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Institutional microbial analysis of odontogenic infections and their empirical antibiotic sensitivity

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ABSTRACT

Most purulent orofacial infections are of odontogenic origin. It is well established that odontogenic infections are polymicrobial in nature. Empiric antibiotics were administered before the culture and sensitivity test results were obtained and specific antibiotics were administered based on the culture and sensitivity test results. But resistance was a challenging problem all throughout along with development of more virulent strains of microorganisms which were more infectious and resistant to many known antibiotics.

Objective: To identify the causative aerobic and anaerobic micro-organisms responsible for orofacial infections and to evaluate the resistance against empirical antibiotics used in the treatment of space infections.

Method: 142 patients with head and neck fascial space infections of odontogenic origin were randomly taken, the pus samples and aspirates were collected aseptically from patients for aerobic and anaerobic microbiological study.

Results: In this study the most common aerobic organism isolated was *streptococcus viridians* (34.49%), most common anaerobe was *peptostreptococci,* (61.11%) and the most common mixed organism was *streptococcus with peptostreptococci* (30%). Amoxicillin was the most commonly used empirical drug in all cases and showed highest resistance (96.55%) for all the organisms. But linezolid (100%) was sensitive to all the aerobic, anaerobic and mixed group of organisms. Metronidazole (100%) turned out to be sensitive to the entire anaerobic group. Clindamycin (100%) appeared sensitive to the entire aerobic group.

Conclusion: Knowledge about the pathologic flora involved in head and neck infection in a locality and their sensitivity and resistance to commonly used antibiotics will help the clinician in administering appropriate antibiotics.

1. Introduction

Head and neck space infections are mostly of odontogenic origin[1,2]. The role of bacteria in this was not discovered until the commencement of 20th century.[1] Odontogenic infection varies from periapical abscesses to superficial space and deep neck infection. In addition to systemic toxicity, it also causes advanced complications such as suppurative mediastinal spread, an airway obstruction, mediastinal involvement, pericarditis, arterial erosion, meningitis and extracranial or intracranial extension of infection.[3,4]

It is well established that odontogenic infections are not caused by a single organism; instead they are polymicrobial in nature[1,5–10]. These infections consists of various facultative anaerobes, such as the *Streptococci viridans* group, the *Streptococcus anginosus* group, and strict anaerobes, especially anaerobic cocci, such as *Peptostreptococci, Prevotella, Fusobacterium* species and *Bacteroides*.[1] Empiric antibiotics were prescribed before the culture and sensitivity tests results were obtained and specific antibiotics were selected based on the culture and sensitivity test results.

Resistance can either be inherent or acquired by the processes of genetic mutation or gene transfer.[11] The molecular biology of the antibiotic resistance can be mainly of the following four ways.[11–13] (1)

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Alteration of drugs target site. (2) Inability of the drugs to reach its target. (3) Inactivation of the antimicrobial agents. (4) Active efflux of antibiotics from the cell.[11–13] To cope up with the penicillin resistance, synthetic antibiotics were synthesized; however resistance was developed to these newer synthetic drugs also.[13] The treatment of odontogenic infection is based upon three fundamental elements. (1) Recognition of airway compromise. (2) Surgical intervention, (3) Administration of specific antibiotic.[14]

Culture analysis remains the backbone of clinical practice and the findings of a number of prospective and retrospective studies that give a valuable insight of the bacteria which are often the cause.[1] Microorganisms involved in infections can multiply very rapidly and bacteria can also freely exchange genes by conjugation, transformation and transduction between widely divergent species.[11,12] Indiscriminate use of antibiotics led to the development of more virulent strains of microorganisms which were more infectious and resistant to many antibiotics, hence making the treatment modalities tough. The aims of the study was to qualitatively evaluate different aerobic and anaerobic flora with their antibiotic sensitivity in head and neck space infections of odontogenic origin and also to understand the efficacy of currently used empirical antibiotics in the management of odontogenic infections. Objectives of the study are to identify the causative aerobic and anaerobic micro- organisms responsible for head and neck facial space infections and to evaluate the resistance against empirical antibiotics used in the treatment of space infections.

2. Materials and methods

Around 142 patients with head and neck fascial space infections of odontogenic origin were randomly taken for the study from September 2012 to September 2016. This includes males and females within an age group of 5 to 73 years. Pus samples and aspirates were collected aseptically from patients for aerobic and anaerobic microbiological study. Proper medical, dental and surgical history, clinical signs and symptoms were recorded and relevant investigations were done. All the patients were informed and explained about the details of the study and consent forms were signed from each patient.

2.1. Inclusion criteria

- ❖ Patients with head and neck fascial space infections of odontogenic origin.
- ❖ Patient who had not taken antibiotics for head and neck fascial space infections of odontogenic origin.

2.2. Exclusion criteria

- ❖ Patients who have taken antibiotics randomly for head and neck fascial space infections of odontogenic origin.
- ❖ Patients not willing to participate in the study.
- ❖ Patients with head and neck fascial space infections other than that of odontogenic origin.
- ❖ Patients with negative culture and sensitivity results.

3. Procedure

3.1. Aerobic culture

The site was anesthetized depending on the condition; pus samples were collected both intra and extra orally by transport cotton swab stick (Fig. 1) directly from the site and inoculated into the media plates; nutrient agar medium, blood agar medium and macConkey agar medium. Then these plates were immediately incubated at 37 °C for 24–48 h and were kept ready for observation of colonies (Fig. 2) and further gram staining, biochemical and antibiogram tests.

Fig. 1. Transport medium (Brain heart infusion broth and Transport cotton swab.

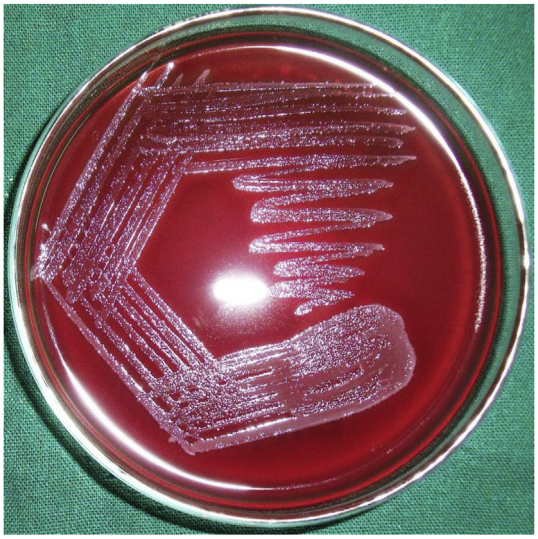

Fig. 2. Streptococcus viridians.

3.2. Anaerobic culture

The pus samples were collected by sterile 18 gauges and 38 mm length needle with 5 ml syringe. The transport medium used in the study was 1.5 ml brain heart infusion broth (Fig. 1). The sample was kept in the incubator without disturbing the anaerobic atmosphere for 24 h. Nutrient agar and blood agar supplemented with hemin and vitamin, macConkey agar and tryptic soy-serum in bacitracin vancomycin agar media plates were prepared and the incubated clinical sample was streaked on to the media plates. The plates were then sealed and placed in the anaerobic jar (Fig. 4) and was then kept in the incubator, under 37 °C for 5–7 days; undisturbed. After 5–7 days, the plates were ready for the observation of colonies and further biochemical and antibiogram tests.

The grown colonies of organisms were spread over the mueller hinton agar media plate and labelled antibiotic discs were placed. This plate was again incubated for 12–24 h at 37 °C. A zone of inhibition (Fig. 3) appeared surrounding the antibiotic disc indicating the sensitivity of organism to the particular antibiotic and was measured by the help of WHO quality control chart to assess the sensitivity. Clinical signs and symptoms were recorded frequently to assess the dissolution of infection.

4. Statistical analysis

The data was analyzed by student *t*-test and chi square test for statistical significance within group and between groups. For the analysis SPSS (16.0 version) was used. All the data has been represented as frequencies and proportions. The data was evaluated using chi square test. P value < 0.05 considered as statistically significant.

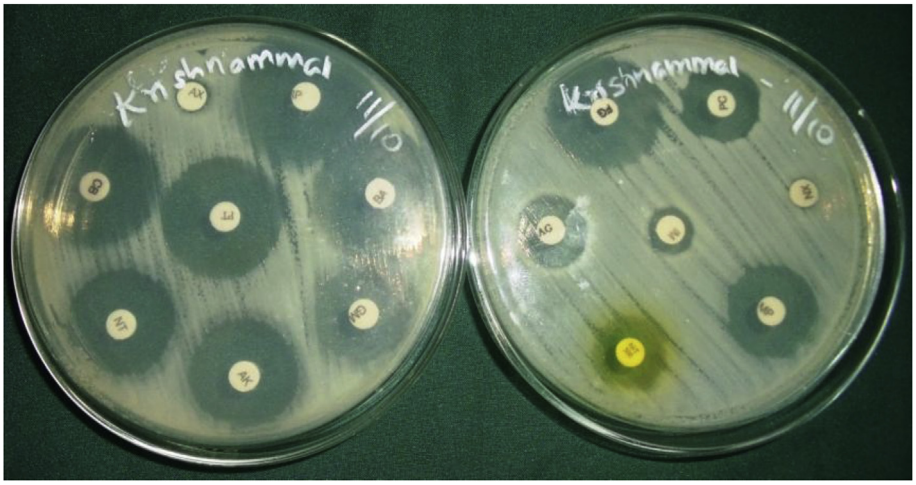

Fig. 3. Mueller hinton agar plate with antimicrobial disc showing antibiotic sensitivity.

Fig. 4. Anaerobic jar, gas pack and indicator tablets with media plates.

5. Results

Out of 142 patients; 17 samples were sterile and 125 cases were taken up for the study, Out of 125 cases, 29 (23.2%) Aerobic organisms, 36 (28.8%) anaerobic organisms and 60 (48%) mixed organisms were isolated. $P < 0.05$ significant compared aerobics with anaerobic and mixed, $P < 0.05$ significant compared anaerobic with mixed (see Table 1).

Out of 29 aerobic organisms 10 (34.49%) were *Streptococcus viridans* and was the most common organism isolated followed by 6 (20.69%) *Staphylococcus aureus*, 5 (17.25%) coagulase negative *Staphylococcus*, 4 (13.79%) *Pseudomonas aeruginosa* and both *Escherichia coli* and *Klebsiella pneumonia* were isolated from 2 (6.89%) specimens each. $P < 0.05$ significant compared *Streptococcus viridians* with other organisms (Table 2).

In anaerobic group of organisms, *Peptostreptococcus* 22 (61.11%) was the most common organism isolated followed by *Bacteroides* 10 (27.78%), and *Actinomyces* 4 (11.11%). $P < 0.05$ significant compared *Peptostreptococcus* with other organisms. (Table 3).

Streptococcus viridians with Peptostreptococcus were isolated from 18 (30%) cases and was the most common mixed organism isolated followed by *Staphylococcus aureus with Peptostreptococcus* in 12 (20%) cases, *Streptococcus viridans with Bacteroides* in 9 (15%) cases, *Staphylococcus aureus with Bacteroides* in 6 (10%) cases, *Coagulase negative staphylococcus with Bacteroides* from 1 (1.67%) cases, *Streptococcus viridans with Actinomyces* in 8 (13.33%) cases and *Staphylococcus aureus with Actinomyces* in 6 (10%) cases. $P < 0.05$ significant compared *Streptococcus viridians & Peptostreptococcus* with other organisms (Table 4).

Among the pencillin group (Fig. 5) there was resistance to Amoxicillin in 28 (96.55%) out of 29 aerobic organisms, 31 (86.11%) out of 36 anaerobic organisms and 58 (86.33%) of mixed organisms, followed by ampicillin, cloxacillin, pencillin, augmentin (amoxicillin with clavulenic acid).

Among the miscellaneous group of drugs (Fig. 6), all the aerobic, anaerobic and mixed group of organisms were sensitive to linezolid (100%). Entire anaerobic group were sensitive (100%) to metronidazole and 39 (65%) out of 60 mixed organisms were sensitive to

Table 1
Antibiotics used for the study.

S. No	Antimicrobial Class	Representative Antibiotics
1.	Sulfonamides	Sulfadiazine
2.	Fluoroquinolones	Ofloxacin, Norfloxacin Gatifloxacin, Levofloxacin, Nalidixic acid, Ciprofloxacin, Cotrimoxazole
3.	Aminoglycoside	Gentamycin, Amikacin, Neomycin, Streptomycin
4.	Macrolides	Erythromycin, Azithromycin, Roxithromycin
6.	Penicillin's	Ampicillin, Amoxicillin, Penicillin G, Amoxicillin and clavulanic acid, Piperacillin, Cloxacillin, Meropenem
7.	Cephalosporin	Cefotaxime, Cefixime, Cefuroxime, Cefpodoxime Cephalexin, Ceftazidime, Cefazolin
8.	Broad Spectrum Antibiotics	Doxycycline, Tetracycline, Chloramphenicol
9.	Miscellaneous antibiotics	Linezolid, Clindamycin Bacitracin, Vancomycin, Furoxone, Nitrofurantoin, Septran, Sporidex

Table 2
Aerobic organisms.

S. No.	Aerobic Organisms	Frequency	Percentage (%)
1	Streptococcus Viridans	10	34.49
2	Staphylococcus Aureus	6	20.69
3	Coagulase negative staphylococcus	5	17.25
4	Pseudomonas Aeroginosa	4	13.79
5	E. Coil	2	6.89
6	Klebsiella Pneumonia	2	6.89
	Total	**29**	**100**

Table 3
Anaerobic organisms.

Sl. No	Anaerobic Organisms	Frequency	Percentage (%)
1	Peptostreptococcus	22	61.11
2	Bacteroides	10	27.78
3	Actinomyces	4	11.11
	Total	**36**	**100**

Table 4
Mixed organisms.

S. No	Mixed Organisms	Frequency	Percentage (%)
1	Streptococcus Viridans + Peptostreptococcus	18	30.00
2	Staphylococcus Aureus + Peptostreptococcus	12	20.00
3	Streptococcus Viridans + Bacteroides	9	15.00
4	Staphylococcus Aureus + Bacteroides	6	10.00
5	Coagulase negative staphylococcus + Bacteroides	1	1.67
6	Streptococcus Viridans + Actinomyces	8	13.33
7	Staphylococcus Aureus + Actinomyces	6	10.00
	Total	**60**	**100**

metronidazole. Resistance to metronidazole was 21 (35%) out of 60 mixed organisms. Entire aerobic group were sensitive (100%) to clindamycin, 30 (83.33%) out of 36 anaerobic groups were sensitive to clindamycin. And 38 (63.33%) out of 60 mixed organisms were sensitive to clindamycin. Resistance to clindamycin was 6 (16.77%) out of 36 anaerobes. and 22 (36.67%) out of 60 mixed organisms. Vancomycin and bacitracin turned out to be highly resistant and least sensitive. Furoxone, nitrofurantoin, septran, sporidex showed highest resistantance. $P < 0.05$ significant compared linezolid with other drugs in the group.

6. Discussion

According to the literature, submandibular space is the most common site involved in multiple space infection followed by lateral pharyngeal, buccal and submental spaces.[7,16] This was supported by Opeyemi O. Daramola and Poeschl PW.[16,17] In the present study of 125 cases we also found submandibular space (20%) to be the most commonly involved site in multiple space infection. In our study vestibular space 46 (36.8%) showed more predisposition, deviating from literature by A.J Raga et al.[6] who said that the submandibular space was the most common location for a single-space abscess (30%). Out of 125 cases, 46 (36.8%) cases were vestibular space followed by 24 (20%) submandibular, 16 (12.8%) buccal, 10 (10%) canine, 8 (6.4%) submassetric, 6 (4.8%) canine and buccal, 5 (4%) sublingual, 4 (3.2%) palatal space, temporal and ludwigs were affected in 3 (2.4%) cases each. From the above study, vestibular space turned out to be the most common site of infection followed by submandibular space.

The typical odontogenic infection is caused by a mixture of aerobic and anaerobic bacteria, ie, approximately 70% of these infections are caused by mixed flora.[18] In the present study most of the infections are of mixed organisms 60 (48%), followed by pure anaerobes in 36 (28%) and pure aerobes in 29 (23.3%) cases. Andrew Bridgeman[9] in 1995 states that odontogenic maxillofacial infections consist of aerobic, facultative anaerobic and obligate anaerobic bacteria with the aerobes and facultative anaerobes being outnumbered by strict anaerobic bacteria by a factor of at least 2:1 with *streptococci* predominate.

In this study, out of 125 cases, pure aerobic organisms caused infection in 29 cases. Out of this, 10 (34.49%) were *Streptococcus viridians* followed by *Staphylococcus aureus* 6 (20.69%) cases, *Coagulase negative Staphylococcus* 5 (17.25%) cases, *Pseudomonas aeruginosa* 4 (13.79%) cases, and both *Escherichia coli* and *klebsiella pneumonia* were isolated from 2 (6.89%) specimens each(Table 2).

In this study (Table 3), out of 36 anaerobic organisms, 22 (61.11%) were *Peptostreptococcus* followed by 10 (27.78%) *Bacteroides*, and 4 (11.11%) *Actinomyces*. Mixed species found were (Table 4) *Streptococcus viridians with Peptostreptococcus* isolated from 18 (30%) cases and was the most common mixed organism isolated followed by *Staphylococcus aureus with Peptostreptococcus* in 12 (20%) cases, *Streptococcus Viridans with Bacteroides* in 9 (15%) cases, *Staphylococcus Aureus with Bacteroides* in 6 (10%) cases, *Coagulase negative staphylococcus with Bacteroides* in 1 (1.67%) case, *Streptococcus viridans with Actinomyces* in 8 (13.33%)

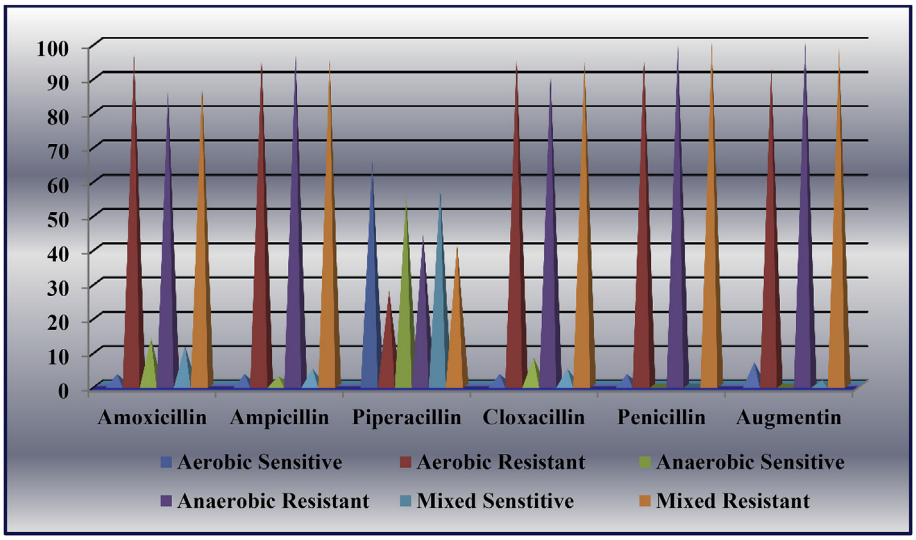

Fig. 5. Percentage of cases sensitive and resistant to penicillin group.

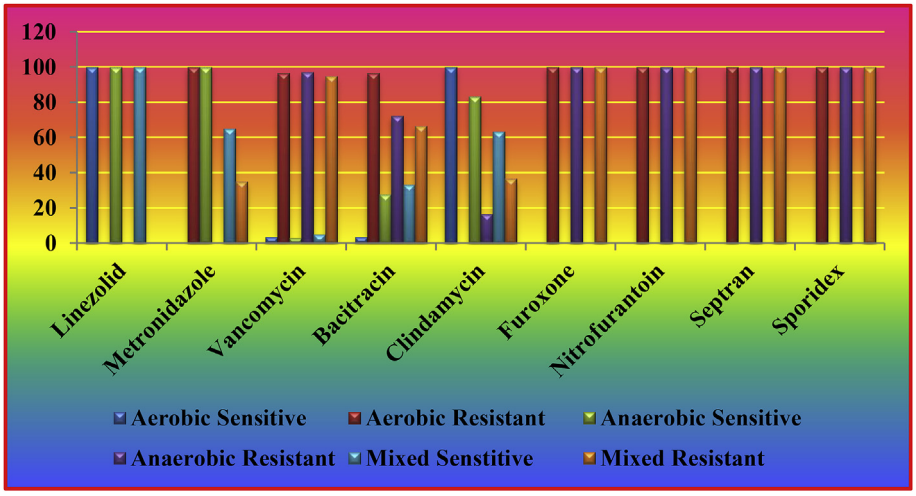

Fig. 6. Percentage of cases sensitive and resistant to miscellaneous group of drugs.

cases and *Staphylococcus aureus with Actinomyces* in 6 (10%) cases.

According to the literature it has been found that *Streptococus viridians* was the most common pathogen in the head and neck space infections[1,6,13,19]. This study also proves the same. The second most common microorganism isolated was the *Staphylococcus* aureus 5 (17.25%). These results were also supported by the previous studies.[20]

The third most common micro organism isolated in this study was *Coagulase negative Staphylococcus* 4 (13.79%) which was found an important source of nosocomial infections. In this study, we found significant level of resistance to commonly used antibiotics in (6%) *Coagulase negative Staphylococci*.

Penicillin has been the antibiotic of choice for most odontogenic infections.[8–10,20] But resistant organisms have developed due to its long and widespread use.[21,23]

In our center Amoxicillin with Metronodazole was the most common empirical antibiotics prescribed to patients with odontogenic infections. And in study among the pencillin group, there was resistance to amoxicillin in 28 (96.55%) out of 29 aerobic organisms, 31 (86.11%) out of 36 anaerobic organisms and 58 (86.33%) of mixed organisms, followed by ampicillin, cloxacillin, pencillin, augmentin (amoxicillin with clavulenic acid).

Among the fluroqunolones, organisms showed highest sensitivity towards ofloxacin and levofloxacin. Sensitivity to ofloxacin was seen in 17 (58.62%) out of 29 aerobic organisms, 19 (52.77%) out of 36 anaerobes and 25 (41.66%) out of 60 mixed organisms. Resistance to ofloxacin was 12 (14.36%) out of 29 aerobic organisms, 17 (47.22%) out of 36 anaerobic organisms and 35 (58.33%) out of 60 mixed organisms. This result was supported by Munish Kohli[23]et al. in 2009. In his study ofloxacin was the most sensitive drug. The most resistant drugs were amoxicillin and ampicillin. The gram negative colonies were sensitive to cefotaxime.

In the present study, among aminoglycosides 5 (17.24%) out of 29 aerobic organisms, 3 (8.33%) out of 36 anaerobic organisms and 12 (12%) out of 60 mixed organisms were sensitive to gentamycin. Resistance to gentamycin was noted in 24 (82.76%) out of 29 aerobes, 33 (91.67%) out of 36 anaerobes, and 48 (80.00%) out of 60 mixed organisms, Streptomycin showed least sensitivity and highest resistance.

In the macrolide group, organisms were least sensitive to Erythromycin (3.45%) and showed higher resistance (96.67%). But sensitivity to azitromycin was 6 (20.69%) out of 29 aerobic organisms, 8 (22.22%) out of 36 anaerobic organisms, and 18 (30%) out of mixed organisms. Resistance to azitromycin was seen in 23 (79.31%) out of 29 aerobic organisms, 28 (77.78%) out of 36 anaerobic organisms and 42 (70%) out of 60 mixed organisms followed by roxithromycin. This high resistance to macrolides was supported by Paul. W. Poeschl[24] et al. in 2010. He concluded that the high resistance rate for macrolides was striking and may necessitate an adoption of newer antibiotic regime in the future.

Among cephalosporins group, sensitivity to cefixime was 20 (68.97%) out of 29 aerobic organisms, 28 (77.78%) out of 36 anaerobic organisms and 45 (75%) out of 60 mixed organisms. Resistance to cefixime was 9 (31.03%) out of 29 aerobic organisms, 8 (22.22%) out of 36 anaerobic organisms and 15 (25%) out of 60 mixed organisms. Sensitivity to cefotaxime was 18 (62.07%) out of 29 aerobic organisms, 24 (66.67%) out of 36 anaerobic organisms and 39 (65%) out of 60 mixed organisms. Resistance to cefotaxime was 11 (37.93%) out of 29 aerobic organisms, 12 (33.33%) out of 36 anaerobes and 21 (35%) out of 60 mixed organisms followed by ceftriaxone, cephalexin, cefradiazone, and the least sensitive in the group were cephpodoxime and cefazolin.

Among the broad spectrum antibiotics, organisms showed highest sensitivity and least resistance to doxycyclin. Sensitivity to doxycyclin was 15 (51.72%) out of 29 aerobes, 21 (58.33%) out of 36 anaerobic organisms and 34 (56.67%) out of mixed organisms. Resistance to doxycyclin was 14 (48.27%) out of 29 aerobic organisms, 15 (41.67%) out of 36 anaerobic organisms and 26 (43.33%) out of 60 mixed organisms. There was highest resistance and least sensitivity towards tetracycline, chloramphenicol and meropenem.

Among the miscellaneous group of drugs (Fig. 6), all the aerobic, anaerobic and mixed group of organisms were sensitive to linezolid (100%). Entire anaerobic group were sensitive (100%) to metronidazole and 39 (65%) out of 60 mixed organisms were sensitive to metronidazole. Entire aerobic group were sensitive (100%) to clindamycin, 30 (83.33%) out of 36 anaerobic groups were sensitive to clindamycin. And 38 (63.33%) out of 60 mixed organisms were sensitive to clindamycin. Resistance to clindamycin was 6 (16.77%) out of 36 anaerobes and 22 (36.67%) out of 60 mixed organisms. John G. Bartlett[25] et al., in 1975 reported that clindamycin proved equally effective in anaerobic pulmonary infections and in his study there were no therapeutic failures reported with clindamycin.

Vejayan Krishnan,[4] in 1993 described that pencillin resistant organisms have developed due to its long and widespread use so that clindamycin became preferred antibiotic for empiric therapy in his study. In literature, lots of reports about the resistance of amoxycillin and hence alternative antibiotic replacement have been reported such as clindamycin[5,15]. Even clindamycin failure with penicillin therapy and a rate of penicillin resistance also has been reported.

7. Conclusion

Specificity of empirical antibiotic therapy could be improved with good knowledge about the pathologic flora in the locality. There should be substitution of miscellaneous group of antibiotics such as linezolid, clindamycin, third generation cephalosporins such as cefixime, cefotaxime, and fluroqunolones such as ofloxacin and levofloxacin for amoxicillin in the empirical management of odontogenic space infections.

It can be concluded that the knowledge about the pathologic flora involved in head and neck infection in a locality and their sensitivity and resistance to commonly used antibiotics will help the clinician in administering appropriate antibiotics at the earliest phase of infection, which will adequately control the infection and hence minimize the morbidity rate.

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