Bacteriological study of root canals associated with periapical abscesses

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Objective. The aim of this study was to identify microorganisms from root canals with periapical abscesses and to ascertain the susceptibility of *Peptostreptococcus prevotii* and *Fusobacterium necrophorum* to antimicrobials.

Study design. Thirty root canals were microbiologically sampled by using sterile paper points. The concomitant microorganisms were identified through the use of established methods. The susceptibility of *P. prevotii* and *F. necrophorum* to antimicrobials was evaluated by using the E test method.

Results. A total of 117 different bacterial strains were recovered, including 75 strict anaerobes or microphilic species. The most frequently isolated strict anaerobes were *P. prevotii*, *Peptostreptococcus micros*, and *F. necrophorum*. Facultative bacteria such as *Gemella morbillorum* and *Streptococcus mitis* were also found, albeit less frequently. The data revealed that *P. prevotii* and *F. necrophorum* were susceptible to the tested antibiotics.

Conclusions. Gram-positive anaerobic bacteria predominate in the mixed microbiota of root canals with periapical abscesses. Moreover, *P. prevotii* and *F. necrophorum* are susceptible to the tested antibiotics.


Endodontic therapy plays an important role in removing bacteria, their by-products, and their substrates by disrupting, then destroying, the microbial ecosystem through chemicals and mechanical methods. If root canal instrumentation and treatment are not performed, the infection can reach the periapical tissue, causing inflammatory alterations in this region.¹

Many studies have been performed to identify the microorganisms present in infected root canals and to correlate them with clinical signs and symptoms.²⁻⁴ Periapical abscesses are characterized clinically by pain or swelling, or both.⁵ Such abscesses are a significant odontogenic infection because of their potential to progress through the cortical bone and to spread over the sinuses and other facial spaces of the head and neck, with possibly lethal consequences. Therefore, early recognition of the etiology of periapical abscesses is essential to the development of appropriate therapies.⁶

Most periapical abscesses do not require antibiotic therapy or bacteriologic investigation. Patients who need antibiotics as an adjunct to root canal therapy—medically compromised individuals, for example—usually respond well to empirical treatment that is not predicated on the results of culture and susceptibility testing.

Several studies have revealed that the microbiota associated with periapical abscesses are usually polymicrobial, with the mean number of species ranging from <3 to 8.5 per specimen.⁶⁻¹¹ However, it is important to periodically obtain culture and susceptibility data to monitor possible changes in the types and antibiotic resistance of microorganisms responsible for periapical abscesses.¹²,¹³ The E test system (AB BIODISK, Solna, Sweden), a plastic strip with a continuous gradient of antibiotic with 15 minimum inhibitory concentration (MIC) dilution, is a simple and reliable method for susceptibility testing of all anaerobic bacteria.¹⁴

The aim of this study was to identify microorganisms in root canals with periapical abscesses and to determine the susceptibility of *Peptostreptococcus prevotii* and *Fusobacterium necrophorum* to benzylpenicillin, amoxicillin, amoxicillin and clavulanate potassium, metronidazole, clindamycin, erythromycin, and azithromycin.

MATERIAL AND METHODS

Patients

In accordance with the protocols of the Ethical Committee at the Piracicaba School of Dentistry (Piracicaba, SP, Brazil), the microbial samples were obtained from adult patients who presented at the emergency department at the Piracicaba School of Dentistry. Pa-
tients who had received antibiotic therapy in the 6 months before presenting at the emergency department and those in whom it was not possible to reach an adequate length of the root canal to take the microbiologic sample were excluded from our study. Therefore, of 70 patients initially examined, samples for this study were collected from 30 root canals (30 patients). The patients ranged from 11 to 53 years of age. The population consisted of 13 male patients and 17 female patients, all of whom had pain and swelling. Furthermore, their symptoms met the criteria for acute periapical abscesses described by Torabinejad and Walton.15

**Patient sampling**

The microbiologic investigation was performed under strict aseptic conditions. A standardized routine of root canal therapy was instituted, and in each case a single root canal was sampled. In multirooted teeth, only the largest canal was selected to preserve the identity of a single endodontic/microbiologic ecosystem. Necrotic pulp tissue was observed in 27 root canals and previous endodontic treatment in 3.

Before sampling the contents of the root canal, the restorations and carious lesions were completely removed. Then the tooth was isolated by using a rubber dam disinfected with 5.25% sodium hypochlorite for 30 seconds applied with a cotton-tipped applicator.16 The sodium hypochlorite was neutralized with 5% sodium thiosulfate,17 and sterile saline solution was used as a final wash. The access cavity was prepared with sterile burs (Gates-Glidden, Dentsply, Maillefer, Ballaigues, Switzerland) but without the use of a water spray, which allowed us to preserve the contents of the radicular pulp tissue. The coronal necrotic pulp tissue was carefully removed, and subsequent enlargement of the coronal third of the root canal was performed to prevent contamination of the sampling paper point by the contents of the coronal pulp. When the tooth had an atresic root canal that interfered with the penetration of the paper point, patency was accomplished through minimal instrumentation with a No. 10 file (C+ Files, Dentsply, Maillefer, Ballaigues, Switzerland), without any irritant. Pre-existing root fillings were removed by mechanical means as completely as possible, and, in these cases, the canal was copiously irrigated with a sterile saline solution to remove treatment residues before our microbial investigations were begun. In no case was the sampling preceded by irrigation with any chemically active agent. In patients in whom a dry canal was identified, 0.5 mL of sterile saline solution was injected before sampling.

Microbiologic samples were then collected by introducing sterile paper points (Tanari-Tariman Ltda, Manaus, AM, Brazil) to the full length of the canal, which was determined through standard initial radiographs. The paper points were held in place for 60 seconds under a continuous flow of nitrogen to preserve the anaerobic bacteria.18 The teeth in which it was not possible to reach the full length of the canal were excluded from the microbiologic sampling.

The paper points were immediately placed in an Eppendorf tube containing 1.0 mL of Viability Medium Götéborg Agar (VMGA) III transport medium17,19 and were submitted to the endodontic microbiology laboratory within 15 minutes. Inside the anaerobic workstation (Don Whitley Scientific, Bradford, England), the Eppendorf tube was vortexed for 1 minute. The VMGA III medium was diluted to 1/10, 1/100, 1/1000, and 1/10,000 by using prereduced suspension medium (fastidious anaerobe broth; Lab M, Bury, England). Fifty microliters of each dilution were inoculated onto plates containing 5% defibrinated sheep blood–fastidious anaerobe agar (FAA; Lab M) and incubated in the anaerobic workstation at 37°C in an atmosphere of 10% H2, 10% CO2, and 80% N2 for 2, 5, and 14 days to differentiate strict anaerobes from facultative anaerobes. Selecting for gram-positive anaerobes and actinomycetes involved the use of a 5% defibrinated sheep blood–FAA + nalidixic acid (0.001% wt/vol; Lab M) agar plate at 37°C anaerobically, for 2, 5, and 14 days. Selecting for gram-negative anaerobes involved the use of a 5% defibrinated sheep blood–FAA + nalidixic acid + vancomycin (0.00025% wt/vol; Lab M) agar plate at 37°C anaerobically, for 2, 5, and 14 days. Selection for *Clostridia* and other anaerobes involved the use of a 5% defibrinated sheep blood–FAA + neomycin (0.0075% wt/vol; Lab M) agar plate at 37°C anaerobically, for 2, 5, and 14 days.

Fifty microliters of the dilutions were also inoculated onto plates containing 5% sheep blood + brain-heart infusion agar (Oxoid, Hampshire, England), which were aerobically incubated at 37°C and examined after 18 hours and 2 days, to differentiate aerobes from facultative anaerobes.

**Identification of bacteria**

After the incubation period, a bacterial morphology analysis was performed with light stereomicroscopy (Lambda Let 2; Atto Instruments Co, Hong Kong, China). The different colony types were subcultured onto fresh prereduced medium (FAA + 5% sheep blood) to obtain pure cultures. Different colonies were selected on the basis of their appearance on the agar plates. The pure cultures were initially identified in terms of their Gram morphology, gaseous requirements, and ability to produce catalase.

Each colony obtained by anaerobic incubation was used to inoculate 2 plates of fresh FAA + 5% sheep
blood (Lab M). One plate was incubated aerobically and the other anaerobically, both for 2 days. The bacterial growth on each plate was compared to determine the gaseous requirements of the bacterial species.

These procedures allowed us to make the primary identification of the strain as gram-positive or gram-negative, coccus or bacillus, catalase-positive or catalase-negative, and aerobic or anaerobic. On the basis of these primary results, the appropriate kit for identification was selected.

**Microbial speciation**

The following biochemical identification systems were used for the primary speciation of individual isolates: Rapid ID 32 A (bioMérieux, Marcy-l’Etoile, France) for strict anaerobic gram-negative and gram-positive rods; RapID ANA II System (Innovative Diagnostics Systems Inc, Atlanta, Ga) for strict anaerobic gram-positive cocci; API Staph (bioMérieux) for staphylococci and micrococci (gram-positive cocci; catalase-positive cocci); Rapid ID 32 Strep (bioMérieux) for streptococci (gram-positive cocci; catalase-negative cocci); and the Rapid NH System (Innovative Diagnostics Systems Inc) for *Eikenella, Haemophilus, Neisseria*, and *Actinobacillus*.

Additional tests were performed for the black-pigmented gram-negative anaerobes, including fluorescence testing under long-wave (366-nm) ultraviolet light; hemagglutination of 3% sheep erythrocytes, lactose fermentation by application of the fluorogenic substrate 4-methylumbelliferyl-β-galactosidase (Sigma Chemical Co, St Louis, Mo), as described by Aicoforado et al20; and the determination of trypsinlike activity by application of the synthetic fluorogenic peptide, as described by Aicoforado et al,20 Nakamura et al,21 and Slots.22

**Epsilometer test**

The Epsilometer test (E test) was performed by using brucella agar medium (Oxoid), supplemented with 5% sterile defibrinated sheep blood, added to 600 μL of vitamin K<sub>1</sub> and 600 μL of bovine hemin (Sigma Chemical Co) in 90-mm (diameter) plates. The microorganisms *Peptostreptococcus prevotii* (Gram-positive) and *Fusobacterium necrophorum*, (Gram-negative) were selected for this test. The inocula of *P prevotii* and *F necrophorum* were prepared in an anaerobic workstation (Don Whitley Scientific) by suspending pure colonies of each microorganism in brucella broth to achieve the visual turbidity of 1 McFarland standard 3×10⁸). An inoculum was applied to each plate with a fresh sterile cotton swab. The E test strips containing benzylpenicillin, amoxicillin, and amoxicillin were combined with clavulanic acid, metronidazole, clinda-

<table>
<thead>
<tr>
<th>No. of species per root canal</th>
<th>Frequency (n = 30)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (no growth)</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>16.7</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>16.7</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>3.3</td>
</tr>
</tbody>
</table>

**RESULTS**

In 30 root canals sampled, 19 teeth had restorations, 8 teeth were decayed, 2 were without coronal sealing, and 2 were intact. One tooth had both restoration and decay. In addition, 27 teeth had necrotic pulps and 3 had received previous endodontic treatments. The dental groups involved were incisors (12/30), premolars (9/30), molars (8/30), and canines (1/30); 15 upper and 15 lower teeth were used.

A total of 117 cultivable isolates were recovered from the 30 root canals examined, indicating a mean incidence of 3.9 bacteria per root canal (Table I). Of these 117 isolates, 75 were identified as strict anaerobes and 42 as facultative anaerobes, with 29 gram-negative and 88 gram-positive species (Table II).

Eighty percent of the root canals (n = 24) had strict anaerobe bacteria, and 76.6% had facultative anaerobe mycin, erythromycin, and azithromycin and then applied to each plate, in duplicate. Plates were incubated in an anaerobic workstation (Don Whitley Scientific) at 37°C for 48 hours. After incubation, an elliptical zone of growth inhibition was seen around the strip. The MIC was read from the scale at the intersection of the zone with the strip. In this study, the susceptibility breakpoints against anaerobes were determined by using the National Committee for Clinical Laboratory Standards (NCCLS) criteria.23 The breakpoints (in micrograms/milliliters) used to determine the susceptibility were as follows: benzylpenicillin, ≤0.5; amoxicillin, ≤4; amoxicillin combined with clavulanic acid, ≤2; metronidazole, ≤8; and clindamycin, ≤2. The breakpoints of erythromycin and azithromycin against anaerobes have not been determined by the NCCLS23; therefore, for this study, we used ≤4 μg/mL, as did Spangler and Appelbaum24 and Kuriyama et al.11 In all species, the tests were read after 24 and 48 hours of incubation.
The following were isolated from single root canals: Actinomyces naeslundii, Actinomyces viscosus, Aerococcus viridans, Bacteroides spp, Capnocytophaga spp, Clostridium acetobutylicum, Clostridium butyricum, Clostridium hystitiforme, Enterococcus sp, Enterococcus faecium, Eubacterium aerofaciens, Eubacterium limosum, Lactobacillus lactis, Lactobacillus minute, Lactobacillus acidophilus, Lactobacillus Neisseria spp, Peptostreptococcus asaccharolyticus, Peptostreptococcus magnus, Peptostreptococcus tetradius, Prevotella buccae, Prevotella oris, Streptococcus acidominimus, Streptococcus intermedius, and Streptococcus mutans.

However, these antibiotics had antimicrobial activity against 80% of \( P \) prevotii.

Tables III and IV show the MICs of the antibiotics to both bacteria and the antimicrobial susceptibility data based on the NCCLS criteria.

### DISCUSSION

Culture procedures have traditionally been used in the assessment of the microbiota associated with various infectious diseases, including infections of endodontic origin. The culturing techniques have a reasonable degree of agreement in terms of the identification of oral microorganisms compared with that of the “checkerboard” DNA-DNA hybridization method. The major advantage of the culture procedure is its ability to enable the detection of unexpectedly viable cells (molecular procedures enable the detection of only target microbial species). Many molecular techniques assist in the identification of cultivable microorganisms.

The strict anaerobes \( P \) prevotii, \( P \) micros, \( F \) necrophorum, and \( S \) constellatus and the facultative anaerobes \( G \) morbillorum and \( S \) mitis were the most fre-
The presence of black-pigmented bacteria was also evaluated in the current study. These microorganisms were found in 8 of 30 root canals (26.7%). *P. nigrescens* and *Prevotella corporis* were both isolated in 10% of the cases, whereas *Prevotella loescheii* was found in 6.6%. These findings are similar to those reported by Sundqvist et al.\(^8\) and Baumgartner et al.\(^{29}\). In contrast, in the studies by Oguntebi et al.\(^{26}\) and Williams et al.\(^6\) the black-pigmented bacteria were less frequently isolated. *Porphyromonas endodontalis* was not isolated in the present study, a finding in accord with those of Khemaleelakul et al.\(^{30}\). Gomes et al.\(^{31}\) reported that a minimum concentration of *Porphyromonas* species is necessary for their isolation and, consequently, for their clinical recognition. Gomes\(^4\) suggested that the presence of *Porphyromonas* species at a low concentration is difficult to detect through the use of culture methods; therefore, the inadequate growth of such microorganisms does not necessarily signal a lack of anaerobic conditions. van Winkelhoff et al.\(^{32}\) have already described the difficulties in isolating these bacterial species through the use of culture methods. Moreover, Dymock et al.\(^{33}\) and Baumgartner et al.\(^{34}\) have reported that different populations have correspondingly different compositions of microbiota—or it may be that these species consist of both culturable and nonculturable biotypes.

Our results indicate that the microbiota of root canals with periapical abscesses have polymicrobial characteristics and are predominated by anaerobic gram-positive cocci. The role of anaerobic bacteria in periapical abscesses cannot be overstated; in fact, these bacteria were isolated from 80% of the root canals in this study.

The root canals with previous endodontic treatment had an average of 2.6 microorganisms per root canal. The microbiota of such root canals were represented mainly by facultative gram-positive species, a finding in agreement with those of Sundqvist et al.\(^{35}\). Therefore, the microbiota of root canals in which endodontic therapy failed differed markedly from the microbiota of untreated teeth, even when the teeth had periapical abscesses.

These findings play an important role not only in the identification of the microorganisms present in the root canals with periapical abscesses, but also in the development of specific antibacterial methods to supplement conventional emergency treatments. The indiscriminate use of antibiotics to complement dental treatments should be avoided because it may result in allergic reactions, superinfection development instigated by resistant bacterial species, and patients’ unnecessary exposure to both the toxicity and the side effects of the medication.\(^{36}\)

The E test method was used in the present study because it provides a simple and a rapid method for quantitative susceptibility testing that is suitable for all anaerobes. Moreover, the MIC obtained with this test are generally in very good agreement with those obtained by agar dilution methods, which is the reference method of the NCCLS.\(^{14,37-39}\)

The anaerobic endodontic isolates have shown to be highly sensitive to benzylpenicillin, amoxicillin, amoxicillin/clavulanate potassium, metronidazole, and clindamycin, with MICs substantially below the critical concentrations.

In this study, the susceptibility breakpoints were based on NCCLS criteria,\(^{23}\) which are widely used in various bacterial studies. However, the NCCLS\(^{25}\) breakpoints may be too strict for some test antibiotics because the breakpoints are below the typical sera or tissue concentrations of the antibiotics. The bacterial strains that were determined to be unsusceptible to

### Table III. MIC of the antibiotics to *P. prevotii*

<table>
<thead>
<tr>
<th>Antimicrobial agents</th>
<th>MIC (µg/mL)(^*)</th>
<th>50%</th>
<th>90%</th>
<th>Range of MIC</th>
<th>Susceptibility rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzylpenicillin</td>
<td>0.016</td>
<td>0.38</td>
<td>&lt;0.016-0.38</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>0.19</td>
<td>0.25</td>
<td>0.032-0.25</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Amoxicillin + clavulanic acid</td>
<td>0.125</td>
<td>0.19</td>
<td>0.064-0.19</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Metronidazole</td>
<td>0.016</td>
<td>0.38</td>
<td>&lt;0.016-0.38</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Clindamycin</td>
<td>0.38</td>
<td>0.125</td>
<td>&lt;0.016-0.125</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Erythromycin</td>
<td>1.0</td>
<td>1.0</td>
<td>0.016-1.0</td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td>Azithromycin</td>
<td>1.5</td>
<td>8.0</td>
<td>0.016-8.0</td>
<td>80%</td>
<td></td>
</tr>
</tbody>
</table>

\(^*\)Fifty percent and 90%, at which 50% and 90% of the isolates are inhibited, respectively.

MIC, Minimum inhibitory concentration.
certain antibiotics according to the present criteria might actually be clinically susceptible to those antibiotics because they may be affected by other factors such as infection site or dosage.11 P prevotii and F necrophorum were used in our study because they were the predominant species found in the root canals of our patients.

Benzylpenicillin (penicillin G) and penicillin V are the most used natural penicillins. Benzylpenicillin is the parenteral antibiotic of choice when a rapid effect or a high serum concentration of the drug is required.40 The microorganisms tested had high susceptibility to benzylpenicillin.

Amoxicillin is extended-spectrum penicillin. It was developed to provide coverage against certain gram-negative species—particularly Haemophilus influenzae, Escherichia coli, and Proteus mirabilis.41 Amoxicillin resistance is well documented in the genera Prevotella, Porphyromonas, Bacteroides, and Fusobacterium.42 Such resistance has also been documented for anaerobic gram-positive bacteria.42,43 However, the latter data were from hospital isolates. Our results indicate that the species isolated from root canals with periapical abscesses remain particularly susceptible to amoxicillin. Furthermore, some authors44-46 have recommend amoxicillin as a first-choice antibiotic for dental infection because of its broader spectrum, longer action, and ability to compete with food for absorption. However, amoxicillin can cause gastrointestinal side effects, hypersensitivity, and the development of resistant strains and it is inactivated by β-lactamase.47

The efficacy of β-lactamase has been improved by combining amoxicillin with clavulanate potassium. This combination has been found to be active against a range of penicillin-resistant strict anaerobes48,49; in addition, it prevents the destruction of simultaneously administered β-lactamase antibiotics.41 Our results have shown the good antimicrobial activity of this formulation, which is in accordance with the findings of Lewis et al.49

Penicillins are the most frequently used antimicrobial agents because of their historical effectiveness, minimal toxicity, and relatively low cost.50 The effectiveness of the tested penicillins against P prevotii and F necrophorum remains positive. One hundred percent of the species tested were susceptible to these antibiotics (Tables III and IV). Moreover, penicillin has been the preferred drug for the treatment of odontogenic infections. However, bacterial resistance to penicillin has become a problem of great clinical significance because of its widespread use for many years.51

Erythromycin and clindamycin have been prescribed for patients who are allergic to penicillin.52-55 However, it has been noted that erythromycin is not effective against Fusobacterium.56 Erythromycin has a spectrum similar to that of penicillins G and V, but it does not achieve high concentration in blood; in addition, it is less effective against important anaerobes.41 Our findings further supported the poor antimicrobial activity of erythromycin against F necrophorum (Table IV). Fusobacteria are more frequently isolated from severe odontogenic infections than from milder infections.57 Kuriyama et al11 have suggested that erythromycin may be effective against mild or moderate infections in people with penicillin allergies, but it may not be suitable in cases of more severe infection. Our this study, only 20% of the F necrophorum species were susceptible to erythromycin. However, 80% of the P prevotii species were susceptible to this antibiotic.

Clindamycin has a bacteriostatic effect—except at high doses, when it becomes bactericidal. It has excellent activity against strict anaerobes including β-lactamase–producing bacteria.52-55 Our findings revealed that clindamycin was effective against the strict anaerobes tested (Tables III and IV). Because of its propensity to cause antibiotic-associated colitis, it has not been widely used for more routine mild-to-moderate odontogenic infections. The limited use of clindamycin is probably why it remains effective against a broad range of microorganisms.41,54

<table>
<thead>
<tr>
<th>Antimicrobial agent</th>
<th>MIC (μg/mL)*</th>
<th>Range of MIC</th>
<th>Susceptibility rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
<td>90%</td>
<td>0.016 - 0.016</td>
</tr>
<tr>
<td>Benzylpenicillin</td>
<td>0.016</td>
<td>100%</td>
<td>&lt;0.016 - 0.016</td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>0.016</td>
<td>100%</td>
<td>&lt;0.016 - 0.047</td>
</tr>
<tr>
<td>Amoxicillin + clavulanic acid</td>
<td>0.016</td>
<td>100%</td>
<td>&lt;0.016 - 0.023</td>
</tr>
<tr>
<td>Metronidazole</td>
<td>0.016</td>
<td>100%</td>
<td>&lt;0.016 - 0.047</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>0.023</td>
<td>100%</td>
<td>&lt;0.016 - 0.19</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>128</td>
<td>100%</td>
<td>0.047 - &lt;256</td>
</tr>
<tr>
<td>Azithromycin</td>
<td>0.38</td>
<td>40%</td>
<td>&lt;0.016 - 4</td>
</tr>
</tbody>
</table>

*Fifty percent and 90%, at which 50% and 90% of the isolates are inhibited, respectively.
Metronidazole is a bactericidal antibiotic. Because of its effectiveness against anaerobic microorganisms, it has been suggested for the treatment of periapical abscesses, usually combined with penicillin. In this study, metronidazole worked well against *F. necrophorum* and *P. prevotii* in terms of the recommended MIC breakpoint. This finding is in accordance with those of Citron et al. Azithromycin achieves higher blood concentration than erythromycin, without the gastrointestinal side effects. Azithromycin was tested as a substitute for erythromycin and was found to be effective against 80% of the *P. prevotii* and 40% of the *F. necrophorum* species. *P. prevotii* and *F. necrophorum* are susceptible to benzylpenicillin, amoxicillin, and amoxicillin combined with clavulanic acid, metronidazole, and clindamycin antibiotics. Thus, these antibiotics are recommended for use in patients at high risk of bacterial endocarditis or when antibiotic therapy is indicated during the treatment of patients with periapical abscesses. Clindamycin can be recommended for the treatment of severe infection in patients allergic to penicillin, as was also suggested by Kuriyama et al. Penicillin still appears to be the drug of choice for the treatment of oral infections. In oral infections, clindamycin seems to be a reasonable alternative for patients who are allergic to penicillin.

**REFERENCES**


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