check-ups every 3–6 months are effective in reducing recurrence by up to 60%.	PubMed
(Heitz-Mayfield, 2024)	Desain : Narrative review Sampel: Up-to-date scientific articles, experimental studies, and clinical guidelines	Peri-implant mucositis bersifat reversibel, sedangkan peri-implantitis bersifat progresif dan irreversible. Diagnosis klinis melalui *bleeding on probing* (BoP) dan radiografi marginal bone loss sangat penting. Pemeriksaan rutin dengan probing lembut dan radiografi standar dapat mendeteksi dini perubahan tulang ≥0.5 mm, mencegah progresi mucositis menjadi peri-implantitis.	PubMed
Zizzari, V. L., Di Giacomo, V., & Tetè, G. (2023)	Desain : Systematic review and network meta-analysis (NMA) research Sampel: The 13 RCTs include: 1. Types of surgical interventions compared: ● Open Flap Debridement (OFD) ● Resective Therapy (RT) ● Augmentative Therapy (AT) 2.Adjunctive therapies: ● Laser therapy ● Photodynamic therapy (PDT) ● Local antibiotics	Peri-implant mucositis occurs in 43–47% of patients and peri-implantitis in 22%. The main factors: poor oral hygiene, smoking, periodontitis, and systemic diseases. Prevention through strict plaque control, regular visits, and patient education can reduce the risk by up to 40%. A combination of mechanical + laser approaches has been shown to improve clinical outcomes compared to a single method.	PubMed

Author & Year	Method	Key Results / Findings	Data base
	• Phosphoric acid • Ozone therapy		
(Wijesundara, S., Sharma, L. A., Alavi, S. E., & Sharma, A. 2023)	Desain: Systematic Review (PRISMA-based) Sampel: 5 clinical studies (≥20 patients, follow-up ≥2 years)	Surgical methods (resective, regenerative, and combined) are effective in reducing inflammation and improving implant stability. The combination of regenerative therapy (DBBMC + EMD + doxycycline) gave the best results, lowering BoP by up to 86% and maintaining bone stability by 92.5%. The main risk factors: periodontitis, rough implant surfaces, and poor oral hygiene.	MDPI
(Jepsen et al., 2015)	Desain : Evidence-based review of four systematic reviews and EFP expert discussions Sampel: Scientific articles and previous research data related to peri-implant mucositis and peri-implantitis	Primary prevention of peri-implantitis through the management of mucositis is the main strategy. Patient mechanical plaque control and routine professional examinations (3–6 months) are the gold standard. The prevalence of mucositis is 43% and peri-implantitis is 22%. Risk factors: plaque accumulation, smoking, semen residue, and lack of annual supportive therapy.	PubMed
(Renvert et al., 2018)	Desain: Consensus-based systematic review (hasil World Workshop 2017) Sampel: Previous scientific studies and literature on peri-implant health, mucositis, and peri-implantitis	Establish definitions and diagnostic criteria for peri-implant health, mucositis, and peri-implantitis. The diagnosis is based on a combination of clinical signs (BoP, suppuration) and radiographic (bone loss >2 mm). Periodic assessment and baseline recording of radiographs are important for early detection of peri-implant complications.	Pubmed
(Sidjaja, 2000)	Desain : prospective and retrospective clinical study (direct observation of patients' clinical cases during the period of 16 years 1987–2003) Sampel: Patients with bone implant restoration at FKG University of Indonesia (±167 implant cases)	The most complications in implants were screw loosening (17 cases) and implant disintegration (7 cases). The main factors of the cause: poor occlusion control, trauma, and low oral hygiene. Effective treatment includes occlusion correction, replacement of damaged components, and annual routine check-ups. Patient education plays a big role in prevention.	Garuda
(Ang et al., 2025)	Desain : Observational analytics by design cross-sectional Sampel: 105 patients (265 implants)	The prevalence of peri-implantitis was 20.95% per patient and 11.7% per implant. Risk factors: history of periodontitis, lack of oral maintenance, and length of implant use. It does not have a significant effect on quality of life, but plaque control and regular maintenance of 3–6 months is important to prevent complications.	Google Scholar
(Rachmawati et al., 2019)	Desain : Case Report Sample: 1 female patient aged 40 years	Penetrasi implan ke sinus maksilaris menyebabkan inflamasi dan abses. CBCT terbukti efektif mendeteksi komplikasi seperti penebalan mukosa sinus dan posisi implan yang salah. Pencegahan dilakukan dengan analisis pra-bedah dan menjaga jarak aman ≥2 mm dari dasar sinus.	Google Scholar

Author & Year	Method	Key Results / Findings	Data base
(Bahrami et al., 2024)	Disain : Systematic Review of Randomized Controlled Trials (RCTs) Sampel: 14 RCT studies with a total of 322 articles screened	aPDT terbukti aman dan efektif menurunkan PD, BOP, dan PI secara signifikan serta mengurangi bakteri periopatogen tanpa efek samping berarti. Efek bertahan hingga ≥6 bulan, terutama bila dikombinasikan dengan mechanical debridement. Disarankan sebagai terapi adjuvan standar peri-implantitis.	PubMed
(Susanna Halim, Florenly, Mellisa Winata, Marco Luman, 2025)	Disain: Literature Review + Case Report Sampel: English, 2020–2024, full text, original/review/case report 3 patients	Non-surgical therapies (mechanical debridement, antiseptic, local/systemic antibiotics) are effective in improving the condition of peri-implant tissue. All cases showed a decrease in inflammation and clinical improvement without surgery. The best results are achieved in patients with good oral hygiene and regular maintenance.	Google Scholar
(Maitimu & Suwandi, 2024)	Disain: Systematic Review Based on the PICOS framework Sample: 3 RCT (Randomized Clinical Trial)	CGF is effective and biocompatible in accelerating bone regeneration as well as improving the clinical parameters of peri-implantitis. The radiographic results are similar to those of collagen membranes, although the stability of CGF is lower. It is recommended as an efficient and safe adjunct therapy in the prevention of implant failure.	Google Scholar
(Sarmiento et al., 2016)	Disain: Observational retrospective Sample: 270 implants with a diagnosis of peri-implantitis	Propose a new classification of peri-implantitis based on etiology (biofilm, iatrogenic, exogenous irritants, AKT, external pathologies). 78.8% of cases are caused by biofilms. This system improves the accuracy of diagnosis and the selection of specific therapies against the main cause, resulting in better prognosis.	PubMed

Discussion

The reviewed literature indicates that peri-implantitis is a multifactorial inflammatory condition in which microbial biofilm is the principal initiating factor, while patient-related and implant-related conditions influence susceptibility and progression. Rokaya et al. (2020) and Schwarz et al. (2018) consistently identify poor plaque control, previous periodontitis, and smoking as important risk indicators. These findings suggest that preventive measures should not be limited to implant placement or postoperative treatment; instead, risk assessment should begin before surgery and continue throughout the functional lifespan of the implant. The prevalence estimates reported by Schwarz et al. (2018) and Ang et al. (2025) also highlight the clinical burden of peri-implantitis, although differences in populations and diagnostic definitions limit direct comparisons.

A key distinction emerging from the reviewed studies concerns peri-implant mucositis and peri-implantitis. Whereas mucositis is characterized by reversible soft-tissue inflammation, peri-implantitis involves progressive supporting-bone loss (Heitz-Mayfield, 2024). Accordingly, the evidence summarized by Jepsen et al. (2015) supports early plaque removal, patient education, and professional maintenance as essential measures to prevent progression. Clinical monitoring should integrate bleeding on probing, suppuration, probing depth, and serial radiographic findings rather than relying on a single parameter. Renvert et al. (2018) emphasize that diagnostic interpretation must consider baseline clinical and radiographic information; therefore, isolated bone-loss thresholds should not be applied without clinical context.

Regarding treatment, the reviewed studies generally support mechanical biofilm disruption as a foundational intervention, with adjunctive approaches selected according to disease severity and treatment response. The findings summarized by Bahrami et al. (2024) suggest that antimicrobial photodynamic therapy may improve short- to medium-term inflammatory outcomes when combined with debridement. However, improvements in bleeding or probing depth do not necessarily demonstrate complete disease resolution or

long-term implant survival. Similarly, the surgical evidence synthesized by Wijesundara et al. (2023) indicates potential benefits of regenerative procedures and selected biomaterial combinations, but the results depend on defect morphology, surface decontamination, and clinical setting. Thus, adjunctive lasers, photodynamic therapy, local antimicrobials, and regenerative materials should be viewed as context-dependent options rather than universally superior treatments.

Technical and prosthetic factors also require attention because an implant may remain vulnerable to inflammation despite successful initial osseointegration. Poorly accessible restorations, residual cement, unfavorable implant positioning, and occlusal complications can impede cleaning or contribute to adverse outcomes (Roccuzzo et al., 2023; Tallarico et al., 2025). The clinical observations reported by Sidjaja (2000) and the case report by Rachmawati et al. (2019) further illustrate the importance of mechanical evaluation and appropriate imaging in selected complications. These findings reinforce the need for coordinated treatment planning involving surgical, periodontal, and prosthodontic considerations.

Long-term supportive care appears to be a recurring determinant of favorable outcomes across the reviewed literature. Even after successful active treatment, peri-implant tissues may remain susceptible to recurrent inflammation, particularly when oral hygiene is inadequate or modifiable risk factors persist. Atieh et al. (2021) and Stiesch et al. (2023) underscore the role of structured supportive peri-implant care. Although maintenance intervals of three to six months are frequently proposed in the included literature, visit frequency should be individualized according to disease history, plaque control, smoking status, systemic conditions, and clinical response. Patient participation is therefore integral to prevention, not merely an additional component of professional treatment.

Several limitations should be considered when interpreting this review. The included evidence comprises narrative reviews, systematic reviews, observational studies, and individual case reports, which differ substantially in design, follow-up duration, diagnostic criteria, and outcome reporting. Consequently, the percentages reported for inflammation reduction, bone stability, recurrence, or preventive benefit should not be pooled or interpreted as directly comparable effect estimates. Furthermore, the present manuscript does not document a reproducible search strategy, formal quality appraisal, or quantitative synthesis; its conclusions should therefore be interpreted as a narrative synthesis rather than a systematic estimate of treatment effectiveness. Future studies should prioritize standardized diagnostic criteria, longer follow-up, patient-centered outcomes, and direct comparisons of adjunctive interventions.

Overall, the evidence supports an integrated, risk-based approach combining early diagnosis, effective plaque control, appropriate prosthetic design, individualized therapy, and continuing maintenance. The most clinically meaningful indicator of success is sustained control of inflammation and absence of progressive bone loss over time, rather than improvement at a single follow-up visit.

Conclusion

Based on the findings of this literature review, it can be concluded that peri-implantitis is a complex and multifactorial complication of dental implant treatment involving biological, mechanical, and systemic factors that may compromise long-term implant stability and success. The major contributing factors include bacterial plaque accumulation, poor oral hygiene, smoking, uncontrolled systemic diseases, a history of periodontitis, and inappropriate prosthetic design. Effective prevention and management require a comprehensive approach emphasizing optimal plaque control, patient education, early detection of peri-implant mucositis, appropriate prosthetic planning, and regular professional maintenance every three to six months. Both non-surgical and surgical interventions play important roles in controlling inflammation, reducing probing depth, and maintaining peri-implant bone stability. Adjunctive therapies, including antimicrobial photodynamic therapy (aPDT) and concentrated growth factor (CGF), show promising potential in improving clinical outcomes and supporting tissue regeneration, although their long-term effectiveness requires further investigation. Furthermore, managing systemic risk factors and ensuring patient adherence to supportive peri-implant care are essential for minimizing disease recurrence and preventing implant failure. Overall, successful peri-implantitis prevention and treatment depend on individualized, evidence-based, and multidisciplinary strategies that integrate clinical intervention, continuous monitoring, and patient participation to maintain peri-implant tissue health and improve the long-term prognosis of dental implants.

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Susanna Halim: Conceptualization, supervision, methodology, and writing – review and editing. Angelica Valerine: Literature search, data collection, and writing – original draft. Stevi Nencia Purba: Literature screening, data extraction, and analysis. Nora Fine Damayanti Sianipar: Literature review, data interpretation, and manuscript preparation. Minantari Sihotang: Data synthesis, manuscript revision, and final editing. All authors reviewed and approved the final version of the manuscript

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