Original Article

Microbiological profile of aerobic and anaerobic bacteria and its clinical significance in antibiotic sensitivity of odontogenic space infection: A prospective study of 5 years

ABSTRACT

Introduction: Odontogenic infections are mixed aerobic-anaerobic microbial flora. Infections caused by anaerobic bacteria are serious and life-threatening. The microbial specificity in odontogenic infections is technique sensitive depending on the sampling and culturing of specimens.

Materials and Methods: A prospective study was carried out on 100 consecutive cases of odontogenic infections treated at our institute over a period of 5 years by surgical intervention and intravenous antibiotics. This study evaluates the pathogenic potential and virulence factors of aerobes and anaerobes as well as its synergistic interrelations with other infectious flora, by culturing of specimens and testing antibiotic sensitivity in standard microbiological methodology in correlation with patient demographic factors.

Results: Of the 100 patients of odontogenic space infection, males were more affected, between third and fourth decades. Caries is the most common etiology with involvement of mandibular molars. Submandibular and buccal space is commonly involved. The most common microorganisms isolated being *Staphylococcus aureus* and *Streptococcus viridans* are facultative anaerobes which belong to aerobes and *Peptostreptococcus* predominated among obligate anaerobes. The empirical antibiotic regimen followed is amoxicillin plus clavulanic acid with Metronidazole, followed by surgical treatment. Clindamycin was preferred as the second line of choice in patients resistance to penicillin drugs with comparable efficacy in it.

Conclusion: Our study expanded the knowledge base of the microbial flora associated with odontogenic infections, with special reference to anaerobes. Successful management of odontogenic space infection lies in decompression, removal of etiological factors, and also in selecting appropriate antimicrobial therapy depending on microbial flora isolated, for recovery of patients and preventing complications associated with fascial space infection.

Keywords: Culture and antibiotic sensitivity, facultative anaerobes, obligate anaerobes, odontogenic space infection

INTRODUCTION

The oral cavity is a source of multiple anatomic microniches where the physicochemical of microorganisms result in a complex microbiota. The oral cavity is a reservoir of unique and selective microbial composition that many organisms commonly isolated from neighboring ecosystems, such as the gut and the skin, are not found in the mouth. The oral microbiome is formed by a wide range of Gram-positive and Gram-negative bacteria species which includes obligate anaerobe (metabolize energy anaerobically and are killed by a normal atmospheric concentration of oxygen) and facultative

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anaerobe (obtain energy from aerobic respiration if oxygen is present but is capable of switching to fermentation or anaerobic respiration in the absence of oxygen).[1]

Oral anaerobic bacteria cause several types of infections including periodontitis, ulcerative gingivitis, pericoronitis, dental abscess and cellulitis, and sometimes life-threatening. Bacteria carried by blood in gingival sulci and pockets can infect and may cause bacteremia and septicemia. Polymicrobial anaerobic infections contain organisms such as *Actinomyces spp, Bacteroides spp, Capnocytophaga spp, Eubacterium spp, Fusobacterium spp, Lactobacillus spp, Peptostreptococcus spp, Peptococcus spp, Propionibacterium*, and *Veillonella spp.*[2] Identification of microbiology profile is useful in providing the preliminary information indicating the presence of anaerobes and the change in therapy while the patient is undergoing the treatment. It also helps in establishment of etiologic agents or toxins responsible for specific diseases and confirming the treatment drug which has *in vitro* activity against important pathogens.

The odontogenic infections are complex with the involvement of various fascial spaces, it takes several days for the infection to resolve in spite of appropriate treatment. Although penicillin was considered the long-awaiting panacea for dental infection, the bacteriological spectrum of the oral flora and the understanding of its complexities have undergone rapid evolution since penicillin was introduced, microorganisms are still a step ahead. The newer and more potent antibiotics too have faced a stiff resistance.[3]

In view of the above situations, this study is to emphasize the detection of pathogenic microorganisms which include facultative anaerobes and obligate anaerobes by microbiological examination and culture of specimens, thereby representative of the infection, so the importance of early and correct diagnosis of infections results in prompt treatment and supportive care.

MATERIALS AND METHODS

Source of data
Hundred patients of odontogenic space infections reported to the department of oral and maxillofacial surgery of our institution from November 2014 to December 2019 were analyzed, irrespective of age and sex included in the study group after obtaining the approval from institutional ethical committee.

Inclusion criteria
Inclusion criteria included maxillofacial infections of odontogenic origin which have to be treated with extraction and incision and drainage.

Exclusion criteria
Exclusion criteria included immunocompromised (systemic disease or metabolic disorder, congenital defects or primary immunodeficiencies, iatrogenic and social factors), pregnancy, and history of allergy to any drugs.

Sample collection and processing in microbiology laboratory
Sample collection
The puncture site was disinfected with 70% isopropyl alcohol and then with a 10% solution of povidone-iodine solution. The disinfectant was allowed to dry prior to collection of samples. Under aseptic conditions, the aspiration was performed from the deepest part of the lesion and about 2.5–4 ml of pus was collected using a 5 ml syringe of 22- to 23-gauge needle. Precaution was taken to express the excess air from the syringe. The needle was removed and discarded in a sharps container, and the cap was replaced with a sterile cap on the syringe to transport the specimen.

The aspirated pus was immediately transported to the department of microbiology within 10 min. One part of the pus was inoculated into brain heart infusion broth (BHI broth) for aerobic organisms and culture and the second part was inoculated into thioglycollate medium for anaerobic organisms and culture. Pus sample was subjected to Gram's stain, aerobic and anaerobic culture, and antimicrobial susceptibility testing. Ethical committee approval and informed consent were obtained.

Methods of aerobic organisms' isolation and culture
The pus sample was inoculated into blood agar, chocolate agar, MacConkey agar, and BHI broth and incubated at 37°C for 18–24 h. After 24 h, the growth was observed, was subjected to Gram's stain, and was identified by standard biochemical reactions. For Gram positive cocci catalase, coagulase, bacitracin, and optochin sensitivity, bile esculin was done andfor Gram negative bacilli the following biochemical tests were done for the identification which includescatalase, oxidase, motility, IMViC, triple sugar iron, urea hydrolysis test, Hugh–Leifson's Oxidative Fermentative test, nitrate reduction test, sugar fermentation tests, amino acid decarboxylase and dihydrolase test and X and V Factor test.If no growth was observed in the first culture, subcultures from BHI broth were made on blood agar and MacConkey's agar and incubated at 37°C for 18–24 h and growth was observed.[4]

Methods of anaerobic organisms' isolation and culture
For anaerobic culture, the pus sample was inoculated into anaerobic blood agar and laked kanamycin-vancomycin blood agar (LKV). The plates were kept in HiAnaeroGas Pack in HiMedia GasPAK at 37°C for 48–72 h. If no growth was

observed in the first culture, subcultures were made from thioglycollate medium on anaerobic blood agar and plates were in GasPAK and incubated at 37°C for 48–72 h and then growth was observed. Pseudomonas aeruginosa was kept in anaerobic GasPAK as control. The growth was seen after 48 h, which was subjected to Gram stain and was identified by standard biochemical tests.[4]

Peptostreptococcusspp was identified based on the Gram stain showing large Gram positive cocci in pairs and chains, colony morphology, and biochemical reactions include catalase, indole production, urease production, and glucose fermentation.[4]

Actinomycesspp was identified based on Gram stain showing long filamentous Gram positive bacilli with sulfur granules, colony morphology, and biochemical reactions include catalase, aerotolerance, indole production, urease, nitrate reduction, esculin, and gelatin hydrolysis.[4]

Bacteroidesspp was identified based on colony morphology and the biochemical tests include Catalase, Growth on 20% Bile (Bacteroides Bile Esculin Agar [BBE agar]), Indole production, Esculin hydrolysis, Lipase production and fermentation of sugars like arabinose, rhamnose, salicin, trehalose and susceptibility to antibiotics like Penicillin (2 U Disk), Rifampicin (15 μg), Kanamycin (1 μg) and Colistin *(10 μg).*

Porphyromonasspp was identified based on colony morphology and brown to black pigmented colonies and biochemical tests include inhibition of growth on Laked Kanamycin Vancomycin agar, inhibition of growth in presence of 20% bile (BBE agar), Indole production and no fermentation of glucose and susceptibility to antibiotics such as Penicillin (2 U Disk), Rifampicin (15 μg) and Kanamycin (1 μg).[4]

Prevotellaspp. was identified based on colony morphology and pigmentation, biochemical reactions include growth in presence of 20% (BBE agar), Indole production, esculin hydrolysis, lipase production, esculin hydrolysis, gelatin liquefaction, and Sugar fermentation tests like arabinose, lactose, sucrose and salicin and Susceptibility to antibiotics like Penicillin (2 U Disk), Rifampicin *(15 μg),* Kanamycin (1 μg) and Colistin *(10 μg).*

Antimicrobial susceptibility testing
The bacterial isolates found were subjected to antibiotic susceptibility testing by Kirby–Bauer disc-diffusion technique according to Clinical and Laboratory Standards Institute (CLSI) guidelines. For Anaerobic microorganisms-CLSI M11-A8 Document 2012,[5] the antibiotics used are mentioned in

Table 1 and for Aerobic microorganisms-CLSI M100-S22 Document 2014,[6] the antibiotics used are mentioned in Table 2. The results were reported as sensitive, moderately sensitive, or resistant to the different antibiotics.[6] The susceptibility tests were performed for the following drugs.

A detailed preoperative medical history of all patients was recorded. The evaluated parameters included gender, age, site of space infection, dental focus of infection, the length of hospital stay, the antibiotic administered, and microbiologic spectrum. Patients were diagnosed on the basis of clinical examination and radiographic interpretation. Routine hematology investigations were done. Periapical and panoramic X-rays were done to determine the odontogenic focus.

All patients underwent surgical incision (either through extraoral or intraoral approach) and drainage and received intravenous antibiotics for 3 days and later changed to oral antibiotics. The first line of treatment consisted of empirical antibiotic therapy of amoxicillin/clavulanic acid administered as 1000/200 mg (1.2 g) IV twice daily and metronidazole 500 mg/100 ml IV infusion thrice daily. Second line of treatment was intravenous administration of clindamycin 600 mg 8 hourly and was used in patients who failed to improve in 48 h after receiving inhospital treatment with amoxicillin/clavulanic acid and allergic to penicillin. After culture and sensitivity, depending on the clinical course of the disease, appropriate antibiotics were given. The routine treatment also consisted of the administration of analgesics and anti-inflammatory drugs.

Table 1: Antimicrobial susceptibility testing for anaerobes

Gram positive bacteria	Gram negative bacteria
Penicillin G	Gentamicin
Vancomycin	Amikacin
Amoxycillin	Doxycycline
Amoxycillin-clavulanic acid	Metronidazole
Co-trimoxazole	Erythromycin
Cefotaxime	Roxithromycin
Cephalexin	Clindamycin
Levofloxacin	Imipenem

Table 2: Antimicrobial susceptibility testing for aerobes

Gram positive bacteria	Gram negative bacteria
Ampicillin	Gentamicin
Erythromycin	Ceftriaxone
Clindamycin	Ceftazidime
Cefoxitin	Amikacin
Co-trimoxazole	High-level gentamicin
Linezolid	Aztreonam
Tetracycline	Imipenem
Ciprofloxacin	Piperacillin-tazobactam

Specimens for culture and sensitivity tests were procured by aspiration. Extraoral approach was preferred to eliminate contamination with oral flora. However in certain cases where the extraoral approach was not possible, specimens were collected intraorally after proper preparation of the site, by cleaning with antiseptic agent 1% providing iodine solution. The pus sample/specimen was transported immediately to the department of microbiology and the sample was processed by Gram staining, aerobic culture, and anaerobic culture. Ethical committee approval was obtained for the study.

RESULTS

Out of 100 cases of odontogenic space infections, males were predominantly affected (76%) compared to females patients (24%) with the age of patients ranged from 14 to 65 years. The most commonly affected age group was the third and fourth decades (46%).The most common causes of odontogenic infection were caries (62%), pericoronitis (38%), and periodontitis (22%). The most frequently involved teeth were mandibular first molars (36%) followed by third molars (20%), and second molars (18%) [Figure 1].

The most commonly involved space was submandibular followed by buccal space [Figure 2]. Out of 100 cases, pathogens were isolated in 92 cases and 8 cases yielded negative culture because these 8 cases were receiving antibiotic therapy for at least 48 h prior to incision and revealed no growth. One hundred and fifteen isolates were obtained, strict aerobes of 66 (52%), facultative anaerobes of 11 strains (9%), strict anaerobes of 38 (30%), and mixed flora seen as 12 (9%) strains were isolated [Figure 3]. The microorganisms were divided into two broad groups of facultative anaerobes and obligate anaerobes which further constituted Gram-positive cocci and bacilli and Gram-negative cocci and bacilli. Among facultative anaerobes, Gram-positive cocci included *Streptococcus viridans, Staphylococcus aureus, Enterococcus faecalis, and Coagulase negative Staphylococci.* Anaerobic Gram-positive cocci include *Peptostreptococcus anaerobius.* Gram-positive bacilli were *Actinomyces spp* and no Gram-negative cocci were isolated. Gram-negative bacilli consisted of *Prevotella spp, Porphyromonas asaccharolytica, and Bacteroides spp*. Among aerobic and facultative anaerobes, *S. aureus* and *S. viridans* were the most predominant isolates (50.43%), [Figure 4]. Among obligate anaerobes, *Peptostreptococcus spp* predominated and accounted for (23.75%) followed by *Bacteroides spp* and *Prevotella spp* [Figure 5].

Overall resistance to penicillin was 41.5% among obligate anaerobes due to beta-lactamase production. Amoxicillin and clavulanic acid combination proved superior efficacy,
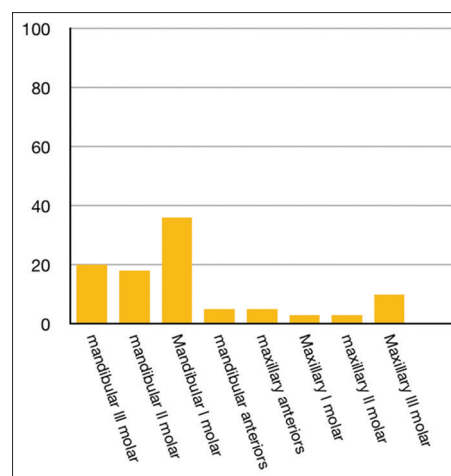

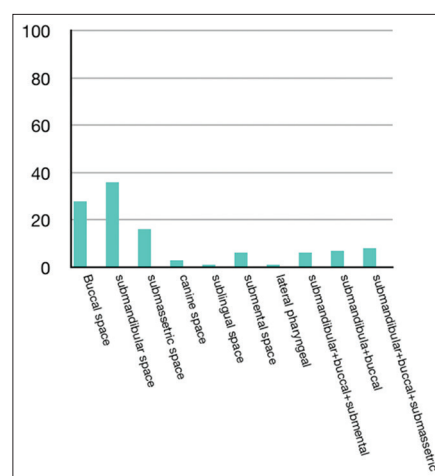Figure 1: Distribution of site in odontogenic space infection

Figure 2: Space involved in Odontogenic space infection
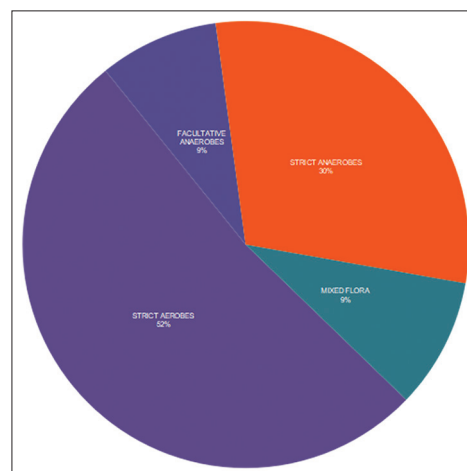

Figure 3: Types of flora isolated in pus sample

as 100% strains were sensitive to it. The results showed very low sensitivity to the macrolide group. Only 26.67% of organisms were found sensitive to erythromycin, which shows less effectiveness toward anaerobic genera isolated
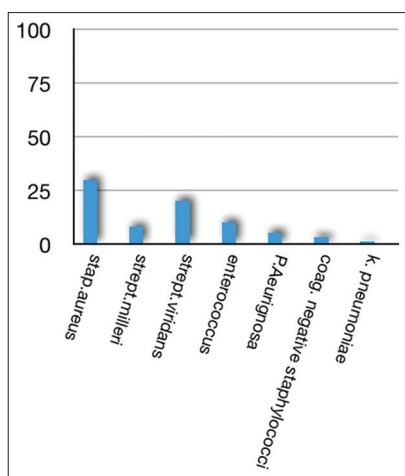
Figure 4: Prevalence of strict aerobes and facultative anaerobes in pus sample
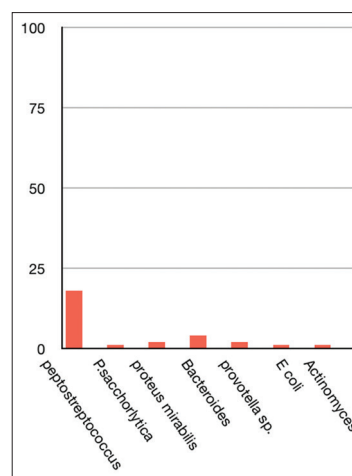

Figure 5: Prevalence of strict anaerobes in pus sample

in our cases. Cefotaxime (third generation Cephalosporin) was found to be highly effective (83% sensitivity).Contrary to belief, ciprofloxacin had 83.33% sensitivity among microorganisms, which is comparable to cefotaxime. *Bacteroides spp* were resistant to erythromycin and gentamicin. Metronidazole is only effective against obligate anaerobes. Clindamycin was preferred as the second line of choice in patients resistance to penicillin drugs with comparable efficacy in it.

DISCUSSION

Odontogenic space infections are mixed aerobic–anaerobic infections. Odontogenic infection occurs due to complex interaction of an array of microorganisms which are noninfective in pure cultures. This connotes that an infectious milieu is created by an interdependent and synergistic metabolism between microorganisms.[3] Presentation of the patient condition is dictated by complex microflora, involved tooth and anatomic routes of spread.[7] Incision and drainage is the primary treatment for sure, but an understanding of the involved microorganisms and sensitivity pattern constitutes an important part of it. Many times even after proper surgical treatment, the patient's condition fails to improve, one of the important reasons for this is resistant bacterial strains and selection of wrong antibiotics. However, laboratory data regarding bacterial profile and antimicrobial susceptibility are crucial information for the clinician who is considering the administration of the antimicrobial therapy. However, it may take several days or even longer to obtain such data. Hence, antibiotics may be chosen empirically.[8]

The incidence of anaerobic microflora in dentoalveolar abscesses for a long period is underestimated owing to a combination of inadequate sampling and transport together with poor laboratory techniques. However, reports based on both aerobic and anaerobic culturing techniques have anaerobic bacteria prevalent in orofacial, head-and-neck infections. Anaerobic bacteria in odontogenic abscess were first isolated by Head and Koss in 1919. On the other hand, Sabiston *et al.* after 1976 onward, by using modern anaerobic culture methods, observed that more than 65% of bacteria isolated were anaerobic which is coinciding with our study.[9]

More recently, Chow *et al.* noted the importance of anaerobic bacteria in orofacial and odontogenic infections. Our study in correlation with the above studies demonstrates that anaerobic pathogens were predictably identified in specimens from orofacial infections that have been properly obtained and transported.[8]

Furthermore, the emergence of clinically significant antimicrobial resistance may complicate the outcome of head and neck infections, the susceptibility patterns of anaerobes have profoundly influenced therapeutic decisions in this context in recent years, with a major impact on the antimicrobial therapy of orofacial odontogenic infections, to summarize guidelines for effective treatment.

Clinical parameters

In our study, 100 patients with orofacial odontogenic space infections were considered. The most commonly involved age group was in the third and fourth decades of life. The mean age group was 35.2 years. This finding is comparable to the age distribution reported by Hunt *et al.*[10] and Virolainen *et al.*[11] Males were more commonly involved than females. This finding can be compared to the sex distribution given by Goldberg *et al.*[12] Mandibular first molars were involved in a maximum number of cases in our study population ($n = 36$), followed by third molars unlike the other studies that have reported the most frequent

involvement of mandibular third molars.[13,14] This might be because it is the first permanent tooth to erupt in the oral cavity and is apparently most susceptible to caries, multiple space infections in this study.

The occurrence of odontogenic infection was attributed to the presence of carious teeth in 66 patients (66%), pericoronitis in 19 patients (19%), and periodontitis in 15 patients (15%) which correlates with the study of Flynn *et al*. who reported caries as the most frequent dental disease leading to severe odontogenic infection (65%), followed by pericoronitis (22%) and periodontal disease (22%).[15]

In the study sample of 100 patients, 86% presented with involvement of single odontogenic space, and 14% presented with involvement of multiple odontogenic spaces, and a total of 107 spaces were involved. In patients with odontogenic infection of single space, submandibular space was most commonly affected (41.8%) followed by buccal (32.55%) space. This finding was similar to the findings of Kim *et al*.[16] and Storoe.[14] In multiples space infection, submandibular + buccal space in nine patients (61.9%) and submandibular + submental space in four patients (38.0%) involved.

All patients were treated by incision and drainage with extraction of offending teeth. Specimens for culture and sensitivity tests were procured by aspiration in airtight syringes and sent for the microbiology department immediately.

Patients generally remain hospitalized until the infection resolves, without any further airway compromise. Storoe and Haug, *et al*. found an average stay of 6.66 days–8.27 days. In our study, the length of hospital stay with a mean range of 6 ± 2 days with a mean duration of 5.5 days for Intravenous antibiotics, followed by oral administration,[17] thrice daily for a week. The mean preoperative mouth opening was 16.2 mm, and a progressive increase in the mouth opening was seen postoperatively with a mean postoperative mouth opening value of 21.52 mm after 3 days. There was a significant decrease in pain on subsequent follow-up. There was no difference in the mean leukocyte count of the patients at the time of admission till discharge.

Second line of treatment was intravenous administration of clindamycin 600 mg 8 hourly and was used in patients who failed to improve in 48 h after receiving inhospital treatment with amoxicillin/clavulanic acid.[11]

Microbiological profile

Odontogenic infections are polymicrobial. The common pathologic sequence is a necrotic pulpal inflammation extending into the periapical area in the form of a dentoalveolar abscess which, if unattended, may penetrate through the cortical bone to involve the potential spaces created by fascial insertions.[18]

According to Finegold, the organisms of greatest importance in mixed polymicrobial infections are those that are most virulent, those that are resistant to commonly employed antimicrobial agents, and those present in greatest numbers. Anaerobic bacteria appear to fulfill all these criteria in odontogenic infection.[8]

Our study revealed 115 isolates or strains from 100 pus specimens. Bacteria were isolated from all except 8 pus samples. Ninety-two samples of patients revealed aerobic and facultative anaerobic flora (59.45%), obligate anaerobic flora (30.46%), and mixed flora (10.09%) in pus culture. Gram-positive cocci (53%) were isolated more compared to Gram-negative bacilli (15%). In aerobic and facultative anaerobe, *S. aureus* (26%) predominated followed by *S. viridans and Klebsiella pneumoniae (%), Streptococcus milleri (17%), Enterococcus spp (8.6%), Haemophilus influenzae (1%), P. aeruginosa (5%), Proteus mirabilis* (2%), and *Coagulase negative Staphylococci (1*%). Obligate anaerobes isolated were Peptostreptococcusspp(16%), Bacteroidesspp (4%), and Prevotellaspp (1%) Actinomycesspp (1%) and Porphyromonasasaccharolytica(2%). The anaerobic organisms isolated from the specimens in our study correlate with the anaerobic organisms isolated from the previous studies conducted by Sabiston in 1974.[9] Studies conducted by Tomari Kuriyama 2000 which reported that a combination of anaerobic Gram-positive cocci and anaerobic Gram-negative bacilli were found in odontogenic infections.

No growth was observed in 8% of cases in our study which could be due to the patient being under antibiotic therapy prior to admission in hospital. The literature articulates that the predominant species are aerobes when swabbing is used to obtain the pus specimen, and aspiration yields the majority of anaerobic rods in culture. In our study, there was a predominance of aerobes even though the specimen was procured via aspiration technique as our patients presented at an early stage could be one of the reasons, as it is seen that in initial stages aerobes predominate and when within a closed space available oxygen is utilized, anaerobes take over.[3]

Antimicrobial susceptibility testing

Penicillin has traditionally been considered the drug of choice for the empiric therapy associated with the emergence of penicillin-resistant organisms in these infections. The mechanism involves a beta-lactamase activity that has

been demonstrated in anaerobic Gram-negative bacilli. The incidence of orofacial odontogenic infections containing beta-lactamase producing bacteria ranges from 13.3% to 38.5%, which can act as "indirect" pathogens by protecting nearby susceptible anaerobic and facultative pathogenic organisms from penicillin therapy.[19]

The isolation of penicillin-resistant *Bacteroides spp* and the growing awareness of the likely importance of strict anaerobes have highlighted the need for reliable information on antimicrobial susceptibility (Heimdahl *et al.,* 1980).[20]

In our study, penicillin showed excellent activity against all aerobic microorganisms (66%) but resistance was seen commonly in anaerobes (41.5%) due to the production of beta-lactamase. Gentamicin and amikacin had the highest percentage of resistance, a finding similar to studies done by Aderhold *et al*.[21] Amoxicillin/clavulanic acid had excellent activity against all 115 strains of both the aerobic and anaerobic pathogens, in our series of a patient making it superior in activity than amoxicillin alone. The addition of clavulanic acid increases the spectrum to *Staphylococcus spp* and other anaerobes by conferring beta-lactamase resistance.[22]

First- and second-generation cephalosporins are very active against aerobic and anaerobic Gram-positive cocci but are unpredictable in their activity against anaerobic Gram-negative bacilli. However, cefotaxime, a third-generation cephalosporin, is characterized by a high level of *in vitro* activity against anaerobic bacteria including mixed flora of dentoalveolar abscesses. Cephalosporins in our experience generally responded well to almost all aerobic and anaerobic Gram-positive cocci organisms isolated except anaerobic Gram-negative rods.

Ciprofloxacin among quinolone groups has been replaced by its advanced versions such as levofloxacin and moxifloxacin these days. Ciprofloxacin has equal efficacy compared to fluroquinolones. In the past, erythromycin was recommended for the treatment of mild odontogenic infections as the antibiotic of the first choice for patients with known hypersensitivity to penicillins. This is no longer valid because of widespread resistance to this drug among oral anaerobes.[14] In our study, erythromycin and gentamicin showed less effectiveness toward the anaerobic genera isolated in these cases. *Bacteroides spp* were resistant to erythromycin and gentamicin.

Metronidazole is only effective against obligate anaerobes. The combination of penicillin with metronidazole adequately covers the microbial flora of odontogenic abscesses and compensates for the limited activity of penicillin against beta-lactamase producing strains of anaerobic bacteria.[20] Furthermore, metronidazole levels in abscess fluid exceed those necessary to kill most obligate anaerobic Gram-negative bacilli. In our study, all facultative anaerobic and strict anaerobic isolates were susceptible to combination therapy of amoxicillin-clavulanate with metronidazole drug therapies.

Clindamycin is a powerful anti-anaerobic agent which is also active against Streptococci and Methicillin-resistant *S. aureus*. Its spectrum of activity includes nearly all the likely pathogens of odontogenic infections, and thus, it represents a useful therapeutic agent for these infections due to its activity against beta-lactamase production by some of the polymicrobial flora and also in penicillin-allergic patients.[23] In addition, it exhibits superior penetration into the jaw bone and abscess cavities, it can be used as monotherapy over metronidazole or as a first-line agent for the treatment of odontogenic space infection on the basis of its excellent clinical efficacy against penicillin-resistant oral anaerobes.[24] In our study in two patients who were resistant to penicillin, clindamycin was used as an alternative drug of choice. A recent study by Tancawan reported that the efficacy and tolerability of amoxicillin/clavulanic acid were comparable to clindamycin in achieving clinical success for the treatment of odontogenic infections.[25]

CONCLUSION

The results of our study clearly indicate that there is a change in pattern as anaerobes, which dominated the bacterial population in contrast to the recent studies. Gram positives were much more in number against Gram-negative organisms. Aerobe and facultative anaerobes found were only Gram-positive cocci, whereas anaerobic population consisted of Gram-positive cocci, Gram-positive bacilli, and Gram-negative bacilli. Most commonly isolated organisms were *Peptostreptococcus spp* of obligate anaerobes and *S. aureus* of facultative anaerobes. Penicillin resistance was within the expected limits as mentioned before.

In the end, it would be apt to state that our study saw a changing trend in terms of predominance of anaerobic bacteria which has expanded the knowledge base of the microbial flora associated with dental infection. Early recognition and meticulous treatment of odontogenic infections by surgical drainage and adjunctive antibiotic therapy are necessary because of the risk of spread along multiple contiguous fascial spaces. The combination of amoxicillin with clavulanic acid is the first-line antibacterial of choice, effective against the majority of microorganisms

responsible for odontogenic infections. Alternatively, the use of clindamycin remains as the second line of treatment because of its broad spectrum of activity and resistance to beta-lactamase degradation in penicillin allergic patients.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Samaranayake L, Matsubara VH. Normal oral flora and the oral ecosystem. Dent Clin North Am 2017;61:199-215.
2. Flynn TR, Shanti RM, Hayes C. Severe odontogenic infections, part 2: Prospective outcomes study. J Oral Maxillofac Surg 2006;64:1104-13.
3. Naim H, Rizvi M, Gupta R, Azam M, Taneja N, Shukla I, *et al.* Drug resistance and molecular epidemiology of carbapenem resistant gram-negative bacilli isolates. J Glob Infect Dis 2018;10:133-9.
4. Forbes BA. Baily And Scott's Diagnostic Microbiology. St. Louis: C.V Mosby; 2000.
5. Clinical and Laboratory Standards (CLSI). Methods for Antimicrobial Susceptibility of Anaerobic Bacteria; Approved Standard – Eighth edition. CLSI Document M11- A8. Wayne, PA: Clinical and Laboratory Standards (CLSI); 2012.
6. Clinical and Laboratory Standards. Performance Standards for Antimicrobial Susceptibility Testing; Twenty Fifth Informational Supplement. CLSI Document M100- S25. Wayne, PA: Clinical and Laboratory Standards; 2015.
7. Topazian RG, Goldberg MH, Hupp JR. Oral and Maxillofacial Infections. 4th ed. Philadelphia: W.B. Saunders; 2002.
8. Kuriyama T, Karasawa T, Nakagawa K, Saiki Y, Yamamoto E, Nakamura S. Bacteriologic features and antimicrobial susceptibility in isolates from orofacial odontogenic infections. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;90:600-8.
9. Sabiston CB Jr., Gold WA. Anaerobic bacteria in oral infections. Oral Surg Oral Med Oral Pathol 1974;38:187-92.
10. Hunt DE, King TJ, Fuller GE. Antibiotic suseptibility of bacteria isolated from oral infections. J Oral Surg 1978;36:527-9.
11. Virolainen E, Haapaniemi J, Aitasalo K, Suonpää J. Deep neck infections. Int J Oral Surg 1979;8:407-11.
12. Goldberg MH, Nemarich AN, Marco WP 2nd. Complications after mandibular third molar surgery: A statistical analysis of 500 consecutive procedures in private practice. J Am Dent Assoc 1985;111:277-9.
13. Flynn TR, Hoekstra W, Lawrence FR. The use of drains in oral and maxillofacial surgery. J Oral Maxillofac Surg 1983;41:508.
14. Storoe W, Haug RH, Lillich TT. The changing face of odontogenic infections. J Oral Maxillofac Surg 2001;59:739-48.
15. Allen D, Loughnan TE, Ord RA. A re-evaluation of the role of tracheostomy in Ludwig's angina. J Oral Maxillofac Surg 1985;43:436-9.
16. Kim MK, Chuang SK, August M. Antibiotic resistance in severe orofacial infections. J Oral Maxillofac Surg 2017;75:962-8.
17. Rega AJ, Aziz SR, Ziccardi VB. Microbiology and antibiotic sensitivities of head and neck space infections of odontogenic origin. J Oral Maxillofac Surg 2006;64:1377-80.
18. Boyanova L, Kolarov R, Gergova G, Deliverska E, Madjarov J, Marinov M, *et al.* Anaerobic bacteria in 118 patients with deep-space head and neck infections from the University Hospital of Maxillofacial Surgery, Sofia, Bulgaria. J Med Microbiol 2006;55:1285-9.
19. Kuriyama T, Karasawa T, Nakagawa K, Saiki Y, Yamamoto E, Nakamura S, *et al*. Past administration of B-lactam antibiotics and increase in the emergence of B-lactamase – Producing bacteria in patients with orofacial odontogenic infections. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;89:186-92.
20. Borthen L, Heimdahl AT, Nord CE. Selective suppression of the anaerobic oropharyngeal microflora with local metronidazole. Br J Oral Maxillofac Surg 1987;25:49-560.
21. Aderhold L, Knothe H, Frenkel G. Bacteriology of dentigenous pyogenic infections. Oral Surg 1981;52:583-7.
22. Shakya N, Sharma D, Newaskar V, Agrawal D, Shrivastava S, Yadav R. Epidemiology, microbiology and antibiotic sensitivity of odontogenic space infections in central India. J Maxillofac Oral Surg 2018;17:324-31.
23. Levimda ME, Eusterman VD. Oral infections and antibiotic therapy. Otolaryngol Clin North Am 2011;44:57-78.
24. Warnke PH, Becker ST, Ingo NG, Haerle F, Ullmann U, Russo PA, *et al*. Penicillin compared with other advanced broad spectrum antibiotics regarding antibacterial activity against oral pathogens isolated from odontogenic abscesses. J Cranio Maxillofac Surg 2008;36:462-7.
25. Tancawan AL, Pato MN, Abidin KZ, Asari AS, Thong TX, Kochhar P, et al. Amoxicillin/clavulanic acid for the treatment of odontogenic infections: A randomised study comparing efficacy and tolerability versus clindamycin. Int J Dent. 2015;1-9.