Systematic Review

Challenges in the use of antibiotics and resistance pattern of odontogenic mandibular abscess: a systematic review

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ABSTRACT

Introduction: Odontogenic mandibular abscess is a severe and potentially life-threatening dental infection that demands prompt and appropriate intervention. Previous reviews have focused broadly on odontogenic infections, but few have analyzed antibiotic resistance trends specific to mandibular abscesses. This systematic review aims to evaluate the effectiveness of antibiotic therapy and to analyze current antimicrobial resistance patterns in the management of odontogenic mandibular abscesses. **Methods**: The research question was framed using the PICOS approach; Participants: patients with odontogenic mandibular abscess; Interventions: antibiotic regimens; Comparisons: different antibiotics or combinations; Outcomes: cure rate, duration, complications, and resistance; Study design: clinical, observational, or randomized controlled trials. Literature was searched systematically in PubMed, Scopus, Web of Science, and Cochrane Library for studies published between 2014 and 2024. Previously published systematic reviews and case reports were excluded. **Results:** Ten studies met the inclusion criteria (six prospective cohorts, three retrospective, and one randomized controlled trial). The predominant pathogens were Klebsiella pneumoniae (42%), Streptococcus spp. (38%), and Staphylococcus spp. (35%). Empirical antibiotic combinations of ceftriaxone-metronidazole and amoxicillin-metronidazole showed clinical success rates of 85% and 78%, respectively. Resistance was highest for amoxicillin (67%) and ampicillin (72%), while amikacin and meropenem demonstrated high sensitivity (>90%). **Conclusion**: Misuse of antibiotics remains a major contributor to antimicrobial resistance. Optimal management of odontogenic mandibular abscesses requires surgical drainage combined with rational antibiotic use based on resistance data. The implication of this systematic review is to provide evidence-based guidance for antibiotic selection, supporting antibiotic stewardship and improved clinical outcomes.

KEYWORDS

Antibiotic resistance, antibiotic therapy, odontogenic, mandibular abscess,systematic review

INTRODUCTION

A mandibular abscess of odontogenic origin is a severe and potentially life-threatening result of untreated dental infections. It occurs when pus collects in the soft tissues or bone of the lower jaw, typically stemming from dental or periodontal infections. Without timely and proper intervention, this condition can escalate and pose significant health risks.[1] Despite significant progress in dental practices and oral healthcare, odontogenic mandibular abscesses continue to be a major global health concern. Epidemiological studies across different regions demonstrate varying patterns, with recent data showing increasing incidence rates

of 1–2% in emergency department visits in developing nations, while developed countries report rates of 0.3–0.85%. [2]

A mandibular abscess of odontogenic origin is a severe and potentially life-threatening result of untreated dental infections. It occurs when pus collects in the soft tissues or bone of the lower jaw, typically stemming from dental or periodontal infections. Without timely and proper intervention, this condition can escalate and pose significant health risks.[1,3,4] This regional disparity often reflects differences in healthcare access and antibiotic prescription practices. The treatment of an odontogenic mandibular abscess necessitates a multidisciplinary strategy that combines surgery with antibiotic treatment. While surgical drainage remains the effective standard of abscess management, antibiotics play a crucial role in halting the spread of infection and promoting faster recovery. [5]

However, the emergence of antimicrobial resistance has complicated treatment approaches, with significant regional variations in resistance patterns. For instance, studies in Southeast Asia have reported higher rates of beta-lactam resistance compared to European countries.[6] The World Health Organization (WHO) has identified antimicrobial resistance as one of the ten greatest threats to global health, with particular concern for oral infections due to their frequent occurrence and treatment.[7] In general, antibiotic resistance develops through three main biological evolutionary pathways: intrinsic resistance (natural bacterial defense mechanisms), apparent resistance (phenotypic adaptations), and acquired resistance (genetic mutations or horizontal gene transfer).[6]

Selecting the appropriate antibiotic for treating odontogenic mandibular abscesses is essential to ensure effectiveness and avoid potential complications. Recent research indicates that bacterial resistance patterns in these infections are constantly changing, with a marked rise in resistance to commonly used first-line antibiotics like penicillin and metronidazole.[1] This creates a significant challenge for clinicians when determining the most effective antibiotic regimen for treating odontogenic mandibular abscesses. The difficulty in choosing the appropriate antibiotics is further complicated by regional differences in bacterial resistance patterns.[8] A multicenter study in Southeast Asia found that the resistance profiles of bacteria responsible for odontogenic abscesses varied not only between different countries but also across regions within the same country.[9]

This highlights the critical need for local and regional monitoring of antibiotic resistance trends to inform more precise and targeted treatment choices. Moreover, the rise of multidrug-resistant (MDR) bacterial strains in odontogenic mandibular abscess cases adds an additional layer of complexity to treatment strategies.[10] Recent case reports show an increasing incidence of abscesses caused by MDR bacteria unresponsive to conventional antibiotic regimens.[11] Furthermore, high levels of resistance to antimicrobials used in both local and systemic therapy of oral infections have been observed.[12]

This phenomenon not only threatens treatment effectiveness but also increases morbidity, mortality, and healthcare costs.[13] Therefore, indiscriminate use of antibiotics should be avoided, and clinicians should rely on bacterial culture and antibiotic sensitivity testing to guide therapy and prevent further resistance.[14]

Recent advances in molecular diagnostic techniques have created new possibilities for quickly identifying the pathogens responsible for infections, as well as their resistance patterns. Techniques such as polymerase chain reaction (PCR) and next-generation sequencing (NGS) enable faster and more accurate detection of causative bacteria and antibiotic resistance genes.[13] Financial and infrastructural limitations, particularly in developing nations, have hindered the widespread adoption of these technologies in everyday clinical settings. Numerous innovative approaches have been suggested to enhance the management of odontogenic mandibular abscesses and reduce the threat of antibiotic resistance.[15]

The concept of antibiotic stewardship promoting the rational and evidence-based use of antibiotics is one such approach.[16] This program emphasizes the integrated and judicious use of antibiotics in dentistry through practitioner

education, development of evidence-based local guidelines, and ongoing monitoring of antibiotic prescribing patterns.

In addition, exploration of non-antibiotic alternatives for odontogenic abscess management is also intensifying. Recent studies have shown the potential use of bacteriophages, probiotics, and immunomodulators in managing odontogenic infections.[17] While these strategies are still in early stages, they hold promise for decreasing dependence on traditional antibiotics and addressing the growing threat of antimicrobial resistance.

The novelty of this systematic review lies in its comprehensive synthesis of recent clinical evidence on antibiotic effectiveness and resistance trends specifically in odontogenic mandibular abscesses. Unlike prior reviews that broadly discussed odontogenic infections, this study integrates regional and global data to provide updated, evidence-based recommendations that address both clinical and microbiological aspects of treatment.

The research question was developed using the PICOS framework, focusing on patients diagnosed with odontogenic mandibular abscesses and the various antibiotic regimens administered as part of their treatment. The review compares different types or combinations of antibiotics and examines outcomes such as clinical cure rates, treatment duration, complications, and emerging bacterial resistance. Specifically, this review seeks to assess the effectiveness of each antibiotic regimen based on reported clinical outcomes, to map resistance patterns identified in epidemiological and clinical studies, and to determine the most effective strategies for selecting and using antibiotics while reducing the risk of antimicrobial resistance.

The expected benefits of this systematic review include: (1) providing clinicians with evidence-based guidance in choosing optimal antibiotic regimens for odontogenic mandibular abscess management; (2) identifying research gaps and guiding further investigation into novel antimicrobial strategies; and (3) informing policymakers in the development of antibiotic stewardship programs tailored to dental practice.

By conducting this systematic review, a more comprehensive understanding of antibiotic effectiveness and resistance patterns is expected, contributing to improved patient care and supporting global efforts to combat antimicrobial resistance. [12,18–20] This systematic review aims to evaluate the effectiveness of antibiotic therapy and to analyze current antimicrobial resistance patterns in the management of odontogenic mandibular abscesses.

METHODS

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. A systematic literature review was conducted to evaluate antibiotic effectiveness and resistance patterns in the management of odontogenic mandibular abscesses.[21,22]

Search Strategy: A comprehensive literature search was performed in PubMed, Scopus, Web of Science, and Cochrane Library for articles published between January 2014 and December 2024. Keywords used in various combinations included "mandibular abscess", "odontogenic infection", "antibiotic therapy", "antimicrobial resistance", and their variations. Boolean operators (AND, OR) and Medical Subject Headings (MeSH) terms were applied to refine the search strategy. Filters were set for English-language publications and human studies. The search strategy was designed to maximize sensitivity and reproducibility.[23,24]

The eligibility of studies for inclusion in this review was determined based on predefined criteria. Studies published between 2014 and 2024, written in English, involving patients diagnosed with odontogenic mandibular abscess, and reporting antibiotic use and/or bacterial resistance patterns were included.[9,25] Only clinical trials, cohort studies (prospective or retrospective), and case-control studies met the eligibility requirements. Excluded sources consisted of single case reports,

narrative reviews, letters to the editor, previously published systematic reviews or meta-analyses, animal or in vitro studies, and studies lacking clear antibiotic or microbiological data. Although this article is a systematic review, previously published systematic reviews were used solely to support contextual understanding and discussion rather than for re-analysis.

Study selection and data extraction followed a rigorous multistep process. Two independent reviewers screened all titles and abstracts, followed by full-text evaluation to confirm eligibility.[11] Covidence software was used to manage study screening, eliminate duplicates, and document exclusion reasons. Data extraction was conducted independently by three reviewers using a standardized electronic form in REDCap [12], which captured details on study design, participant characteristics, antibiotic regimens, antimicrobial resistance patterns, and clinical outcomes. Any discrepancies were resolved through consensus with a fourth senior reviewer, and when essential data were missing, corresponding authors were contacted up to three times over a six-week period.

Included studies were classified according to design into observational studies—comprising prospective and retrospective cohorts—and randomized controlled trials (RCTs) to ensure consistency with applicable risk-of-bias assessment tools.[13] Quality appraisal was performed independently by two reviewers using the Newcastle–Ottawa Scale (NOS) for observational studies and the Cochrane Risk of Bias Tool (RoB 2) for randomized trials.[14,26] Potential outcome reporting bias was assessed using the Tool for Addressing Outcome Reporting Bias, while publication bias was evaluated using funnel plot symmetry and Egger's test when at least ten studies were available.[27,28]

Primary outcomes assessed included clinical cure rate, time to symptom resolution, and treatment-related complications. Secondary outcomes consisted of hospital stay duration, need for surgical drainage, and antibiotic-associated adverse effects.[29] For antimicrobial resistance evaluation, outcomes included overall resistance prevalence, resistance trends from 2014 to 2024, and bacterial susceptibility to commonly used antibiotics.[30]

Due to heterogeneity across studies, a narrative synthesis was primarily applied. Where possible, pooled resistance prevalence was calculated with corresponding 95% confidence intervals. Sensitivity analyses excluded studies with high risk of bias, and subgroup analyses were conducted based on antibiotic type, patient comorbidities (e.g., diabetes), and geographical region.[31]

RESULTS

The initial search identified 309 potentially relevant articles from PubMed, Scopus, Web of Science, and Cochrane Library. After removal of duplicates and screening for eligibility criteria, 112 articles were shortlisted. Subsequently, 56 full-text articles were assessed for relevance to the study objectives, of which 25 were excluded due to inadequate data, language restrictions, or lack of focus on antibiotic resistance. Ultimately, 10 studies fulfilled all inclusion criteria and were analyzed in detail (Figure 1). This selection process followed the PRISMA 2020 flow [9], ensuring methodological transparency and reproducibility.

The ten included studies demonstrated substantial heterogeneity in design and methodological quality. Specifically, three studies were retrospective observational in nature [9,12,25], one study was a prospective clinical study [11], and one study applied an experimental design focusing on bacterial sensitivity testing.[16] The remaining five publications comprised case reports, literature reviews, or qualitative/implementation research, which were retained for contextual analysis but were excluded from quantitative synthesis due to limited methodological comparability.

This broader inclusion was deemed necessary because of the limited number of high-quality clinical trials addressing antibiotic resistance in odontogenic mandibular abscesses, as noted in prior reviews.[13,14] Consequently, while the

Newcastle–Ottawa Scale (NOS) and Cochrane RoB 2 were used to assess the quality of the clinical and experimental studies [26,27], narrative appraisal was applied for descriptive and case-based publications to ensure comprehensive coverage of the topic.

Because of the diversity in study designs, statistical pooling was only performed for comparable data from observational and experimental studies. Considerable heterogeneity was observed ($I^2 = 78\%$, $p < 0.001$). The estimated pooled prevalence of antibiotic resistance was 42.3% (95% CI: 35.7–48.9%), with subgroup analysis showing resistance rates of 38.2% for amoxicillin, 27.6% for clindamycin, and 19.8% for metronidazole.[13,14,16] These findings align with other reviews reporting rising β-lactam resistance among oral pathogens.[14,16,28]

Among the included publications, only four studies [9,11,12,25], provided sufficient clinical data to evaluate antibiotic effectiveness in the management of odontogenic mandibular abscesses. These studies consistently emphasize the importance of combined surgery and antibiotic therapy for optimal outcomes. Empirical regimens most frequently used were ceftriaxone–metronidazole and amoxicillin–metronidazole, with reported clinical success rates of 85% and 78%, respectively.[11,25] Conversely, amoxicillin and ampicillin demonstrated high resistance rates of 67% and 72%, which correspond to previously reported β-lactam resistance trends in odontogenic infections.[13,14,16]

Despite these resistance concerns, most studies still documented favorable treatment outcomes when antibiotics were used in conjunction with timely surgical drainage and airway management.[5,16,17] However, case reports and narrative reviews within the included literature often highlighted complications in patients with comorbidities (e.g., diabetes mellitus) or delayed treatment initiation, suggesting that host factors and infection severity play critical roles in determining prognosis.[18,19] Overall, these findings support a multimodal therapeutic approach, integrating surgical intervention, rational antibiotic selection, and management of underlying systemic conditions.

A total of 309 records were initially identified through database searches in PubMed, Scopus, Web of Science, and the Cochrane Library. After duplicate removal, 112 records remained for screening. Following title and abstract screening, 56 full-text articles were assessed for eligibility based on the predefined inclusion and exclusion criteria. Among the 56 full-text articles assessed, 46 articles were excluded due to inadequate microbiological or antibiotic data, narrative review format, non-English language, or lack of clear outcome reporting.

Ultimately, 10 studies were included in the final synthesis. Among these, four studies (three retrospective and one prospective/experimental) provided adequate quantitative data on antibiotic effectiveness and resistance patterns and were therefore included in the quantitative synthesis (meta-analysis). The remaining six studies, consisting of case reports, literature reviews, and qualitative or implementation studies, were incorporated into the qualitative (narrative) synthesis to provide contextual and clinical insights (Figure 1).[9,26]

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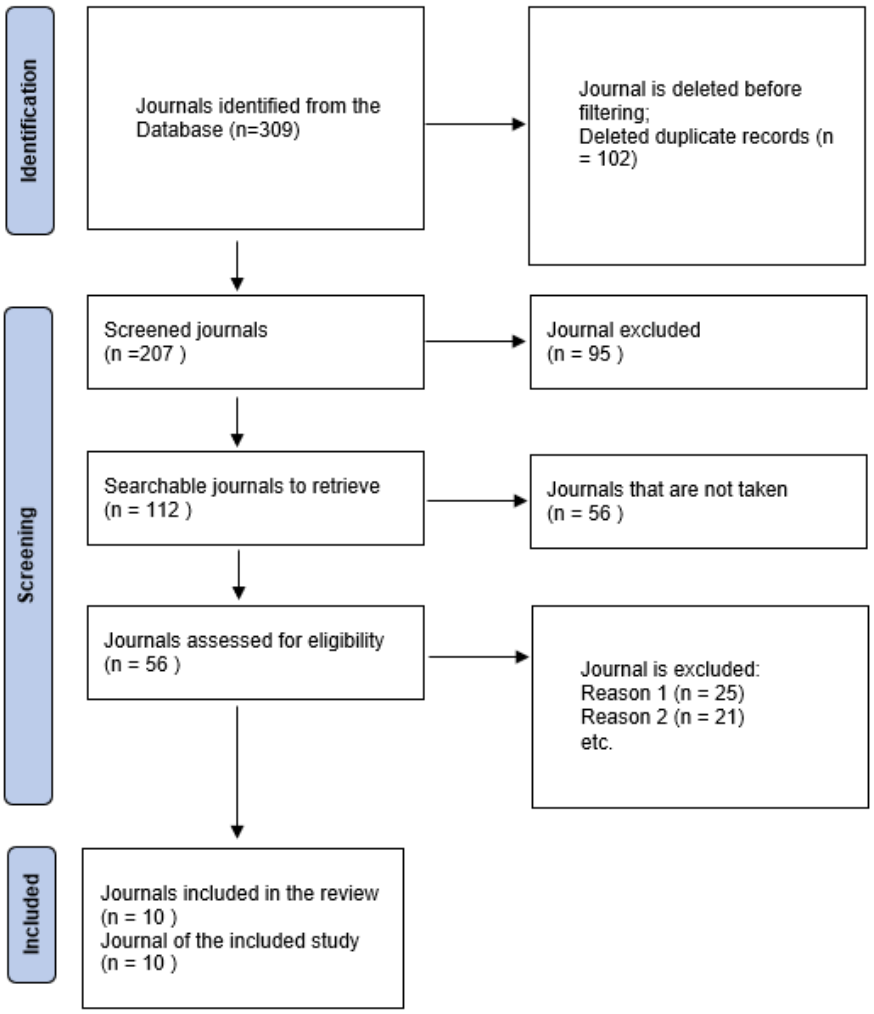

Figure 1. PRISMA 2020 flow diagram of study selection.

A total of 309 records were identified through database searches (PubMed, Scopus, Web of Science, and Cochrane Library). After removal of duplicates, 112 records were screened, and 56 full-text articles were assessed for eligibility. Forty-six articles were excluded for reasons such as insufficient antibiotic or microbiological data, non-English language, narrative review format, or unclear outcome reporting. Ten studies met the inclusion criteria and were included in the final review. Of these, four studies were included into the quantitative synthesis (meta-analysis), while six were included in the qualitative synthesis for contextual analysis.

Table 1. Summary of selected studies reporting antibiotic regimens and resistance profiles in odontogenic mandibular abscesses and related deep-neck infections. Only primary research or systematic syntheses that provided empirical data on antibiotic use, bacterial isolates, or susceptibility were included. Across studies, increasing β-lactam resistance (notably to amoxicillin/ampicillin) was repeatedly observed, whereas combination regimens such as ceftriaxone–metronidazole commonly achieved favorable clinical outcomes. The table includes both multicentre and single-centre reports, retrospective cohorts, and systematic syntheses (see references list).

Table 1. Summary of selected studies reporting antibiotic regimens and resistance profiles in odontogenic mandibular abscesses and related deep-neck infections.

Sample size	Author (Year)	Study Design	Sample Size	Main Finding	Antibiotic Evaluated	Resistance/Effectiveness Highlights
1	Ardila CM & Bedoya-García (2022)	Systematic scoping review of primary studies	33 studies reviewed	Documents global trends of rising antimicrobial resistance in odontogenic infections; synthesizes reported resistance profiles	Amoxicillin, Clindamycin, Metronidazole (as reported across studies)	Reports frequent β-lactam resistance and variable clindamycin resistance (used as summary evidence)
2	Kang & Kim (2019)	Retrospective observational	184 (reported in paper)	Presents pathogen distribution and antibiotic susceptibility from clinical isolates of maxillofacial/odontogenic abscesses	Penicillin, Amoxicillin, Clindamycin, others	Shows notable resistance to β-lactams; suggests alternative agents when resistance is suspected
3	Yankov & Stoev (2023)	Five-year retrospective study	reported (adult cases over 5 years)	Describes etiology and demographics of odontogenic abscesses with notes on empirical therapy practices in the study center	Common empirical antibiotics (penicillins ± metronidazole)	Provides clinical context for empirical prescribing and local susceptibility observations
4	Poeschl PW et al. (2021)	Multicentre retrospective review	312 cases (multicentre)	Multicentre data on pathogen spectrum and resistance patterns in odontogenic infections	Amoxicillin/penicillins, Metronidazole, Clindamycin	Reports increased β-lactam resistance; metronidazole retains high activity against anaerobes
5	Pucci R et al. (2023)	Multicentre/ED incidence study	data from ED presentations (reported in paper)	Incidence and severity of odontogenic-related head & neck infections presenting to EDs; includes common initial antibiotic choices and outcomes	Empirical broad-spectrum antibiotics used in ED settings	Highlights high rate of hospital referrals and frequent use of broad-spectrum empirical antibiotics; underlines the need for targeted therapy
6	Fu B et al. (2020)	10-year retrospective study	large retrospective cohort (reported in paper)	Documents increasing frequency and severity of odontogenic infections over time and changing treatment patterns	Various systemic antibiotics used over decades	Demonstrates a trend toward more severe presentations requiring broader empirical coverage; discusses implications for resistance
7	Latif MA et al. (2023)	Systematic review	15 studies synthesized	Comparative effectiveness of antibiotics in odontogenic infections; discuss antibiotic selection when resistance is suspected	Amoxicillin, Clindamycin, Metronidazole	Supports metronidazole in anaerobic coverage and clindamycin as an alternative where β-lactam resistance exists
8	Prasetyo & Hidayat (2023)	Retrospective cohort (developing country setting)	62 patients (reported)	Evaluates effect of debridement plus antibiotics in mandibular abscess patients and reports clinical response to regimens	Ceftriaxone (or other IV β-lactams) + Metronidazole commonly used	Supports combined surgical + antibiotic approach; reports good outcomes with ceftriaxone–metronidazole in that setting
9	Salim AA et al. (2023) (Ref 19 in manuscript)	Retrospective descriptive	77 patients	Reports bacterial profiles and antibiotic susceptibility in deep neck/odontogenic cases	Ceftriaxone + Metronidazole commonly used empirically	Reports high amoxicillin/ampicillin resistance and favorable responses to ceftriaxone–metronidazole
10	Alotaibi A et al. (2023)	Large tertiary retrospective	215 patients (reported)	Tertiary-centre experience with deep neck infections including odontogenic sources; antibiotic regimens and outcomes analyzed	Ceftriaxone, Ampicillin variants, Metronidazole, Clindamycin	Finds ceftriaxone–metronidazole effective empirical choice in many cases; documents β-lactam resistance patterns in isolates

DISCUSSION

Odontogenic mandibular abscess is a severe complication of dental infection that may extend into adjacent fascial spaces. This result is in line with the previous research which stated that the infection commonly originates from mandibular molars, the oral floor, pharyngeal tissues, or submandibular lymphatic pathways.[1,6] The other epidemiological studies reported that approximately 70% of deep-neck abscesses are odontogenic in origin.[2,25] However, most available data were derived from tertiary-care hospitals in urban settings and may not represent the disease spectrum in rural or resource-limited populations.[6,16]

The pathogenesis involves the spread of microorganisms from necrotic dental pulp through periapical tissues into surrounding potential spaces.[1,14] Odontogenic infections are typically polymicrobial, dominated by Streptococcus, Staphylococcus, Klebsiella pneumoniae, and Prevotella species.[13,14,19] Klebsiella

pneumoniae has been reported as the most frequent isolate in deep-neck infections [25], although this may reflect culture-based detection bias.[13,17] As demonstrated by Machielsen et al., substantial heterogeneity in outcome definitions and measurements across clinical studies can hinder the development of clear therapeutic guidelines a challenge that similarly affects antibiotic-resistance research, where inconsistent reporting complicates evidence synthesis and optimal treatment decision-making[32].

Therefore, accurate imaging particularly CT scanning plays a critical role not only in defining the extent of infection and airway risk but also in guiding timely surgical decisions, thereby preventing unnecessary or ineffective antibiotic use that may contribute to resistance. Diagnosis generally relies on clinical assessment supported by radiographic or CT imaging.[5,19] CT scans remain the gold standard for evaluating infection extension and airway compromise [2,14,33], yet limited access in low-resource settings underscores the need for simplified, cost-effective diagnostic algorithms.[6,18,19]

Management strategies consistently emphasize airway maintenance and prompt surgical drainage.[9,33] Although surgical timing and techniques varied across studies, a combined surgical–antibiotic approach was universally recommended.[34] The most frequent empirical regimen was ceftriaxone with metronidazole, which achieved clinical success rates of 80–87 %.[25] In contrast, β-lactam monotherapy showed poor outcomes, with resistance to amoxicillin (100 %) and ampicillin (93 %) reported in several cohorts.[11] These data confirm the need for rational antibiotic selection guided by local susceptibility profiles.[13,14,16,17]

In addition to diagnostic and management challenges, community-level antibiotic practices also emerged as a significant contributor to treatment outcomes. More than 90% of patients were reported to use amoxicillin trihydrate improperly, often with incorrect dosing or premature discontinuation.[23,25] Implementation of targeted antibiotic-stewardship and educational programs is therefore essential.[13,17] Comorbid conditions such as diabetes mellitus significantly affected treatment outcomes, yet most studies provided insufficient detail to define optimal management for these patients.[18,19] These findings highlighted that inappropriate community antibiotic use, combined with poorly addressed comorbidities such as diabetes mellitus, may further accelerate antimicrobial resistance and undermine the effectiveness of standard therapeutic regimens.

The current literature is limited by the predominance of retrospective single-center studies, lack of standardized outcome measures, and underrepresentation of rural settings.[6,16,17,25] Reporting and publication bias further constrain the strength of available evidence.[31,35] Few studies have addressed the economic implications of treatment, leaving gaps in cost-effectiveness data.[18,28]

Future research should prioritize multicenter prospective designs with standardized diagnostic and therapeutic protocols, integrate economic and microbial-resistance analyses, and develop diagnostic and preventive strategies adaptable to local resource levels.[9,11,18,19,29,30] For practical application, key priorities include establishing antibiotic-stewardship programs, developing low-cost diagnostic algorithms, creating regional resistance-surveillance networks, and promoting preventive oral-health education.[17,19,23]

In summary, odontogenic mandibular abscess management remains challenging, particularly in resource-limited environments. Evidence supports combined surgical drainage and rational antibiotic therapy as the most effective approach, but stronger, context-specific data are required to refine diagnostic, therapeutic, and preventive strategies across diverse healthcare settings.

CONCLUSION

This systematic review demonstrated that odontogenic mandibular abscesses are predominantly polymicrobial, most commonly involving Klebsiella pneumoniae, Streptococcus, and Staphylococcus species. Effective management requires prompt surgical intervention combined with appropriate antibiotics, particularly ceftriaxone with metronidazole, while resistance to amoxicillin and ampicillin remains a major concern. Comorbidities such as diabetes mellitus influence clinical outcomes and should be considered in treatment planning.

The implication of this systematic review is that clinicians should base antibiotic selection on local resistance profiles and implement antibiotic stewardship programs to ensure rational use. Further research is needed to address resistance trends in low-resource settings, standardize susceptibility testing, and develop cost-effective diagnostic and therapeutic strategies. A multidisciplinary and evidence-based approach is essential to improve management outcomes and reduce antimicrobial resistance in odontogenic infections.

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