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DENTAL IMPLANT ASSOCIATED FACTORS & FAILURE

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Abstract

Background: *Dental implants have revolutionized the restoration of oral function and aesthetics in edentulous patients. Despite high success rates, the incidence of implant failure remains a significant clinical concern, largely due to both mechanical and biological complications.*

Objective: *This literature review explores the multifactorial etiology of dental implant failures, focusing on surgical, patient-related, prosthetic, and systemic risk factors. Special attention is given to peri-implantitis, biomechanical stress, and bruxism, systemic health conditions such as diabetes and osteoporosis, and lifestyle habits including smoking.*

Methodology: *This review was conducted by analyzing recent peer-reviewed studies focusing on biological, mechanical, systemic, and surgical risk factors contributing to dental implant failure.*

Conclusion: *The findings highlight the need for individualized treatment planning and risk mitigation to improve the long-term success and stability of dental implants.*

INTRODUCTION

1.1 Overview of Implant Dentistry

Over the past few decades, implant dentistry has gained significant popularity as a reliable method for treating tooth loss. It offers patients who are partially or completely edentulous a long-lasting restoration of both aesthetics and masticatory function [1]. Dental implants have become accessible to the general population due to their high success rates, procedural predictability, and relatively low complication rates before and after implantation.

1.2 Structural Design and Components

The most common implant body design is the root-form implant, featuring screw threads to securely anchor the implant in the bone. The abutment is the component that supports the prosthesis or superstructure [2].

1.3 Rising Incidence of Complications

Despite their excellent clinical track record, the increasing usage of implants has corresponded with a rise in complications, especially mechanical failures [3]. Like other engineered structures, dental implants are vulnerable to fracture over time. These failures,

though less commonly discussed than biological failures, are equally significant.

1.4 Defining Peri-Implant Diseases

Various diagnostic thresholds are used to define peri-implant diseases. Studies continue to investigate the prevalence of peri-implantitis and its correlation with bone loss severity [4].

2. Risk Factors Associated with Implant Failure

2.1 Clinical and Procedural Correlates

Multiple clinical factors have been associated with an increased rate of implant failure. These include:

- Low insertion torque for immediately or early loaded implants
- Placement by inexperienced surgeons
- Implant location in the maxilla or posterior regions
- Heavy smoking
- Bone quality types III and IV
- Sites with limited bone volume
- Shorter-length implants
- Overloading due to prosthetic design (e.g., overdentures)

Recent research suggests that even with these variables, newer implant surface technologies (e.g., moderately roughened implants) may yield comparable outcomes [5, 6].

2.2 Implant Materials and Surface Modifications

A dental implant is an alloplastic biomaterial surgically inserted into the jawbone to address functional and/or aesthetic concerns [7]. Implanting success depends significantly on surface roughness. Six primary categories of surface modifications include: as-machined, plasma spray, laser peening, and others [8]. Design elements like thread pitch, depth, geometry, and helix angle also impact primary stability [9, 10].

3. Classification of Implant Failures

3.1 Early vs. Late Failures

Failures are generally classified as:

- **Early failures**: Occur before loading or within the first 6 months post-surgery
- **Late failures**: Occur after 6 months, usually due to chronic conditions or overloading [11, 12].

Most early failures are biological, involving surgical trauma, infections, or micromotion of the implant, which disrupts osseointegration [13-15].

3.2 Biological Causes

Biological causes often include peri-implantitis, a progressive loss of bone support due to inflammation. Approximately 50% of late failures occur within the first year after loading, and 40% after the second year [16, 17].

4. Mechanical and Time-Dependent Failures

4.1 Monotonic vs. Fatigue Failures

Mechanical failure types can be:

- **Monotonic failures**: Sudden overload due to poor design or excessive force
- **Time-dependent failures**: Develop gradually due to fatigue or stress corrosion [18, 19].

4.2 Influence of Occlusal Load

The type and amplitude of masticatory forces influence mechanical complications. The type of prosthesis (fixed or removable) alters the way occlusal forces are transmitted to the implant [20, 21]. Parafunctional habits like bruxism and clenching can dramatically increase implant stress, accelerating failure [22].

5. Multifactorial Causes of Failure

5.1 Systemic and Lifestyle Factors

Implant prognosis is also influenced by:

- Implant location (especially in the maxilla)
- Smoking, age, and sex
- Systemic diseases (e.g., diabetes)
- Bone quantity and quality
- Surface properties of the implant [23, 24].

Genetic predispositions and immune factors are being increasingly recognized in early failure. Smoking impairs systemic immunity and healing, raising failure rates—11% in smokers versus 5% in nonsmokers [25, 26].

5.2 Thermal Trauma and Other Complications

Excessive heat generation during drilling or placement can cause bone necrosis, resulting in long-term structural failure around the implant [27].

S. No.	Risk Factor Category	Specific Factor	Impact on Dental Implant Success
1.	Age-related	Elderly patients (>60)	Slower healing, higher failure rates
		Growing children/teens	Unpredictable jaw growth, drifting teeth [28, 29].
2.	Dental Health	Mesial tooth drift	Affects implant positioning, causes occlusal issues [30].
3.	Bruxism	Parafunctional habits	Excessive loading causes micromotion and failure [31, 32].
4.	Smoking	Tobacco use	Impairs healing, increases peri-implantitis risk [33-36].
5.	Pharmacological	Bisphosphonates	Risk of osteonecrosis, impaired healing [37]
6.	Surgical	Sinus penetration	Causes infection or sinus dysfunction
		Damage to adjacent teeth	Implant failure due to trauma [38, 39].
7.	Infectious	Peri-implantitis	Bone loss, inflammation, implant mobility [40-42].
8.	Systemic	Diabetes (hyperglycemia)	Slower healing, poor bone formation [43-46].
		Osteoporosis	Decreased bone density impairs implant anchorage [47-49].
		Cardiovascular disease	Impaired bone healing, reduced integration [50].
9.	Medical	Radiation therapy	Reduced osseointegration, healing delays [51]
		Corticosteroids / HIV therapy	Higher infection risk, delayed tissue repair [52].
		Coagulopathies	Bleeding complications, delayed recovery [53].
		Organ transplant with immunosuppression	Reduced bone regeneration, risk of failure [54, 55]

Methodology:

Data Collection: The data collection for the literature review was conducted systematically identifying and evaluating peer-reviewed articles. The articles were searched using the keywords “dental Implants”, “dental Implant failure”, Implant complications”, and Implant biomechanics”.

Selection of Articles: The articles were selected which were published in the databases of PubMed, Scopus, Web of Science, Google Scholar. Based on the relevance systemic reviews, clinical trial, meta-analysis, cohort studies were considered which focused on risk factors and failures rates of dental implants. The articles selection was restricted to the articles published in English, published in indexed journals, published in time span of 2005-2025, and articles having focus on mechanical, biological, systemic, and surgical risks of dental implants.

Discussion

The findings of this literature review reflect the multifaceted nature of dental implant failure, highlighting the interplay between biological, mechanical, surgical, and patient-related variables. While dental implants offer a highly successful and predictable form of treatment for tooth replacement, they are not without risk, particularly in patients with certain predisposing conditions or under suboptimal procedural techniques.

Biological failures, especially early ones, are commonly attributed to failed osseointegration, which can result from surgical trauma, improper implant placement, early loading, or infection [56]. The inflammatory condition peri-implantitis remains the leading cause of late-stage failures, often exacerbated by inadequate plaque control, poor oral hygiene, or a history of periodontitis. Systemic diseases such as diabetes and osteoporosis negatively affect bone metabolism and healing, compromising implant stability [37].

The mechanical complications on the other hand are often underreported in literature and their increasing prevalence as implants remain functional over longer periods. Fatigue-induced fractures, component

loosening, and material corrosion can arise from repeated biomechanical loading, bruxism, or inappropriate prosthetic design. Stress distribution is especially critical, as overload due to parafunctional habits like clenching or improper occlusal adjustments can lead to microfractures and eventual failure [37].

Surgical factors also play a pivotal role. Bone quality and quantity, especially in the posterior maxilla or regions with Type III/IV bone, significantly influence implant outcomes. Improper angulation, insufficient irrigation during drilling, or proximity to vital anatomical structures (e.g., maxillary sinus or nerves) can all lead to complications. In cases of immediate or early loading, achieving primary stability becomes even more critical.

Pharmacological factors, such as bisphosphonates or long-term corticosteroids, are associated with osteonecrosis and compromised healing capacity. Patients undergoing radiotherapy or organ transplant recipients on immunosuppressants require tailored protocols to avoid delayed complications. The rising prevalence of these cases demands a deeper understanding of their implications on implant [57].

Preventive measures remain the cornerstone of long-term implant success. These include proper patient selection, preoperative imaging, precision-guided placement, optimal prosthetic design, and stringent post-operative maintenance. Regular clinical follow-up, patient education, and the use of antimicrobial strategies can significantly reduce the incidence of peri-implant complications [57, 58].

Literature indicates a growing need for interdisciplinary collaboration. Future research should bridge clinical outcomes with materials science and biomechanics, possibly employing digital simulations, finite element analysis, and patient-specific modeling. These innovations may help predict failure patterns and inform design improvements.

The implant failure is rarely the result of a single factor. A comprehensive, multidisciplinary approach involving personalized treatment plans, continuous monitoring, and patient education is essential to achieving sustainable success in implant dentistry.

CONCLUSION

The study concludes that all diverse risk factors contributing to dental implant failure should be by the clinicians. Evidence-based decision-making is the most essential for improving patient outcomes. Systemic evaluation, patient habits, mechanical stress factors, and surgical techniques all these multidimensional approaches are critical to minimizing implant failure. The implementation of preventive strategies will enhance immediate and long-term success in dental implantology.

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During the preparation of this work the author(s) used ChatGPT to enhance the readability of the article. After using this tool/service, the author(s) reviewed and edited the content as needed and took(s) full responsibility for the content of the publication.

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