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THE ROLE OF ANTIBIOTICS IN PREVENTING POSTOPERATIVE INFECTIONS IN ORAL IMPLANTOLOGY

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Abstract

The use of antibiotics in oral implantology remains a subject of clinical relevance and scientific debate. While dental implants demonstrate high long-term success rates, postoperative infections, though relatively rare, can compromise osseointegration and lead to implant failure. Antibiotic prophylaxis is commonly employed to minimize these risks, especially in complex surgeries or patients with systemic risk factors. However, recent evidence challenges the routine administration of antibiotics in all cases, highlighting minimal benefits in healthy individuals undergoing standard implant placement. Moreover, widespread and often unjustified antibiotic use contributes to the global rise in antimicrobial resistance and exposes patients to potential adverse effects. This review explores the rationale, types, and timing of antibiotic use in implantology, examining current guidelines and the strength of available evidence. It also addresses alternative strategies for infection prevention, including strict surgical asepsis, antiseptic rinses, local antimicrobial agents, and the role of patient education. The review concludes by emphasizing the need for a risk-based, evidence-driven approach to antibiotic prescribing, integrating both clinical judgment and public health responsibility. Personalized protocols and continuous updates of clinical guidelines are essential to ensure safe, effective, and responsible use of antibiotics in modern dental implantology.

Keywords: antibiotics, implantology, infection prevention, resistance, biofilm

Introduction

Oral implantology is one of the most predictable and widely used methods of prosthetic rehabilitation in contemporary dentistry. With success rates exceeding 90–95%, implant-prosthetic treatment is considered an effective and long-lasting solution for partial or total edentulism. However, like any invasive surgical procedure, the insertion of dental implants involves a risk, even if low, of postoperative infectious complications, which can compromise osseointegration and lead to implant failure. Infections can occur in the form of acute surgical site infections, abscesses, or as delayed inflammatory reactions, such as peri-implantitis [1-3].

In this context, the use of antibiotics as a method of preventing these complications has become a frequent practice in oral implantology. Antibiotics are prescribed to reduce bacterial load during and after surgery, preventing microbial invasion of traumatized tissues and supporting the osseointegration process in an environment as little contaminated as possible. However, this widespread practice is not without controversy [2,3].

Although numerous clinical guidelines and studies support the prophylactic administration of antibiotics in oral implantology, there are more and more voices in the literature that question the usefulness and justification of routine use,

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especially in cases without major risk factors. In an era marked by the alarming rise in bacterial resistance and global concerns about overmedication, every decision to prescribe an antibiotic must be supported by strong, evidence-based arguments [1-4].

In clinical practice, the decision to administer antibiotics varies depending on the clinician's therapeutic protocol, the type of intervention (simple or advanced, with or without bone addition), the patient's general condition, medical history, and immune status. Also, the timing of administration (preoperative, intraoperative, postoperative) and duration of treatment differ significantly between practitioners, reflecting the lack of universal consensus and uniform recommendations. In some cases, antibiotics are even given to healthy patients undergoing simple interventions without clear evidence of benefit [2-4].

At the same time, the need to differentiate between antibiotic prophylaxis and the treatment of already established infections is also highlighted. Prophylaxis involves administering the drug in the absence of an infection, for preventive purposes, while treatment involves managing an active infection. Confusion between the two approaches can lead to overdiagnosis and overtreatment [2-5].

Table 1 summarizes essential concepts related to antibiotic use in oral implantology, including prophylactic and therapeutic strategies, the importance of osseointegration, the role of biofilm formation, and the growing concern of antibiotic resistance. Understanding these concepts is crucial for optimizing clinical protocols and ensuring long-term implant success while minimizing unnecessary antibiotic exposure [2-9].

Table 1. Key concepts in antibiotic use for oral implantology

Concept	**Definition**	**Relevance in implantology**	**Clinical implication**
Prophylactic antibiotic use	Administration of antibiotics before infection occurs	Aimed at preventing surgical site infections	Recommended in high-risk or complex procedures
Therapeutic antibiotic use	Use of antibiotics to treat an established infection	Targets active bacterial contamination	Requires culture-based or empirical choice
Osteointegration	Direct structural and functional connection between bone and implant	Critical for implant stability and success	Compromised by infection or inflammation
Biofilm	Structured bacterial community on surfaces	Forms on implant surfaces, resists antibiotics	Difficult to eradicate once mature
Antibiotic resistance	Bacteria's ability to survive antibiotic exposure	Increases with unnecessary antibiotic use	Major concern in routine prophylaxis

Against the backdrop of these challenges, recent literature has begun to critically reconsider the role of antibiotics in implantology, focusing on the risk-benefit ratio, the side effects of unjustified use, and the impact on public health. At the same time, complementary alternatives are also being explored, such as local antimicrobial

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therapies, the use of antiseptics, or the development of implants with antibacterial surfaces [2,6,8].

The purpose of this review is to provide a synthetic and critical analysis of the role of antibiotics in the prevention of postoperative infections in oral implantology. The pathogenic mechanisms of peri-implant infections, the types of antibiotics used, the effectiveness proven in clinical trials, as well as the risks and limitations associated with systemic therapy, will be discussed. At the same time, the need for a personalized and rational approach will be emphasized, in line with the principles of evidence-based medicine and modern trends to avoid overmedication.

Pathophysiology of postoperative infection in implantology

Postoperative infections are one of the most feared complications in oral implantology, as they can compromise the integrity of peri-implant tissues and lead to osseointegration failure. Understanding the pathophysiology of these infections is essential for developing effective prevention and treatment strategies. The infection occurs as a result of bacterial colonization of the surgical wound, followed by microbial replication, the release of toxins, and the initiation of a nonspecific and subsequently specific inflammatory response [2-5].

Contamination can occur in several stages of the implant procedure: during surgical opening (through non-sterile instruments or incorrect handling), during implant insertion (through biofilm present on prosthetic components or implant), or in the immediate postoperative period, when the mucosal seal is not fully formed and the natural defense barriers are compromised. During this critical interval, bacteria from the oral flora can penetrate the peri-implant space and initiate an inflammatory response [3-5].

At the microscopic level, bacterial colonization follows a well-defined pattern: the adhesion of bacteria to the implant surface is followed by the formation of a mature biofilm. Biofilm is a complex, polymicrobial structure, protected by an extracellular matrix, which confers high resistance to the action of antibiotics and immune mechanisms. Bacterial species frequently involved in peri-implant infections are similar to those in chronic periodontitis, including *Porphyromonas gingivalis*, *Tannerella forsythia*, *Treponema denticola*, but also opportunistic bacteria such as *Staphylococcus aureus* [4-6].

The host's immune response is initially mediated by cells of the innate immune system – macrophages and neutrophils – which try to limit the spread of phagocytosis infection and the release of proinflammatory cytokines (IL-1β, TNF-α, IL-6). Normally, this reaction is transient and supports the healing process. However, in the event of an imbalance between host defenses and bacterial aggression, inflammation becomes persistent, leading to destruction of peri-implant connective and bone tissue [4-7].

An aggravating factor is the rough structure of modern implant surfaces, which, although it favors osseointegration, also provides an ideal substrate for bacterial adhesion and biofilm retention. Once formed, the biofilm can sustain a chronic infection that is mildly symptomatic, but with a progressive, destructive effect on the bone – a situation encountered in chronic peri-implantitis. The adaptive immune system becomes active in more advanced stages of infection, through the intervention of T and B lymphocytes, but without the necessary efficiency to eliminate the biofilm. This explains why peri-implant infections tend to become chronic and refractory to conventional treatment, sometimes requiring explantation of the device [4-8].

In addition to direct contamination, several predisposing factors can increase the risk of postoperative infection: smoking, poor oral hygiene, altered metabolic status

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(e.g., diabetes), use of bone grafts, extensive surgery, immunosuppression, or chronic systemic therapies. Also, the intervention time, the surgical technique, and the clinician's experience directly influence the infectious risk [4-7].

Antibiotics in the surgical context – indications and types used

The use of antibiotics in oral implantology is centered on reducing the risk of postoperative infection, especially in the context in which the oral flora is abundant and potentially pathogenic. Their administration can be classified into two broad categories: prophylactic (preventive) and therapeutic (in the presence of an active infection). In implantology, the main interest is in prophylactic antibiotic therapy, aimed at minimizing perioperative bacterial contamination and supporting osseointegration [5-8].

Prophylactic antibiotics are generally recommended in high-risk surgeries, such as multiple implant insertion, simultaneous use of bone grafts, sinus lift, interventions in previously infected areas, or patients with significant comorbidities (e.g., uncontrolled diabetes, immunosuppression, severe cardiovascular conditions). In these cases, the potential benefit of antibiotics outweighs the risks associated with taking them [6-8].

The most commonly used antibiotics in oral implantology are amoxicillin, due to its broad spectrum and good tolerability, and clindamycin, used especially in cases of penicillin allergy. Other options include metronidazole, often in combination with amoxicillin to cover the anaerobic flora, and less often, azithromycin or cephalosporins. The choice of antibiotic must take into account the risk of side effects, local bacterial resistance, and the patient's history. Administration regimens vary considerably between clinicians and guidelines. A commonly used protocol involves the administration of a preoperative dose of amoxicillin (2 g 1 hour before the intervention), followed or not by a postoperative regimen of 3–5 days. Studies suggest that the single preoperative dose is often sufficient in low-risk cases, while prolonged regimens should be reserved for more complex situations. Clindamycin is usually administered 600 mg preoperatively, then 300 mg every 8 hours for 3 days postoperatively [5-11].

Official recommendations, such as those of the European Association for Osseointegration (EAO) or the American Academy of Implant Dentistry (AAID), vary slightly, but converge on the idea that antibiotics should not be administered routinely in all cases. Instead, they should be reserved for advanced surgeries or patients at high risk of infection. This selective approach aims to reduce the incidence of adverse reactions and combat the global phenomenon of antimicrobial resistance. Antibiotics have a well-established role in implant surgery, but their use must be rational, adapted to the patient's risk and the complexity of the intervention. Empirical administration, without clear clinical criteria, contributes to overmedication and reduces the overall effectiveness of treatment. An evidence-based approach and individualization of therapy are essential to protect the efficacy of antibiotics and increase long-term implant success [5-11].

Table 2 summarizes the most commonly prescribed antibiotics in oral implant surgery, including their typical indications, dosage regimens, and key considerations. Selection should be based on patient history, allergy profile, and surgical complexity. Rational use of antibiotics minimizes infection risk while reducing the likelihood of adverse effects and antimicrobial resistance [8-15].

Table 2. Commonly used antibiotics in oral implant surgery: indications and regimens

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Antibiotic	Typical indications	Dosage and timing	Notes/considerations
Amoxicillin	Standard prophylaxis in healthy patients	2 g orally 1 hour pre-op	Most commonly used; effective against Gram-positive and some Gram-negative bacteria.
Clindamycin	Patients allergic to penicillin	600 mg orally 1 hour pre-op, then 300 mg every 8h for 3 days	Risk of C. difficile infection; good anaerobic coverage
Metronidazole	Anaerobic infections or adjunct to amoxicillin	500 mg every 8h for 5–7 days	Often used in complex cases or infected sites
Azithromycin	Alternative for penicillin-allergic patients	500 mg 1 hour pre-op, then 250 mg daily for 3 days	Long half-life; less GI irritation
Cephalexin	Mild penicillin allergy or when amoxicillin is contraindicated	2 g orally 1 hour pre-op	Cross-reactivity is possible; use with caution

Scientific evidence on the effectiveness of antibiotics in prevention

The effectiveness of antibiotics in preventing postoperative infections in oral implantology has been intensively studied, but the data in the scientific literature are often contradictory, especially regarding the need for their routine use in low-risk cases. Multiple clinical trials, meta-analyses, and professional guidelines attempt to draw a clear line between real benefit and unjustified use [8-10].

One of the most cited studies is the meta-analysis conducted by Esposito et al. (2010), which demonstrated that the administration of a single preoperative dose of amoxicillin (2 g 1 hour before the intervention) significantly reduced the risk of early implant loss compared to placebo. This strategy was considered sufficient for most cases, especially in standard interventions without complex adjacent procedures. Subsequently, other randomized trials confirmed these results, highlighting a modest but statistically significant reduction in infectious complications in groups that received antibiotic prophylaxis [8-11].

On the other hand, some research has shown that in the case of healthy patients undergoing simple implantation procedures, the administration of antibiotics did not produce a significant difference in the rate of postoperative infections. For example, studies published by Martin et al. and Caiazzo et al. have not shown clear benefits in the use of postoperative antibiotics in the absence of other risk factors. These conclusions support the idea that the real benefit of antibiotics is dependent on the clinical context and does not justify their universal administration [9-11].

More recently, a meta-analysis published in 2021 concluded that only patients with systemic risk factors or complex surgeries (e.g., bone augmentation, sinus lift) appear to benefit from prolonged antibiotic prophylaxis. In contrast, in patients without comorbidities and with good oral hygiene, the benefits are marginal and the risks may outweigh the advantages. Another important element is the differentiation between short and long regimes. The preoperative single-dose regimen appears to be sufficient in most cases, according to EAO and AAID

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guidelines. Administration of antibiotics for more than 3–5 days postoperatively has not demonstrated superior efficacy, but increases the risk of adverse effects and bacterial selection [9-12].

Risks and limitations of antibiotic use

Although antibiotics are frequently used in oral implantology for preventive purposes, their administration is not without risks, especially in the absence of a clear clinical justification. Inappropriate or excessive use of these drugs can lead to systemic complications, the emergence of bacterial resistance, alteration of the microbiome, and even implant treatment failure. One of the most important risks is the development of antimicrobial resistance. Frequent administration of antibiotics, especially in contexts where the benefit is minimal or non-existent, favors the selection of resistant bacteria. In the oral cavity, this selection can lead to the development of resistant strains of commensal or pathogenic flora, such as *Streptococcus mutans*, *Staphylococcus aureus,* or *Enterococcus faecalis*. These resistant bacteria can become sources of infection that are difficult to treat, both locally and systemically, especially in immunocompromised patients [7,10-13].

Systemic side effects are another important aspect. The most common are gastrointestinal disorders (nausea, diarrhea, intestinal dysbiosis), but type I allergic reactions (urticaria, angioedema, anaphylactic shock) can also occur, especially to penicillins. Clindamycin, although used as an alternative in case of allergy, is known for its increased risk of pseudomembranous colitis, induced by *Clostridioides difficile*. Thus, even a treatment considered "trivial" can have serious systemic consequences, especially in elderly patients or patients with chronic diseases [10-13].

One aspect that is often overlooked is the impact on the oral and intestinal microbiome. The administration of antibiotics disrupts the balance of commensal bacterial flora, reducing diversity and facilitating colonization with opportunistic microorganisms. In the oral cavity, this disturbance can lead to the appearance of candidiasis, halitosis, or worsening of gum inflammation. In the long term, oral dysbiosis can indirectly contribute to the onset of peri-implantitis [10-14].

In addition to the adverse effects, another critical point is overmedication. Many patients receive antibiotics even for minor surgeries, without associated risk factors, out of routine or out of a desire to "prevent any complications". This practice, although well-intentioned, is not supported by evidence and adds an unnecessary therapeutic burden to the patient. In addition, it contributes to the trivialization of the use of antibiotics and to the loss of their effectiveness in situations where they are needed [10-15].

Alternative and complementary infection prevention strategies

Amid concerns about the overuse of antibiotics and the development of antimicrobial resistance, alternative and complementary strategies for preventing postoperative infections in oral implantology are becoming increasingly relevant. They aim to strictly control bacterial contamination, support the healing process, and reduce the need for systemic antibiotic therapy, especially in cases with low infectious risk. Asepsis and rigorous antisepsis are the first pillar of prevention. Compliance with strict protocols for sterilization of instruments, correct wearing of protective equipment, and atraumatic handling of tissues significantly reduces the risk of intraoperative contamination. The use of sterile drapes, limiting the number of people in the intervention room, and avoiding unnecessary exposure of the implant are simple measures, but with a major impact on infection control [11-15].

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Current perspectives in postoperative infection prevention in oral implantology increasingly emphasize complementary, personalized, and minimally invasive solutions. Recent studies have demonstrated the effectiveness of regenerative therapies such as A-PRF+ in the management of periodontal defects, with encouraging outcomes even in smokers. At the same time, oral parafunctions and impacted molar pathology are recognized as significant predisposing factors for inflammatory complications and peri-implant instability, supporting the need for well-planned prophylactic interventions[16-20]. The use of occlusal guards, advanced temporary prosthetic composite materials, and modern anxiety-reduction strategies in pediatric patients contributes to creating an oral environment that favors healing and prevents bacterial colonization. These approaches, integrated with strict antisepsis, local irrigation with antimicrobial agents, and patient education, can significantly reduce the need for systemic antibiotic therapy. As such, modern implantology is increasingly shifting toward a preventive, multidisciplinary model centered on the patient and tailored to individual risk, preserving therapeutic efficacy while minimizing microbial resistance [17-23].

Recent literature on biomaterials and emerging technologies outlines promising directions in regenerative medicine and implantology. Biodegradable polymers, successfully used in cardiac tissue repair, provide a functional model for similar applications in bone and gingival regeneration. Hydrogels, studied in the treatment of central nervous system injuries, show strong potential for supporting angiogenesis and cellular migration, making them viable candidates for peri-implant integration. Likewise, 3D bioprinting applied to renal tissue regeneration opens new perspectives for producing customized biological structures. Artificial intelligence, already used in orthodontic diagnostics, can be further extended to digitally guided implant planning. Moreover, studies on traumatic irritation fibroma provide relevant insights into chronic tissue responses, indirectly contributing to the understanding of implant biocompatibility. These research areas support the development of personalized, bioactive, and predictable therapeutic solutions that respond to current clinical challenges in oral implantology [16,24-28].

Preoperative rinsing with antiseptic solutions, such as chlorhexidine 0.12–0.2%, temporarily reduces salivary bacterial load and may decrease the risk of bacterial inoculation in the operative area. Also, irrigation of the surgical wound with saline solution or antiseptic solutions during the intervention helps to eliminate tissue debris and microorganisms. These measures are frequently omitted, but can in many cases replace the need for systemic antibiotic prophylaxis [29-31].

Another complementary strategy is the use of local antimicrobial therapy. Applying gels, patches, or collagen impregnated with antibiotics or antiseptic agents directly to the implant site provides high concentrations locally without exposing the entire body to the drug. This significantly reduces the risk of systemic side effects and avoids disruption of the microbiome. For example, metronidazole or chlorhexidine-based gels are effective in reducing the incidence of infectious complications in the peri-implant area immediately postoperatively.

Implant materials with antibacterial properties represent a promising direction of research. Surfaces treated with silver, copper, or zinc ions, coated with antimicrobial peptides or functionalized with nanoparticles, can inhibit bacterial colonization without harming osteogenic cells. These approaches are under clinical evaluation and offer real prospects for implants with reduced infectious risk [30-32].

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Conclusions

The use of antibiotics in oral implantology aims to prevent infectious complications that can compromise the osseointegration and long-term success of dental implants. Although numerous studies support the effectiveness of a single dose of preoperative antibiotic, the benefit of systematic and prolonged use in all cases remains limited and controversial. The administration of antibiotics should be guided by the assessment of the patient's risk and the complexity of the intervention, not by routine.

Against the background of increasing bacterial resistance and the associated risks, alternative strategies such as rigorous antisepsis, local antimicrobial therapies, and the use of bioactive materials are becoming increasingly relevant. At the same time, patient education and systemic disease management play an important role in preventing postoperative infections.

Prophylactic antibiotic therapy in implantology must be approached rationally, individually, and integrated into a complex, evidence-based clinical protocol. Optimizing this balance between prevention and therapeutic responsibility is essential for maintaining the success of implant-prosthetic treatments in modern dentistry.

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