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Comprehensive Comparative Analysis of Antibiotic Susceptibility Parameters in Common Oral Infections Particularly Focused on Amoxicillin, Amoxicillin Clavulanate, Tetracycline, Metronidazole, and Clindamycin: An Original Research Study

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ABSTRACT:

Aim: This study aims to compare the analysis of antibiotic susceptibility in oral infections, focused on amoxicillin, amoxicillin clavulanate, tetracycline, metronidazole, and clindamycin.

Materials and Methods: This study examined 80 patients aged 35 to 60 with oral infections, specifically periodontitis and dental abscesses around the left mandibular first molar. Participants had no antibiotic treatment in the past 30 days and showed symptoms of both conditions. Exclusion criteria included recent mouthwash use, systemic diseases, mental instability, pregnancy, and smoking. Informed consent was obtained, and samples were collected using sterile swabs or through incision and drainage. These samples were sent to a microbiology lab for bacterial culture and sensitivity analysis, testing effectiveness against antibiotics like Amoxicillin, Amoxicillin/Clavulanate, Tetracycline, Metronidazole, and Clindamycin.

Statistical Analysis and Results: This study examined 80 patients with oral infections, specifically periodontitis and dental abscesses around the left mandibular first molar, including 44 males and 36 females aged 35 to 60 years. Bacterial susceptibility to key antibiotics—Amoxicillin, Amoxicillin/Clavulanate, Tetracycline, Metronidazole, and Clindamycin—was assessed through sampling. Dental abscesses are mostly involved with facultative anaerobes like Streptococcus and Staphylococcus, while Porphyromonas gingivalis was associated with periodontitis. Amoxicillin and Clindamycin demonstrated a high sensitivity rate of 9.7% for Streptococcus, and Amoxicillin/Clavulanate showed 9.5 %. Tetracycline and Metronidazole had lower sensitivity rates of 89% and 81%, respectively. Statistical analysis via one-way ANOVA provided insights into effective antibiotic treatments for guiding clinical practice.

Conclusion: This study concluded that amoxicillin-clavulanate and clindamycin are most effective against the mixed aerobic and anaerobic bacteria common in these infections, while amoxicillin remains a strong first-line option for milder cases. The choice of antibiotic should be guided by the infection's nature and severity, local resistance patterns, and patient-specific health factors, including allergies.

Introduction

Oral infections encompass a broad spectrum of conditions, ranging from everyday problems such as dental caries (cavities) and periodontal disease (gum disease) to more serious afflictions like odontogenic space infections, which can result in significant swelling and discomfort. These infections are primarily instigated by a variety of pathogens, including bacteria, fungi, and viruses, that disrupt the delicate balance of the oral microbiome, leading to an increase in harmful organisms.[1,2] Furthermore, oral infections do not exist in isolation; they are often intricately linked to systemic

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health issues, including cardiovascular disease and diabetes, highlighting the interconnectedness of oral health with overall bodily health. Effective treatment of these infections typically necessitates professional dental intervention, which may involve procedures such as root canals or surgical drainage to remove the source of infection. Additionally, medications like antibiotics are commonly prescribed to combat bacterial infections and reduce inflammation. Timely and appropriate treatment is crucial to prevent the progression of these infections, as delays can lead to serious complications, such as systemic infections or the spread of bacteria to other parts of the body.[3,4] One prevalent oral disease resulting from multiple microbial agents is dental caries. Fortunately, the incidence and progression of caries have decreased in recent years due to successful population-based prevention strategies. If dental caries progress into the tooth's pulp space, they can lead to pulpitis and subsequently infect the root canal, resulting in tooth necrosis. Periodontal diseases, which affect about 10-15% of the global population in their severe forms, represent a group of infectious inflammatory conditions. Gingivitis, the early stage of periodontal disease, manifests as inflammation in the superficial gingival tissues. If this inflammation escalates to destroy deeper periodontal (tooth-supporting) tissues, it leads to periodontitis, a major cause of tooth loss among adults. Beyond the physical toll, periodontitis significantly affects quality of life and poses a considerable financial challenge to national health systems.[5,6] The formation of polymicrobial oral biofilms on tooth surfaces initiates the inflammatory response that can end up being tissue-destructive. Moreover, the deregulated host response to these biofilms is a critical factor in the development of periodontitis. A well-researched bacterium commonly associated with periodontitis-related biofilms is the Gram-negative anaerobe, Porphyromonas gingivalis. Another bacterium related to periodontitis is Tannerella forsythia, a Gram-negative species with less clearly defined virulence factors.[7] Antibiotic susceptibility in oral infections shows considerable variability, raising growing concerns about resistance to commonly used antibiotics. While some antibiotics, like amoxicillin-clavulanate and clindamycin, are highly effective against many oral pathogens, others may display considerable resistance. Often, the most effective treatment plan requires surgical intervention alongside antibiotic therapy, making susceptibility testing essential for selecting the appropriate drug.[8,9] Key findings from recent reviews highlight that many oral pathogens exhibit high resistance to antibiotics such as clindamycin and metronidazole, with resistance to erythromycin and azithromycin also recorded. Amoxicillin resistance is becoming a concern, particularly with certain strains of Prevotella. On the other hand, amoxicillin-clavulanate is often identified as highly effective against a wide range of oral bacteria, while clindamycin remains a strong option, especially when resistance to amoxicillin is suspected.[10,11] For Gram-negative aerobic bacteria commonly found in oral infections, antibiotics like gentamicin and ciprofloxacin have demonstrated broad effectiveness. Given the rising resistance rates, having a targeted therapy approach is increasingly important; relying solely on empirical treatment can pose significant risks. Thus, antibiotic susceptibility testing is crucial, particularly in cases of severe or resistant infections. When it comes to treatment considerations, amoxicillin-clavulanate is usually the go-to choice for first-line empirical therapy in odontogenic infections. Clindamycin serves as a valuable alternative, particularly for patients with penicillin allergies or suspected resistance. Severe or complicated infections may require a combination of antibiotics, and surgical intervention is often essential for effective treatment. Moving forward, continuous monitoring of antibiotic susceptibility patterns will be vital for adapting treatment guidelines and combating the spread of antimicrobial resistance.[12,13] This study aims to compare the analysis of antibiotic susceptibility in oral infections, focused on amoxicillin, amoxicillin clavulanate, tetracycline, metronidazole, and clindamycin.

Materials and Methods

This comprehensive study examined a cohort of 80 patients who presented with oral infections, specifically classified as periodontitis and dental abscesses. The focus was particularly directed toward infections localised in the region of the left mandibular first molar. The inclusion criteria were meticulously designed to target adults aged 35 to 60 years, encompassing both male and female participants. Critical to the study's integrity, all individuals included had not undergone any form of antibiotic treatment within the prior 30 days and exhibited both dental abscesses and symptoms

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characteristic of periodontitis. Patients were systematically excluded from the study for several reasons: those who had recently used mouthwash within the preceding 24 hours, individuals diagnosed with systemic diseases that could complicate infection management, patients with any form of mental instability, pregnant women due to potential risks associated with antibiotic use, and smokers, whose habits could interfere with healing and treatment outcomes. Before the initiation of any clinical procedures or evaluations, informed consent was secured from all participants, ensuring they understood the study's purpose, procedures, and any potential risks. To evaluate the susceptibility of bacteria to antibiotics in cases of oral infections, meticulous attention was given to the collection of samples from infected regions in a total of 80 patients. This process involved using sterile swabs to gently extract pus and necrotic tissue from intraoral sites, such as dental abscesses and other lesions. In certain cases, more invasive techniques like incision and drainage were employed to gather the necessary specimens. Once collected, these samples were swiftly transported to a microbiology laboratory for comprehensive bacterial culture and sensitivity analysis. In the laboratory, the specimens were cultured in nutrient-rich media—primarily using agar plates specifically designed to foster robust bacterial growth. The skilled technicians placed the samples into these richly prepared environments, ensuring optimal conditions for bacterial proliferation. Subsequently, a carefully selected panel of antibiotics was introduced to the cultures, enabling the assessment of each antibiotic's efficacy in inhibiting bacterial growth. From these laboratory procedures, each antibiotic tested was systematically categorised based on its effectiveness against the bacteria, resulting in classifications of susceptible, resistant, or displaying intermediate susceptibility. This classification was vital for shaping personalised treatment strategies tailored to the individual pathogen profiles of the patients. The process of sample collection was meticulous; the sterile swab was delicately manoeuvred to extract the infected material, capturing the essence of the bacterial presence. Once the samples were cultured, antibiotic-impregnated paper discs were strategically placed onto the surface of the agar plates. These plates were incubated overnight, allowing time for optimal bacterial growth while providing the conditions necessary for evaluating the antibiotics' effectiveness and interpreting the results involved measuring the size and presence of zones of inhibition surrounding each antibiotic disc. A distinct, clear zone indicated that the bacteria were susceptible to the antibiotic tested, demonstrating its potential effectiveness. Conversely, the absence of a clear zone suggested resistance, indicating that the antibiotic would be ineffective against that particular strain of bacteria. Additionally, smaller zones of inhibition hinted that while the antibiotic might show some efficacy, it would likely require higher dosages to achieve the desired therapeutic effect. Bacterial cultures obtained from both dental abscesses and periodontitis cases in the study population enabled a thorough assessment of antibiotic susceptibility patterns, particularly focusing on key agents, including Amoxicillin, Amoxicillin/Clavulanate, Tetracycline, Metronidazole, and Clindamycin. Ultimately, this study aims to provide a nuanced understanding of antibiotic susceptibility patterns in oral infections, with a concentrated and detailed analysis of these specific antibiotics to inform clinical decision-making and optimise treatment regimens.

Statistical Analysis and Results

In this study, for comparisons involving antibiotic resistance profiles, we applied the paired Student's t-test to evaluate differences between resistance and sensitivity, resistance-resistance, and sensitivity-sensitivity among the strains tested. Additionally, the one-sample Student's t-test was utilised, applying thresholds of greater than 25% for resistance and less than 75% for sensitivity. This methodology is particularly effective for comparing proportions across distinct groups, allowing for an in-depth examination of categorical data and ensuring that our results accurately reflect the trends and relationships present in the dataset.

Results

This extensive study focused on a cohort of 80 patients who were experiencing oral infections, specifically periodontitis and dental abscesses localized around the left mandibular first molar. The demographic makeup of the participants included a balanced mix of adults aged between 35 and 60 years, with a total of 44 males and 36 females. This information is meticulously outlined in Table 1, which breaks down the age and gender

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demographics of the contributing patients in detail. Additionally, Graph 1 provides a visual representation of patient distribution alongside relevant context to better understand the population studied. In assessing bacterial susceptibility to various antibiotics used to treat these oral infections, a rigorous sampling protocol was followed. Infected regions were carefully identified and sampled, ensuring that the bacterial cultures obtained from both dental abscesses and cases of periodontitis were as accurate as possible. This allowed for a thorough investigation into the antibiotic susceptibility patterns of the isolated bacterial strains. The study concentrated on several key antibiotics essential for treating such infections: Amoxicillin, Amoxicillin/Clavulanate, Tetracycline, Metronidazole, and Clindamycin. Each antibiotic was evaluated for its effectiveness against the isolated bacterial strains, and the results were classified into three categories: susceptible, resistant, or exhibiting intermediate susceptibility. Table 2 provides a comprehensive bacteriological analysis of the microbial ecosystems typically associated with dental abscesses and periodontitis. The results indicated that dental abscesses were predominantly characterised by the presence of facultative anaerobic bacteria, including species such as Streptococcus and Staphylococcus, alongside obligate anaerobes like Fusobacterium and Prevotella. In contrast, periodontitis was particularly associated with Porphyromonas gingivalis, which is known for its role in periodontal diseases. The following tables present detailed antibiotic susceptibility data for each bacterial species involved in the infections. In Table 3, the findings for amoxicillin revealed a remarkably high susceptibility rate, with 87 strains (97%) of Streptococcus showing sensitivity to this antibiotic, while only a minimal amount displayed resistance. Table 4, focusing on Clindamycin, echoed these results, indicating similar high sensitivity rates for Streptococcus, thereby reinforcing Clindamycin's effectiveness in treating these oral infections. When examining the susceptibility to Amoxicillin/Clavulanate, illustrated in Table 5, 85 strains (95%) of Streptococcus exhibited sensitivity, emphasising the antibiotic's role in managing these specific infections. Table 6 presents data on Tetracycline, which showed a susceptibility rate of 80 strains (89%). Lastly, Table 7 details the findings for Metronidazole, indicating that 70 strains (81%) were sensitive, which once again highlighted the lesser degree of resistance observed among Streptococcus species. To encapsulate the results, Table 8 summarises the statistical analysis of the collected data, utilising one-way ANOVA to assess the variations among the studied groups. This analysis provided robust insights into the overall susceptibility patterns within the patient population, allowing for a clearer understanding of which antibiotics are most effective for treating periodontitis and dental abscesses related to the left mandibular first molar. The findings of this study can significantly inform clinical practices and antibiotic prescribing habits for effective treatment outcomes in patients suffering from these common yet challenging oral infections.

Table 1: Age & gender based statistical description of contributing patients

Age Group (Yrs)	Male	Female	Total	P value
35-40	7	9	16	0.03*
41-45	9	6	15	0.40
46-50	5	7	12	0.02*
51-55	14	6	20	0.80
56-60	9	8	17	0.60
Total	44	36	80	*Significant
*p<0.05 significant				

Graph 1: Patients demographic distribution and associated details

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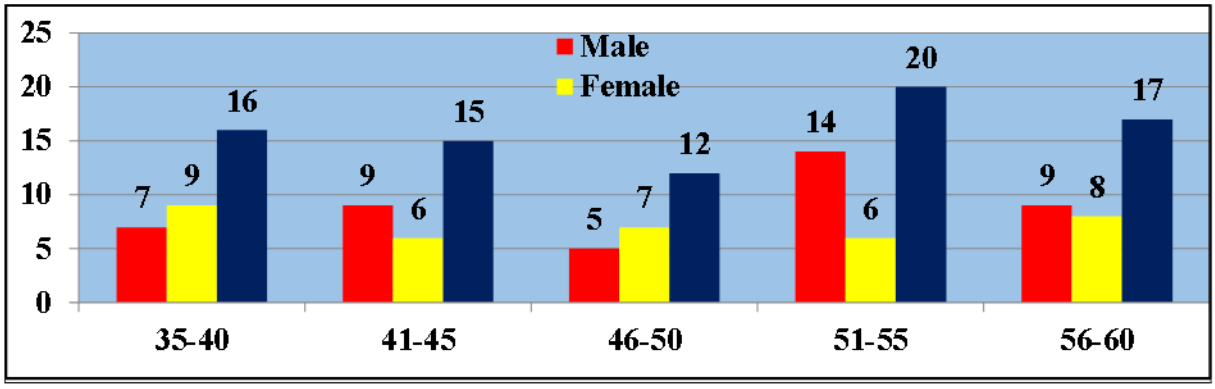

Table 2: A detailed bacteriological analysis of dental abscesses and periodontitis entails a thorough investigation into the diverse microbial ecosystems associated with these two common oral health conditions

Oral infections	Bacteria
Dental abscess	Facultative anaerobes: Streptococcus, Staphylococcus Obligate anaerobes: Fusobacterium species, Prevotella species
Periodontitis	Porphyromonas gingivalis.

Table 3: The following information presents the distribution of amoxicillin antibiotic susceptibility categorised by the specific bacterial species involved, along with the corresponding number of identified strains and their percentages. In this context, "R" denotes resistant strains, "S" indicates sensitive strains, and "I" represents strains with intermediate susceptibility

Antibiotic	Strains	Streptococcus	Staphylococcus	Fusobacterium Nucleatum	Porphyromonas Gingivalis	Prevotella Intermedia
Amoxicillin	R	4(8.5%)	4(8.5%)	3(15%)	2(18%)	2(24%)
	S	87(9.7%)	88(98%)	11(84%)	6(83%)	4(75%)
	I	0	0	0	0	0

Table 4: The following information presents the distribution of clindamycin antibiotic susceptibility categorised by the specific bacterial species involved, along with the corresponding number of identified strains and their percentages. In this context, "R" denotes resistant strains, "S" indicates sensitive strains, and "I" represents strains with intermediate susceptibility

Antibiotic	Strains	Streptococcus	Staphylococcus	Fusobacterium Nucleatum	Porphyromonas Gingivalis	Prevotella Intermedia
Clindamycin	R	4(8.5%)	4(8.5%)	3(15%)	2(18%)	2(24%)
	S	87(9.7%)	88(98%)	11(84%)	6(83%)	4(75%)
	I	0	0	0	0	0

Table 5: The following information presents the distribution of amoxicillin clavulanate antibiotic susceptibility categorised by the specific bacterial species involved, along with the corresponding number of identified strains and their percentages. In this context, "R" denotes resistant strains, "S" indicates sensitive strains, and "I" represents strains with intermediate susceptibility

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Antibiotic	Strains	Streptococcus	Staphylococcus	Fusobacterium Nucleatum	Porphyromonas Gingivalis	Prevotella Intermedia
Amoxicillin Clavulanate	R	5(5%)	5(5%)	4(18%)	3(36%)	3(51%)
	S	85(95%)	85(95%)	10(76%)	5(65%)	3(50%)
	I	0	0	0	0	0

Table 6: The following information presents the distribution of tetracycline antibiotic susceptibility categorised by the specific bacterial species involved, along with the corresponding number of identified strains and their percentages. In this context, "R" denotes resistant strains, "S" indicates sensitive strains, and "I" represents strains with intermediate susceptibility

Antibiotic	Strains	Streptococcus	Staphylococcus	Fusobacterium Nucleatum	Porphyromonas Gingivalis	Prevotella Intermedia
Tetracycline	R	12(15%)	12(15%)	2(10%)	2(18%)	2(2.5%)
	S	80(89%)	80(89%)	12(14%)	6(80%)	3(70%)
	I	0	0	0	0	0

Table 7: The following information presents the distribution of metronidazole antibiotic susceptibility categorised by the specific bacterial species involved, along with the corresponding number of identified strains and their percentages. In this context, "R" denotes resistant strains, "S" indicates sensitive strains, and "I" represents strains with intermediate susceptibility

Antibiotic	Strains	Streptococcus	Staphylococcus	Fusobacterium Nucleatum	Porphyromonas Gingivalis	Prevotella Intermedia
Metronidazole	R	19(22%)	19(22%)	2(70%)	5(56%)	4(3.5%)
	S	70(89%)	70(89%)	5(26%)	3(70%)	2(20%)
	I	0	0	0	0	0

Table 8: Estimation amongst all studied groups using one-way ANOVA

Variables	Degree of Freedom	Sum of Squares ∑	Mean Sum of Squares m∑	F	Level of Sig. (p)
Between Groups	6	3.540	2.437	1.6	0.02*
Within Groups	21	2.244	2.123	_	
Cumulative	126.28	26.04	*p<0.05 significant		

Discussion

Syrjänen S et al reviewed in their study that the oral cavity functions as a distinct ecological niche within the human body, establishing a direct link between the digestive and respiratory systems. The complex and diverse endogenous microbiota in this region is collectively termed the oral microbiome. Among the various oral infections, several warrant particular attentions. Dental caries is the most widespread condition globally, resulting from the demineralisation of tooth structure driven by bacterial metabolism. Periodontal disease is a chronic inflammatory disorder

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that compromises the supporting structures of teeth and can ultimately lead to tooth loss. Odontogenic infections arise from dental tissues or their environs, such as with tooth abscesses, and can propagate to adjacent anatomical spaces. Additionally, opportunistic fungal infections, primarily those caused by Candida species, pose a significant threat to immune-compromised individuals or those with chronic systemic diseases.[14-16] Babeer A et al showed in their study that the aetiology of these infections is multifactorial. Bacterial invasion typically occurs when pathogenic microorganisms breach the dental pulp or gingival tissues. Disruption of the oral microbiome can result from poor oral hygiene, high sugar intake, and tobacco use, fostering an environment conducive to pathogenic overgrowth. Patients with underlying medical conditions, such as chronic illnesses like HIV, cancer, or diabetes, exhibit heightened susceptibility to oral infections. A compromised immune system is also a critical factor, as it is essential in regulating oral microbial populations; thus, individuals with an impaired immune response are at greater risk.[17,18] Sun J et al included in their study that for treatment and management, professional dental intervention is crucial to address the primary infectious focus, often requiring specific procedures. Antibiotic therapy is typically integral to the treatment regimen to curb bacterial proliferation, with commonly employed combinations like penicillin and metronidazole being standard practice. In the case of abscesses, drainage of purulent material is a key intervention to resolve the infection. Effective management of severe oral infections often necessitates an interdisciplinary approach, involving coordinated efforts among dentists, medical physicians, and various specialists.[19] Kullar R et al reviewed in their study that delaying treatment can precipitate significant complications. Infectious processes may extend into adjacent deep neck compartments, potentially resulting in serious states such as retropharyngeal or parapharyngeal abscesses. Ludwig's angina is another ominous and rapidly progressing infection that can arise within the submandibular space. If untreated, these infections can yield systemic and life-threatening complications, including septicemia, meningitis, or necrotising mediastinitis.[20] Rajendra Santosh AB et al showed in their study that in the field of dentistry, the systemic use of antibiotics is relatively constrained. This is primarily due to the effectiveness of optimal oral hygiene practices, which include the use of topical antiseptics, localized application of antibiotics, and various surgical interventions. These methods are generally superior for addressing the majority of dental and periodontal conditions. When antibiotics are employed prophylactically in dentistry, they typically consist of specific short-term, broad-spectrum agents like amoxicillin, metronidazole, and clindamycin.[21] Janket SJ et al reviewed in their study that antibiotics play a crucial role during dental procedures when managing various infections, which can be categorised into prophylactic, localised, focal, odontogenic, and non-odontogenic types. Odontogenic infections, the most common among these, adversely affect the structures of the teeth and gums, often presenting as dental caries, pericoronitis, periodontitis, pulpitis, or even pulpal necrosis. In contrast, non-odontogenic infections originate from surrounding non-dental anatomical structures, such as the mucous glands or tongue. These infections have the potential to escalate into severe conditions that may invade deeper anatomical spaces, leading to significant complications and, in some cases, even resulting in mortality.[22,23] Spellberg B et al included in their study that certain dental procedures carry a heightened risk of triggering infections, especially in patients who are already vulnerable. These procedures include tooth extractions, surgical interventions for periodontal disease, the placement of dental implants, tooth re-implantation, endodontic surgeries, as well as the placement of subgingival antibiotic fibres and administration of intraligamental local anaesthetic injections. Given the increased likelihood of infections during these interventions, the use of antibiotic prophylaxis may be necessary to mitigate the risk of complications, whether they arise from dental sources or from other adjacent structures.[24,25]

Conclusion

In this study, the authors evaluated antibiotic susceptibility in oral infections, specifically focusing on amoxicillin, amoxicillin-clavulanate, tetracycline, metronidazole, and clindamycin. The findings indicate that both amoxicillin-clavulanate and clindamycin demonstrate superior efficacy against the mixed aerobic and anaerobic bacterial populations typically encountered in oral infections. Amoxicillin, in isolation, serves as a robust first-line therapeutic option for less

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severe cases. The selection of an appropriate antibiotic should be guided by the nature and severity of the infection, prevailing local resistance patterns, as well as the patient's individual health profile, including any allergies. These findings highlight the necessity for further research to clarify the mechanisms underlying these outcomes and to enhance clinical practice in the fields of oral medicine and radiology moving forward.

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