

Implants Under Pressure: Risk Assessment, Material Selection, and Occlusal Management in Bruxism-Affected Prosthodontic Rehabilitation: A Literature Review

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Abstract

Dental implants represent a predictable and well-documented option for the rehabilitation of partially or completely edentulous patients; however, biological and mechanical complications remain clinically relevant concerns that may compromise long-term outcomes. Among the contributing risk factors, bruxism has attracted increasing attention due to its association with excessive and repetitive occlusal loading on implant components and peri-implant bone. Unlike natural teeth, osseointegrated implants lack a periodontal ligament, making them more susceptible to parafunctional force transmission. Evidence on the impact of bruxism on implant survival, mechanical complications, and peri-implant tissue health remains heterogeneous. This narrative review examines current evidence on biomechanical consequences of bruxism, patient risk stratification, restorative material selection, and occlusal management strategies, with the goal of informing a risk-stratified, protocol-driven approach to implant prosthodontics in bruxism-affected patients.

Key Words: Bruxism; Dental Implants; Prosthodontic Rehabilitation; Risk Assessment; Occlusal Management; Mechanical Complications; Restorative Materials; Zirconia; CAD/CAM; Occlusal Loading; Digital Dentistry.

INTRODUCTION

Dental implants have established themselves as one of the most predictable and successful alternatives for the rehabilitation of partially or completely edentulous patients. Advances in implant design, surface properties, surgical techniques, and restorative materials have consistently improved survival rates and long-term clinical outcomes, and implant-supported prostheses now represent a cornerstone of modern prosthodontic practice [1]. Despite the high success rates reported in the literature, biological and mechanical complications continue to be a significant clinical concern, as they may compromise the longevity of rehabilitation and increase the need for maintenance and

retreatment. The proper identification and management of risk factors associated with implant therapy therefore remains essential throughout patient planning and follow-up. [1,2]

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Among the patient-related factors that may influence implant prognosis, bruxism has received increasing attention due to its potential impact on peri-implant tissues and prosthetic components [2]. Historically described as the habit of grinding or clenching the teeth, bruxism is now understood as a repetitive jaw-muscle activity that may occur during sleep or wakefulness and is no longer classified as a pathology per se; rather, it is considered a complex, multifactorial behavior whose clinical significance depends on the intensity, frequency, and duration of muscular activity, as well as individual patient characteristics. [3,4]

The clinical relevance of bruxism in implant dentistry is fundamentally explained by the biomechanical differences between natural teeth and osseointegrated implants. Natural teeth benefit from the periodontal ligament, a structure that provides shock absorption, proprioception, and adaptive load distribution [3]. Implants, by contrast, are rigidly anchored in bone and lack this buffering mechanism; as a result, occlusal forces are transmitted more directly to the peri-implant bone and restorative components. This distinction has raised legitimate concerns about the ability of implant-supported rehabilitations to withstand the repetitive and potentially excessive loads generated by parafunctional habits. [2,5]

Although several studies suggest an association between bruxism and increased risk of mechanical complications, the extent of its influence on implant success remains debated. Variations in diagnostic methods, inclusion criteria, and follow-up protocols have contributed to inconsistent findings across the literature. The relationship between occlusal overload and peri-implant biological complications has similarly not been fully clarified. [3,6]

Given the multifactorial nature of bruxism and the biomechanical challenges inherent to implant-supported restorations, a comprehensive approach integrating risk assessment, appropriate material selection, and individualized occlusal management is essential. The aim of this narrative review is to examine the current scientific evidence regarding the biomechanical consequences of bruxism, patient risk stratification, material selection strategies, and occlusal management protocols intended to improve the longevity and clinical success of implant-supported prosthodontic rehabilitations. [2,5]

BIOMECHANICAL CONSEQUENCES; WHAT EXCESSIVE OCCLUSAL FORCE ACTUALLY DOES TO IMPLANT SYSTEMS

Before considering patient risk factors or treatment strategies, it is important to understand the biomechanical

mechanisms through which bruxism may compromise implant-supported rehabilitations [6]. Unlike normal masticatory loading, bruxism is characterized by repetitive parafunctional activity capable of generating occlusal forces significantly greater than those expected during physiologic function. Beyond increased force magnitude, bruxism also involves prolonged loading duration, higher contact frequency, and considerable lateral and shear components, all of which substantially increase the biomechanical demands placed on the implant-prosthesis-bone system. [7,8] Moreover, evidence of masseter muscle hypertrophy in individuals with frequent bruxism reflects a greater capacity to sustain occlusal forces, further compounding the mechanical burden on implant-supported restorations. [9]

The biomechanical response of implants to parafunctional forces differs fundamentally from that of natural teeth. Natural dentition benefits from the periodontal ligament, which provides shock absorption, proprioception, and adaptive load distribution [10]. Osseointegrated implants, by contrast, are rigidly integrated into bone and exhibit minimal mobility; as a result, excessive occlusal forces cannot be effectively attenuated and are transmitted more directly to the surrounding bone and prosthetic components. [5,7] This absence of a periodontal ligament is considered the primary biomechanical factor underlying the increased susceptibility of implant-supported restorations to parafunctional overload. [7,8]

When excessive forces are repeatedly applied, stress concentrations develop throughout the implant-prosthetic complex. Finite element analyses consistently demonstrate that the highest stress levels occur within the crestal cortical bone, the implant-abutment interface, prosthetic screws, and restorative materials. [10,11] Non-axial loading associated with grinding movements is particularly detrimental because it increases bending moments and promotes uneven stress distribution. [8,10,11] Over time, these accumulated stresses may contribute to mechanical fatigue and progressive structural degradation of both prosthetic and implant components. [11,12]

Clinically, bruxism has been consistently associated with a range of mechanical complications, including screw loosening, ceramic chipping, framework fracture, prosthetic component failure, and, less frequently, implant body fracture. [12] These events are thought to result primarily from accumulated damage rather than isolated episodes of overload. Although some studies have reported higher implant failure rates among patients with bruxism, the direct relationship between occlusal overload and peri-implant bone loss remains inconclusive.

Current evidence suggests that biomechanical overload may concentrate stress within the crestal bone region; however, peri-implant bone loss and implant failure are likely multifactorial outcomes influenced by biological, prosthetic, and patient-related variables. [7,8,13]

Overall, available evidence supports the concept that bruxism creates a unique biomechanical environment characterized by excessive and repetitive loading, direct force transmission to bone, and elevated stress distribution throughout the implant-prosthetic complex [12]. Understanding these biomechanical principles provides the rationale for patient risk stratification and informs subsequent decisions regarding restorative material selection and occlusal management aimed at minimizing overload-related complications. [14]

RISK ASSESSMENT AND PATIENT STRATIFICATION; WHO IS TOO HIGH-RISK, AND WHO JUST NEEDS A PLAN

Given that bruxism may contribute to significant biomechanical consequences at the implant level, accurate patient stratification represents a critical step in treatment planning. In current clinical practice, a diagnosis of “probable” bruxism is generally established when clinical findings such as wear facets, linea alba, and masseteric hypertrophy, are combined with the patient’s self-report of clenching or grinding [15]. The simultaneous presence of both elements fulfills the minimum requirement for study inclusion in most published research. [12] To confirm the diagnosis, polysomnographic recording represents the gold standard; however, this level of instrumental verification has rarely been incorporated into clinical studies evaluating implant outcomes in bruxing patients. [13]

The absence of a standardized diagnostic criterion for bruxism is a recognized limitation of the current literature. One systematic review identified this gap as a key source of inconsistency across studies, since there is no minimum acceptable diagnostic method universally required for inclusion. [14] This heterogeneity not only affects the comparability of results but also complicates any attempt to draw definitive clinical conclusions about implant prognosis in bruxism-affected patients [16].

A binary classification of “bruxism” versus “non-bruxism” is insufficient for determining implant prognosis, since multiple co-existing factors must be considered during patient assessment. A retrospective case-control study demonstrated that when bruxism is accompanied by smoking, there is a measurable increase in marginal bone loss. [12,17] Furthermore, a cross-sectional analysis found

that when psychological factors such as depression or chronic stress co-exist with bruxism, the risk of developing peri-implantitis increases significantly; when bruxism was evaluated independent in the absence of psychological comorbidities, only a tendency toward increased risk was observed, suggesting that bruxism rarely acts in isolation as a sole determinant of biological failure. [17] When cases presenting bruxism alone were examined, an elevated risk of peri-implantitis was identified, though the concurrent presence of pre-existing periodontal disease also contributed substantially to risk stratification. [15]

According to the available evidence, the presence of bruxism increases the risk of implant failure by a factor of 2.2 to 4.7; however, these figures do not constitute an absolute contraindication to implant placement. Achieving successful outcomes requires individualizing treatment, classifying the patient into the appropriate risk category, and implementing a protocol tailored to their specific clinical profile. [16]

The elevated risk associated with bruxism depends on the concurrent presence of modifying variables including smoking, pre-existing periodontal disease, and the diagnostic method employed. Clinicians should develop a personalized treatment plan that includes occlusal protection strategies and implant number and position planning adapted to the patient’s biomechanical risk. [18] In practice, a more detailed and standardized diagnostic approach allows for classification of patients into low, medium, or high-risk categories for implant failure. Factors such as tobacco use and psychological comorbidities may place a patient in the high-risk category; however, no single combination of factors has been shown to inevitably result in failure across all cases. The patient must be evaluated as a whole, since only by considering the complete clinical picture is it possible to make truly individualized and evidence-guided decisions. [19,20]

MATERIAL SELECTION; ENGINEERING RESTORATIONS THAT CAN TAKE THE LOAD

Following biomechanical risk stratification, material selection becomes a decisive variable influencing the long-term performance of implant-supported rehabilitations. The clinical objective extends beyond fracture prevention: the aim is to optimize load distribution and reduce peak stress concentrations within the implant-prosthesis-bone system [21]. Accordingly, restorative materials should be selected based on their mechanical reliability, fatigue behavior, and interaction with occlusal loading conditions under repetitive parafunctional activity.

Zirconia: Strength and Fracture Resistance

Zirconia-based ceramics demonstrate high flexural strength and fracture toughness, supporting their use in high-load implant-supported restorations. [18] Systematic reviews report favorable survival outcomes for monolithic and partially veneered zirconia restorations in posterior regions under functional loading conditions. [19,20] Despite these advantages, zirconia exhibits a relatively high elastic modulus, which may limit its capacity for stress dissipation and increase load transmission to surrounding structures. [21] Tribological interactions also remain clinically relevant; antagonist wear has been documented under specific surface and occlusal conditions, though polishing and surface refinement significantly reduce this effect. [22] Overall, zirconia is primarily indicated for posterior full-contour restorations or frameworks in patients presenting elevated functional and parafunctional demands. [18,20]

Lithium Disilicate: Esthetic-Mechanical Trade-off

Lithium disilicate ceramics offer favorable optical properties and reliable adhesive performance, justifying their widespread application in anterior implant restorations. [23] Compared with high-strength polycrystalline ceramics, however, lithium disilicate demonstrates reduced fracture resistance and lower fatigue performance under cyclic loading. [19,23] Clinical evidence indicates that while survival rates are acceptable under normal functional loads, mechanical complications increase in the presence of parafunctional activity. [20] Its use in bruxism-affected patients should therefore be

restricted to low-load anterior regions or cases where occlusal schemes can reliably minimize non-axial forces. [23]

PMMA and CAD/CAM Polymer-Based Materials: Stress Modulation Potential

Polymeric CAD/CAM materials, particularly PMMA-based systems, exhibit a lower elastic modulus compared to ceramic alternatives, enabling greater energy absorption and potentially more favorable stress distribution within implant-supported prostheses. [24] This biomechanical behavior may help reduce peak load transmission during transitional phases or in high-risk functional scenarios. However, their reduced fatigue resistance and accelerated wear behavior limit their suitability as definitive restorative materials. Current evidence supports their primary use in provisional restorations, long-term temporization, or staged loading protocols where retrievability and occlusal adjustment are clinically advantageous. [24,25]

Metal-Ceramic Restorations: The Established Reference

Metal-ceramic restorations remain a well-documented and highly predictable option in implant prosthodontics, demonstrating consistent long-term survival rates. [25] The primary technical limitation continues to be veneering ceramic chipping, which occurs more frequently under conditions of elevated occlusal stress. Despite the emergence of all-ceramic systems, metal-ceramic restorations maintain clinical relevance in posterior rehabilitations with high functional demands and moderate esthetic requirements. [26]

Table 1. Comparative Summary of Restorative Materials in Bruxism-Affected Implant Patients. PFM = porcelain-fused-to-metal; PMMA = polymethylmethacrylate; FPD = fixed partial denture. Elastic modulus values are approximate and may vary by manufacturer and fabrication method

Material	Flexural Strength	Elastic Modulus	Fatigue Resistance	Clinical Indication in Bruxism	Chipping Risk
Monolithic Zirconia	High (>900 MPa)	High (~200 GPa)	High	Posterior full-contour crowns/FPDs; high-load cases	Low (monolithic)
Lithium Disilicate	Moderate (~400 MPa)	Moderate (~95 GPa)	Moderate	Low-load anterior regions only; limited in high-risk patients	Moderate
PMMA/CAD/CAM Polymer	Low (~100 MPa)	Low (~2–3 GPa)	Low	Provisional/transitional; staged loading protocols	Low (ductile failure)
Metal-Ceramic (PFM)	High (framework)	High (metal)	High	Posterior high-load cases; moderate esthetic demand	Moderate–High (veneer)

Clinical Implications: Toward an Individualized Material Strategy

Current evidence does not support the existence of a universally superior restorative material for bruxism-affected implant patients. Material selection should be guided by an integrative assessment of parafunctional severity, implant position, prosthetic design, occlusal scheme, and esthetic requirements. Implant complications associated with bruxism are multifactorial, and material properties represent only one component within a broader biomechanical system (table1). [21] This reinforces the need for individualized, risk-adapted restorative planning in every patient.

OCCUSAL MANAGEMENT PROTOCOLS; DESIGNING THE BITE TO PROTECT THE INVESTMENT

An accurate occlusal diagnosis is foundational to reducing biomechanical complications and extending the longevity of implant-supported restorations [23]. Because implants lack a periodontal ligament and exhibit reduced proprioception, and because the implant-bone connection is inherently rigid, periodic occlusal evaluation and maintenance must be considered essential components of any implant therapy protocol, particularly in patients with parafunctional activity such as bruxism. When occlusal forces are significantly elevated, they affect restorations, prosthetic components, and peri-implant tissues alike. [26,27]

The consequences of excessive occlusal force extend beyond the prosthesis itself. Evidence links greater magnitudes of traumatic occlusal loading to marginal bone loss in the range of 1.0 to 3.0 mm, reflecting the direct effect on peri-implant tissue integrity [28]. Bruxism increases biomechanical stress around implants, and parafunctional habits demonstrably modify clinical success rates for implant-supported restorations and the implant-bone interface. For this reason, implementing implant-protective occlusal protocols aimed at reducing mechanical stress and preserving peri-implant tissue health is not optional, it is a clinical necessity. [26,27]

The occlusal scheme itself has a measurable impact on prosthetic complication rates. In patients with bruxism, an inappropriate occlusal design significantly increases the incidence of ceramic fractures and material chipping in full-arch fixed implant prostheses, highlighting the importance of thoughtful occlusal design and routine maintenance. [29]

Finite element analyses have demonstrated that occlusal splints may reduce stress concentration at the implant

level by 33% to 73%, reinforcing their role as an adjunctive protective strategy. The overall risk of implant failure in bruxism-affected patients has been estimated at 2.2 to 4.7 times that of non-bruxers, a figure that underscores the need for structured management. [29,30]

Treatment does not end with prosthesis delivery. Patients with bruxism require continuous and structured maintenance. Regular follow-up visits allow for early detection of wear and incipient complications; occlusal splints reduce biomechanical stress but do not completely eliminate parafunctional forces and do not guarantee the absence of complications. [31]

Occlusal Splint Therapy and Structured Maintenance Protocols

The success of implant-supported rehabilitations in bruxism-affected patients depends not only on treatment planning and prosthetic design, but also on continuous occlusal maintenance throughout the life of the restoration. Because implants lack a periodontal ligament and have reduced proprioception, parafunctional forces are transmitted directly to the implant-prosthesis complex, increasing the risk of mechanical complications and prosthetic material failure. [26,27]

Periodic occlusal evaluation should therefore be considered a primary component of implant maintenance protocols. Regular occlusal reviews allow the clinician to identify changes in occlusal contacts, detect early signs of prosthetic overload, and implement corrections before complications develop [32]. Occlusal conditions are dynamic and may change over time due to dental wear, restorative modifications, tooth migration or extrusion, alterations in vertical dimension, or progression of parafunctional habits. Occlusal adjustment should not be viewed as a one-time procedure; rather, it is an ongoing process extending across the functional lifespan of the restoration. [26]

Hard acrylic stabilization splints are commonly recommended for patients with confirmed or suspected sleep bruxism. [33] These devices help redistribute occlusal forces, reduce direct loading on implant-supported restorations, and serve as a protective barrier between arches during nocturnal parafunctional activity. While splints do not eliminate bruxism, they can meaningfully reduce, control, and limit its biomechanical consequences, helping to preserve prosthetic components over time. [27,34]

A practical four-step protocol for occlusal maintenance in implant patients has been proposed and consists of: (1) patient-reported symptom review, including muscle

fatigue, awareness of clenching, or prosthetic complications; (2) assessment of restoration integrity, including wear facets, ceramic chipping, screw stability, and component condition; (3) a complete occlusal scheme analysis evaluating contacts in maximum intercuspation, excursive movements, and the presence of interferences capable of generating unfavorable loading patterns; and (4) evaluation of the need for additional protective measures such as occlusal splints, as well as monitoring for spatial changes including tooth migration, super-eruption, or inter-arch relationship modifications. (Table 2) [28]. Individualized treatment planning is therefore essential. No universal occlusal scheme can be applied to all patients; occlusal design must be adapted according to each patient's specific risk profile and clinical characteristics. [33,34]

Table 2. *Four-Step Occlusal Maintenance Protocol for Implant Patients with Bruxism. MIP = maximum intercuspal position; VDO = vertical dimension of occlusion. [28,33].*

Step	Action	Clinical Focus
1	Patient symptom interview	Muscle fatigue, pain, awareness of clenching, prosthetic events
2	Restoration integrity assessment	Wear facets, chipping, screw tightness, component condition
3	Occlusal scheme analysis	Contacts in MIP, excursions, interferences, dynamic loading patterns
4	Risk evaluation and protective intervention	Splint indication, spatial changes (migration, supra-eruption, VDO)

CONCLUSION

The evidence reviewed in this narrative review collectively supports a shift in clinical perspective: bruxism should no longer be regarded as a straightforward contraindication to implant therapy but rather recognized as a significant, manageable biomechanical risk modifier. As understanding of the interactions between occlusal loading, implant systems, restorative materials, and patient-specific variables continues to evolve, implant prosthodontics is progressing toward a more individualized and preventive model of care.

The findings presented here suggest that successful rehabilitation in bruxism-affected patients is unlikely to depend on any single material choice, prosthetic design, or occlusal intervention taken in isolation. Predictable outcomes appear to result from the coordinated application of multiple strategies: comprehensive risk assessment, appropriate restorative planning, careful material selection, evidence-based occlusal management, and structured long-term maintenance protocols. This approach acknowledges the inherent heterogeneity of bruxism and allows treatment decisions to be tailored to each patient's individual biomechanical risk profile.

Emerging digital workflows, CAD/CAM technologies, and additive manufacturing techniques offer additional opportunities to enhance treatment personalization and biomechanical optimization. Although the long-term clinical implications of these innovations in bruxism-affected patients remain under investigation, they have the potential to further support a protocol-driven approach

aimed at reducing complication rates and improving prosthetic longevity.

Integrating risk assessment with individualized restorative and occlusal protocols represents the most rational and evidence-aligned pathway for optimizing implant rehabilitation in patients exposed to elevated functional loading. Future research should focus on validating standardized diagnostic criteria for bruxism, establishing consensus-based clinical protocols, and identifying the specific combinations of preventive strategies that provide the greatest benefit across different risk categories. Ultimately, treating bruxism-affected implant patients well requires not just better materials or better splints, it requires better planning from the first clinical encounter through the lifetime of the restoration.

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