Acta Scientific Dental Sciences
Volume 10 Issue 7 July 2026
Review Article

Implant Failure and Prosthodontic Failure in Implant Dentistry: Etiology, Diagnosis, and Clinical Management

Girish Galagali* and Nigama B

Department of Prosthodontics, Navodaya Dental College, Raichur, Karnataka, India

***Corresponding Author:** Girish Galagali, MDS (Prosthodontics), Professor and Head of Department, Department of Prosthodontics, Navodaya Dental College, Raichur, Karnataka, India.

Received: May 14, 2026
Published: June 30, 2026
© All rights are reserved by **Girish Galagali and Nigama B.**

Abstract

Dental implant therapy has become a predictable and evidence-based modality for the replacement of missing teeth, with long-term survival rates exceeding 90-95% reported in systematic reviews and meta-analyses. Despite high success rates, complications may arise during the osseointegration phase or following prosthetic loading, potentially compromising treatment outcomes and necessitating corrective intervention.

Implant-related complications are broadly classified into two distinct categories: implant failure and prosthodontic failure. Implant failure involves biological disturbances affecting osseointegration and the bone-implant interface, resulting in implant mobility and loss of integration. Prosthodontic failure refers to mechanical or technical complications associated with the prosthetic superstructure while the implant fixture remains stable and osseointegrated.

This narrative review discusses both failure categories from biological and mechanical perspectives, with emphasis on their etiology, diagnostic criteria, and evidence-based clinical management. Early implant failure results from disrupted osseointegration during the initial healing phase due to thermal injury, surgical trauma, infection, or insufficient primary stability. Late implant failure is most commonly driven by peri-implantitis, a plaque-associated destructive inflammatory process, as well as sustained occlusal overload and systemic risk factors including uncontrolled diabetes mellitus and tobacco smoking.

Prosthodontic failures include screw loosening, abutment or framework fracture, and ceramic veneer chipping. These complications arise from mechanical fatigue, prosthetic misfit, excessive cantilever forces, and parafunctional loading, and are generally amenable to correction without removal of the implant fixture.

The differential diagnosis integrates clinical mobility assessment, peri-implant probing, resonance frequency analysis, and standardised radiographic evaluation. Eight structured comparative and diagnostic tables are presented to support systematic, evidence-anchored clinical decision-making, including a four-step diagnostic decision algorithm and a comprehensive risk stratification framework. Management of biological implant failure follows the 2023 European Federation of Periodontology and American Academy of Periodontology clinical practice guidelines, encompassing stepwise non-surgical and surgical approaches. Prosthodontic failures are managed through targeted prosthetic repair and occlusal correction.

Systematic pre-treatment risk stratification, meticulous surgical technique, evidence-based prosthetic design, and adherence to regular maintenance protocols are identified as the most effective determinants of long-term implant success. Accurate differentiation between biological and mechanical failure categories is essential for appropriate clinical decision-making and prevention of unnecessary surgical intervention.

Keywords: Dental Implants; Implant Failure; Prosthodontic Complications; Peri-Implantitis; Osseointegration; Mechanical Complications

Abbreviations

BOP: Bleeding on Probing; CBCT: Cone Beam Computed Tomography; EFP: European Federation of Periodontology; AAP: American Academy of Periodontology; FDP: Fixed Partial Denture/Fixed Dental Prosthesis; HbA1c: Glycated Hemoglobin; ISQ: Implant Stability Quotient; PD: Probing Depth; RFA: Resonance Frequency Analysis; T2DM: Type 2 Diabetes Mellitus.

Introduction

Dental implants have substantially expanded the rehabilitative options available for partially and completely edentulous patients. Implant-supported restorations offer several advantages over conventional prosthetic alternatives, including improved masticatory efficiency, enhanced esthetics, preservation of alveolar bone volume, and increased patient satisfaction [6]. Iterative refinements in implant surface technology, implant macrodesign, surgical protocols, and prosthetic materials have contributed to the high survival rates observed in modern implant dentistry.

The success of implant therapy depends fundamentally on two factors: biological integration of the implant with the surrounding bone and functional stability of the prosthetic restoration. The biological basis of implant therapy is osseointegration, introduced by Branemark and colleagues as a direct structural and functional connection between ordered living bone and the surface of a load-bearing implant at the light microscopic level [8]. Albrektsson and colleagues subsequently operationalized this concept into clinical success criteria that remain in use today [1].

Despite the predictability of implant therapy, complications may arise during the healing phase or following prosthetic loading. These complications may result from biological disturbances affecting the bone-implant interface or from mechanical and technical problems related to prosthetic components. Implant therapy complications are classified into implant failure, which involves biological disturbances affecting the implant fixture, and prosthodontic failure, which involves mechanical or technical complications affecting the prosthesis or implant components [2,3]. Correct identification of the underlying cause is essential because the etiology, diagnosis, and management of these two categories differ substantially. This review provides a structured, evidence-based framework for both failure categories, supported by eight comparative and diagnostic reference tables designed for direct clinical application.

Implant failure

Implant failure refers to the inability of a dental implant to achieve or maintain stable osseointegration within the surrounding bone under functional loading conditions. Loss of osseointegration results in instability of the implant and eventual failure of the implant-supported restoration [1,3].

According to the criteria proposed by Albrektsson and colleagues, implant failure may be characterized by implant mobility, persistent pain or discomfort, recurrent infection at the implant site, and progressive marginal bone loss detectable radiographically [1]. The 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases further refined diagnostic thresholds, defining pathological peri-implant bone loss as bone resorption of 0.5 mm or more beyond expected physiological remodeling, accompanied by bleeding on probing and/or suppuration [4]. Table 6 presents a structured comparison of implant success, survival, and failure criteria based on this framework.

Early implant failure

Early implant failure occurs before successful osseointegration has been established, typically within the first weeks to months following implant placement. Disruption of the biological healing process prevents the formation of a stable bone-implant interface. Esposito and colleagues identified the primary biological factors contributing to early implant failure as surgical trauma, thermal injury to bone during osteotomy preparation (temperatures exceeding 47 degrees C for more than one minute), peri-operative infection, poor bone quality or quantity, insufficient primary stability, and premature loading before adequate bone healing has occurred [3]. These factors may act independently or synergistically to impair osseointegration.

Late implant failure

Late implant failure occurs after osseointegration has been established and the implant has been subjected to functional loading. The most common cause of late implant failure is peri-implantitis, defined as a plaque-associated pathological condition occurring in tissues around dental implants, characterised by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone [4,7]. The prevalence of peri-implantitis has been estimated at approximately 22% of implants

and 43% of implant patients in long-term studies [9]. Additional contributing factors include sustained occlusal overload, implant fracture resulting from fatigue failure of the implant body, systemic conditions adversely affecting bone metabolism, and unfavourable prosthetic design. Table 5 presents a structured temporal classification distinguishing early and late implant failure with their respective mechanisms and management approaches.

Clinical presentation

Clinically, implant failure may present with implant mobility, pain during mastication, inflammation and erythema of peri-implant soft tissues, suppuration, increased probing depths exceeding 6 mm, and radiographic evidence of marginal bone loss [4]. Implant mobility is pathognomonic of loss of osseointegration and indicates irreversible failure of the bone-implant interface. Early detection of these signs is essential to prevent progression of the disease and to preserve options for subsequent rehabilitation.

Prosthodontic failure

Prosthodontic failure refers to complications associated with the prosthetic components of implant-supported restorations while the implant fixture remains osseointegrated and stable. These complications typically involve mechanical or technical failures affecting prosthetic screws, abutments, frameworks, or restorative materials [2]. Table 3 presents a structured comparison of the key distinguishing features between implant failure and prosthodontic failure.

Mechanical complications

Mechanical complications arise from excessive or repetitive mechanical stress acting on implant components. Screw loosening is among the most frequently reported mechanical complications, with reported incidence rates ranging from 6% to 43% depending on the type of restoration and loading conditions [2]. Screw loosening may occur due to improper torque application during seating, component misfit generating micromotion at the implant-abutment interface, occlusal overload, or parafunctional habits such as bruxism. Screw fracture, abutment fracture, and deformation or accelerated wear of prosthetic components represent more severe mechanical complications and are associated with biomechanical overloading [2,6]. Table 7 summarises reported five-year complication rates by restoration type.

Technical complications

Technical complications involve problems related to restorative materials and prosthetic fabrication. Ceramic fracture or chipping is one of the most prevalent technical complications, with reported rates of approximately 13% for implant-supported fixed dental prostheses at five-year follow-up [5]. Additional technical complications include fracture of the prosthetic framework, loss of prosthesis retention, wear of prosthetic teeth, and cement failure. Such complications typically result from unfavourable occlusal forces, material fatigue over time, or suboptimal prosthetic design [2].

Biological consequences of prosthetic design

Prosthetic design may also exert indirect effects on peri-implant biological health. Overcontoured restorations, inappropriate emergence profiles, and excessive cantilever extensions promote plaque accumulation in peri-implant tissues and increase the risk of peri-implant mucositis and peri-implantitis [4,7]. This interaction between mechanical design and biological response highlights the importance of integrating prosthodontic and periodontal considerations in implant treatment planning.

Clinical presentation

Clinically, prosthodontic failure may present as mobility of the prosthesis without accompanying implant mobility, audible or tactile detection of screw loosening, fracture of the restoration, ceramic chipping, or loss of retention. In these situations the implant fixture characteristically remains stable within the surrounding bone and does not exhibit mobility on clinical examination.

Etiology of implant and prosthodontic failures

The etiology of implant complications is multifactorial and can be systematically organised across four levels: patient-level factors, implant-level factors, prosthesis-level factors, and clinician-level factors.

- Patient-level factors include systemic conditions, smoking, parafunctional habits, and oral hygiene status. These factors modulate the biological and mechanical environment in which the implant must function and are discussed in detail in Section 5 below and summarised in Table 1.

- Implant-level factors include implant surface characteristics, implant diameter, length, and position, as well as the quality and quantity of the surrounding bone. Poor bone quality (Lekholm and Zarb type IV bone) is associated with higher rates of early implant failure due to reduced primary stability and slower bone apposition [3,6].
- Prosthesis-level factors include prosthetic design, occlusal scheme, cantilever length, and the material properties of restorative components. Excessive cantilever forces, unfavourable crown-to-implant ratios, and prosthetic misfit generate pathological stress at the implant-bone interface and at prosthetic connections, predisposing to both biological and mechanical complications [2].
- Clinician-level factors include surgical technique, osteotomy preparation protocol, implant positioning, and the accuracy of prosthetic fabrication. Inadequate implant angulation, insufficient irrigation during bone preparation, and improper torque application during prosthetic seating are modifiable technical risk factors that directly influence complication rates [3,6].

Risk factors for implant failure

Recognition and quantification of risk factors during treatment planning is essential for informed patient counselling and for minimising the likelihood of implant failure. Table 1 presents a structured six-domain risk stratification framework applicable to pre-treatment planning.

- Tobacco smoking reduces vascular supply to oral tissues, impairs neutrophil-mediated immune responses, and compromises bone healing at the cellular level. A meta-analysis by Hinode and colleagues reported a statistically significant twofold elevation in implant failure odds among smokers relative to non-smokers (OR 2.17; 95% CI 1.67-2.83), with greater risk observed in the maxillary arch than in the mandible [10]. The effect is dose-dependent, with heavy smokers exhibiting the highest risk.
- Uncontrolled diabetes mellitus impairs neutrophil chemotaxis and phagocytosis, reduces angiogenesis, disrupts collagen synthesis, and compromises osseointegration at the molecular level. Patients with poorly controlled diabetes (HbA1c >8%) have been shown to exhibit significantly higher rates of peri-implant bone loss and implant failure compared with normoglycaemic individuals. Conversely, well-controlled diabetic patients demonstrate implant survival rates comparable to non-diabetic patients, reinforcing the importance of glycaemic optimisation prior to implant placement [6].
- Parafunctional habits, particularly bruxism, generate occlusal forces that may exceed the fatigue tolerance of implant components, resulting in accelerated screw loosening, ceramic fracture, and in severe cases, implant fracture. Bruxism has been consistently identified as a significant risk factor for mechanical complications in implant prostheses, and implant therapy in bruxist patients requires careful occlusal management and protective appliance therapy [2,6].
- Poor bone quality and quantity reduce primary implant stability at placement, which is a prerequisite for successful osseointegration. Insufficient primary stability, defined as an ISQ below 65, is associated with micromotion at the bone-implant interface during the healing phase and an increased risk of fibrous encapsulation rather than osseointegration [6].
- Poor oral hygiene is the primary modifiable risk factor for peri-implant mucositis and peri-implantitis. Plaque accumulation at the peri-implant margin initiates an inflammatory cascade that, in susceptible individuals, progresses to irreversible bone loss. Patients who do not adhere to regular supportive implant maintenance exhibit significantly higher rates of peri-implantitis and implant failure [4,7].

Risk Domain	Low Risk	Moderate Risk	High Risk
Systemic and Medical Status	Non-smoker; no systemic disease; no medications affecting bone metabolism or wound healing	Controlled systemic disease (e.g., well-managed T2DM, HbA1c <7%); light smoker (<10 cigarettes/day)	Uncontrolled diabetes (HbA1c >8%); heavy smoker; bisphosphonate or anti-resorptive therapy; immuno-suppression; prior head and neck radiotherapy

Periodontal and Peri-Implant History	No prior periodontitis; consistently excellent plaque control; no history of implant complications or loss	Treated and clinically stable periodontitis; acceptable maintenance adherence; no prior implant loss documented	Untreated or recurrent periodontitis; documented prior implant failure; persistently poor oral hygiene at recall visits
Alveolar Bone Status	Adequate bone volume without augmentation; dense cortical bone (Type I–II per Lekholm/Zarb classification)	Minor bone deficiency manageable by simultaneous guided bone regeneration; predominantly Type III bone quality	Severely atrophic ridge requiring staged reconstruction; Type IV bone; anatomical proximity to inferior alveolar canal or maxillary sinus floor
Parafunctional Activity	No clinical or historical evidence of bruxism or clenching habits	Mild bruxism identified clinically and managed with a well-tolerated hard acrylic occlusal splint	Severe bruxism with documented prosthetic fatigue; poor splint compliance; evidence of prior implant component fracture attributable to overload
Prosthetic Complexity	Single-unit or short-span restoration; confirmed passive fit at delivery; favorable crown-to-implant ratio	Multi-unit fixed partial denture; moderate cantilever extension; minor fit discrepancy correctable at chairside	Full-arch extended cantilever prosthesis; poor passive fit confirmed on Sheffield test; overdenture with severely worn or fractured attachments
Maintenance Compliance	Consistent attendance at recall (minimum every 6 months); meticulous peri-implant home care	Occasional missed recall appointments; satisfactory but inconsistent self-care and plaque control routine	Non-compliant with recall schedule over a sustained period; no meaningful engagement with peri-implant self-care

Table 1: Patient risk stratification framework for implant therapy across six clinical and behavioral domains.

Note: Risk domains should be assessed independently during pre-treatment planning. The presence of two or more high-risk domains in a single patient warrants detailed risk counseling and should prompt modification of the proposed treatment plan or intensification of the post-treatment maintenance protocol. FPD = fixed partial denture; HbA1c = glycated hemoglobin; ISQ = implant stability quotient; T2DM = type 2 diabetes mellitus.

Diagnostic approach

Accurate diagnosis is essential for distinguishing between implant failure and prosthodontic complications and for selecting appropriate management strategies. Diagnosis integrates clinical examination, radiographic evaluation, and assessment of prosthetic components. Table 2 presents a structured four-step diagnostic decision algorithm that integrates the assessment principles described below.

Clinical assessment

Evaluation of implant mobility is the most definitive clinical indicator of loss of osseointegration [1]. Probing depth measurements around implants should be obtained and compared with baseline values; probing depths exceeding 6 mm in combination with BOP and bone loss are diagnostic of peri-implantitis according to the 2017 World Workshop consensus criteria [4]. Suppuration upon probing further supports a diagnosis of active peri-implant infection.

RFA provides an objective, non-invasive assessment of implant stability by measuring the ISQ on a scale of 1 to 100. ISQ values below 65 at the time of prosthetic loading or a significant decline in ISQ values over serial measurements may indicate inadequate osseointegration or progressive bone loss, prompting further investigation [6]. RFA is particularly valuable for monitoring implant stability during the healing phase and in cases of suspected early failure.

Radiographic evaluation

Standardised periapical radiographs or CBCT are used to detect and quantify marginal bone loss. Bone loss of 0.5 mm or more beyond the expected remodelling that occurs in the first year of loading, combined with clinical signs of inflammation, is consistent with a diagnosis of peri-implantitis [4]. Serial radiographs are essential for monitoring disease progression and evaluating the response to treatment.

Prosthetic component examination

Examination of prosthetic components is necessary to identify screw loosening, abutment fracture, framework failure, or ceramic chipping. When the prosthesis exhibits mobility while the implant remains stable and non-mobile, the complication is prosthodontic in origin. Occlusal analysis should be performed to determine whether excessive occlusal forces, prosthetic cantilevers, or premature contacts are contributing to mechanical complications. When implant mobility is accompanied by radiographic bone loss and peri-implant inflammation, biological implant failure is the primary diagnosis.

CLINICAL PRESENTATION — Implant or prosthesis area concern: mobility/pain/esthetic change/screw access visible		
	▼	
STEP 1. Apply bidigital pressure to the implant body. Is the implant fixture itself mobile?		
	YES -> Implant mobility present -> IMPLANT FAILURE confirmed	NO -> Implant is stable -> proceed to Step 2
	▼	
Diagnosis: Implant Failure (Biological)	Investigation: Quantify bone destruction (periapical X-ray or CBCT)	Investigation: Assess peri-implant infection (probing, BOP, suppuration)
Remove implant; debride implant socket; bone graft if required; plan delayed reimplantation after full healing	Bone loss >=0.5 mm above remodeling threshold = peri-implantitis; stage and grade per Table 8; initiate treatment protocol accordingly	Non-surgical debridement as first-line step; escalate to surgical access if inflammation unresolved; follow EFP/AAP 2023 stepped care guidelines
STEP 2. Implant is stable. Does the prosthesis move, feel loose, or produce an audible click on loading?		
	YES -> Prosthesis mobility confirmed -> PROSTHODONTIC FAILURE	NO -> No prosthesis movement detected -> proceed to Step 3
	▼	
Diagnosis: Prosthodontic Failure (Mechanical)	Investigation: Access screw channel; attempt re-torquing	Investigation: Examine abutment and framework for fracture
Re-torque or replace prosthetic screw; repair ceramic fracture; refine and adjust occlusal contacts; remake prosthesis if misfit is confirmed	Loose screw: re-torque to manufacturer-specified value; fractured screw: retrieve fragment and replace component; assess parafunctional loading as contributing factor	Abutment fracture: replace abutment component; framework fracture: laboratory remake required; review crown-to-implant ratio and cantilever length
STEP 3. No mobility. Has serial radiographic review identified marginal bone loss versus established baseline?		
	YES -> Bone resorption >=0.5 mm beyond physiological threshold -> PERI-IMPLANT DISEASE	NO -> Bone levels radiographically stable -> proceed to Step 4

▼		
Diagnosis: Peri-Implant Disease (Workup Required)	Classification: Stage and Grade per Table 8	Management: Initiate stepwise protocol
BOP + progressive bone loss = peri-implantitis; BOP alone, no bone loss = mucositis (reversible); cross-reference Table 4 for full disease classification	Stage I: Non-surgical debridement; Stage II-III: Surgical access; Stage IV: Explantation and site reconstruction	Grade A: Enhanced monitoring only; Grade B: Intensify maintenance frequency; Grade C: Aggressive risk factor modification + active treatment
STEP 4. Bone stable, no mobility. Is there ceramic fracture, esthetic deterioration, or patient occlusal complaint?		
	YES -> Technical or material complication identified -> TECHNICAL FAILURE	NO -> No complication identified on comprehensive examination
▼		
Diagnosis: Technical Prosthodontic Failure	Outcome: Routine Maintenance and Scheduled Recall	Outcome: Reinvestigate or Specialist Referral
Repair or replace fractured ceramic veneer; refine and correct occlusal scheme; reassess prosthetic design for overloading risk	Record updated baseline probing and radiographic data; reinforce oral hygiene instruction; schedule recall at maximum 6-month intervals	Perform RFA/ISQ assessment if osseointegration status uncertain; request CBCT if periapical film insufficient; refer to specialist if diagnosis remains unclear

Table 2: Structured four-step diagnostic decision algorithm for the clinical evaluation of implant and prosthodontic complications.

Note: Each diagnostic step should be completed in sequence before proceeding to the next. Skipping steps risks premature misclassification. BOP = bleeding on probing; CBCT = cone beam computed tomography; RFA = resonance frequency analysis; ISQ = implant stability quotient.

Comparison and classification reference tables

The tables presented below provide structured classification frameworks designed to complement the diagnostic algorithm in Table 2. Together they address the comparative features of the two primary failure categories, the taxonomy of peri-implant diseases, the temporal classification of implant failure, the important distinction between success and survival outcome reporting, and benchmark complication rates by restoration type. All tables are formatted for direct clinical and academic reference application.

Characteristic	Implant Failure	Prosthodontic Failure
Definition	Biological inability to establish or preserve a functional bone–implant union; results in implant fixture instability and loss of load-bearing capacity	Deterioration of mechanical or structural integrity of the prosthetic superstructure while the implant body maintains its osseous anchorage
Primary structure affected	Implant body and surrounding bone–implant interface	Prosthetic elements: retaining screws, abutments, veneering materials, and prosthetic frameworks
Hallmark clinical sign	Detectable implant mobility under bidigital pressure — pathognomonic of osseointegration loss	Prosthesis movement or looseness while the implant fixture itself remains immobile and stable
Radiographic finding	Progressive marginal bone resorption exceeding physiological remodeling limits (≥0.5 mm above threshold)	Bone levels typically stable; framework or screw discontinuity may be identifiable on close inspection

Primary etiological drivers	Peri-implant infection, unresolved inflammation, biomechanical overloading, impaired systemic healing capacity	Mechanical fatigue, excessive occlusal stress, component misfit, parafunctional loading patterns
Management objective	Eliminate infection, reconstruct the implant site, and facilitate re-osseointegration at a delayed stage	Restore prosthetic integrity through component repair or replacement; osseointegrated fixture is retained throughout
Overall prognosis	Guarded; may necessitate complete surgical retreatment of the implant site	Favorable in most cases; timely prosthetic correction is usually sufficient to restore function

Table 3: Comparative features of implant failure and prosthodontic failure across seven clinical and management parameters.

Note: BOP = bleeding on probing; CBCT = cone beam computed tomography; ISQ = implant stability quotient.

Condition	Inflammatory Status	Bone Level	Reversibility	Management Implication
Peri-Implant Health	Absent	Within baseline remodeling limits	Maintainable	No active treatment; preventive measures reinforced at scheduled recall visits
Peri-Implant Mucositis	Present (BOP ± suppuration); no systemic signs	No bone destruction beyond initial physiological remodeling	Reversible	Non-surgical debridement; intensive oral hygiene instruction; resolves with sustained plaque control
Peri-Implantitis	Present (BOP and/or suppuration); erythema; mucosal swelling	Progressive bone destruction ≥0.5 mm beyond physiological remodeling threshold	Irreversible without clinical intervention	Stepwise protocol per EFP/AAP 2023: non-surgical first; surgical access if inflammation persists
Hard/Soft Tissue Deficiency	Variable; depends on etiology and site history	Deficient bone volume and/or keratinized soft tissue	Reconstructive	Bone grafting and/or soft tissue augmentation; may precede or accompany implant placement

Table 4: Classification of peri-implant diseases and conditions adapted from the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions (Berglundh., *et al*. 2018).

Note: BOP = bleeding on probing. The four diagnostic categories represent a clinical continuum from health to tissue deficiency. Peri-implant mucositis is reversible with effective plaque control; peri-implantitis is not reversible without active clinical intervention.

Failure Type	Time Frame	Biological Mechanism	Primary Etiological Factors	Management Approach
Early Failure (Pre-osseointegration)	Within the first weeks to approximately 3 months post-placement	Failed osseointegration; fibrous encapsulation instead of bone apposition	Surgical trauma, bone overheating (>47°C sustained), peri-operative infection, poor bone quality, insufficient primary stability, premature mechanical loading	Implant removal; site debridement; identify and eliminate the etiological factor; delayed reimplantation after full healing
Late Failure (Post-osseointegration)	Months to years after functional loading has commenced	Loss of an established bone–implant union due to biological or biomechanical challenge	Peri-implantitis, sustained occlusal overloading, parafunctional habits, uncontrolled systemic disease, implant fatigue fracture	Manage the underlying cause (infection protocol or occlusal correction); implant removal if mobility is confirmed; plan staged reconstruction

Table 5: Temporal classification of implant failure into early and late categories, based on the framework of Esposito., *et al*. (1998), with etiological factors and management approaches.

Note: Early and late failure differ not only in their triggering mechanisms but also in their implications for retreatment planning.

Criterion	Implant Success (Albrektsson., *et al*. 1986)	Implant Survival (Implant Present in Mouth)	Implant Failure (Osseointegration Lost)
Implant mobility	Entirely absent under bidigital palpation — mandatory criterion	May be present; implant is counted in the denominator regardless	Present — pathognomonic of complete osseointegration loss
Marginal bone loss	≤1.5 mm during first year of loading; ≤0.2 mm/year thereafter	No bone loss threshold stipulated for survival reporting	Progressive bone destruction confirmed on serial radiographic comparison
Pain and discomfort	Completely absent at rest and under functional occlusal load	Not applied as an exclusion criterion	May accompany mobility and active peri-implant infection
Peri-implant infection	No evidence of active suppuration or uncontrolled infection	Not specified in survival endpoint definition	Active suppuration and/or unresolved peri-implant inflammation
Radiographic stability	Marginal bone level unchanged on serial standardised periapical radiographs	Implant radiographically present; bone level stability not required	Visible crestal bone destruction evident on comparison films
Objective stability (RFA)	ISQ ≥65 confirming clinically adequate osseointegration	Not routinely incorporated into survival assessment	ISQ below accepted threshold or demonstrably declining over serial measurements
Summary implication	Gold standard for outcome reporting; all biological and functional criteria must be met	Implant physically present in mouth regardless of active complications; overestimates true health	Implant non-functional; explantation required or already performed

Table 6: Distinction between implant success, implant survival, and implant failure based on criteria proposed by Albrektsson., *et al*. (1986) and updated clinical thresholds incorporating resonance frequency analysis.

Note: The conflation of survival and success reporting has historically inflated apparent implant outcome rates. Clinicians should apply the success criteria when counseling patients on realistic long-term expectations. ISQ = implant stability quotient; RFA = resonance frequency analysis.

Restoration Type	Screw Loosening (5-yr)	Ceramic/Material Fracture (5-yr)	Screw Fracture (5-yr)	Clinical Notes
Single Crown (Implant-Supported)	~6%	~13%	~3%	Ceramic fracture dominates; screw loosening more common in posterior single units under heavy occlusal load
Fixed Partial Denture (3–4 units)	~8–15%	~13%	~5%	Cantilever FDPs show substantially higher complication rates; framework fracture risk increases with span length
Full-Arch Fixed Prosthesis (All-on-4/All-on-6)	~20–43%	~15%	~8%	Highest overall mechanical complication burden; screw loosening is the most frequent finding
Implant-Supported Overdenture (2–4 implants)	~30–40% (attachment wear)	~10% (acrylic fracture)	~5%	Attachment mechanism wear and fracture is the predominant complication; close recall intervals are mandatory

Table 7: Reported 5-year prosthodontic complication rates by implant-supported restoration type, derived from Goodacre., *et al*. (2003) and Pjetursson., *et al*. (2012).**Note:** Rates are approximate pooled estimates and vary by study population, implant system, and loading protocol.

Clinical management

Management of implant complications depends on the type, location, and severity of failure. Treatment must address the underlying aetiology in addition to the specific complication presenting.

Management of implant failure

Biological implant failures typically require removal of the failed implant followed by thorough debridement of the implant site to eliminate infected or necrotic tissue. Bone grafting procedures, using autogenous bone, xenografts, allografts, or barrier membranes, may be necessary to reconstruct lost bone volume before delayed implant placement [3,6]. A minimum healing period of four to six months following grafting is generally recommended before reimplantation.

For peri-implantitis specifically, current evidence-based management encompasses both non-surgical and surgical approaches. The 2023 clinical practice guidelines published by the EFP and AAP recommend a stepwise approach beginning with non-surgical debridement and antiseptic adjuncts, followed by surgical intervention, including resective or regenerative procedures, in cases where non-surgical therapy fails to achieve resolution of inflammation and stabilisation of bone levels [11]. Control of modifiable risk factors, including smoking cessation, glycaemic optimisation, and oral hygiene reinforcement, are integral components of peri-implantitis management. Table 8 presents a structured staging and grading framework for peri-implantitis that complements this management approach.

Part A: Staging — Severity at Time of Clinical Assessment			
Stage	**Soft Tissue Signs**	**Radiographic Bone Loss**	**Recommended First-Line Management**
I (Incipient)	BOP present; mild suppuration possible; PD ≥4 mm at one or more sites	<25% of implant length; ≤3 mm vertical bone loss	Non-surgical debridement with antiseptic adjuncts; intensified oral hygiene instruction; reduce recall interval to 3 months
II (Moderate)	BOP and/or suppuration; PD ≥6 mm; mucosal swelling and erythema	25–50% of implant length; 3–5 mm vertical bone defect	Surgical access for direct implant surface decontamination; regenerative fill with bone substitute if defect morphology permits

III (Advanced)	Pronounced BOP; suppuration; PD ≥8 mm; soft tissue recession at implant margin	>50% of implant length; >5 mm vertical bone loss; exposed implant threads	Resective or regenerative surgery; consider implant removal if mobility is confirmed at any stage of workup
IV (Failure)	Clinical implant mobility; severe surrounding inflammation; possible peri-implant fistula formation	Complete peri-implant bone destruction; implant non-functional in the arch	Explantation; thorough socket debridement; bone reconstruction with staged reimplantation after full healing
Part B: Grading — Rate of Disease Progression and Risk Factor Profile			
Grade	Rate of Bone Loss		Associated Risk Factor Profile
A (Slow)	No measurable bone loss over 5 years of monitoring; resorption rate <0.5 mm/year		Non-smoker; systemically healthy; fully compliant with recall; no identifiable risk amplifiers present
B (Moderate)	Moderate bone destruction of 0.5–1.0 mm/year on serial radiographic review		Controlled systemic disease; light smoker; moderate biofilm accumulation; inconsistent recall attendance
C (Rapid)	Rapid bone destruction exceeding 1.0 mm/year; multiple implants affected simultaneously		Heavy smoker; poorly controlled metabolic disease; bruxism; prior implant loss; consistently non-compliant with maintenance

Table 8: Proposed staging and grading framework for peri-implantitis adapted from the 2017 World Workshop classification (Berglundh., *et al*. 2018; Schwarz., *et al*. 2018), with management recommendations aligned to the 2023 EFP/AAP clinical practice guidelines (Herrera., *et al*. 2023).

Note: Stage reflects disease severity at the time of clinical assessment. Grade reflects the biological rate of disease progression and the risk factor burden driving that progression. These two dimensions should be assessed independently. BOP = bleeding on probing; PD = probing depth.

Management of prosthodontic failure

Prosthodontic failures are generally less severe and can usually be managed without removing the implant fixture. Treatment may involve retightening of loose prosthetic screws to the manufacturer-specified torque using a calibrated torque wrench, replacement of fractured screws or abutments, repair or replacement of fractured ceramic veneering, adjustment of occlusal contacts to eliminate premature contacts and reduce parafunctional stress, or complete redesign of the prosthesis to improve biomechanical stability and load distribution [2]. Where prosthetic misfit is identified as a contributing factor, remake of the prosthesis with improved passive fit is indicated. The use of occlusal splints is recommended in patients with bruxism to protect implant components from excessive fatigue loading.

Maintenance and follow-up

Regular supportive implant maintenance is critical for early detection of biological and mechanical complications and for long-term implant success. Maintenance visits should include clinical probing, mobility assessment, radiographic monitoring at defined intervals, professional debridement of peri-implant tissues, and reinforcement of oral hygiene instruction. Patients with a history of periodontitis or other risk factors require more frequent maintenance intervals [4,7].

Conclusion

Dental implant therapy represents a highly evidence-based and clinically effective approach to the rehabilitation of edentulous patients, supported by long-term survival data from multiple systematic reviews and meta-analyses. Nevertheless, complications may arise during or after implant therapy that require careful differential diagnosis and targeted management.

Implant failures, involving biological disturbances of osseointegration, generally represent more serious complications and may require implant removal, site reconstruction, and staged

reimplantation. Prosthodontic failures, involving mechanical or technical complications of prosthetic components, are typically amenable to correction without removal of the implant fixture.

Early diagnosis, thorough preoperative risk assessment, meticulous surgical technique, evidence-based prosthetic design, and adherence to regular maintenance protocols are the most effective determinants of long-term implant success. The eight classification, risk stratification, and diagnostic reference tables presented in this review (Tables 1 through 8) are intended to assist clinicians in systematically evaluating complications and implementing appropriate, evidence-based management strategies consistent with current international guidelines, including the 2017 World Workshop consensus criteria for peri-implant disease classification and the 2023 EFP/AAP clinical practice guidelines for peri-implantitis treatment.

Acknowledgements

The authors acknowledge the Department of Prosthodontics, Navodaya Dental College, Raichur, Karnataka, India, for providing institutional support. No specific funding was received for the preparation of this manuscript.

Conflict of Interest

The authors declare no conflict of interest, financial or otherwise, related to the subject matter or materials discussed in this manuscript. No commercial relationships, consultancy arrangements, honoraria, speaker fees, or equity interests relevant to this work are held by either author.

Bibliography

1. Albrektsson T., *et al*. “The Long-Term Efficacy of Currently Used Dental Implants: A Review and Proposed Criteria of Success”. *International Journal of Oral and Maxillofacial Implants* 1.1 (1986): 11-25.
2. Goodacre CJ., *et al*. “Clinical Complications with Implants and Implant Prostheses”. *Journal of Prosthetic Dentistry* 90.2 (2003): 121-132.
3. Esposito M., *et al*. “Biological Factors Contributing to Failures of Osseointegrated Oral Implants: (I). Success Criteria and Epidemiology”. *European Journal of Oral Sciences* 106.1 (1998): 527-551.
4. Berglundh T., *et al*. “Peri-Implant Diseases and Conditions: Consensus Report of Workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions”. *Journal of Clinical Periodontology* 45.20 (2018): S286-S291.
5. Pjetursson BE., *et al*. “A Systematic Review of the Survival and Complication Rates of Implant-Supported Fixed Dental Prostheses (FDPs) after a Mean Observation Period of at Least 5 Years”. *Clinical Oral Implants Research* 23.6 (2012): 22-38.
6. Misch CE. “Contemporary Implant Dentistry”. 3rd ed. St. Louis: Mosby Elsevier, (2008).
7. Schwarz F., *et al*. “Peri-Implantitis”. *Journal of Clinical Periodontology* 45.20 (2018): S246-S266.
8. Brånemark PI., *et al*. “Osseointegrated Implants in the Treatment of the Edentulous Jaw: Experience from a 10-Year Period”. *Scandinavian Journal of Plastic and Reconstructive Surgery Supplement* 16 (1977): 1-132.
9. Derks J and C Tomasi. “Peri-Implant Health and Disease: A Systematic Review of Current Epidemiology”. *Journal of Clinical Periodontology* 42.16 (2015): S158-S171.
10. Hinode D., *et al*. “Influence of Smoking on Osseointegrated Implant Failure: A Meta-Analysis”. *Clinical Oral Implants Research* 17.4 (2006): 473-478.
11. Herrera D., *et al*. “Prevention and Treatment of Peri-Implant Diseases: The EFP S3 Level Clinical Practice Guideline”. *Journal of Clinical Periodontology* 50.26 (2023): 4-76.