International Journal on Oral Health

Conscious Prescription of Antibiotic in Endodontics: Indications and Rational Use

Mini Review

Volume 6 Issue 1- 2026

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Article History

Received: March 17, 2026 Accepted: March 23, 2026 Published: March 23, 2026

Introduction

Some authors emphasize the serious concern surrounding the indiscriminate use of antibiotics. It is estimated that, by around the year 2050, bacteria resistant to currently available antibiotics will cause infections that are difficult to control and may become the leading cause of death worldwide [1,2]. Álvarez-Martínez, Barrajón-Catalán, Micol (2020) [2] emphasizes that, shortly after the development of new drugs, resistant strains had already been identified. The World Health Organization (WHO) [3] considers antimicrobial resistance one of the major threats to public health and global development. It is estimated that multidrug-resistant bacteria were directly responsible for 1.27 million deaths and contributed to an additional 4.95 million deaths worldwide in 2019, the year of the most recent major assessment of this kind.

According to André Julião of FAPESP agency (São Paulo State Research Foundation) [4], bacteria resistant to most classes of antimicrobials, previously restricted to hospital settings, are becoming increasingly present in everyday life. Antibiotic-resistance bacteria are microorganisms that have developed resistance to multiple types of antibiotics, making the treatment of infections much more difficult. This resistance also arises from the inappropriate or excessive use of antibiotics, such as when they are taken without medical prescription, discontinued before the recommended duration, or used to treat viral diseases such as influenza and the common cold. In hospitals, the problem may be aggravated in already debilitated patients who require invasive procedures. Hospital environments with inadequate cleaning and failures in infection control also favor the spread of antibiotic-resistance bacteria. These organisms may also cause severe infections in otherwise healthy individuals, especially older adults and children, whose immune systems are either still developing or in decline. The increased presence of antibiotic-resistance bacteria in the environment may have been the route of contamination of a two-year-old domestic dog infected with a resistant strain of Klebsiella pneumoniae. The animal was admitted to a veterinary hospital with severe hemorrhagic gastroenteritis, probably after accidentally ingesting something. The dog remained hospitalized for several days while the condition progressed to severe pancreatitis, diffuse peritonitis, and, ultimately, death, despite receiving combination antibiotic therapy. Transmission from humans is considered likely, as they may have carried the bacteria into the domestic environment after hospital admissions [5].

In another case, a bacterium commonly found on human skin caused sepsis in an 18-year-old young woman. The causative agent was a methicillin-resistant variant of Staphylococcus aureus, which led to her death. This bacterial species is commonly present on human skin and is usually not harmful to health. The patient had been admitted to the hospital just over 24 hours earlier with persistent torticollis and a painless pimple on her face [6]. Bacteria possess a single chromosome dispersed throughout the cytoplasm and are therefore highly susceptible to genetic alterations. These alterations may range from a simple mutation caused by an error during DNA replication to more elaborate mechanisms. Such modifications in genetic sequences may result in bacterial death, but they may also enable the synthesis of other amino acids and other unprogrammed by-products. New genetic sequences can confer major advantages to bacteria, such as enhanced adhesion to surfaces, improved ability to metabolize alternative nutrients (common in hostile environments), capsule production, and other virulence factors. However, the greatest concern lies in antibiotic resistance genes [7].

When Alexander Fleming accidentally discovered penicillin, the first antibiotic, in 1928, other researchers such as Griffith had already ob-

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served that bacterial colonies could undergo transformation, that is, acquire genes from their surrounding environment, as was confirmed in the 1940s, characterizing transformation. Subsequently, conjugation was observed, in which different bacterial strains share plasmids carrying resistance genes, first identified in Japan in the late 1950s. Transduction refers to the acquisition of new genetic sequences mediated by viruses, namely bacteriophages, which may likewise kill the bacterium or improve its survival. There are also transposons, which are DNA segments capable of moving from one location to another within the same gene or chromosome. Transposons were described in the 1950s and are also capable of conferring resistance to certain antibiotics [7]. The fact is that new drugs take months or years to be developed, tested, and refined, whereas bacteria may acquire resistance within hours or even minutes. It is, in many respects, a race humanity has already lost. Therefore, the best strategy remains reducing the indiscriminate use of antibiotics, so that emerging bacterial strains are not exposed to new drugs and do not develop resistance. At the hospital level, where the extensive use of specific antibiotics is often necessary, this represents a major problem. In Dentistry, the two areas that most frequently prescribe this class of drugs are Endodontics and Oral Surgery, and their use should be avoided whenever possible.

The clinical rationale for the use of systemic medications in Dentistry refers to the scientific and clinical justification for prescribing a drug based on the patient's condition, evidence-based guidelines, and the expected therapeutic benefit relative to potential risks [8]. The clinical rationale for medication uses in Endodontics implies that systemic drugs should be prescribed only when clearly indicated. In most cases, endodontic infections can be effectively managed through local treatment procedures [9]. Therefore, systemic medications, particularly antibiotics, should be considered only when local measures alone are insufficient to control the condition, such as in cases involving systemic involvement, spreading infection, or medically compromised patients [9,10]. This approach aligns with the principles of antimicrobial stewardship, which aim to promote the appropriate use of antibiotics to optimize patient outcomes while minimizing the development of antimicrobial resistance [10].

Although certain pharmacological approaches are empirically adopted in clinical practice, their antimicrobial efficacy, particularly in highly biofilm contaminated conditions, remains insufficiently validated in scientific literature [11]. Furthermore, the increasing dissemination of misinformation through social media and chatbots highlights the need for clear, evidence-based guidance regarding the appropriate use of antibiotics in endodontic practice [12]. The aim of this review is to provide an updated scientific overview to guide evidence-based antibiotic prescribing in endodontic treatment.

Microbiology and Clinical Rationale

Endodontic infections are generally polymicrobial, organized in intrarradicular biofilms, with a predominance of anaerobic microorganisms, which directly influence the pathological evolution, interfering with therapeutic procedures. As a form of treatment, the use of systemic antibiotics alone does not replace local infection control, since resolution depends primarily on eliminating the cause through endodontic access, chemomechanical preparation, adequate irrigation, and drainage when indicated. Systemic antibiotics cannot penetrate inside root canals because the pulp tissue is necrotic and no longer has blood circulation, preventing the antibiotics from reaching the root canal system and kill bacteria. From this perspective, performing chemomechanical reduction of the intrarradicular microbial load, drainage when necessary and a good temporary restoration of the tooth are the main determinants of clinical improvement [13]. Furthermore, there is the anatomical complexity of the root canal system, which will be decontaminated through a chemical substance inserted into this space via irrigation, and, when placed in the main canal, will reach the finest ramifications, something that systemic antibiotics will never be able to do [14].

The microbiological complexity of these infections and the bacterial organization within biofilms limit the effectiveness of systemic antibiotic therapy as a stand-alone strategy, reinforcing its role as an adjunctive therapy rather than a primary treatment measure [13]. Therefore, systemic antibiotic therapy should be reserved for specific situations, particularly in the presence of signs of systemic spread, progression of infection, or clinical conditions that increase patient vulnerability [8,9]. Conversely, in pulpal and periapical conditions without systemic involvement, the routine use of antibiotics lacks consistent support in the literature, including in painful cases, and therapeutic management should remain focused on local control of the infectious source [8,15].

Within root canals containing necrotic pulps, there is an accumulation of bacteria that can be controlled with simpler substances, whose mechanisms of action are less complex than those of antibiotics and therefore do not promote bacterial resistance. These are the so-called disinfectants, which, when confined exclusively within the root canal system, would not cause toxic effects to living tissues. Thus, substances that are toxic to living tissues may, with proper training, be used to eliminate biofilms within the root canal such as sodium hypochlorite, chlorhexidine, and calcium hydroxide.

Where Antibiotic Prescription is Inappropriate in Endodontics

Inappropriate antibiotic prescription remains a frequent concern in endodontic practice, particularly in urgency settings [16]. Although most endodontic infections are effectively managed through local operative measures, systemic antibiotics are still commonly prescribed in situations where they offer no additional therapeutic benefit [17,18]. Systemic antibiotic prescribing is not recommended in the following clinical situations [13,19]:

a.In symptomatic irreversible pulpitis for pain control, without evidence of systemic spread;

b.Pulp necrosis without accompanying systemic manifestations;

c.Symptomatic apical periodontitis; including tenderness to percussion or pain to occlusal function and radiographic widening of the periodontal ligament space, when systemic involvement is absent;

d.Chronic apical abscess; even in the presence of a sinus tract and periapical radiolucency;

e.Localized acute apical abscess; when there are no signs of systemic dissemination and drainage can be achieved.

In these clinical conditions, adequate local intervention such as the removal of the source of inflammation or infection by root canal debridement in combination with the incision and/or drainage associated with appropriate analgesic therapy constitutes the standard of care [20,21]. Evidence suggests that adjunctive systemic antibiotics do not significantly reduce pain or swelling when effective local treatment is provided [18]. Unnecessary and prolonged antibiotic exposure in these contexts contributes not only to increasing the risk of promoting antimicrobial resistance while unjustifiably increasing the risk of severe anaphylactic reactions and side effects [13,18,22].

Clinical Indications for Considering Systemic Antibiotics in Endodontics

Given the high frequency of inappropriate prescribing, clear criteria are required to distinguish cases that benefit from systemic therapy. Therefore, current evidence and international guidelines clearly establish that systemic antibiotics in endodontics must be reserved for specific clinical scenarios involving systemic spread or medically compromising conditions [13,18]. The European Society of Endodontology (ESE) states that most endodontic infections are confined to the root canal system and can be successfully managed by appropriate local operative measures without the need for systemic antibiotics [19].

Antibiotic therapy must be considered strictly adjunctive and never a substitute for definitive treatment [17,19].

Indications for systemic antibiotics include the presence of systemic signs and symptoms such as fever (>38°C), malaise, lymphadenopathy, trismus associated with diffuse swelling, or cellulitis [18]. Evidence of rapidly progressing infection, fascial space involvement, or signs suggestive of systemic dissemination warrants immediate antibiotic therapy with urgent local intervention. Reimplantation of avulsed permanent teeth, with or without soft tissue trauma requiring surgical management, such as suturing or debridement, also necessitates systemic antibiotic therapy which may improve prognosis [13]. Antibiotic prophylaxis is indicated in high-risk cardiac patients as defined by ESC and AHA [23] criteria according to guidelines indications, with appropriate timing, dosage and antimicrobial spectrum [24].

When antibiotics are indicated, narrow-spectrum agents should be prioritized whenever possible. Amoxicillin is commonly recommended as first-line therapy when antibiotics are indicated and there is no penicillin allergy [13,16]. Duration of therapy should be limited to the shortest effective course, typically reassessed within 48 to 72 hours. Antibiotics should be discontinued once systemic signs and symptoms are resolved, rather than completing arbitrarily prolonged regimens [19]. The AAE (American Association of Endodontists) and ESE (European Society of Endodontology) recommend 3 to 5 days of antibiotic therapy with reassessment at this interval [19], although very short periods of 1 to 2 days are also questioned, as they may generate bacterial resistance, which is still a matter of controversy in the literature. Regardless, strict adherence to these clinical criteria is essential to reduce unnecessary antimicrobial exposure and to support global efforts in antimicrobial stewardship.

Decision-Making in Endodontic Urgencies

Consideration should be given to medically compromised patients since interdisciplinary consultation may be warranted. This evidence-based structured algorithm reinforces a fundamental principle: systemic antibiotics are adjunctive measures reserved for cases of systemic involvement or medically significant risk and must never substitute definitive local endodontic treatment [13,18,19]. Patient counseling regarding warning signs, such as fever, progressive swelling, trismus, dysphagia, or clinical worsening, is also part of this approach, as it promotes judicious antimicrobial use and reinforces evidence-based practice [9]. Evidence from dental antimicrobial stewardship research further supports the role of structured interventions in improving prescribing practices, particularly through audit, feedback, and implementation strategies aimed at reducing inappropriate antibiotic use in dental settings [25-27] (Figure 1).

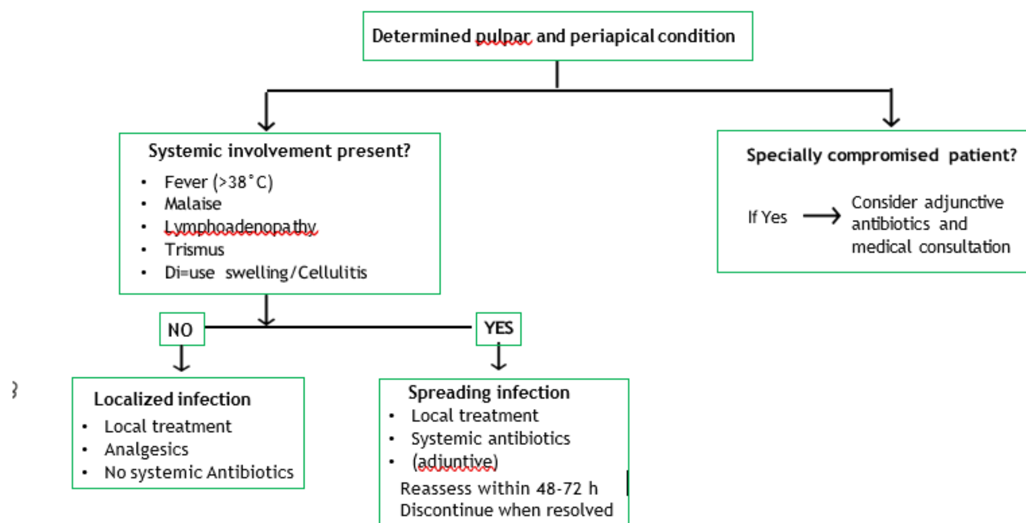

Figure 1: Clinical Decision-Making Algorithm for Antibiotic Use in Endodontic Practice. Structured pathway for the rational prescription of systemic antibiotics in endodontics. The algorithm is based on current evidence and international guidelines for antimicrobial stewardship in endodontics.

Intracanal use of Antibiotics

Just as the use of systemic antibiotics in Endodontics is contraindicated when not clinically necessary, intracanal use should likewise not be recommended. In contaminated root canals with necrotic pulp, there is no vital tissue, and the infection can be controlled with disinfecting agents that do not promote bacterial resistance.

In 2004, Banchs and Trope [28] reintroduced into the literature the use of triple antibiotic paste as an intracanal medication in root canals with necrotic pulps in cases of incomplete root development, based on a clinical case with favorable follow-up outcomes. Following this publication, several authors turned their attention to this clinical situation, and the use of triple antibiotic paste began to be recommended for intracanal application. On the other hand, other studies investigated the antimicrobial effect of calcium hydroxide paste compared with that of triple antibiotic pastes and found that, statistically, both medications showed similar results [29-31]. The rationale for the intracanal use of antibiotic paste in cases of incomplete root development was that calcium hydroxide would be more aggressive to the stem cells of the dental papilla because of its high pH. Subsequently, the cytotoxic effects of these medications were investigated, and antibiotic pastes were found to be more harmful than calcium hydroxide to these cells [32,33]. Therefore, there is no justification for the use of aggressive medications capable of promoting bacterial resistance in cases of incomplete root development when another viable intracanal medication is available that does not produce these deleterious effects.

Conclusion

In Endodontics, infection management should remain centered on local treatment, since the predominantly intrarradicular and polymicrobial nature of these infections limits the benefit of systemic antibiotic therapy when used alone. For this reason, antibiotics should be reserved for specific situations such as adjunctive therapy, and their routine use is not justified in the absence of systemic involvement or risk of dissemination. In this context, adoption of antimicrobial stewardship strategies, including judicious indication, adequate clinical

Citation: Andrade FB, Chiang EBM, Chemelo VS. Conscious Prescription of Antibiotic in Endodontics: Indications and Rational Use. *Int J Orl Health.* 2026; 6(1): 1-4. DOI : 10.51626/ijoh.2026.06.00054

documentation, early reassessment, and patient guidance, represents a clinically responsible and scientifically consistent measure to reduce unnecessary antimicrobial use and contribute to addressing bacterial resistance in endodontic practice.

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