PERI-IMPLANT DISEASES: PATHOGENESIS, EARLY DIAGNOSIS, AND MODERN TREATMENT APPROACHES

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Abstract: Peri-implant diseases are inflammatory conditions affecting the soft and hard tissues surrounding dental implants and represent one of the major challenges in modern implant dentistry. With the increasing use of dental implants worldwide, the prevalence of peri-implant mucositis and peri-implantitis has risen significantly, threatening long-term implant survival. These conditions are primarily biofilm-induced and influenced by host immune response and systemic risk factors. Early diagnosis and timely intervention are crucial to prevent progressive bone loss and implant failure. This article provides a comprehensive review of the pathogenesis of peri-implant diseases, modern diagnostic approaches, and contemporary treatment strategies, including non-surgical, surgical, and regenerative therapies. Emphasis is placed on early detection, risk assessment, and individualized treatment planning to improve clinical outcomes.

Keywords: peri-implant diseases, peri-implantitis, peri-implant mucositis, dental implants, diagnosis, treatment strategies

Introduction

Dental implants have become a widely accepted and predictable treatment modality for replacing missing teeth, offering high success rates and improved quality of life for patients. Despite these advantages, biological complications associated with implants have emerged as a significant concern in clinical practice. Among these complications, peri-implant diseases represent the most common cause of late implant failure.

Peri-implant diseases are inflammatory conditions affecting the tissues surrounding osseointegrated implants and are broadly classified into peri-implant mucositis and peri-implantitis. Peri-implant mucositis is characterized by reversible inflammation of the peri-implant soft tissues without supporting bone loss, whereas peri-implantitis involves progressive bone resorption and, if left untreated, may lead to implant loss.

The increasing prevalence of peri-implant diseases is associated with multiple factors, including poor oral hygiene, history of periodontitis, smoking, systemic diseases, and inadequate maintenance care. Given the often silent and progressive nature of peri-implantitis, early diagnosis and effective management are essential to ensure long-term implant success.

The aim of this article is to review the current understanding of peri-implant disease pathogenesis, evaluate modern diagnostic methods, and discuss contemporary treatment approaches based on recent scientific evidence.

Materials and Methods

A narrative review of the scientific literature published between 2000 and 2025 was conducted using electronic databases including PubMed, Scopus, and Web of Science. Search terms included *peri-implant diseases*, *peri-implantitis diagnosis*, *implant biofilm*, *peri-implant bone loss*, and *peri-implant treatment*.

Inclusion criteria:

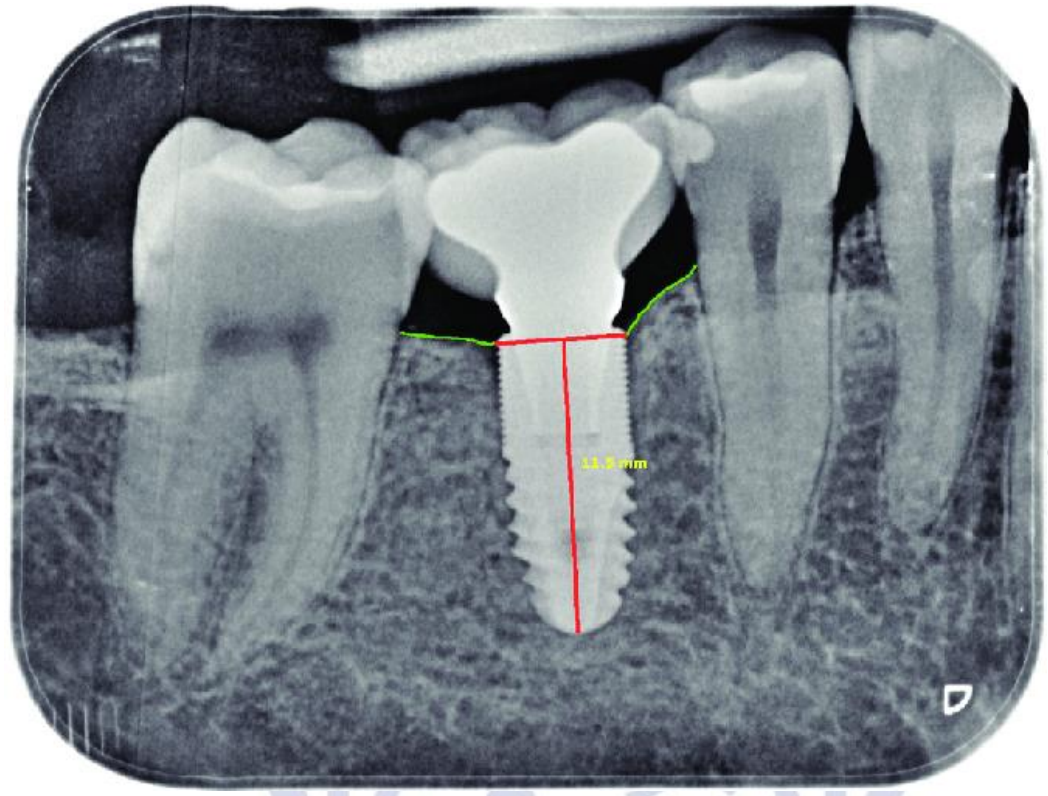
- Original clinical studies
- Randomized controlled trials
- Systematic reviews and meta-analyses
- Consensus reports

Exclusion criteria:

- Case reports
- Non-English publications
- Studies with unclear diagnostic criteria

Data were analyzed with respect to disease mechanisms, diagnostic accuracy, treatment efficacy, and long-term clinical outcomes.

Pathogenesis of Peri-Implant Diseases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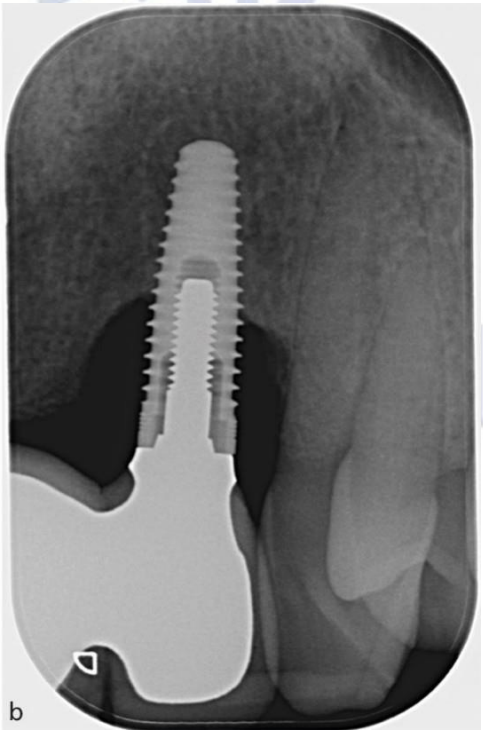
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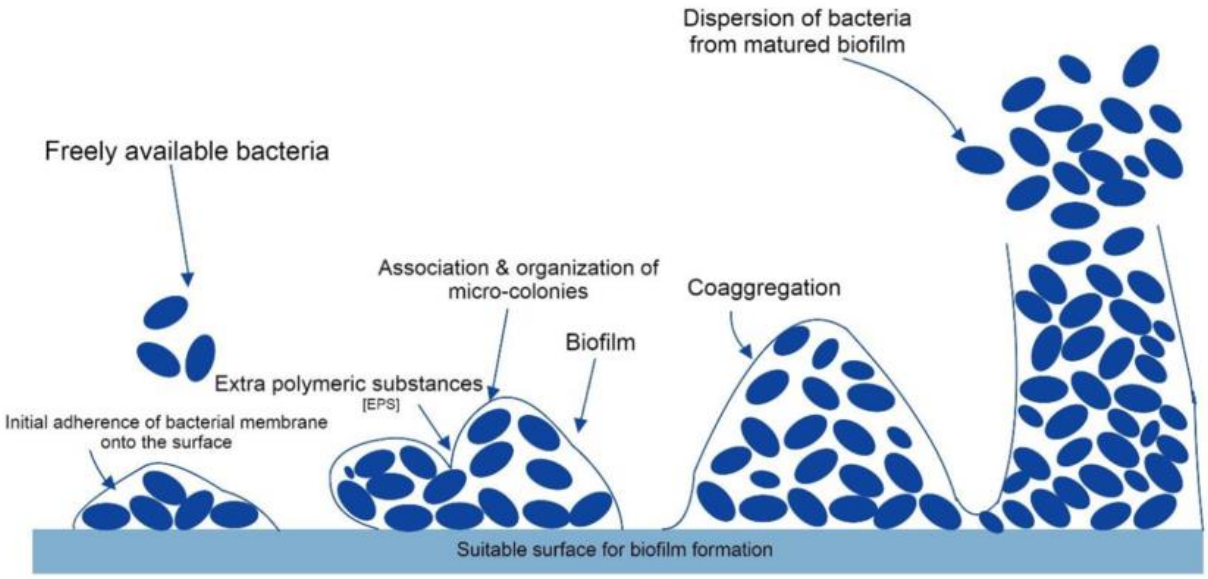

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Microbial Biofilm and Host Response

Peri-implant diseases are primarily initiated by the accumulation of bacterial biofilm on implant surfaces. The microbial composition of peri-implant biofilms resembles that of periodontitis, dominated by Gram-negative anaerobic bacteria.

Biofilm accumulation triggers an inflammatory host response characterized by infiltration of neutrophils, macrophages, and lymphocytes. Persistent inflammation leads to tissue destruction and, in peri-implantitis, progressive alveolar bone loss.

Anatomical and Histological Differences

Unlike natural teeth, dental implants lack periodontal ligament fibers and have a reduced vascular supply in peri-implant tissues. These anatomical differences result in a weaker defense mechanism and facilitate the apical spread of inflammation.

Histological studies demonstrate a larger inflammatory infiltrate around implants compared to teeth, explaining the rapid progression of peri-implant bone loss.

Risk Factors

Several local and systemic risk factors contribute to disease development:

- History of periodontitis
- Poor plaque control
- Smoking
- Diabetes mellitus
- Excess cement remnants
- Improper implant positioning

These factors modulate host susceptibility and disease severity.

Results

Clinical Manifestations

Peri-implant mucositis presents with erythema, swelling, bleeding on probing, and increased probing depth without radiographic bone loss. Peri-implantitis is characterized by bleeding and/or suppuration on probing, increased probing depth, and progressive bone loss visible on radiographs.

Early Diagnostic Methods

Clinical Examination

Routine probing around implants is essential for early detection. Bleeding on probing is considered a key indicator of inflammation.

Radiographic Assessment

Periapical radiographs and cone-beam computed tomography (CBCT) are used to evaluate marginal bone levels. CBCT provides three-dimensional assessment and is particularly useful in advanced cases.

Biomarkers

Emerging research highlights the potential role of biomarkers in peri-implant crevicular fluid, such as inflammatory cytokines and enzymes, for early diagnosis and disease monitoring.

Treatment Strategies

Non-Surgical Therapy

Non-surgical treatment is the first-line approach for peri-implant mucositis and early peri-implantitis. It includes:

- Mechanical debridement using titanium or plastic instruments
- Antiseptic irrigation

- Local or systemic antimicrobial therapy

These approaches are effective in controlling inflammation at early stages.

Surgical Treatment

Advanced peri-implantitis often requires surgical intervention. Surgical approaches include:

- Open flap debridement
- Implant surface decontamination
- Resective surgery

Surgical therapy improves access for debridement and reduces pocket depth.

Regenerative Therapy

Regenerative procedures aim to restore lost peri-implant bone using bone grafts, membranes, and biologic agents. Guided bone regeneration techniques show promising results in selected defect morphologies.

Supportive Peri-Implant Therapy

Long-term success depends on regular maintenance care, professional plaque removal, and patient education. Supportive therapy significantly reduces disease recurrence.

Discussion

Peri-implant diseases represent a complex interplay between microbial challenge and host response. The lack of early symptoms often delays diagnosis, emphasizing the importance of regular monitoring and risk assessment.

Modern diagnostic tools and biomarker research offer opportunities for earlier detection and personalized treatment. While non-surgical therapy is effective in early disease stages, advanced peri-implantitis requires combined surgical and regenerative approaches.

Despite advances, standardized treatment protocols are still lacking, and long-term outcomes vary. Future research should focus on prevention, early diagnosis, and biologically driven therapies.

Conclusion

Peri-implant diseases are prevalent inflammatory conditions that pose a serious threat to implant longevity. Understanding disease pathogenesis, implementing early

diagnostic strategies, and applying appropriate treatment modalities are essential for successful management. A preventive, patient-centered approach combined with regular maintenance care remains the cornerstone of long-term implant success.

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