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Peri-Implant Diseases

A project submitted to

The college of dentistry, University of Mosul, Department of oral diagnosis in partial fulfillment for the Bachelor of dental surgery

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Certification of the supervisor

I certify that this project entitled "**peri Implant Diseases** " was prepared by the fifth-year student **Farha Ammar Mahdi** under my supervision at the collage of Dentistry/ University of Mosul in partial fulfillment of the graduation requirements for the Bachelor dental surgery.

Lecturer Dr. Abdulsattar Salim Mahmood

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Dedication

To **my beloved family**, whose unwavering support and encouragement have been my guiding light. This work is dedicated to you, for your endless love and faith have been the foundation of my journey. Thank you for always believing in me.

To everyone who taught me even a little through the life, to that difficult times that made me who I am now

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List of Abbreviation

Abbreviation	Meaning
PI	*Peri-implantitis*
PIM	*Peri-implant mucositis*
PID	*Peri- implant disease*
BOP	*Bleeding on probing*
PMBL	*Progressive marginal bone loss*
DEXA	*Dual energy x-ray absorptiometry*
CHX	*Chlorhexidine*
HGF	*Human gingival fibrosis*
NP	*Nanoparticle*
MNP	*Micro nanoparticle*
ROS	*Reactive oxygen species*
Zi	*Zirconia*
ZiHa	*Zirconia Hydroxyapatite*

Introduction:

Although dental implants have demonstrated remarkable efficacy in tooth replacement over the past few decades, with survival rates surpassing 95% over a decade, the longevity of implants is compromised by biological complications (Papapanou *et al*., 2018).

Depending on the population studied and the case definition used, epidemiologic data on peri-implant diseases (PIDs) worldwide show various results. Peri-implant diseases were defined during the 2017 World Workshop as biofilm-associated pathological conditions affecting osseointegrated dental implants, and they were further classified into peri implant health, peri-implant mucositis, and peri-implantitis (Berglundh *et al*., 2018; Heitz-Mayfield and Salvi, 2018; Schwarz *et al*., 2018).

Peri-implant mucositis is characterized by inflammation in the soft tissue compartment, whereas peri-implantitis also features loss of the implant-supporting bone. It is assumed that untreated peri-implant mucositis is the precursor to peri-implantitis (Jepsen *et al.*, 2015).

The onset of peri-implantitis was shown to occur early on, and its progression was characterized by a nonlinear, accelerating pattern that, in the absence of therapy, may ultimately lead to implant loss (Derks *et al*., 2016).

There is evidence from experimental clinical studies that peri-implant mucositis is a reversible condition if adequate bacterial plaque control is implemented (Meyer *et al*., 2017; Salvi *et al*., 2012).

Aims of the study :

The aims of this study is to comprehensively analyze the etiological factors, risk indicators, pathogenesis, and treatment modalities associated with peri-implant diseases.

Objectives including:

1: Peri-implant mucositis

2: Peri-implantitis.

3: The study seeks to evaluate the potential therapeutic applications of metallic nanoparticle coatings in the prevention and management of these conditions.

4: Integrating current evidence and emerging innovations.

Chapter one :

1. Peri-implant health

peri-implant health requires the absence of clinical signs of inflammation (i.e. erythema and swelling) including no bleeding on probing, this determination is true to evidence from the periodontal literature that the absence of bleeding on probing is consistent with periodontal health (Araujo and Lindhe, 2018). In clinical health, the peri-implant mucosa forms a tight seal around the trans-mucosal component of the implant itself, the abutment or the restoration (Renvert *et al*., 2018) figure1. The height of the soft tissue around the implant following placement influences the initial probing depth, however, the probing depth associated with peri-implant health should be ≤5.0 mm.(Araujo and Lindhe, 2018).

It should also be noted that peri-implant tissue health can exist following treatment of peri-implantitis with variable levels of bone support (Araujo and Lindhe, 2018)**.**

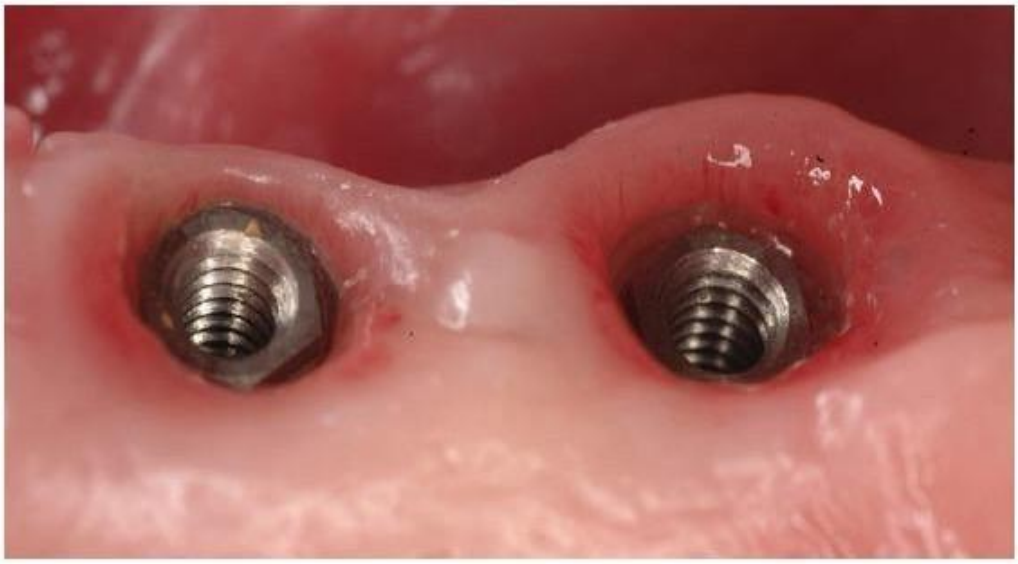

Figure 1. Intraoral view of healthy peri-implant soft tissues, with visible microvessels (Manicone *et al*., 2012).

2. Peri-implant mucositis (P.I.M)

The initiation of an inflammatory response is causally associated with the experimental accumulation of bacterial biofilms around Ti dental implants. The experimental P.I.M lesion is characterized by an infiltration of inflammatory cells into the connective tissue lateral to the barrier epithelium. The inflammatory cell infiltration in long-lasting P.I.M is increased compared to the early experimental P.I.M lesion, which lasted for three weeks. Biofilm-induced P.I.M is reversible at the host biomarker level once biofilm control is restored. The clinical indications of inflammation may persist for a period exceeding three weeks. The host-microbe equilibrium is disrupted by biofilm accumulation at the implant-mucosa interface, resulting in an inflammatory lesion that ultimately leads to PIM (figure 1). Consequently, the therapeutic implication is that the management and prevention of P.I.M necessitate the adequate clearance of biofilm. It is imperative to understand P.I.M, as it is considered a precursor to peri implantitis (PI). (Heitz-Mayfield and Salvi, 2018).

The following were some of the main findings for the researchers:

(i) A weighted mean prevalence of 22% for PI and 43% for PIM was found by meta-analysis

(ii) Blood upon probing is a crucial clinical indicator that helps distinguish PIDs from peri-implant health

(iii) Patients with PIM who did not receive frequent supportive care were more likely to develop PI

(iv) smoking was found to be a modifiable risk factor related to the patient and excess cement to be a local risk indicator for the development of PIM, while plaque formation was found to be an etiological factor

(v) It has been demonstrated that patient-administered mechanical plaque control—using powered or manual toothbrushes—is an effective preventative intervention

(vi) Professional intervention, which included mechanical debridement and advice on oral hygiene, resulted in a decrease in clinical indications of inflammation

(vii) No additional treatments (antiseptics, systemic and local antibiotics, air-abrasive devices) were found to increase the effectiveness of professionally performed plaque removal in lowering clinical indicators of inflammation (Jepsen *et al.*, 2015).

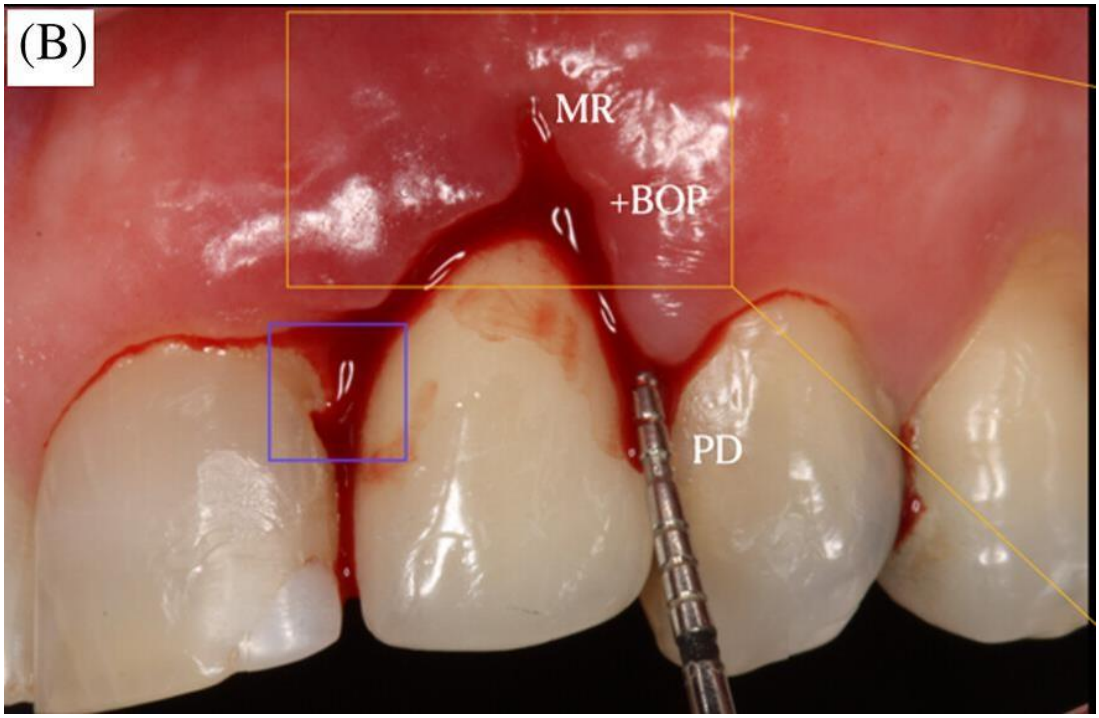

Figure 2. Clinical view of inflamed peri-implant mucosa evidencing inadequate soft tissue phenotype, marginal recession (MR), probing depth (PD) > 6 mm, and profuse bleeding on probing (BOP) at all sites (Galarraga-Vinueza and Tavelli, 2023)

3. peri-implantitis(P.I.)

Epidemiological studies on PIDs, particularly PI, are increasingly gaining attention within the medical community (Afrashtehfar *et al*., 2022).

PI has been documented to have a prevalence of up to 56%, with reported prevalence rates between 12 and 43%. The variation in reported prevalence can be attributed to the absence of precise diagnostic criteria and case definitions for the diseases *(*Romandini *et al*., 2021).

Implant failure is frequently correlated with osseointegration failure. A dental implant is deemed unsuccessful if it becomes dislodged becomes mobile, or experiences peri-implant bone loss exceeding 1.0 mm within the first year and 0.2 mm thereafter. PI may ultimately lead to implant loss due to bone atrophy developing around the site. PI treatment is most effectively achieved when the lost implant-supporting firm and soft tissues are regenerated (Schwarz *et al*., 2006).

Probing depth, bleeding on probing (BoP), and bone loss have been utilized to categorize PI into three levels of severity:

- **Early:** Peri-implant measurements of 4 mm or greater and bone deterioration of less than 25% are considered pre-implantitis.
- **Moderate:** Probing depths around dental implants that are 6 mm, with bone deterioration ranging from 25 to 50% of the implant length, are classified as moderate PI
- **Advanced**: a pocket depth of 8 mm, with bone deterioration exceeding 50% of the implant length, is categorized as advanced PI (Aldahlawi *et al*., 2018; Raza *et al*., 2023) (Figure3)(Figure 4).

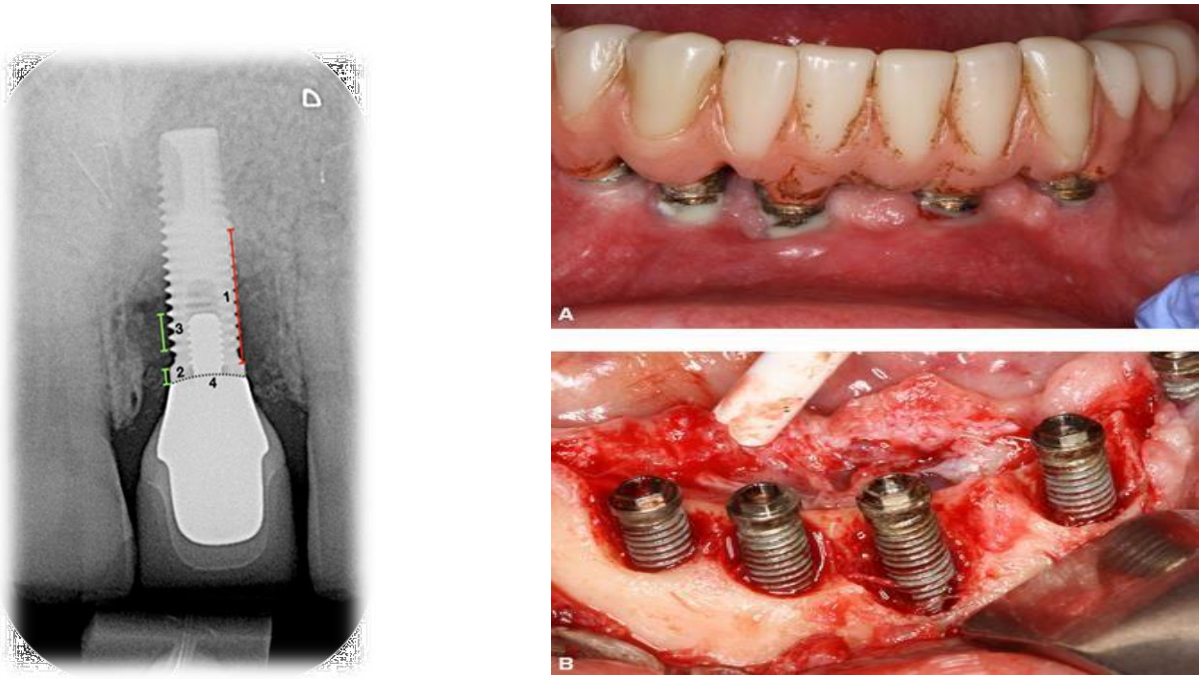

Figure 3. Typical radiographic and clinical appearance of advanced peri-implantitis.(Klinge *et al*., 2018; Sahrmann *et al*., 2024)

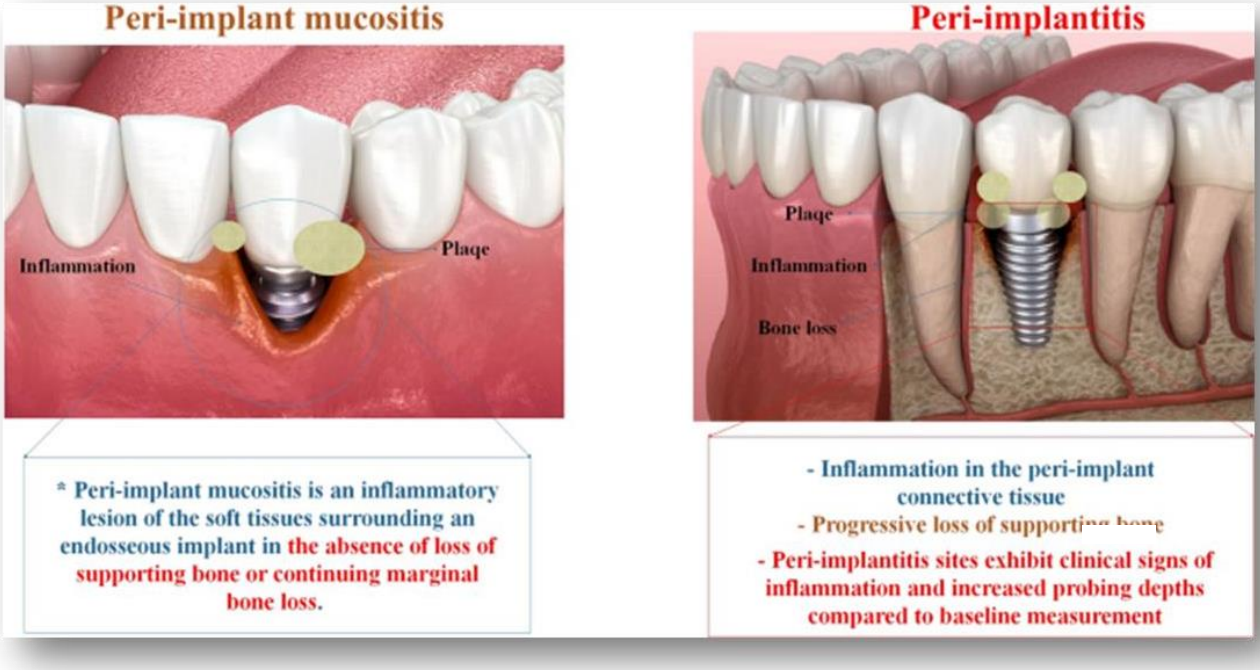

Figure 4. The essential characteristics of peri-implant diseases (PIDs)(Alves *et al*., 2022)**.**

4. Potential Etiologies and Risk Factors

The American Academy of Periodontology and the European Federation of Periodontology jointly published a classification of peri-implantitis (Berglundh *et al.*, 2018).

The new classification included implant health, peri-implant mucositis, peri-implantitis, and hard- and soft-tissue deformities. Hard- and soft-tissue deformities of dental implants may result in peri-implantitis; the potential factors include improper implant placement, inadequate bone quality, inadequate bone quantity, and traumatic occlusion (Misch *et al*., 2005)

4.1 Improper implant placement

Improper implant placement can result in compromised hard-tissue and soft-tissue defects around an implant; this can develop relatively quickly to bone loss around an implant and a diagnosis of peri-implantitis. Improper surgical implant placement is an iatrogenic risk factor for peri-implantitis. Common examples of improper implant placement include being too close to a contiguous tooth or another dental implant and not having adequate 1.5 to 2.0 mm of bone buccal and lingual to the placed implant (Johnson, 2016).

4.2 Inadequate alveolar bone quality

Inadequate alveolar bone quality may also be a contributing factor, reports classify bone quality into 4 stages depending on the presence or absence of resistance felt with each stage of drilling the bone (Jeong *et al*., 2013) .

Bone density is classified as D1, D2, D3, and D4 bone. Cases that do not show resistance to a 3.5-mm drill are classified as D1, and cases without resistance to all drillsare considered as D4. (Jeong *et al*., 2013), this classification pertains to the density of bone related to trabecular and cortical bone. If implants are placed in inadequate bone

quality classified as D3 and D4 bone, the implant is at a higher risk of peri-implantitis. Other situations contributing to this lack of bone quality include osteoporosis, osteopenia, or other bone diseases like osteogenesis imperfect, rhumatoid arthritis and polyarthritis (Misch, 2007).

4.3 Inadequate bone quantity

Inadequate bone quantity can be correlated to improper implant placement. Inadequate bone quantity results from lack of proper diagnosis and poor surgical implant placement into a site where the bone is insufficient to support the stability of the dental implant.(Wakimoto *et al.*, 2012)

4.4 Poor angulation and positioning of dental implants

Poor angulation and position result from improper diagnosis or clinician error. Angulation and positioning of the implant that results in a thin buccal plate between the implant and the buccal bone is highly susceptible to peri-implantitis. When there is bone loss, dehiscence or fenestration of the implant can occur. (Omori *et al*., 2020)

4.5 Occlusion

Is a contributing factor for peri-implantitis. Occlusal trauma has a positive correlation to increased peri-implant bone loss around dental implants Heavy implant occlusal factors like parafunction and bruxism could cause early failure of the dental implant. Occlusal overload is often regarded as one of the main causes of peri-implant bone loss and implant prosthesis failures. Radiographically, this results in crestal bone loss, mobility of the implant, and damage to the prosthesis. (Misch *et al*., 2005).

4.6 Immediate loading of dental implants

may disrupt the physiologic osteointegration process, interfering with optimal bone remodeling. Interference with the osteointegration can result in inadequate bone

formation and loss of crestal bone around a dental implant, leading to peri-implantitis.(Sakka *et al*., 2012)

4.7 Smoking

Smoking is a well-known risk factor for multiple diseases including cancer, heart disease, and dental implant diseases. Dental implants are negatively impacted by smoking. Smoking changes the microbiome and the immune response around dental implants. Electronic cigarettes also have an adverse effect on implant success Therefore, smoking and tobacco negatively affect the outcome of virtually all therapeutic procedures, including dental implants. The failure rate of implant osteointegration is considerably higher among smokers.Oral hygiene around implants and the peri-implantitis risk are adversely affected by smoking (Guney *et al*., 2024).

4.8 Cement

Peri-implantitis is frequently the result of cement left around an implant prosthesis (Misch *et al*., 2008).

The European Federation of Periodontology consensus report and other systematic reviews concluded that cement is the most common reason for peri-implantitis (Giovannoli *et al*., 2019; Staubli *et al*., 2017).

The host response is an integral part of implant maintenance and osteointegration success (Corrêa *et al.*, 2019).

4.9 Systemic diseases

Systemic diseases can also have a significant role in peri-implantitis and implant failures.it ether:

4.9.1 Indirect relation to peri implant disease like:

Diabetes mellitus The impact of diabetes and glycemic control on the osteointegration of dental implants is well recognized (Javed and Romanos, 2009). Successful dental implant osteointegration can be accomplished in subjects with diabetes with good metabolic control, which is a hemoglobin A1C of 7% or less. Diabetic patients with a controlled health status have a similar osteointegration pattern as subjects without diabetes mellitus.(Ghiraldini *et al*., 2016)

Thyroid problems can have a severe impact on people who are getting dental implants. Individuals with thyroid issues may be more susceptible to infections around the implant area, have slower healing after surgery, and may not recover as well from the procedure. Additionally, thyroid issues can make other factors, like inadequate dental hygiene, smoking, and diabetes, worse and increase the chances of implant problems and complications. Dentists need to be aware of these risks and should check a patient's thyroid health as part of their overall evaluation and treatment plan for implant-related issues.(Molli, 2020)

4.9.2 Direct relation to peri implant disease*:*

Osteoporosis is another systemic disease that has a major impact on implant success. Based on the DEXA dual X-ray absorptiometry and resulting T-score of the patient, we can predictably look for stability of our dental implants upon surgical placement (Alsadi *et al*., 2021).

A healthy patient with ideal bone density of a T-score within -1 or higher standard deviations of the norm may improve osteointegration. In osteopenic patients with a diagnosis of -1 to -2.5 standard deviations from the mean, osteointegration may be successful but may take a longer time. In patients with osteoporosis with a diagnosis of -2.5 or greater standard deviations from the mean, they may have a higher risk for peri-implantitis (Faulkner, 2005).

Other factors affecting peri-implantitis have been associated with selected medications predominantly involving implant prognosis including antiresorptive drugs. Dental practitioners should become increasingly aware of implant failures associated with oral bisphosphonate use. One of the most serious complications of BP therapy is Bisphosphonate Related Osteonecrosis of the Jaws (BRONJ)(de-Freitas *et al*., 2016) Implant failure and implant complications related to bisphosphonates are increasingly being reported (Yip *et al*., 2012).

With regard to the pharmacology of bisphosphates, medications that involve interruption of the homeostasis of bone can ultimately impact on implant success (Lee and Suzuki, 2015).

4.10 Periodontal disease is related to peri-implantitis.

Patients with a history of periodonitis may have an increased risk of peri-implantitis. A dysbiotic microbial community due to improper oral hygiene or other oral factors such as xerostomia may lead to quantities of red complex and orange complex bacteria around dental implants. However, patients with treated periodontitis who receive implants appear to have satisfactory implant longevity. (Lombardo *et al*., 2022).

4.11 Metal corrosion from titanium implants

Metal corrosion may be an initiating factor for inflammation soft-tissue modifications and bone resorption. The mechanisms are not completely understood but may include titanium metal fatigue and stress, reaction to acidic by-products of the bacterial microbiome, chemical reactions to antimicrobial mouth rinses, mechanical damage to debridement by dental practitioners, and chemical reaction to certain diets and alcohol. Further research is required to elucidate these factors (Suárez-López del Amo *et al*., 2018).(Figure 5)

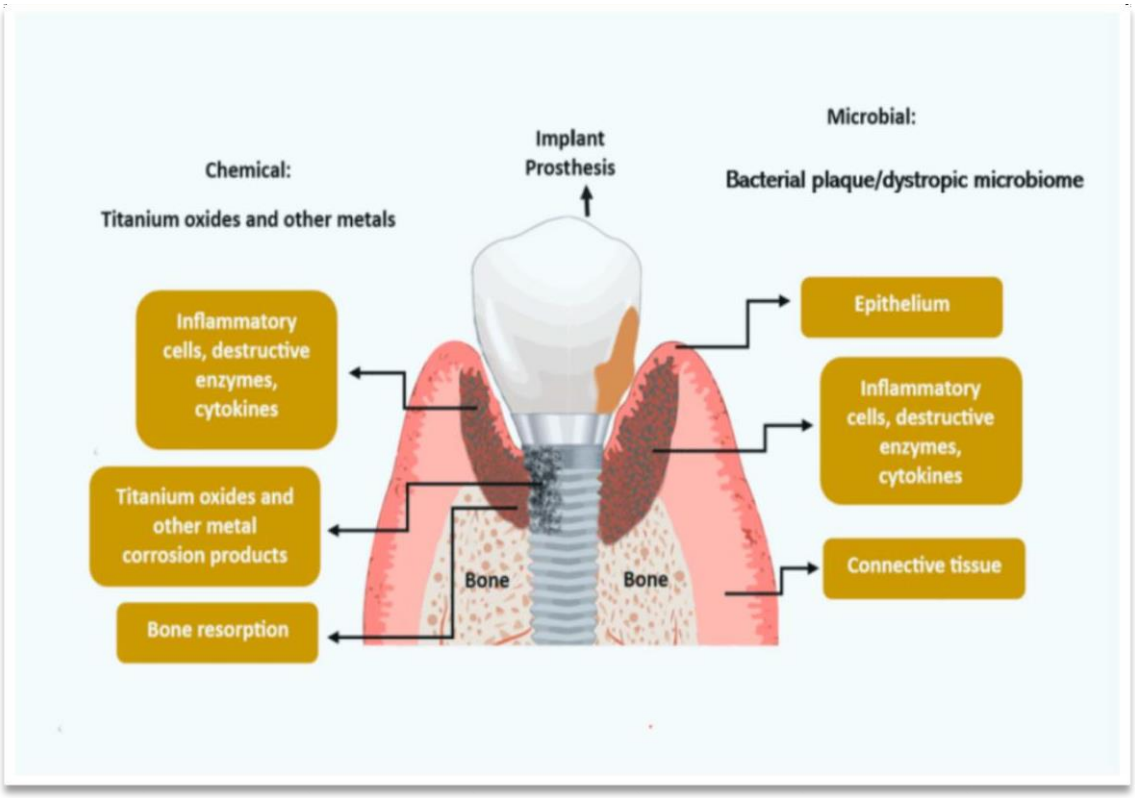

Figure 5. potential etiologies for peri-implantitis (Suárez-López del Amo *et al*., 2018)

5. pathogenesis

Bacterial challenges from dental plaque resulting in loss of attachment on dental implants proceed differently in periodontitis and peri-implantitis. This pathogenic mechanism is not clearly defined but may be related to the anatomic difference between the soft- and hard-tissue attachment around teeth and implants(Misch, 2007).

Several anatomical considerations may explain the difference in pathogenesis. There are two predominant reasons why implants are more susceptible to bacterial challenge than teeth, these include the attachment and vascularity around dental implants. In periodontitis around natural teeth, there is the presence of the periodontal ligament, an epithelial attachment, connective tissue attachment, and alveolar bone. In peri-implantitis around dental implants, there is the presence of epithelial attachment and alveolar bone. Epithelial attachment and bone without the periodontal ligament and the connective tissue

attachment increases the dental implant susceptibility to assault by bacterial plaque(Misch, 2007).

In addition, the vascularity around dental implants is different from natural teeth. There are three primary sources of vascularity around teeth: alveolar bone, periodontal ligament, and periodontal soft tissues. In dental implants, there are alveolar bone and periodontal soft tissue excluding the periodontal ligament as sources of vascularity reflecting the immune response and wound healing capabilities. Since there is no periodontal ligament around dental implants, the network of vascularity including nervous bundles of sensory components is lacking. Therefore, a major source of wound healing and immune response capabilities is lacking for dental implants (Misch, 2007).

6. Treatment of Peri-Implant disease

Peri-implantitis treatments may include:

- Non-Surgical therapy
- Surgical therapy

6.1 Non-surgical treatments

Non-surgical treatment detoxifies and cleanses the implant surface with or without the utilization of adjunctive antibacterial medicament which include:

Manual debridement

Manual debridement using titanium instruments or ultrasonics showed reduced plaque and bleeding scores but had no effect on probing depths. There were also no significant treatment differences between the use of ultrasonics or titanium instruments (Renvert *et al*., 2009).

However, repetitive treatment with oscillating brushes and curettes produced a significantly reduced bleeding index and probing depths at 6 and 12 months compared to baseline (Khan *et al*., 2023)

Adjunctive therapy with antimicrobial therapy and antiseptic mouthrinses

Amoxicillin, azithromycin, or metronidazole may also have beneficial effects. Metronidazole used in conjunction with manual debridement significantly improved probing depths, clinical attachment, and bone fill compared to control 12 months after treatment (Blanco *et al*., 2022).

Adjunctive therapy with antimicrobial therapy and antiseptic mouthrinses may improve peri-implantitis outcomes (Schwarz *et al*., 2015).

Antimicrobial therapy with debridement resulted in greater reduced probing depth compared to debridement alone (Faggion Jr *et al*., 2014).

Mechanical debridement with minocycline resulted in better peri-implantitis resolution compared to chlorohexidine and debridement at 12-month follow-up (Kotsovilis *et al.,* 2008; Muthukuru *et al*., 2012).

Peri-implant therapy with adjunctive antiseptic mouth rinse like chlorohexidine (CHX), sodium chloride (NaCl), hypochlorite, and herbal oral rinses may be effective against peri-implant mucositis and peri-implantitis(Alqutub et al., 2023); (Alzoman et al., 2020).

However, in some peri-implantitis cases, the results may be limited (Menezes *et al*., 2016).

6.2 Surgical treatment

involved elevation of the flap to expose the contaminated implant surface, cleaning and detoxifying with antimicrobial therapy or antiseptic solution, and grafting the osseous defects with or without bone graft and membranes. Surgical protocols may include open-flap debridement, resective osseous peri-implant procedures, or regenerative techniques. Open-flap peri-implantitis procedures may include implant debriding with ultrasonic scalers, curettes, air abrasion, curettes, burs, or laser treatment (Khoury *et al*., 2019).

Resective peri-implant procedures

may include peri-implant pocket elimination and implantoplasty. After 3 years, the implant survival rate of implantoplasty and resective peri-implantitis treatment was reported to be 100%. At 24 months, implantoplasty of contaminated implants during resective peri-implantitis treatment improved probing depth, attachment levels, and the bleeding index. However, the treatment resulted in a higher recession index in the treated implants (Romeo *et al*., 2007).

Regenerative peri-implant techniques

may include biomaterials like synthetic membranes, porcine/bovine membranes, bone graft, bone substitutes, platelet concentrates, calcium carbonate, or hydroxyapatite. Surgical peri-implantitis therapy can reduce peri-implant probing depth by 30–50% (Chan *et al*., 2014;Khoshkam *et al*., 2013).

There are conflicting reports for the use of biomaterials in surgical peri-implantitis treatment. The use of enamel matrix derivative in the treatment of peri-implantitis showed no improvement in probing depths or bone fill (Isehed *et al*., 2016).

Similarly, open-flap surgery with cancellous bone and 10% purified porcine collagen did not improve bleeding on probing or probing depths but significantly reduced buccal gingival recession (Derks *et al*., 2022). (figure 6)

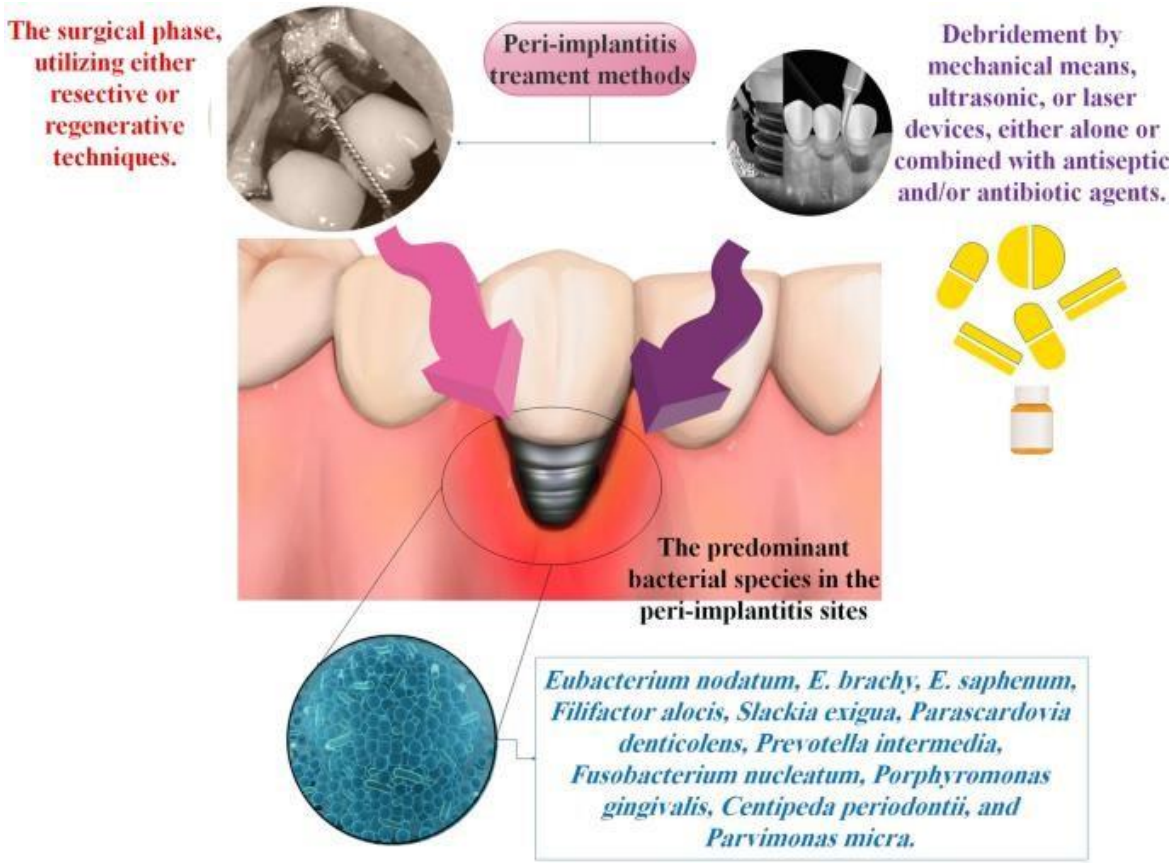

Figure 6. This figure shows the types of peri-implantitis (PI) treatment methods. Treatment for PI consists of two phases the nonsurgical phase and the surgical phase. (de Carvalho *et al*., 2020)

7. The Role of Metallic Nanoparticle Coatings in the treatment of peri-implant disease

It has been shown that metallic NPs have exceptional antibacterial properties that make them valuable as self-modified therapeutic agents both in vitro and in vivo. They have potential therapeutic uses via various antibacterial mechanisms because of their broad spectrum of antibacterial effectiveness (Blair *et al*., 2014; Ewald and Sumner, 2018).

Nano particles not only impede the progression of bacterial resistance but also expand the range of antibacterial activity by circumventing the direct binding of bacterial cells to specific receptors, exhibiting encouraging efficacy against Gram-positive and Gram-negative microorganisms (Gautam *et al*., 2023).

Human gingival fibroblasts (HGFs), the primary cells of the PI soft tissues, were transplanted on AgNP-doped Ti–6Al–4V surfaces to assess the biocompatibility of the modified surfaces. Researchers demonstrated that after 72 h, the HGF proliferation rate started to rise again after its initial stop. When paired with findings from another research carried out by the same team, the antibacterial activity against common periodontal pathogens in this study suggests that AgNP-doped Ti–6Al–4V surfaces might be helpful in implant abutments as a means of reducing PID (Vasilaki *et al*., 2024).

Metallic Nanoparticle that have effects in the treatment of peri-implant disease include (Hosseini Hooshiar *et al*., 2024):

- silver nanoparticles AgNPs
- copper nanoparticles AuNPs
- gold nanoparticles CuNPs
- titanium nanoparticles TiNPs
- zinc oxide nanoparticles ZnO NPs

7.1 Mechanism of action of Metal Nanoparticles

Because of their diverse physiochemical characteristics, NPs have multifaceted bactericidal capabilities. The ionic metals that are liberated from metal nanoparticles (M.N.Ps) exhibit a range of antibacterial activities. They may be very hazardous to bacteria by interacting with their phospholipid layers in bacterial cells or disrupting the functioning of different intracellular macromolecules, including enzymes and DNA. One of the primary mechanisms for the antibacterial effect of NPs is the dynamics of the cell-surface interface, and the surface topography and nanostructure of NPs have a significant impact on their antibacterial activity. The nanostructures of MNPs also play a crucial role in inducing antibacterial effectiveness. Additionally, the nanotoxicity of NPs is often attributed to their ability to induce oxidative stress via the introduction of reactive oxygen species (ROS), which also enables NPs to be fatal to bacterial cells (Jiang *et al*., 2024).(Figure7).

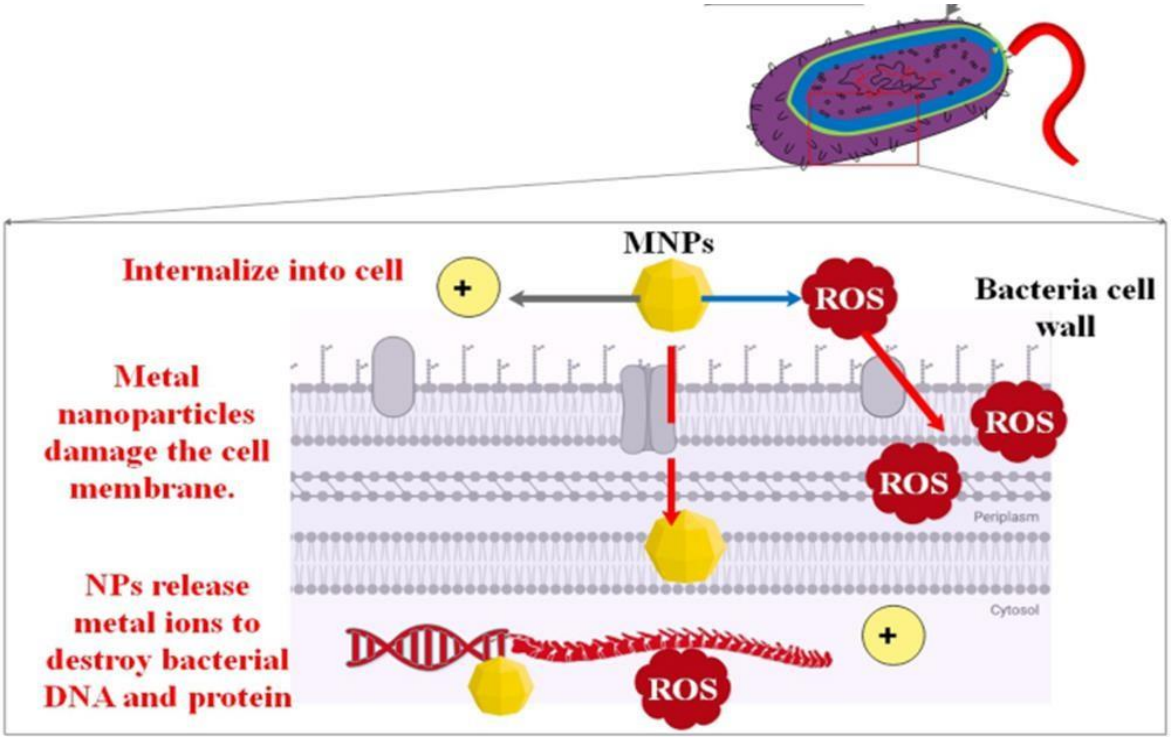

Figure 7. Mechanism of action of metallic nanoparticles (Jiang *et al*., 2024).

AuNPs exhibit unique properties to be used in dentistry and can be a novel application in dental caries, bone regeneration, periodontology, implantology, and tissue engineering (Bapat *et al*., 2020).

AuNPs are added to various biomaterials to boost their benefits because of their antifungal and antibacterial qualities. Because of their excellent surface specificity and biocompatibility, AuNPs may be utilized as osteogenic agents to promote bone growth in PI. AuNPs can stimulate osteogenic properties and expedite cellular proliferation and activity (Bapat *et al*., 2020). **(**Figure 8).

Figure 8. Mechanisim of action of gold nanoparticles (Bapat *et al*., 2020).

8. Hydroxyapatite Nanoparticles

Hydroxyapatite is widely used as a dental implant coating material due to its osseointegration ability (Prabakaran *et al.*, 2021; Safi *et al*., 2019).

It is known that the coating techniques of dental implants directly influence the cell differentiation and calcification of the bone matrix during the phenomenon of osseointegration (Pellegrini *et al*., 2018)

It was observed that the Ha coating was able to modify the structural characteristics of the surface, resulting in a more complex morphology with numerous pores resembling "volcanoes," evenly distributed throughout the sample. The increase in surface roughness, combined with the incorporation of components similar to those naturally present in the organism, such as hydroxyapatite, creates a more favorable environment for blood interaction and, consequently, induction of osteogenic lineage of proteins and cells (Queiroz *et al*., 2013; Polo *et al*., 2020; Marques *et al*., 2015).

Through histological analysis of photomicrographs at 1000× magnification (Figure 9), the characteristics and degree of maturation of the bone tissue whorls formed during implant osseointegration in both groups were observed. At 14 days, it was noted that the zirconia (Zi) group exhibits a greater amount of mature connective tissue with little newly formed bone tissue. In contrast, zirconia hydroxyapatite (ZiHa) shows a higher amount of newly formed bone interspersed with a small amount of connective tissue. By day 28, Zi demonstrates increased newly formed bone with connective tissue present at the center of bone formation. Meanwhile, ZiHa displays significant bone tissue formation with osteocytes present in the bone matrix and without interspersed connective tissue.(Toscano *et al*., 2024).

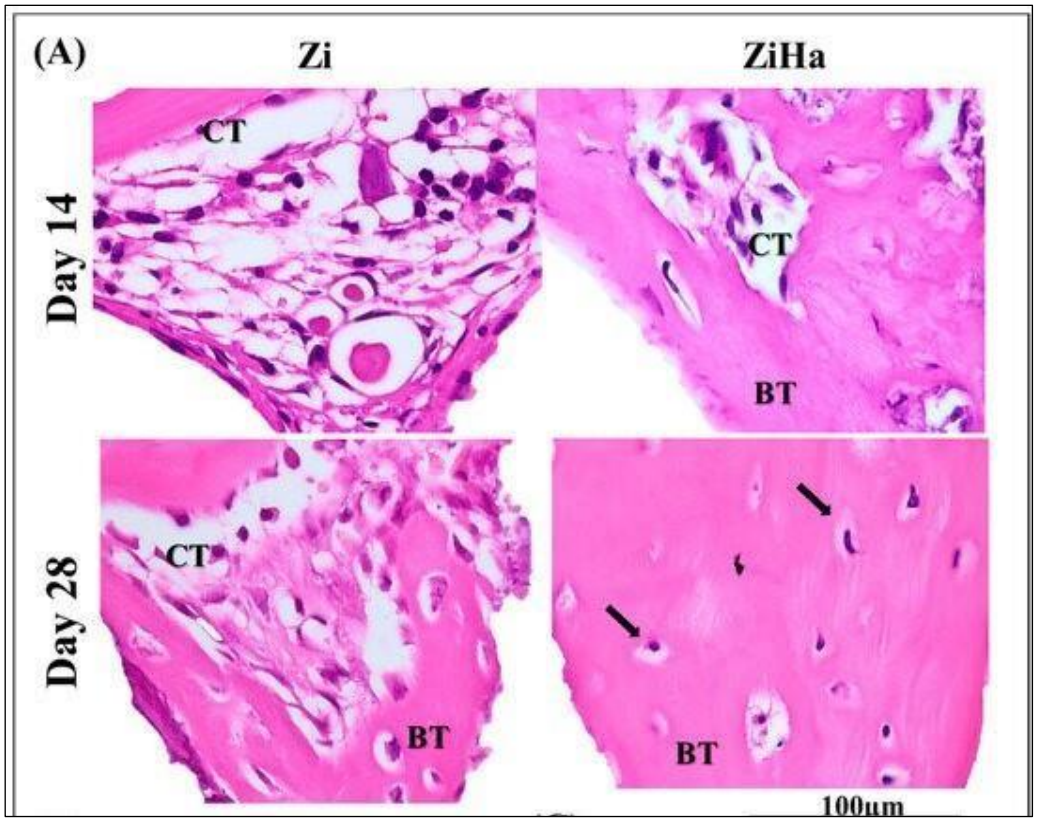

Figure 9. Histological Analysis of Hydroxyapatite coated implant. (Toscano *et al*., 2024)

Chapter two:

9. Discussion

The present systematic review aimed to evaluate the efficacy of alternative and adjunctive measures compared to conventional treatment of peri-implant mucositis and peri-implantitis. The primary goal of peri-implant mucositis treatment has been established as the resolution of inflammation as evidenced by the absence of BOP (Sanz *et al*., 2012).

Based on the current data synthesis, the investigated alternative measures for biofilm removal (i.e., glycine powder air polishing and chitosan brushes) and adjunctive measures (i.e.,local antiseptic therapy, probiotics, home care mouth rinse) failed to improve BOP scores over mechanical debridement alone. In terms of PD values, while the adjunctive use of local antiseptics (i.e., CHX and sodium hypochlorite) along with mechanical debridement led to significantly greater PD reduction The present findings partially align with the results of previous systematic reviews and meta-analyses according to which adjunctive measures for treating peri-implant mucositis (i.e., antiseptics, local and systemic antibiotics, air-abrasive devices) failed to improve the efficacy of professionally administered plaque removal in reducing clinical signs of inflammation, as shown by comparable changes in BOP and PD values, However, the calculations in those analyses were based on pooled data from clinical studies that employed both local and systemic adjunctive measures (i.e., local and systemic antibiotics), which in turn might at least partially explain the aforementioned discrepancies (Schwarz *et al.*, 2015).

Taken together, the use of investigated adjunctive and alternative measures were not found to be superior in resolving peri-implant mucositis, thus supporting recent consensus statements suggesting that non-surgical mechanical instrumentation in

conjunction with oral hygiene reinforcement is a standard-of-care intervention for the management of peri-implant mucositis (Jepsen *et al*., 2015; Renvert *et al*., 2019).

The majority of the included studies reported on residual BOP/BI scores following non-surgical peri-implantitis treatment, and disease resolution (i.e., absence of BOP and further bone loss) was obtained in 14% to 47% of the cases 6 to 12 months after the treatment (Renvert *et al*., 2011; Schär *et al*., 2013; Merli *et al.*, 2020)

Therefore, in line with earlier findings, non-surgical treatment of peri-implantitis seems to have limited efficacy in predictably resolving inflammation, thus supporting the necessity of surgical treatment in the majority of patients diagnosed with peri-implantitis (Renvert *et al*., 2019).

Nonetheless, according to the recent recommendations, non-surgical therapy should always precede surgical intervention in treating peri-implantitis (Wang *et al.*, 2019).

It is worthwhile to note that the treatment outcomes of peri-implant mucositis and peri-implantitis might be influenced by the surface characteristics of the abutment and/or implant. In fact, clinical data have reported greater BOP reduction following the treatment of experimentally induced peri-implant mucositis lesions at implants with machined abutments, as compared to the modified surfaced abutments (Aghazadeh *et al.*, 2020).

Documented by the previous analyses, significantly better outcomes were obtained after surgical non-reconstructive therapy of peri-implantitis at implants with non-modified surfaces compared to modified surfaces, as shown by the superior BOP, PD reductions and superior bone-level preservation at non-modified surfaced implants (Berglundh *et al*., 2018;Carcuac *et al*., 2017).

10. Conclusions

The PI mucositis may be reversed early by treating and eliminating the underlying cause. PI is characterized by marginal bone loss and PI mucosal inflammation, The local administration of antibiotics alone or in combination with nonsurgical or surgical therapy for PI showed positive results despite the lack of data (Hosseini Hooshiar *et al*., 2024).

It is still debatable whether systemically given antibiotics should be used in conjunction with nonsurgical or surgical procedures. However, for the last several years, medication resistance has also increased in patients with gum disease, and the present trend of human bacteria becoming increasingly resistant to antibiotics (Gu *et al*., 2021).

The unique conditions in the gum region and how biofilm builds make antibiotics less effective against these microorganisms. Metallic NPs are relevant to treating PI because they prevent the growth of several bacteria.Therefore, the novel metal NPs provided a unique viewpoint on the development of effective antibacterial and anti-inflammatory scaffolds for the treatment of PI (Ewald and Sumner, 2018b).

Various research has shown the potential of metal NPs such as Au, Ag, Cu, and Zn as an antibacterial coating for Ti dental implant bases. Additionally, metal NPs may be used in conjunction with other therapeutic approaches or instead of antibiotics for PI with further research(Geethalakshmi and Sarada, 2012).

However, their use in the clinic is minimal, These NPs must undergo extensive testing to check for adverse effects to guarantee their safe use, the availability of primary materials, the cost of their processing, their post-use sustainability and recyclability, and other factors must all be taken into account when putting the circular economy idea into practice (Jamkhande *et al.*, 2019).

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