

Risk Factors Associated with Peri-Implantitis: A Review Of Current Evidence

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Abstract: Peri-implantitis is one of the most common biological complications associated with dental implant therapy and represents a major challenge in modern implantology. The increasing prevalence of dental implantation worldwide has been accompanied by a rise in peri-implant diseases, negatively affecting long-term implant survival and treatment outcomes. Peri-implantitis is characterized by inflammatory destruction of peri-implant tissues leading to progressive marginal bone loss and possible implant failure. The aim of this review was to analyze current evidence regarding the major risk factors associated with peri-implantitis. A comprehensive literature search was conducted using international scientific databases and included systematic reviews, meta-analyses, randomized clinical trials, cohort studies, and international consensus reports published between 2018 and 2025. The analyzed studies demonstrated that peri-implantitis is a multifactorial disease influenced by bacterial biofilm accumulation, poor oral hygiene, history of periodontitis, smoking, uncontrolled diabetes mellitus, prosthetic and surgical factors, biomechanical overload, and inadequate maintenance therapy. Recent evidence also highlights the role of inflammatory mediators and host-related factors in disease progression. Early diagnosis, individualized risk assessment, and regular supportive peri-implant therapy are essential for prevention of peri-implant tissue destruction and long-term implant success.

Keywords: Peri-implantitis; dental implants; peri-implant diseases; risk factors; implant failure; bone loss; periodontitis; smoking; diabetes mellitus.

Introduction: Dental implantation has become one of the most predictable and widely used methods for rehabilitation of partial and complete edentulism in modern dentistry. The growing prevalence of tooth loss caused by periodontal diseases, dental caries, trauma, congenital anomalies, and age-related changes has led to a significant increase in the number of implantological procedures worldwide. According to contemporary epidemiological studies, millions of dental implants are placed annually, and the demand for implant-supported rehabilitation continues to rise

due to population aging and increasing aesthetic and functional expectations of patients [1,4].

Dental implants are biocompatible structures, most commonly manufactured from titanium or titanium alloys, surgically inserted into alveolar bone to replace missing teeth. Depending on clinical indications and anatomical conditions, different implant systems may be used, including endosseous screw-type implants, short implants, zygomatic implants, and immediate-placement implants. Modern implantology also differentiates between one-stage and two-stage

implant systems, as well as cement-retained and screw-retained prosthetic designs. Although implant survival rates remain high, biological complications continue to represent a major challenge in long-term implant maintenance [7,9].

Among these complications, peri-implant diseases occupy a central position due to their increasing prevalence and potential to compromise implant survival. According to the consensus reports of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, peri-implant diseases are divided into peri-implant mucositis and peri-implantitis [1,10,11]. Peri-implant mucositis is characterized by reversible inflammation confined to soft tissues surrounding the implant, whereas peri-implantitis involves progressive inflammatory destruction of peri-implant bone and may ultimately result in implant loss [13].

Recent systematic reviews and meta-analyses demonstrate that peri-implant diseases are highly prevalent globally. The prevalence of peri-implant mucositis ranges from 40% to 50% of implant patients, while peri-implantitis affects approximately 15–25% of patients and 10–20% of implants depending on diagnostic criteria and observation periods [3,4,5]. The increasing frequency of peri-implantitis has transformed it into one of the most significant complications in implant dentistry and a major public health concern.

The etiology of peri-implantitis is considered multifactorial. Numerous international studies have identified several local and systemic risk factors associated with disease development and progression. The accumulation of bacterial biofilm and poor oral hygiene remain the primary initiating factors of peri-implant inflammation [4,7]. A history of periodontitis has consistently been reported as one of the strongest predictors for peri-implantitis due to similarities in pathogenic microbiota and host inflammatory response [5,15]. Smoking is another well-established risk factor that negatively influences vascularization, immune response, and osseointegration processes [4,7].

Systemic diseases, particularly uncontrolled diabetes mellitus, also contribute significantly to peri-implant tissue destruction by impairing wound healing and increasing inflammatory activity [6]. In addition, biomechanical overload, residual cement, improper implant positioning, prosthetic design errors, inadequate keratinized mucosa width, and lack of supportive maintenance therapy have all been associated with higher peri-implantitis incidence [7,9,12]. Recent investigations further emphasize the

role of genetic predisposition, immune-inflammatory mediators, and microbiological dysbiosis in the pathogenesis of peri-implant diseases [8,14].

Despite substantial advances in implant surface technologies, digital planning, and surgical protocols, peri-implantitis remains difficult to treat and often demonstrates unpredictable clinical outcomes. Therefore, early identification and management of modifiable risk factors are essential for long-term implant success and prevention of implant failure.

The aim of this review is to analyze current evidence regarding the major risk factors associated with peri-implantitis and to summarize contemporary concepts concerning its epidemiology, pathogenesis, and prevention.

Materials and Methods

This review article was based on a comprehensive analysis of contemporary scientific literature dedicated to peri-implant diseases and the major risk factors associated with peri-implantitis development. The study was conducted according to the principles of evidence-based dentistry and included the evaluation of international clinical guidelines, systematic reviews, meta-analyses, randomized clinical trials, retrospective cohort studies, and observational investigations published between 2018 and 2025. Electronic searches were performed using internationally recognized scientific databases, including PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, and Google Scholar. In addition, international consensus reports and recommendations from leading professional organizations in periodontology and implantology, including the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, were analyzed.

The literature search strategy was developed using combinations of Medical Subject Headings (MeSH) terms and relevant keywords associated with peri-implant diseases and implant complications. The primary search terms included “peri-implantitis,” “peri-implant diseases,” “risk factors,” “dental implants,” “implant failure,” “peri-implant mucositis,” “bone loss,” “periodontitis,” “smoking,” “diabetes mellitus,” and “oral microbiome.” Boolean operators “AND” and “OR” were applied to optimize the search process and improve the specificity of retrieved publications.

The inclusion criteria comprised articles published in English between 2018 and 2025 involving human subjects and focusing on the epidemiology, prevalence, etiological factors, pathogenesis, diagnosis, prevention, and risk assessment of peri-implantitis. Priority was given to studies with high scientific evidence, including systematic reviews, umbrella

reviews, meta-analyses, randomized controlled trials, and prospective or retrospective cohort studies. International consensus statements and evidence-based clinical recommendations were also included due to their high methodological significance.

Publications with insufficient methodological quality, duplicate articles, experimental animal studies, isolated clinical case reports, and studies unrelated to peri-implant disease risk assessment were excluded from the review. All selected studies were analyzed according to study design, sample size, duration of follow-up, diagnostic criteria for peri-implantitis, prevalence data, identified local and systemic risk factors, and clinical outcomes. Special attention was paid to evidence regarding the influence of bacterial biofilm, history of periodontitis, smoking, diabetes mellitus, prosthetic and surgical factors, occlusal overload, and maintenance therapy on peri-implant tissue health.

The collected data were qualitatively synthesized and comparatively evaluated to identify the most significant and consistently reported risk factors associated with peri-implantitis. This methodological approach allowed integration of current global scientific evidence and provided a contemporary understanding of the multifactorial etiology and prevention strategies of peri-implant diseases.

Results

The analysis of contemporary scientific literature demonstrated that peri-implantitis represents one of the most common biological complications associated with dental implant therapy and remains a major challenge in modern implantology. According to recent systematic reviews and meta-analyses, the prevalence of peri-implant mucositis ranges from 40% to 50% among implant patients, whereas peri-implantitis affects approximately 15%–25% of patients and 10%–20% of implants worldwide [3,4,5]. Considerable variability in prevalence data has been reported among studies due to differences in diagnostic criteria, implant systems, and duration of follow-up; however, most authors emphasized a gradual increase in peri-implant disease incidence associated with the growing number of implant procedures globally [3,13].

The reviewed studies confirmed the multifactorial etiology of peri-implantitis and identified several major local and systemic risk factors consistently associated with disease development [4,7,13]. Accumulation of bacterial biofilm and poor oral hygiene were recognized as the principal initiating factors of peri-implant inflammation. Multiple investigations demonstrated a direct association between increased plaque accumulation, bleeding on probing, and

progressive peri-implant bone loss [4,8]. Microbiological analyses revealed that peri-implantitis lesions are predominantly colonized by anaerobic Gram-negative microorganisms similar to those observed in chronic periodontitis [8,13].

A history of periodontitis was identified as one of the strongest predictors of peri-implantitis development [4,5,15]. Patients previously affected by periodontal disease demonstrated significantly higher rates of peri-implant inflammation, marginal bone loss, and implant failure compared with periodontally healthy individuals [6,15]. Several meta-analyses reported that residual periodontal pockets and insufficient periodontal maintenance substantially increased the risk of peri-implant disease progression [5,7].

Smoking was consistently recognized as a major modifiable risk factor associated with peri-implant tissue destruction [4,7]. The analyzed studies demonstrated that tobacco consumption negatively affects vascularization, immune response, and osseointegration processes, thereby increasing susceptibility to peri-implant bone loss and implant failure. Heavy smokers exhibited significantly higher peri-implantitis prevalence and lower implant survival rates compared with non-smokers [4]. Furthermore, a dose-dependent relationship between smoking intensity and peri-implant disease severity was observed in several cohort studies [7].

Systemic conditions, particularly uncontrolled diabetes mellitus, were also strongly associated with peri-implant disease development [6,14]. Hyperglycemia was shown to impair tissue healing, enhance oxidative stress, and intensify inflammatory reactions within peri-implant tissues. Patients with poorly controlled diabetes demonstrated increased bleeding on probing, deeper peri-implant pockets, and more pronounced marginal bone resorption compared with metabolically healthy individuals [6].

Several prosthetic and surgical factors were identified as important contributors to peri-implantitis progression. Improper implant positioning, residual excess cement, inadequate prosthetic contouring, insufficient width of keratinized mucosa, and biomechanical overload were associated with increased peri-implant inflammation and bone loss [7,9,12]. Studies evaluating prosthetic design demonstrated that cement-retained restorations may increase the risk of peri-implant complications due to retained cement remnants acting as bacterial-retentive factors [9]. In addition, occlusal overload and unfavorable force distribution were reported to contribute to microdamage of peri-implant bone and acceleration of inflammatory destruction [12].

Recent investigations further highlighted the role of genetic predisposition, immune-inflammatory mediators, and host response variability in peri-implantitis pathogenesis [8,14]. Elevated levels of pro-inflammatory cytokines, including interleukin-1 β , tumor necrosis factor- α , and receptor activator of nuclear factor kappa-B ligand (RANKL), were frequently associated with progressive peri-implant bone resorption [13]. Several studies suggested that polymorphisms of inflammatory genes may increase individual susceptibility to peri-implant diseases [14].

The reviewed evidence also demonstrated the critical importance of supportive peri-implant maintenance therapy in preventing disease progression [2,12]. Patients enrolled in regular maintenance programs exhibited significantly lower rates of peri-implantitis compared with individuals lacking long-term professional follow-up and oral hygiene monitoring [2]. Preventive strategies such as professional biofilm control, smoking cessation, glycemic control, and individualized risk assessment were consistently emphasized as essential components for long-term implant success [2,5,14].

Overall, the findings of the present review confirm that peri-implantitis is a multifactorial inflammatory disease influenced by complex interactions between bacterial, systemic, behavioral, prosthetic, and host-related factors [4,5,7,13]. Early identification and management of these risk factors play a crucial role in the prevention of peri-implant tissue destruction and improvement of long-term implant prognosis.

Conclusion

Peri-implantitis remains one of the most significant biological complications in contemporary implant dentistry and represents an increasing clinical and public health concern due to the continuously growing number of dental implant procedures performed worldwide. The findings of the present review demonstrate that peri-implantitis is a multifactorial inflammatory disease resulting from complex interactions between bacterial biofilm, host immune response, systemic conditions, behavioral habits, and prosthetic or surgical factors.

The analyzed literature confirms that poor oral hygiene, history of periodontitis, smoking, uncontrolled diabetes mellitus, inadequate supportive maintenance therapy, prosthetic design errors, residual cement, and biomechanical overload are among the most significant risk factors associated with peri-implant tissue destruction and implant failure. Furthermore, recent evidence highlights the important role of genetic predisposition, inflammatory mediators, and microbiological dysbiosis in disease progression.

Despite substantial advances in implant surface technology, digital planning, and surgical protocols, peri-implantitis continues to demonstrate high prevalence and unpredictable therapeutic outcomes. Therefore, early diagnosis, comprehensive risk assessment, and identification of modifiable etiological factors remain essential for successful prevention and long-term implant survival.

Current evidence suggests that individualized treatment planning combined with regular supportive peri-implant maintenance, professional biofilm control, smoking cessation, and management of systemic diseases may significantly reduce the incidence and progression of peri-implant diseases. Consequently, implementation of preventive strategies and personalized patient-centered approaches should be considered fundamental components of modern implantological practice.

Further prospective clinical studies and long-term randomized investigations are required to improve understanding of peri-implantitis pathogenesis and to develop more effective evidence-based protocols for risk prediction, prevention, and treatment of peri-implant diseases.

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