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CLINICAL DIAGNOSIS AND EVIDENCE-BASED MANAGEMENT OF PERI-IMPLANT MUCOSITIS AND PERI-IMPLANTITIS

Naila Ikram[*1], Dr Alisha Jamil[2], Ayesha Amir[3], Dr Abdul Rehman[4], Dr Syed Ruhail Mohsin[5] Mahnoor Ashraf[6], Dr Muniba Shah[7]

[*1,2,3,4,5,6,7]*Department of General Dentistry, Shifa College of Dentistry, Islamabad, Pakistan*

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Corresponding Author: *
Naila Ikram

Abstract

Peri-implant mucositis and peri-implantitis are the most prevalent biological complications associated with dental implants, posing a significant threat to long-term implant survival. With the increasing global use of implant therapy, standardized diagnostic criteria and evidence-based management strategies have become essential. This narrative review aims to summarize the current evidence regarding the clinical diagnosis and evidence-based management of peri-implant mucositis and peri-implantitis, with emphasis on epidemiology, risk factors, pathophysiology, and preventive strategies. A comprehensive literature search was conducted using PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar for studies published between 2010 and 2025. Keywords included "peri-implant mucositis," "peri-implantitis," "diagnosis," and "management." Consensus reports, randomized controlled trials, clinical studies, and systematic reviews were prioritized. Peri-implant mucositis is a reversible inflammatory condition confined to soft tissues, whereas peri-implantitis involves progressive marginal bone loss. Epidemiological data report implant-level prevalence of mucositis ranging from 29%–43% and peri-implantitis from 9%–22%. Major risk factors include history of periodontitis, poor plaque control, smoking, diabetes, residual cement, and inadequate maintenance. Diagnosis relies on bleeding on probing, probing depth assessment, and radiographic evaluation of crestal bone levels. Non-surgical therapy is effective for mucositis, while peri-implantitis often requires surgical intervention. Structured supportive implant therapy significantly reduces disease progression. Early detection, risk factor modification, and adherence to evidence-based therapeutic protocols are critical for preventing disease progression and improving long-term implant outcomes. Continued research is required to standardize treatment protocols and optimize regenerative strategies.

INTRODUCTION

Dental implants have become a predictable and widely accepted treatment modality for the replacement of missing teeth, demonstrating high long-term survival rates. However, biological complications affecting peri-implant tissues have emerged as a significant clinical concern. Among these, peri-implant mucositis and peri-implantitis represent the most prevalent inflammatory conditions compromising implant success [1,2]. The 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions provided standardized definitions and diagnostic criteria, facilitating improved consistency in both clinical practice and research [1,14].

Epidemiological data indicate that peri-implant diseases are common worldwide. Systematic reviews report implant-level prevalence of peri-implant mucositis ranging from approximately 29% to 43%,

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while peri-implantitis affects roughly 9% to 22% of implants, with higher prevalence observed at the patient level [3,4]. More recent population-based investigations further confirm the substantial burden of these conditions, emphasizing the need for structured preventive and therapeutic strategies [5].

Peri-implant diseases are primarily biofilm-induced inflammatory processes. While peri-implant mucositis is confined to the soft tissues and considered reversible, peri-implantitis is characterized by progressive loss of supporting bone and may ultimately lead to implant failure if untreated [2,6]. The pathophysiology involves microbial dysbiosis, host immune-inflammatory responses, and osteoclast-mediated bone resorption, with lesions often exhibiting distinct histopathological features compared to periodontitis [10,11].

Multiple risk factors contribute to disease development and progression, including history of periodontitis, poor plaque control, smoking, uncontrolled diabetes, residual cement, and inadequate maintenance therapy [6–9]. Recognition and modification of these risk indicators are central to effective prevention and long-term implant stability.

Despite advancements in implant surface technology and surgical techniques, management of peri-implantitis remains challenging. Non-surgical therapy may be effective for mucositis, whereas peri-implantitis frequently requires surgical intervention, including resective or regenerative approaches [12,18]. Adjunctive therapies have been explored; however, variability in treatment protocols and outcomes continues to generate clinical controversy [23].

Given the increasing global use of dental implants and the rising prevalence of peri-implant diseases, a clear understanding of standardized diagnostic criteria and evidence-based management strategies is essential. Therefore, this narrative review aims to summarize the current evidence regarding the clinical diagnosis and evidence-based management of peri-implant mucositis and peri-implantitis, with emphasis on prevention, risk assessment, and long-term maintenance.

Review

Literature Search

A comprehensive literature search was conducted to identify relevant studies on the clinical diagnosis and evidence-based management of peri-implant mucositis and peri-implantitis. Electronic databases including PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar were searched for articles published between 2010 and 2025. The search strategy combined Medical Subject Headings (MeSH) and free-text keywords using Boolean operators. The following search string was applied: ("peri-implant mucositis" OR "peri-implantitis") AND ("diagnosis" OR "clinical criteria" OR "radiographic assessment") AND ("management" OR "treatment" OR "non-surgical therapy" OR "surgical therapy").

Only English-language articles were included. Priority was given to consensus reports, randomized controlled trials, clinical studies, and systematic reviews. Reference lists of selected articles were also manually screened to identify additional relevant studies. Articles not directly related to diagnostic criteria or therapeutic management were excluded. The final selection was based on relevance, methodological quality, and alignment with the objectives of this narrative review.

Definitions and Diagnostic Criteria

(According to the World Workshop on the Classification of Periodontal and Peri-Implant Diseases)

The 2017 World Workshop standardized the definitions of peri-implant diseases to ensure uniform diagnosis in clinical and research settings [1].

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Peri-Implant Health

Peri-implant health is characterized by the absence of clinical signs of inflammation, including bleeding on probing (BoP) and suppuration. Radiographically, there should be no progressive bone loss beyond initial physiologic remodeling following implant placement [1].

Peri-Implant Mucositis

Peri-implant mucositis is defined as a plaque-induced inflammatory lesion confined to the peri-implant soft tissues without accompanying bone loss beyond initial remodeling [1,2].

Diagnostic features:

- Presence of bleeding on probing
- Possible erythema and swelling
- No radiographic bone loss

This condition is considered reversible with appropriate plaque control and professional management.

Peri-Implantitis

Peri-implantitis is a plaque-associated pathological condition characterized by inflammation of the peri-implant mucosa along with progressive loss of supporting bone [1].

Diagnostic features:

- Bleeding and/or suppuration on probing
- Increased probing depths
- Radiographic bone loss beyond initial remodeling

In the absence of baseline data, peri-implantitis may be diagnosed when probing depth is ≥6 mm with bone levels ≥3 mm apical to the coronal portion of the implant [1].

Standardized diagnostic criteria emphasize baseline radiographs, routine probing, and longitudinal monitoring for early detection and prevention of disease progression [1,2].

Epidemiology

Peri-implant diseases represent one of the most common biological complications associated with dental implants. Epidemiological data indicate considerable variability in reported prevalence due to differences in diagnostic criteria, study design, and follow-up duration. However, following the standardized case definitions proposed by the World Workshop on the Classification of Periodontal and Peri-Implant Diseases, more consistent prevalence estimates have been reported.

Recent systematic reviews suggest that the implant-level prevalence of peri-implant mucositis is approximately 29–43%, whereas peri-implantitis affects around 9–22% of implants [3,4]. At the patient level, prevalence is generally higher, with peri-implant mucositis affecting nearly 40–65% of implant patients and peri-implantitis reported in 15–30% of individuals [3–5]. The wide range reflects heterogeneity in population characteristics, maintenance protocols, and follow-up periods.

Longitudinal cohort studies demonstrate that peri-implant mucositis often develops within the first few

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years after prosthetic loading if plaque control is inadequate [5]. If left untreated, mucositis may progress to peri-implantitis, particularly in patients with a history of periodontitis or poor supportive care compliance [4,6]. Furthermore, increasing implant survival rates have paradoxically led to a growing cumulative burden of peri-implant diseases over time.

Overall, epidemiological evidence highlights that peri-implant diseases are not rare complications but rather prevalent inflammatory conditions requiring early detection and structured maintenance programs.

Table 1. Reported Prevalence of Peri-Implant Diseases in Systematic Reviews

Study	Implant-Level Prevalence	Patient-Level Prevalence	Key Notes
Derks & Tomasi (2015) [3]	Mucositis: ~43% Peri-implantitis: ~22%	Higher at patient level	Large epidemiological review
Lee et al. (2017) [4]	Mucositis: ~29% Peri-implantitis: ~9%	Variable	Strict case definitions
Romandini et al. (2021) [5]	Mucositis: ~40–65%	Peri-implantitis: ~15–30%	Based on 2017 criteria

Note: Variability is largely attributed to differences in diagnostic thresholds and follow-up duration.

Risk Factors

Peri-implant diseases are multifactorial inflammatory conditions influenced by patient-related, implant-related, and iatrogenic factors. Strong evidence suggests that uncontrolled biofilm accumulation remains the primary etiologic trigger; however, several modifying risk factors significantly increase disease susceptibility and progression [6].

1. Patient-Related Risk Factors

History of Periodontitis:

Patients with a prior history of periodontitis demonstrate a significantly higher risk of developing peri-implantitis due to persistent microbial dysbiosis and host susceptibility [6,7].

Poor Plaque Control:

Inadequate oral hygiene is strongly associated with both peri-implant mucositis and peri-implantitis [6].

Smoking:

Smoking impairs vascularity and immune response, increasing the likelihood of peri-implant bone loss and treatment failure [7].

Diabetes Mellitus:

Poorly controlled diabetes contributes to exaggerated inflammatory response and delayed healing, increasing peri-implant disease risk [8].

2. Implant- and Prosthesis-Related Risk Factors

Residual Cement:

Excess cement is a well-documented local risk factor that promotes biofilm accumulation and inflammation [9].

Implant Surface Characteristics:

Rough implant surfaces may facilitate bacterial colonization if exposed during disease progression [6].

Malpositioned Implants and Prosthetic Overcontouring:

Improper implant angulation or bulky prostheses hinder effective plaque removal [9].

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3. Maintenance-Related Factors

Lack of supportive implant therapy (SIT) and irregular professional follow-ups significantly increase disease incidence over time [7].

Overall, evidence suggests that peri-implant mucositis often represents the initial reversible stage, while progression to peri-implantitis is strongly influenced by systemic and local risk modifiers [6–9].

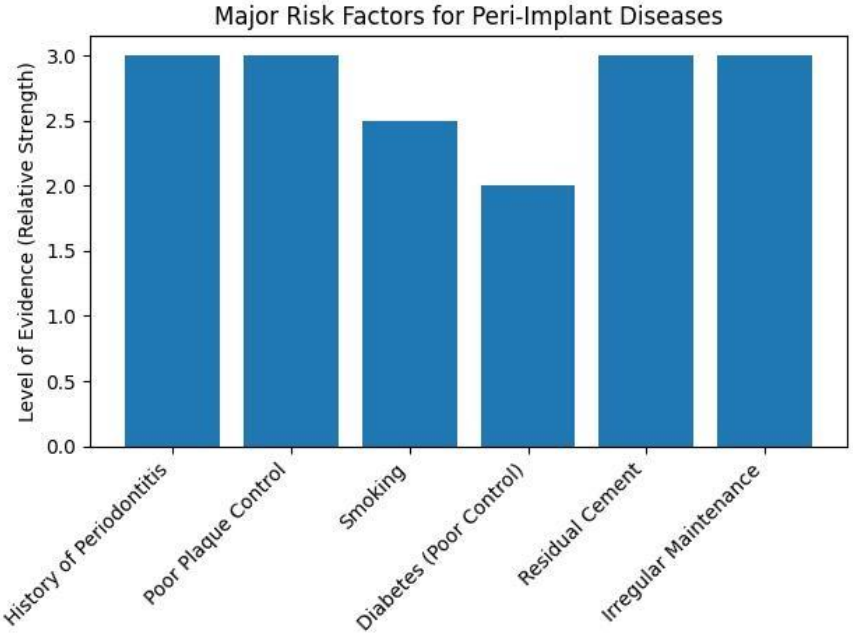

Figure 1. Relative Evidence Strength of Major Risk Factors for Peri-Implant Diseases.

Pathophysiology and Disease Mechanisms

Peri-implant diseases are primarily biofilm-induced inflammatory conditions characterized by a dysregulated host immune response leading to soft tissue inflammation and, in advanced stages, progressive bone destruction [10].

1. Biofilm Formation and Microbial Dysbiosis

Dental implants lack the periodontal ligament and have a different connective tissue attachment compared to natural teeth. This structural difference allows rapid apical spread of plaque-induced inflammation. Accumulation of pathogenic biofilm results in microbial dysbiosis dominated by anaerobic Gram-negative species similar to those seen in periodontitis [10,11].

2. Host Immune-Inflammatory Response

The host response plays a central role in disease progression. Increased levels of pro-inflammatory mediators such as interleukin-1β (IL-1β), tumor necrosis factor-α (TNF-α), and matrix metalloproteinases (MMPs) contribute to connective tissue breakdown [11].

Histologically, peri-implantitis lesions are often larger and more vascularized compared to periodontitis lesions, suggesting a more aggressive inflammatory pattern [10].

3. Bone Resorption Mechanism

Persistent inflammation activates osteoclastogenesis through the RANK/RANKL pathway, resulting in progressive marginal bone loss [12]. Unlike mucositis, which is limited to soft tissues and reversible, peri-implantitis involves irreversible supporting bone destruction.

4. Disease Progression

Experimental and longitudinal studies demonstrate that untreated peri-implant mucositis can transition to peri-implantitis when biofilm persists in the

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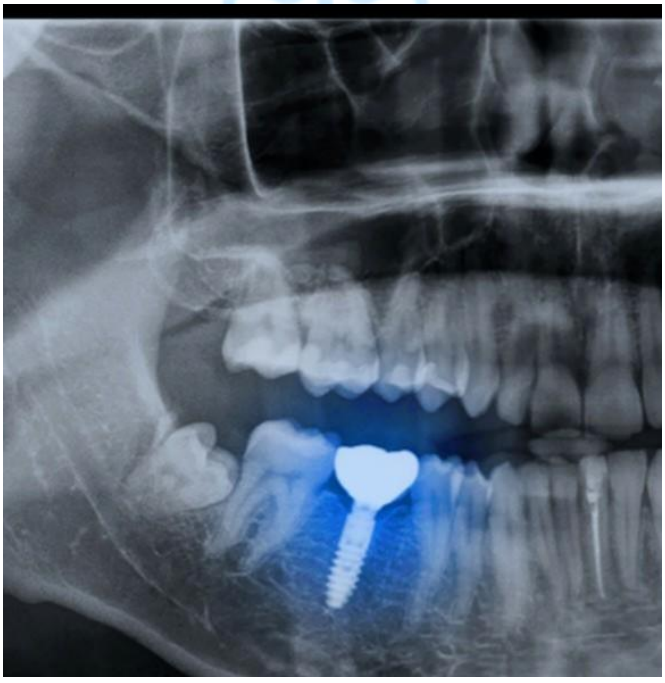
presence of modifying risk factors such as smoking or diabetes [13]. Disease progression may be nonlinear and episodic rather than continuous.

Table 3. Key Pathophysiological Mechanisms in Peri-Implant Diseases

Stage	Biological Event	Clinical Correlation
Biofilm accumulation	Microbial dysbiosis	Bleeding on probing
Inflammatory response	Increased IL-1β, TNF-α, MMPs	Soft tissue swelling and erythema
Osteoclast activation	RANKL-mediated bone resorption	Radiographic marginal bone loss
Advanced destruction	Progressive crestal bone breakdown	Increased probing depth and possible suppuration

Clinical and Radiographic Diagnosis

Accurate diagnosis of peri-implant diseases requires a combination of clinical assessment and radiographic evaluation. Early detection is critical to prevent progression from reversible peri-implant mucositis to irreversible peri-implantitis [14].



1. Clinical Diagnosis

Clinical examination remains the primary diagnostic approach.

Bleeding on Probing (BoP):

Bleeding on gentle probing (approximately 0.25 N force) is a key indicator of peri-implant mucosal inflammation and is considered an early sign of disease activity [14].

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Probing Depth (PD):
Increased probing depth compared to baseline measurements may indicate disease progression. However, probing depth alone is not diagnostic without accompanying inflammatory signs.

Suppuration:
Presence of pus on probing suggests active peri-implant infection and is strongly associated with peri-implantitis [15].

Implant Mobility:
Mobility is a late sign and may indicate loss of osseointegration.
Baseline clinical measurements after prosthesis placement are essential for accurate longitudinal comparison.

2. Radiographic Diagnosis
Radiographs are necessary to confirm peri-implantitis by detecting marginal bone loss.
Periapical Radiographs:
Standardized periapical radiographs using paralleling technique are recommended for evaluating crestal bone levels [14].

Bone Loss Criteria:
In the absence of baseline data, peri-implantitis may be diagnosed when bone levels are ≥3 mm apical to the most coronal portion of the intraosseous implant component, along with clinical signs of inflammation [14].
Cone Beam Computed Tomography (CBCT):
CBCT may be used in advanced or complex cases to assess three-dimensional defect morphology; however, routine use is not recommended due to radiation exposure considerations [15].

Evidence-Based Management
The management of peri-implant diseases depends on disease severity, extent of bone loss, and patient-related risk factors. Evidence-based approaches emphasize early intervention, biofilm control, and risk factor modification to prevent disease progression [16].

1. Management of Peri-Implant Mucositis
Peri-implant mucositis is a reversible inflammatory condition primarily managed through non-surgical therapy.

2. **Mechanical Debridement**:
Professional plaque removal using titanium or carbon-fiber curettes and ultrasonic devices with non-metal tips is considered first-line therapy [16].
Air Polishing Systems:
Glycine or erythritol-based powders have demonstrated improved biofilm removal with minimal surface damage [17].

3. **Adjunctive Antiseptics**:
Chlorhexidine mouth rinses or gels may provide short-term reduction in inflammation; however, evidence suggests limited long-term additional benefit over mechanical debridement alone [16].
Oral Hygiene Reinforcement:
Patient education and reinforcement of plaque control measures remain critical for sustained resolution.

Non-Surgical Management of Peri-Implantitis
In peri-implantitis cases with limited bone loss, non-surgical therapy may reduce inflammation but often fails to completely resolve deep defects [18].

1. Local Antibiotics:
Local delivery of minocycline or doxycycline may provide adjunctive benefits in reducing probing depth and bleeding [19].
Systemic Antibiotics:
Systemic antibiotic therapy remains controversial and is generally reserved for moderate to advanced cases, particularly when combined with surgical intervention [18].
Evidence indicates that non-surgical therapy alone has limited predictability in advanced peri-implantitis.

Surgical Management of Peri-Implantitis
Surgical intervention is recommended when non-surgical therapy fails or when significant bone loss is present.

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1. **Resective Surgery**:
Open flap debridement with implant surface decontamination and implantoplasty may reduce pocket depth and inflammation [18].

2. **Regenerative Therapy:**
Guided bone regeneration (GBR), bone grafts, and membrane placement may improve radiographic bone fill in selected defect morphologies [20].

3. **Surface Decontamination Methods**:
Various methods including laser therapy, air-abrasive devices, and chemical agents have been studied; however, no single method has demonstrated clear superiority [18].

Maintenance Therapy

Supportive implant therapy at 3–6 month intervals significantly reduces recurrence and disease progression [16]. Long-term success depends on strict plaque control, smoking cessation, and glycemic regulation.

Maintenance and Preventive Strategies

Long-term success of dental implants depends largely on structured supportive care and early intervention. Supportive implant therapy (SIT) at 3–6 month intervals is strongly recommended to monitor bleeding on probing, probing depth changes, and radiographic bone levels [21].

Professional mechanical plaque removal combined with individualized oral hygiene reinforcement significantly reduces the incidence of peri-implant mucositis and prevents progression to peri-implantitis [21,22].

Modification of systemic and behavioral risk factors—including smoking cessation, glycemic control in diabetic patients, and management of previous periodontitis—is essential for disease stability. Early detection of mucositis remains the most effective preventive strategy.

Current Controversies and Future Perspectives

Despite advances in implant dentistry, several clinical uncertainties remain. There is no universally accepted gold standard for implant surface decontamination during peri-implantitis surgery [23]. The routine use of systemic antibiotics is debated due to concerns regarding antimicrobial resistance and inconsistent clinical benefit [22].

The predictability of regenerative therapy varies depending on defect morphology and patient-related factors. Additionally, variability in diagnostic thresholds across studies continues to affect epidemiological comparisons.

- Future research is increasingly focused on:
- Biomarkers in peri-implant crevicular fluid
- Personalized risk assessment models
- Surface modification technologies
- Adjunctive therapies such as probiotics and host modulation

Standardization of treatment protocols and long-term randomized trials are needed to strengthen clinical guidelines.

Conclusion

Peri-implant mucositis and peri-implantitis are prevalent inflammatory conditions that threaten long-term implant survival. Accurate diagnosis requires integration of clinical parameters and radiographic assessment. While peri-implant mucositis is reversible with timely non-surgical management, peri-implantitis often necessitates surgical intervention.

Evidence-based management emphasizes biofilm control, risk factor modification, and structured maintenance programs. Continued research into optimized decontamination methods, regenerative strategies, and personalized preventive approaches is essential to improve long-term outcomes in implant dentistry.

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