Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/22867
DOI URL: http://dx.doi.org/10.21474/IJAR01/22867

ISSN (O): 2320-5407
ISSN (P): 3107-4928

RESEARCH ARTICLE

COMPREHENSIVE REVIEW OF COMPLICATIONS IN DENTAL IMPLANT THERAPY

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Manuscript Info

Manuscript History
Received: 16 December 2025
Final Accepted: 18 January 2026
Published: February 2026

Key words:-
Complications, Management, Implant

Abstract

The global rise in life expectancy and the expanding geriatric population have markedly increased the prevalence of partial and complete edentulism, thereby elevating the demand for implant-supported rehabilitation. Advances in implant design, biomaterials, and minimally invasive surgical techniques have significantly enhanced the predictability and long-term survival of dental implants. Successful outcomes depend largely on accurate three-dimensional positioning, ideal angulation, and the maintenance of stable peri-implant hard and soft tissues. However, despite high survival rates, implant therapy is not devoid of complications.Biological complications such as peri-implant mucositis, peri-implantitis, and progressive marginal bone loss can jeopardize peri-implant tissue health and long-term stability. Mechanical and esthetic complications, including improper implant positioning, biomechanical overload, screw loosening, prosthetic fracture, and inadequate keratinized tissue, may further compromise function and appearance. The close relationship between periodontal health and peri-implant tissue stability highlights the importance of a comprehensive periodontal approach. Careful diagnosis, prosthetically driven planning, precise surgical execution, and structured maintenance protocols are essential to prevent and manage complications effectively ,thereby ensuring long-term functional and biological success.

Introduction:-

The principal objective of modern dentistry is to restore normal function, comfort, esthetics, speech, and overall oral health. Although conventional dentures can replace missing teeth, they often provide limited functional efficiencywhen compared with natural dentition. In contrast, implant-supported prostheses closely mimic natural teeth in stability and masticatory performance.[1] Dental implants also play a vital role in preserving alveolar bone by transmitting functional forces to surrounding tissues, thereby reducing bone resorption and maintaining facial

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contours and soft tissue support.Implantology has evolved significantly and now involves multiple dental specialties. Periodontics focuses on bone preservation and augmentation; prosthodontics emphasizes functional and esthetic tooth replacement; orthodontics utilizes implants for anchorage control; and oral and maxillofacial surgery performs advanced surgical procedures.[2] Successful implant therapy relies on careful case selection, comprehensive diagnosis, and meticulous treatment planning. Modern research has shifted from simply reporting survival rates to identifying risk factors associated with implant failure, highlighting the importance of understanding potential complications and their management.

Despite high success rates, implants may present surgical, biologic, mechanical, and esthetic complications. Surgical risks include hemorrhage, nerve injury, and damage to adjacent structures. Biologic complications such as peri-implantitis, infection, and progressive bone loss can threaten implant stability if untreated. Mechanical issues include screw loosening, prosthetic fractures, and implant breakage due to occlusal overload. Esthetic concerns often arise from improper implant positioning or soft tissue deficiencies. Preventive strategies, regular monitoring, and timely intervention are essential to ensure long-term implant success.[3]

Etiology:-

The etiology of implant failure is multifactorial. Infection is a primary cause, leading to peri-implant tissue destruction and compromised osseointegration. Surgical trauma, such as thermal injury during osteotomy preparation or excessive pressure causing bone necrosis, can impair healing. Biomechanical overload from premature loading or occlusal trauma may disrupt the bone–implant interface. Iatrogenic factors, including improper implant positioning, incorrect angulation, or inadequate treatment planning, also contribute significantly to failure.[4]

Risk Factors:-

Careful assessment of risk factors is essential for predictable implant success:-

Anatomic factors include poor bone quality (especially Type IV bone), resorbed alveolar ridges, and the use of short implants (≈7 mm), all of which reduce primary stability and survival rates.

Mechanical factors relate to implant design and dimensions. While most titanium implants demonstrate comparable success, implant diameter plays an important role; wider implants (>4 mm) show improved prognosis. Short implants and rough-surfaced implants may have a slightly higher risk of complications such as peri-implantitis.

Occlusal loading factors involve excessive functional forces. Parafunctional habits, improper occlusal schemes, and implants opposing unilateral occlusal support increase mechanical stress and the likelihood of failure.

Systemic risk factors significantly influence osseointegration and healing. Major high-risk factors include tobacco use, radiation therapy, and uncontrolled diabetes mellitus. Conditions such as chemotherapy, osteoporosis, hormone therapy, and immunocompromised states (autoimmune diseases, hematologic malignancies, HIV infection) further impair healing. Therefore, thorough medical evaluation and systemic stabilization are crucial to minimize complications and enhance long-term implant success.

Classification Of Complications In Implant Therapy:-

A complication in implant therapy is defined as secondary adverse event occurring during or after implant placement or prosthetic rehabilitation. The occurrence of a complication does not necessarily indicate treatment failure or substandard care; however, early recognition and appropriate management are essential for preserving implant success.[9]Several classification systems have been proposed to categorize implant-related complications. In a landmark review[20-22]

Table 1 : Classifications of implant related complications

Author & Year	Basis of Classification	Categories Included
Charles Goodacre (1999)	Based on implant loss and influencing factors	•Implant loss in relation to prosthesis type and arch •Timing after implant placement •Implant dimensions •Bone quality •Surgical events •Marginal bone loss •Peri-implant soft tissue conditions •Mechanical failures

		•Phonetic and esthetic concerns
Carl E. Misch (2008)	Based on treatment phase and causative factors	•Treatment planning–related complications •Procedure-related complications •Anatomy-related complications • Iatrogenic factors • Operator-related factors
Stuart J. Froum (2010)	Comprehensive clinical framework	•Systemic condition and medication-related complications •Implant planning errors •Implant fractures •Implant failures •Peri-implant diseases •Esthetic deficiencies due to malposition

Contemporary literature adopts a broader, biologically and prosthetically integrated classification system.[20-25]

Table 2 : Classification of complications of implant

Author (Year)	Classification	Key Causes / Features
Truhlar (1990)	Early / Late failure	Early: healing disturbance (weeks–months); Late: pathologic process affecting previously osseointegrated implant
Esposito (1998)	Biological (Early/Late); Mechanical; Iatrogenic; Inadequate adaptation	Early: failure to establish osseointegration; Late: failure after loading; Mechanical: implant/screw fracture; Iatrogenic: nerve injury/malalignment; Adaptation: esthetic, phonetic, psychological issues
Goodacre (1999)	Based on prosthesis type, arch, timing, implant factors	Marginal bone loss, peri-implant soft tissue problems, mechanical and esthetic complications
Rosenberg (2000s)	Infectious / Traumatic	Infectious: peri-implantitis; Traumatic: occlusal overload, surgical trauma, radiolucency, mobility with low plaque index
Misch (2008)	Treatment, procedure, anatomy, operator related	Improper diagnosis, surgical errors, anatomical limitations, operator inexperience
Newman, Takei, Klokkevold& Carranza (2021)	Biologic; Mechanical; Esthetic; Surgical	Peri-implant disease; screw loosening/fracture; soft tissue recession; nerve injury/sinus perforation

El Askary et al. [26] 2010have divided the failures into seven categories.

Table 3 : El Askary et al. [26] 2010 classification

Sr.No	Basis of Categories	Sub-Classification / Causes
1	**According to Etiology**	
	A) Restorative Problems	Excessive cantilever, poor abutment fit, improper prosthetic design, incorrect occlusion, parafunctional habits
	B) Surgical Placement	Overheating of bone, lack of primary stability, improper flap design, minimal bone volume, implant placed in infected site, contamination before insertion
	C) Implant Selection	Improper implant type, incorrect length or diameter,

		inappropriate implant for bone quality
2	**According to Origin of Infection**	Peri-implantitis (bacterial), retrograde peri-implantitis, traumatic occlusion, premature/excessive loading
3	**According to Timing of Failure**	Before Stage II (after surgery), At Stage II (healing abutment insertion), After restoration/loading
4	**According to Clinical & Radiographic Status**	Ailing implants, Failing implants, Failed implants, Surviving implants
5	**According to Responsible Personnel**	Dentist (surgeon/prosthodontist/periodontist), Dental hygienist, Laboratory technician, Patient
6	**According to Failure Mode**	Lack of osseointegration (mobility), Unacceptable esthetics, Functional problems, Psychological problems
7	**According to Supporting Tissue Type**	Soft tissue problems, Bone loss (radiographic changes), Combined soft tissue and bone loss

Complications In Implant Planning:-
Inadequate diagnosis and deficient treatment planning are major causes of implant failure. Failure to record a complete medical history, poor evaluation of bone quality and quantity, and improper implant number or distribution can result in occlusal overload and prosthetic failure. Incorrect implant positioning or angulation may injure adjacent teeth, cause fenestration or dehiscence, and compromise esthetics. Lack of awareness of vital anatomical structures such as the inferior alveolar canal, mental foramen, and maxillary sinus may lead to nerve injury, sinus perforation, or vascular damage. Careful preoperative planning and radiographic assessment are essential to prevent these complications.

Biologic Complications:-
These include peri-implant mucositis (soft tissue inflammation) and peri-implantitis (inflammation with bone loss). Other issues include progressive bone loss, peri-implant pocket formation, soft tissue recession, infection, delayed osseointegration, and soft tissue overgrowth. Early diagnosis and maintenance therapy are crucial to prevent implant failure.

Surgical Complications:-
Common surgical problems include nerve injury, sinus perforation, hemorrhage, cortical plate perforation, implant malposition, damage to adjacent teeth, postoperative infection, hematoma formation, failure of primary stability, and wound dehiscence with graft exposure.

Mechanical Complications:-
These involve abutment or screw loosening/fracture, implant fracture, prosthetic component breakage, loss of retention, and material wear, usually related to occlusal overload or fatigue.

Esthetic Complications:-
Gingival recession, black triangles, papilla deficiency, tissue discoloration, improper implant position, and restoration failure may compromise appearance and patient satisfaction.

Immediate Placement and Loading Complications:-
Immediate placement may cause positioning errors, membrane exposure, inadequate soft tissue healing, and esthetic compromise. Immediate loading increases the risk of osseointegration failure and mechanical complications if biomechanical principles and case selection are not strictly followed.

Peri-implantitis:-
Peri-implant mucositis exhibits clinical features similar to gingivitis around natural teeth, including redness, swelling, and other classic signs of inflammation. However, due to structural differences in peri-implant mucosa and the limited light transmission through the metallic implant surface, these visual signs may sometimes be less apparent. For this reason, assessment of bleeding on probing is essential, as it serves as a primary indicator of inflammatory activity in peri-implant tissues.Peri-implant diseases represent a range of inflammatory conditions affecting tissues surrounding dental implants. Peri-implant mucositis is defined as a reversible inflammatory reaction restricted to the soft tissues, whereas peri-implantitis is characterized by progressive inflammation associated with the destruction of supporting bone. The clinical diagnosis of peri-implant disease relies on

parameters such as implant mobility, bleeding on probing, increased probing depth with clinical attachment loss, and the presence of suppuration. Early detection and timely management are crucial to prevent further implant compromise and potential failure. [21–22]

Figure 1 : Peri-Implantitis

Complications Related to Osseointegration:-

It refers to disturbances in the direct structural and functional connection between the implant surface and surrounding bone. Failure of osseointegration may occur early, before loading, and is characterized by implant mobility, pain, and radiolucency around the implant, commonly due to overheating during osteotomy, infection, or excessive micromovement. In some cases, fibrous tissue forms around the implant instead of bone, leading to fibrous encapsulation and loss of stability.[17] Lack of primary stability, especially in poor-quality bone, increases the risk of failure. Early marginal bone loss may occur due to surgical trauma or contamination, while late loss of osseointegration can develop after successful integration, often associated with peri-implantitis, occlusal overload, or systemic factors.[20]

Complications Related To Primary stability:-

It is the mechanical stability of a dental implant at the time of placement, achieved through intimate contact between the implant surface and surrounding bone. It is a critical factor for successful osseointegration. Inadequate primary stability is a significant complication that can lead to early implant failure.

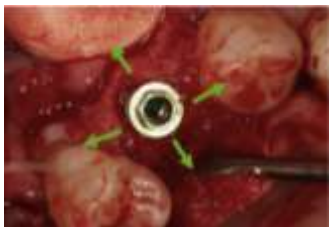

Figure 2 : Lack Of Primary Stability

It commonly occurs in areas of poor bone quality or low bone density, such as the posterior maxilla, or when improper surgical technique, over-preparation of the osteotomy site, or selection of an inappropriate implant size is involved. Insufficient primary stability may result in excessive micromovement during the healing phase, which interferes with bone formation and promotes fibrous tissue encapsulation instead of proper bone to implant contact. Clinically, this can lead to implant mobility, pain, and eventual loss of the implant if not managed appropriately.

Implant Fractures:-

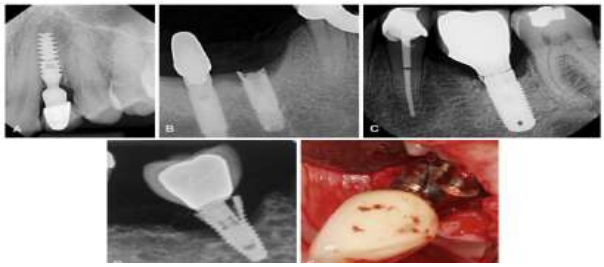

Figure 3: Fractured Implants

Implant fracture represents a relatively rare and late-stage biomechanical complication. Reported incidence is approximately 0.6% of all implant placements, with lower occurrence in completelyedentulous arches and higher prevalence in partially edentulous situations. Multiple etiological factors contribute to implant fracture, including progressive peri-implant bone loss.[22]Manufacturing imperfections in implant materials or fabrication processes may also predispose to mechanical failure. Excessive occlusal loading is a major biomechanical contributor, particularly in posterior regions where masticatory forces are greatest. In addition, parafunctional habits and patient related factors may further increase fracture risk.

Implant Failures:-

Ailing implants:-

- Ailing implants refer to those that display radiographic evidence of bone loss but do not show signs of inflammation or mobility.

Failing implants:-

- An implant that may exhibit bone loss, increasing clinical probing depths, bleeding on probing and discharge may be showing signs of worsening condition, with bone loss potentially continuing to progress.

Failed implants:-

- An implant that displays clinical mobility, a radiolucent area around it, and a dull sound when tapped is a clear indication of its failure.

Surviving implants:-

- Implants are categorized as any that remain in place during evaluation, regardless of visible signs, symptoms, or past issues. These implants may be present but not functioning effectively. Often referred to as "SLEEPERS," they should not be deemed successful simply because they remain in place and are osseointegrated.

Esthetic Complications Due To Implant Malposition:-

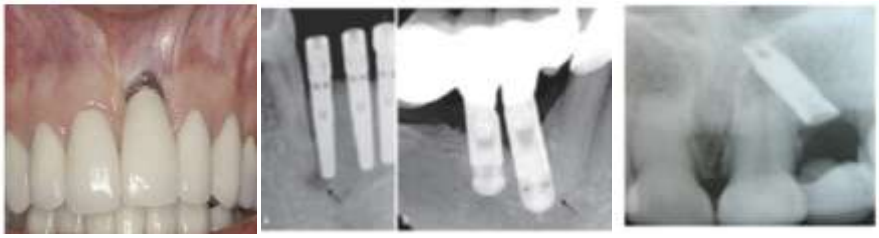

Figure 4 : Malposed Implant

Incorrect implant positioning can result in irreversible hard and soft tissue deficiencies, leading to significant esthetic compromise. Coronoapical malposition may produce either excessive implant exposure with visible metal components or deep placement associated with facial mucosal recession, particularly in the presence of thin facial bone. Orofacial malposition may also create functional and esthetic problems: palatal displacement can interfere with tongue function, whereas facial positioning frequently results in soft tissue recession and compromised esthetics.

Esthetic Complications Due to Improper Implant Angulation:-

Improper implant angulation can cause significant esthetic and functional problems. Buccal or excessive angulation may lead to gingival recession, visible metal display, and poor emergence profile. Lingual misplacement can result in soft tissue irritation and speech discomfort. Off-axis loading increases crestal bone stress, contributing to marginal bone loss and possible implant exposure. Highly angulated abutments (>25°) may further increase mechanical stress and risk of failure.Accurate three-dimensional positioning and proper surgical planning are essential to prevent these complications.

Figure 5 : Improper Implant Angulation

Esthetic Complications Due to Implant Exposure:-
Implant exposure occurs when the implant or abutment becomes visible due to soft tissue recession, thin gingival biotype, labial bone loss, or improper buccal positioning. It may cause grayish discoloration, poor smile esthetics, and increased risk of peri-implant inflammation.

Figure 6 : Implant Exposure

Prevention requires proper three-dimensional implant placement, preservation of labial bone, and careful soft tissue management.

Complications Associated with Systemic Disorders and Medications:-
Systemic diseases and certain medications can adversely affect implant healing, bone metabolism, and immune response, thereby increasing the risk of complications.

Myocardial infarction: Reduced cardiovascular efficiency may compromise tissue perfusion and osseointegration.
Cerebrovascular disease (stroke): Indirect risk due to impaired oral hygiene and maintenance.
Osteoporosis: Decreased bone density may reduce implant stability.
Paget's disease: Abnormal bone remodeling may compromise bone quality.
Parkinson's disease: Poor motor control affects oral hygiene, increasing peri-implant risk.
Diabetes mellitus: Poor glycemic control delays healing and increases infection risk.
Smoking: Strongly associated with higher implant failure rates.
Immunodeficiency and long-term corticosteroid therapy: Impaired immunity and bone healing reduce implant success.
Radiation therapy: Irradiated bone has reduced vascularity and regenerative capacity, increasing failure risk.

Criteria For Implant Success:-
Criteria for implant success emphasize clinical stability, absence of radiographic peri-implant radiolucency, minimal marginal bone loss following loading, absence of pain or pathology, and sustained functional survival over time.

According to the success criteria proposed by Albrektsson and Zarb (1986) and later modified by Roos et al., implant success is defined by:

- Absence of clinical mobility
- No radiographic evidence of peri-implant radiolucency
- Marginal bone loss not exceeding:

- ≤ 1 mm during the first year after functional loading
- ≤ 0.2 mm annually thereafter
- Absence of pain, infection, or peri-implant pathology
- Functional survival rates of:
- 90% at 5 years
- 85% at 10 years

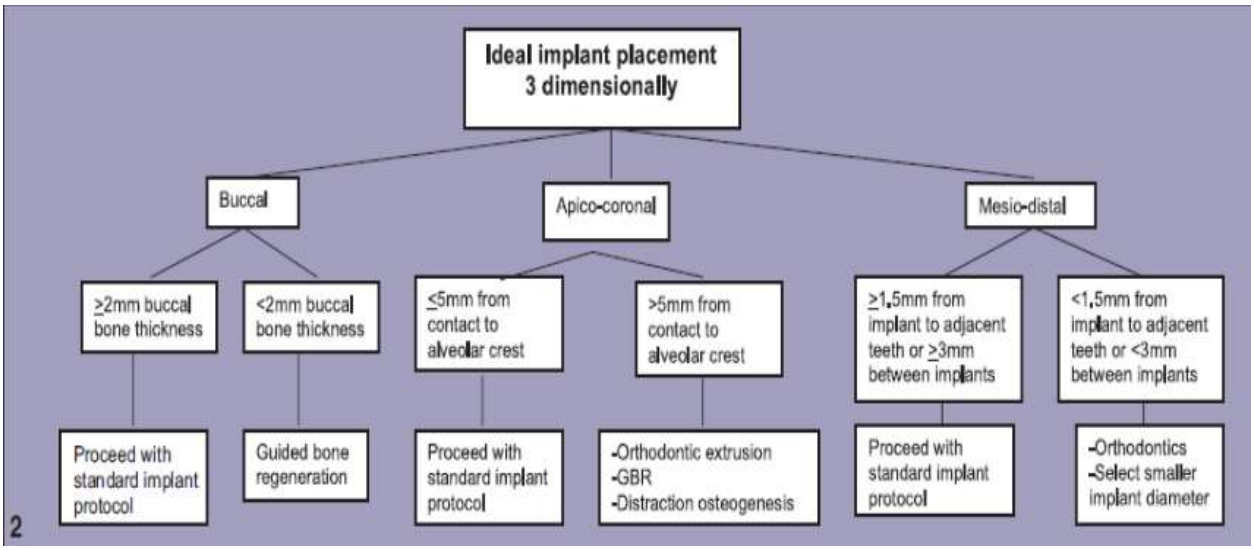

Figure 7 : Ideal Implant Placement 3 Dimensionally

Management Of Implant-Related Complications:-
Comprehensive understanding of potential implant complications is fundamental for timely intervention and long-term success. Appropriate diagnosis and prompt management significantly enhance treatment outcomes.

The management strategies for various implant-related complications are outlined below:
Management of Complications Associated with Implant Planning:-
- Perform careful diagnosis and comprehensive patient evaluation.
- Conduct thorough clinical and radiographic investigations.
- Provide clear preoperative instructions to the patient.
- Strictly follow the manufacturer's surgical guidelines.

Management of Complications Related to Immediate Implant Placement:-
- Correct implant malposition during the initial surgery.
- Remove the implant if angulation cannot be corrected.
- Reinforce proper oral hygiene instructions.
- Manage soft tissue deficiencies with flap procedures or connective tissue grafts to increase keratinized tissue.

Management of Complications Related to Immediately Loaded Implants:-
- Manage early mobility by reducing or eliminating occlusal forces to promote stabilization.
- Schedule regular recall visits to monitor implant stability and peri-implant health.

Peri-Implantitis:-

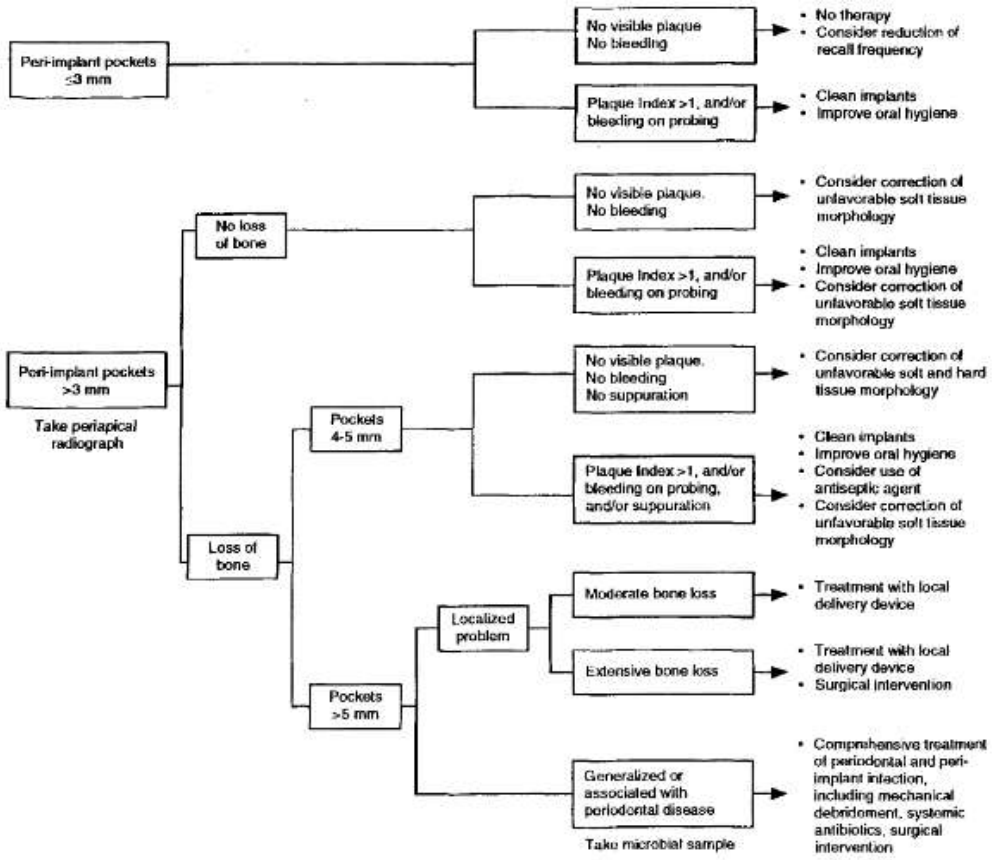

Figure 8 : The decision process for peri-implant diagnosis

Bacterial biofilm on implant surfaces is the main cause of peri-implantitis. Implants are more difficult to decontaminate than natural teeth due to their surface characteristics. Treatment focuses on controlling infection, reducing plaque, eliminating peri-implant pockets, and preventing further bone loss. In selected cases, regenerative surgery may be performed to restore lost bone.

Treatment is typically carried out in two phases, similar to periodontal therapy:

1. **Initial (Non-surgical) Phase:**
   - Removal of plaque and calculus.
   - Control of gingival inflammation.
   - Elimination of any biomechanical overloading of implants through adjustments to the prosthetic superstructure.

2. **Surgical Phase (if required):**
   - Performed when initial therapy is insufficient.
   - Involves advanced procedures similar to those used for severe periodontitis.

Prophylactic Procedures

1. **Oral Hygiene Education and Patient Motivation:**
2. **Cleansable Restorations:**

Maintenance Care:-

Therapeutic Strategies:

Cumulative Interceptive Supportive Therapy (CIST):-

Implants with no plaque or calculus, absence of bleeding on probing (BOP), no suppuration, and probing depth ≤3 mm are considered clinically stable and not at immediate risk for peri-implant disease. Such implants require routine maintenance and should be re-evaluated at least once a year to ensure continued peri-implant health.

CIST Modalities:-

Mechanical debridement; CIST protocol A
Antiseptic therapy; CIST protocol A+B
Antibiotic Therapy – CIST Protocol A + B + C
Regenerative or Resective Therapy CIST Protocol A + B + C + D
Protocol E: Explanation

Management of Improper Implant Angulation:-

- Correct malposition at the time of placement whenever possible.
- Remove the implant if correction is not feasible.
- Maintain strict oral hygiene.
- Manage gingival recession or membrane exposure with flap repositioning or connective tissue grafting.

Management of Implant Fractures:-

- Completely remove the fractured implant using trephines.
- Remove only the coronal fragment to allow prosthetic rehabilitation.
- Retain the apical portion if it remains osseointegrated and asymptomatic.

Management of Systemic and Medication-related Complications:-

- Perform thorough medical evaluation before treatment.
- Discontinue the procedure and seek medical help in case of emergencies; keep emergency drugs available.
- Prescribe antibiotics when indicated.
- Schedule regular follow-ups and advise cessation of smoking.

Management of Implant Failures:-

- Diagnose failure based on clinical and radiographic findings.
- Remove mobile implants immediately.
- Consider replacement after adequate healing.

Implant Maintenance:-

- Ensure prosthetic designs allow easy plaque control.
- Use plastic instruments for gentle scaling.
- Chlorhexidine may be used as an adjunct.
- Instruct patients on meticulous oral hygiene with soft brushes and interdental aids.

Conclusion:-

The long-term success of dental implants depends not only on accurate diagnosis, thorough evaluation, and precise treatment planning, but also on the clinician's awareness and effective management of potential complications. Early identification and timely intervention are critical in preventing treatment failure. Ultimately, preventive strategies and proactive care remain the cornerstone of successful implant therapy underscoring the principle that prevention is always preferable to corrective intervention.

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