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Evaluation of Antibiotic Prescription for Dental Implant Success: A Review

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ABSTRACT

Introduction: This systematic review aims to evaluate the efficacy of antibiotics, particularly those administered preoperatively and postoperatively, in enhancing the success rates of dental implants. Additionally, it seeks to compare current opinions toward antibiotic usage in implant dentistry with documented outcomes of implant success, both with and without antibiotic intervention.

Materials and Methods: We conducted a systematic literature search using the Scopus, PubMed, and Web of Science databases, incorporating studies published between 2010 and January 2023. Search terms included "dental implant," "antibiotic," "prophylaxis," and "survey." Data analysis and graphical representations were generated using Comprehensive Meta-Analysis (CMA) software.

Results: The findings indicate that 81.1% of surveyed dentists routinely prescribe antibiotic prophylaxis for patients undergoing dental implant procedures, irrespective of health status. An additional 5.8% of practitioners tailored their antibiotic prescriptions based on modifiable factors. The initial database search yielded 220 relevant articles from Scopus, PubMed, and Web of Science, which were screened for alignment with the review objectives. Among antibiotics, penicillin and phenoxymethylpenicillin were identified as the preferred first-line medications.

Conclusion: Cross-sectional surveys across various countries reveal a tendency among dentists to prescribe systemic antibiotic prophylaxis for dental implant surgeries without adhering strictly to evidence-based guidelines, often resulting in overprescription. This highlights a critical need for collaboration among dental educators and practitioners to align clinical practices with scientific evidence regarding antibiotic prophylaxis in implant dentistry.

Keywords: Antibiotics; Dental implant; Systematic review; Meta-analysis.

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Introduction

The World Health Organization (WHO) identifies the overprescription of antibiotics and the consequent development of antimicrobial resistance as critical public health challenges in the modern era [1]. Beyond resistance, antimicrobial therapy can induce adverse effects, including secondary infections, toxicity, allergic reactions, skin rashes, nausea, and gastrointestinal disturbances like diarrhea [1-3]. Dental implants have been established as a durable and effective treatment option for tooth replacement [4]. However, implant failures are generally classified into two types: early failures, which occur before or during the implant-abutment connection, and late failures, which emerge after the prosthetic loading of the implant. Early failure is commonly attributed to inadequate osseointegration, influenced by multiple factors such as insufficient primary stability, contamination of the implant surface at placement, surgical trauma, excessive micromovements during the healing phase, poor bone quality or quantity, shorter implant lengths, and smoking [6,7].

The oral cavity, housing the second most diverse microbiome in the human body, presents a unique microbial challenge that often prompts the use of systemic antibiotics to prevent infection and subsequent early implant failure [8]. However, standardized protocols for antimicrobial administration in dental implantology are lacking, with cross-sectional studies revealing substantial variability in the choice of antimicrobial agents, dosages, timings, and durations. Furthermore, evidence supporting the routine systemic administration of antibiotics in dental implant procedures remains limited, underscoring the need to consider the potential adverse effects and the pressing issue of antibiotic resistance [9].

Dental implants generally exhibit high initial success rates, yet failures can still occur under certain conditions [10]. In some cases, the early wound-healing phase may lead to implant failure, primarily due to surgical site inflammation, which can cause scarring and compromise osseointegration [11]. The Canadian Dental Association (CDA) emphasizes antimicrobial prophylaxis as a crucial measure for mitigating infection risks associated with surgical procedures [12]. However, there is ongoing debate regarding the potential for antimicrobial overprescription to contribute to the development of antibiotic-resistant bacterial strains. The literature reflects a wide range of treatment protocols, differing in antibiotic selection, dosage, and timing, resulting in a heterogeneous approach to antibiotic prescribing [13,14]. A significant body of research has produced inconclusive findings, casting doubt on the efficacy of prophylactic antimicrobials in implant dentistry [14]. These gaps in understanding underscore the need for further investigation into the effectiveness of prophylactic antibiotic use, given its substantial impact on patient outcomes, financial considerations, recommended treatment protocols, and clinical decision-making [14]. This systematic review aims to assess the effectiveness of antibiotics, especially those given before and after dental implant surgery. It also aims to examine how current views on antibiotic use in implant dentistry align with documented success rates of implants, both with and without antibiotic usage.

Materials and Methods

Search strategy

This systematic review and meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A systematic search was conducted across Scopus, PubMed, and Web of Science databases using the keywords "dental implant," "antibiotic," "prophylaxis," and "survey." We restricted our search to English-language publications from 2010 to January 2023, which were catalogued and managed using EndNote citation software. Titles, abstracts, and full texts were reviewed to identify studies that met the inclusion criteria. Eligible studies included cohort studies, case-control studies, and clinical trials examining antibiotic prescriptions related to dental implant surgery. Exclusion criteria encompassed studies involving teeth or foreign bodies, non-antibiotic treatment methods, experimental studies, case reports, reviews, and duplicate publications. No original human or animal research was conducted for this review; therefore, Institutional Review Board (IRB) approval and informed consent were not required. All studies included in this review were independently reviewed and had received approval from their respective ethical boards.

Quality assessment and data extraction

Two independent researchers evaluated the quality of each study using the nine-point Joanna Briggs Institute critical appraisal checklist, resolving any disagreements by consensus. All included studies met over half of the quality assessment criteria. The following data were extracted from each study listed in Table 1: publication year, country, number of patients, response rate, type of antibiotic used, and duration of antibiotic therapy.

Additional data collected included information on study design, research question, type and number of publications, manuscript language and country, type of device used, and patient profile.

Statistical Analysis

Data analysis and graphical representations were conducted using Comprehensive Meta-Analysis (CMA) version 3 software (Biostat Inc., Englewood, NJ) with a random effects model, selected to better account for heterogeneity compared to a fixed effects model. The summary estimate was calculated based on the pooled standard deviation in the mean with a 95% confidence interval. Heterogeneity was assessed using the I-squared (I^2) statistic, and publication bias was evaluated through a funnel plot, further validated by Egger's regression test (with $p<0.05$ indicating a significant level of publication bias).

Results

A comprehensive search of the Scopus, PubMed, and Web of Science databases identified 220 articles relevant to our study objectives. After removing duplicate publications and applying inclusion and exclusion criteria, 15 publications were selected for full review (Figure 1). The included studies employed various research methodologies, such as retrospective, prospective, case-control, and cohort designs. A summary of the findings from these studies is provided in Table 1. The target sample comprised 15,355 dentists, although one study did not specify its sample size. Of the total, 3,139 dentists responded to the surveys, yielding a median response rate (RR) of 20.4%, with response rates ranging widely across studies from 15% to 100% (Table 1).

The surveyed dentists represented nine countries across three continents. Seven studies were conducted in Spain, while six studies were carried out in four European countries, specifically Sweden, Italy, and the Netherlands. Four studies took place in Middle Eastern and Asian countries, including Jordan, India, and Saudi Arabia, and three studies were conducted in the United States (Table 1). Additionally, one study was performed in the Dominican Republic, and another in the Netherlands. The findings indicate that 81.1% of dentists routinely prescribed antibiotic prophylaxis for healthy dental implant patients. Furthermore, 5.8% of dentists prescribed antibiotics based solely on specific modulating factors, while 15.2% of respondents reported that they did not use antimicrobials as a preventive measure (Table 1).As shown in Table 1, amoxicillin emerged as the most commonly selected antibiotic, with amoxicillin-clavulanate being the next preferred option. For dentists who primarily prescribed amoxicillin, amoxicillin-clavulanate was often their secondary choice, and the same was observed in reverse. Among other antibiotics, penicillin and phenoxymethylpenicillin were frequently selected as the primary options, followed by penicillin and doxycycline as secondary preferences. The meta-analysis findings indicated that a significant proportion of dental practitioners involved in the study administered antibiotics prophylactically (Figure 2). The likelihood of dentists prescribing prophylactic antibiotics was approximately three times higher among respondents (Odds Ratio: 3.3, $p<0.05$). Amoxicillin was the most widely used antibiotic, with amoxicillin-clavulanic acid prescribed less frequently. Additionally, the consumption of amoxicillin surpassed that of amoxicillin-clavulanate (Figure 3).

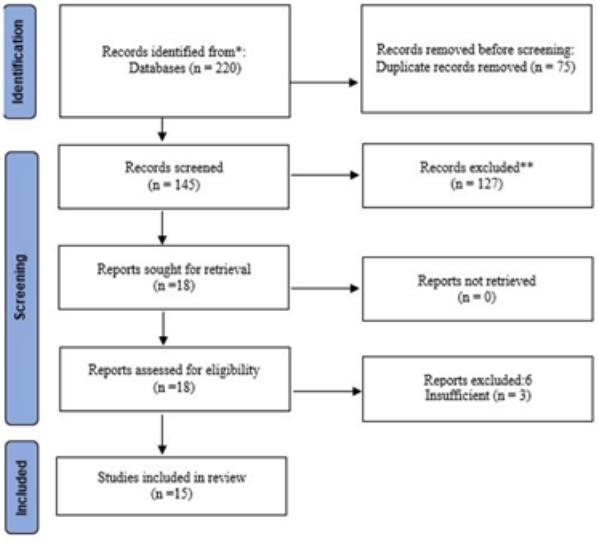

Figure 1. PRISMA flowchart.

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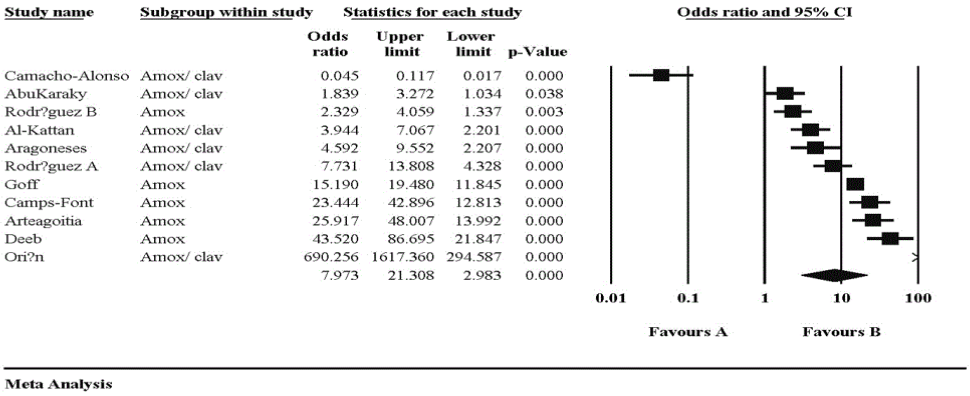

Figure 2. Investigating the relationship between the number of dentists participating in the survey and antibiotic prophylaxis.

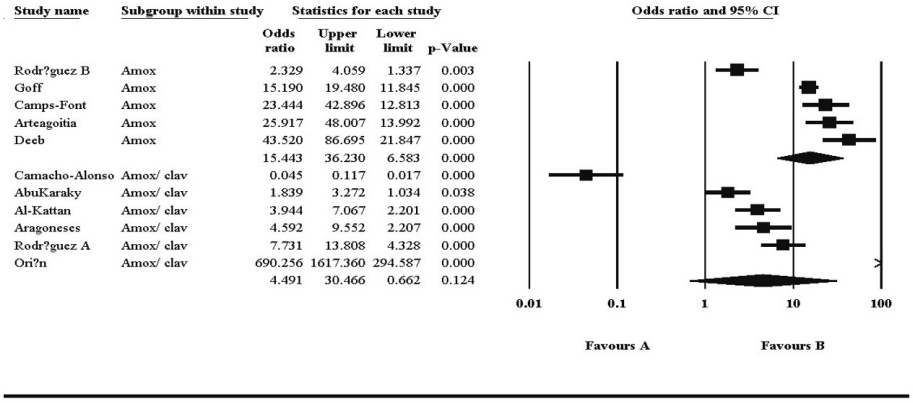

Figure 3. Comparison of the rate of prescribing amoxicillin prophylaxis with the combination of amoxicillin and co-amoxiclav among the dentists participating in the survey.

Table 1. Extracted results of the included studies regarding the prescription of antibiotic prophylaxis in dental implant surgery.

Author/year	*Country*		*RR (%)*	*Antibiotic prophylaxis (N)*			*Antibiotic of choice*	
				Yes	*Mod.*	*No*	*First choice*	*Second choice*
Abukaraky et al., 2011 (34)	*Jordan*	*172*	*70.4*	*140*	*-*	*32*	*Amox. + clav.*	*Amox.*
Marin et al., 2012 (35)	*Chile*	*33*	*-*	*10*	*14*	*12*	*Amox.*	*Doxici.*
Datta et al., 2014 (26)	*India*	*332*	*94.8*	*284*	*-*	*48*	*Penicill.*	*Amox. + clav.*
Deeb et al., 2015 (26)	*United States*	*217*	*15*	*192*	*-*	*25*	*Amox.*	*Penicill.*
Khalil et al., 2015 (33)	*Sweden*	*90*	*75*	*68*	*-*	*22*	*Phenoxy Metilpenicillin*	*Amox.*

Author/year	Country		RR (%)	Antibiotic prophylaxis (N)			Antibiotic of choice	
				Yes	Mod.	No	First choice	Second choice
Al-Kattan and Al-Shibani, 2019 (36)	Saudi Arabia	109	27.25	65	44	0	Amox. + clav.	Amox.
El-Kholey et al., 2018 (28)	Saudi Arabia	133	100	133	-	0	Amox.	Amox. +clav.
Camps-Font et al., 2018 (37)	Spain	247	20.1	211	-	36	Amox.	Amox. +clav.
Arteagoitia et al., 2018 (27)	Spain	233	23.56	207	22	4	Amox.	Amox. +clav.
Camacho-Alonso et al., 2019 (38)	Spain	200	95.24	94	-	106	Amox. + clav.	Amox.
Rodríguez Sánchez et al., 2019b (39)	Italy	160	40	134	25	1	Amox. + clav.	Amox.
Rodríguez Sánchez et al., 2019a (40)	Netherlands	151	24.9	66	80	5	Amox.	Amox. + clav.
Aragoneses 2021 (31)	Dominican Republic	66	-	45	-	21	Amox+ clavulanic	Azitr
Orión 2022 (41)	Spain	300	99	289	-	11	Amox+ clavulanic	Azitr
Goff 2023 (42)	America	764	15	608	-	156	Amox	Amox. + clav.
Total	-	3139	40	2546	185	479	-	-

Discussion

This systematic review examined antibiotic prescribing patterns among dentists performing dental implant surgeries across various countries, based on survey-based studies. Findings revealed that amoxicillin is the most preferred first-choice antibiotic, followed by amoxicillin-clavulanic acid, phenoxymethylpenicillin, and penicillin. Extensive evidence supports the effectiveness of amoxicillin in preventing dental implant failures, which may explain its frequent selection as the antibiotic of choice [9,15]. While amoxicillin-clavulanic acid was also noted as a primary choice in several studies, its effectiveness did not surpass that of amoxicillin alone [16,17].

Response rates (RRs) across studies varied significantly, ranging from 15% to 100%, likely due to differences in sampling techniques. Although most questionnaires were administered online, with only one exception, the methods for contacting participating dentists differed among studies. A majority of surveyed dentists reported routinely prescribing systemic antibiotics for prophylactic purposes. Various studies suggest that the decision to prescribe antibiotics routinely or conditionally is influenced by the patient's medical condition and the complexity of the planned procedure [18,19]. Patients with a history of periodontal disease, for instance, tend to have a higher risk of early implant failure, potentially prompting dentists to prescribe antibiotic prophylaxis more frequently for these individ-

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uals [20,21]. Furthermore, certain clinical guidelines recommend antibiotic prophylaxis for patients with heart disease to prevent infective endocarditis [22,23]. Research has also shown that a single dose of antibiotic prophylaxis administered before surgery can be as effective as a three-day antibiotic course following a bone graft procedure [24,25]. A small percentage of dentists who prescribe antibiotic prophylaxis prior to surgery do so in alignment with current scientific evidence. However, among the 14% of dental practitioners who prescribe preoperative antibiotics, various regimens are employed, including administration two days, one day, 12 hours, eight hours, one hour, 30 minutes, or immediately before surgery [26-28]. In some cases, antibiotic prescribing guidelines also suggest potential overprescription. For example, only one study identified preoperative antibiotics as the most common regimen [29]. The inconsistency between survey-reported antibiotic prophylaxis practices for healthy patients undergoing dental implant surgery and evidence-based recommendations for optimal prescribing may contribute to antimicrobial resistance, potentially impacting patient health adversely [2,30,31]. There is a need to promote educational programs and clinical guidelines to encourage the appropriate use of antibiotic prophylaxis in dental implant procedures [32]. According to Khalil et al., a strategic initiative to combat antibiotic resistance successfully optimized antibiotic prophylaxis in dental implant surgeries [33].

This systematic review highlights that antibiotic prescriptions for dental implant surgery in healthy patients are often inappropriate and unjustified. There is an urgent need to publish targeted clinical guidelines and provide continuous, focused training for dentists who prescribe these medications. Improper prescribing and indiscriminate use of antibiotics may lead to the development of resistant bacterial strains. A limitation of this review is the limited scope of countries and specialists assessed concerning antibiotic prophylaxis prescriptions. Given that this review is based on studies with a moderate to high risk of bias, the results should be interpreted cautiously. This review's limitations include its narrow geographic focus and moderate to high risk of bias in the included studies, which may limit the generalizability of findings. Future research should focus on rigorous studies across diverse settings to establish standardized, evidence-based guidelines for antibiotic use in dental implant procedures. Implementing such guidelines could help reduce antibiotic resistance and improve patient outcomes in implant dentistry.

Conclusion

According to cross-sectional surveys conducted in different countries, most dentists prescribed systemic antibiotic prophylaxis for dental implant surgery without following the scientific evidence and overprescribed this medication. There is a need for dental educators and professionals to work together to bridge the gap between the evidence-based use of antibiotic prophylaxis for dental implant surgery and clinical practice. This review highlights the overprescription of antibiotics in dental implant surgery, especially among healthy patients, with limited adherence to evidence-based guidelines. Amoxicillin remains the preferred choice, yet inconsistent prescribing practices risk fostering antibiotic resistance and compromising patient safety. There is an urgent need for standardized clinical guidelines and ongoing training to support responsible antibiotic use in implant dentistry. Future research should focus on developing and validating guidelines that align with scientific evidence, addressing the variations in practice across regions. Given the moderate to high bias in some studies, these findings should be interpreted cautiously, emphasizing the need for more rigorous research.

Conflict of Interest

There is no conflict of interest to declare.

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